ASTRONAUTICS AND AERONAUTICS: A CHRONOLOGY, 2001–2005

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PREFACE

This report is a chronological compilation of narrative summaries of news reports and government documents highlighting significant events and developments in U.S. and foreign aeronautics and astronautics. It covers the years 2001 through 2005. These summaries provide a day-by-day recounting of major activities, such as administrative developments, awards, launches, scientific discoveries, corporate and government research results, and other events in countries with aeronautics and astronautics programs. Researchers used the archives and files housed in the NASA History Division, as well as reports and databases on the NASA Web site.

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JANUARY 2001

3 January
Using data from the European Space Agency's (ESA's) Infrared Space Observatory, a team of NASA and university researchers identified three stars that they believed contain enough hydrogen to create a Jupiter-like gas planet. The scientists, from Italy, the Netherlands, and the United States, indicated that the stars Beta Pictoris, 49 Ceti, and HD1235344 have particularly fertile environments, which might eventually form planets. Perhaps most significant, the researchers found a "thousand times more hydrogen" in several stars than scientists had discovered in earlier studies.[1]

8 January
NASA astronomer Gerard M. Williger announced the discovery of a massive cluster of quasars and galaxies, a concentration presumed to be the largest structure ever observed in the universe. Collaborating with fellow NASA astronomers Luis E. Campusano, Roger G. Clowes, and Chris P. Haines, Williger had located the body approximately 6.5 billion light-years away from Earth, in the heart of the constellation Leo the Lion. Not prepared to state with certainty that the find was the largest ever discovered, Williger clarified, "We have found nothing bigger in the literature and nobody has brought to our attention anything bigger." Moreover, he speculated that the enormous gathering of quasars might be "an artifact of the Big Bang." Articles in scientific journals and in popular publications expressed excitement at the find.[2]

9 January
A team of astronomers led by Geoffrey W. Marcy of the University of California at Berkeley and R. Paul Butler of the Carnegie Institution of Washington announced that, during a long-term project to search for planets that orbit stars residing within 300 light-years of Earth, they had discovered two new planetary systems. Astronomers had already discovered dozens of planetary systems, but Marcy and Butler had found the first and second examples ever observed of systems with more than one planet orbiting a star. Furthermore, one of the planets discovered was so massive that it defied the parameters that scientists had previously used to define planets. In response to the discovery, one of Butler's colleagues stated simply, "I am astonished." Marcy admitted that he and his team did not know how to classify their discovery, saying, "The outer companion (of this star) is so massive, between 17 and 40 times the mass of Jupiter, that it seems too large for a conventional planet. We frankly don't know what name to give it!"[3]

10 January
At the American Astronomical Society convention, astronomers Victoria M. Kaspi and Mallory S. E. Roberts of McGill University presented evidence dating a known pulsar to 386 AD. Because scientists consider it quite difficult to determine the age of particular pulsars or of any astronomical body, the scientific community regarded the find as especially significant. The

[1] W. F. Thi et al., "Substantial Reservoirs of Molecular Hydrogen in the Debris Disks Around Young Stars," *Nature* 409, no. 6816 (4 January 2001): 60–63; Associated Press, "Study Finds Nearby Star Systems Capable of Making Big Planets," 3 January 2001.
[2] *New York Times*, "Bigger Than A Breadbox, or Anything Else," 8 January 2001; Reuters, "Quasars May Point To Universe's Biggest Structure," 8 January 2001.
[3] Kathy Sawyer, "A Giant Find Startles Astronomers," *Washington Post*, 10 January 2001; Reuters, "Astronomers Find Two New Planetary Systems," 9 January 2001.

researchers had used NASA's Chandra X-ray Observatory to locate the pulsar exactly at the center of a supernova remnant known as G11.2-0.3, which astronomers had already definitively dated. Scientists believed that both the pulsar and the supernova had formed during an explosion in 386 AD—an event that early Chinese astronomers had recorded. Astronomers have experienced difficulty tracking and interpreting the patterns of pulsars, because the formations spin and move rapidly. In light of the successful dating, many scientists hoped that the discovery might help them understand how pulsars develop.[4]

11 January

The People's Republic of China launched a robotic spacecraft from the Gobi desert, a significant step in the country's long-term plan to join the United States and Russia as one of the only nations capable of sending humans into space. The *Shenzhou 2* craft reached orbit about 10 minutes after launch. China had shrouded its 31-year-old space program in secrecy, releasing few details about funding or about China's future goals. *People's Daily*, however, called the launch "an important step in realizing manned spaceflight." President Jiang Zemin urged Chinese space officials to further accomplishments, saying, "I hope you will work persistently and unremittingly to achieve even greater victory." Space experts speculated that a successful *Shenzhou 2* mission could mean that China would be ready to send a man or woman to space in the next two to five years. Chinese officials remained circumspect regarding their exact plans.[5]

20 January

Administrator Daniel S. Goldin became NASA's first head to serve three different presidents when George W. Bush assumed the presidency of the United States. Although some had speculated that Goldin's tenure would end when President William J. Clinton left office, President George W. Bush asked Goldin to remain in his position indefinitely, while the new administration reviewed possible candidates to replace him. Originally appointed by President George H. W. Bush in 1992, Goldin had instituted vast changes at NASA with his "faster, better, cheaper" approach. During his tenure, Goldin had reduced the number of NASA employees from 24,000 to 18,000 while overseeing the successful building and deployment of the International Space Station (ISS).[6]

24 January

The Russian Space Agency launched a cargo ship headed for the aging *Mir* space station. The mission's aim was simple: to remove the 15-year-old space station from orbit safely, by propelling it into Earth's atmosphere. To accomplish the task, Russia selected an unpiloted Progress M1-5 cargo ship, carrying enough fuel for its own journey and to fire *Mir*'s thrusters. A series of mechanical problems, including a fire and a collision with another cargo craft in 1997, combined with Russia's shortage of funds for space endeavors, had led to the Russian government's decision to end *Mir*'s successful run. With the launch of the Progress craft, some cosmonauts and Russian space officials protested the destruction of the last remaining symbol of

[4] NASA, "Chandra Links Pulsar to Historic Supernova," news release 01-02, 10 January 2001.
[5] Associated Press, "Rocket Launch Aids New Space Program," 11 January 2001; Associated Press, "Second Unmanned Chinese Spacecraft Returns to Earth," 16 January 2001.
[6] Frank Morring Jr., "Goldin Sees Station, Innovation as Legacies of His NASA Tenure," *Aerospace Daily*, 8 January 2001; Brian Berger, "Goldin Responds to Presiding over NASA Through Bush Team Transition," *Space News*, 23 January 2001; Bryant Jordan, "NASA's Goldin Likely Gone," *Federal Computer Week*, 11 January 2001, *http://www.fcw.com* (accessed 11 January 2001).

the space heyday of the Soviet Union. Amateur astronomers aimed their telescopes toward the skies to glimpse *Mir* one last time as it orbited Earth.[7]

DiversityBusiness.com named NASA one of the United States' top 50 organizations for providing multicultural business opportunities. Sparked by the efforts of its Office of Small and Disadvantaged Business Utilization, NASA had awarded more than US$2 billion in contracts to minority-owned and women-owned businesses during 2000. NASA joined companies such as Cisco Systems Inc., Microsoft Corporation, and Wal-Mart Stores Inc. among those honored. NASA's hiring of disadvantaged businesses had more than doubled during Administrator Daniel S. Goldin's tenure.[8]

Michael A. Chowdry, the founder and chairperson of Atlas Air Inc., and Jeff Cole, the aerospace editor for the *Wall Street Journal*, died in a plane crash, which occurred minutes after takeoff from the Front Range Airport in Watkins, Colorado. Chowdry had formed Atlas Air in 1992, to lease jumbo cargo jets and to provide flight crews to the airfreight industry. Since 1999, readers of the *Wall Street Journal* had known Cole for his detailed and insightful coverage of the defense and aerospace industries. After interviewing Chowdry, Cole had accepted his invitation to ride aboard a Czech fighter jet. Chowdry was piloting the jet when it crashed.[9]

25 January
NASA made available the first large-scale images revealing a tail of electrified gas streaming from Earth toward the Sun. One of the images, which NASA's Imager for Magnetopause to Aurora Global Exploration (IMAGE) spacecraft had produced, appeared on the cover of *Science*. The IMAGE technology had captured new views of previously unverifiable gas trapped within Earth's magnetic field, known as the magnetosphere. The images placed in the context of the solar system the vast reach of the region affected by Earth's magnetosphere, which extends past the Moon on the night side of Earth. Astronomers compared the perspective the new images provided them, to the perspective satellite images of Earth provide to scientists researching hurricanes.[10]

30 January
Presiding over the launch of a Global Positioning System (GPS) satellite, Major Nina M. Armagno became the first female launch director at the Cape Canaveral Air Force Station. Armagno assumed responsibility for a 400-person crew and for making the final decision about whether to proceed with launch plans.[11]

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[7] Associated Press, "Cargo Ship Intended To Dump Mir Blasts Off Successfully," 24 January 2001; Reuters, "Kazakhstan: Russia To Launch Ship To Bring Mir Era to End," 17 January 2001; Agence France-Presse, "Russia Sets January 18 as Date for Mir's Final Appointment in Space," 4 January 2001; Michael Alicea, "See Mir in Flight—Before It's Gone," *Palm Beach Post* (FL), 21 January 2001.
[8] NASA, "NASA Makes the A-Team for Multicultural Contract Awards," news release 01-10, 24 January 2001.
[9] *Wall Street Journal*, "Crash Kills Atlas Air Chairman and Journal's Aerospace Editor," 25 January 2001.
[10] NASA, "NASA's Image Reveals Earth's Invisible Magnetic Tail," news release 01-08, 25 January 2001; cover of *Science* 291, no. 5504 (26 January 2001).
[11] Kelly Young, "First Woman Directs Launch," *Florida Today* (Brevard, FL), 31 January 2001.

31 January

NASA's Mars Global Surveyor spacecraft completed its primary mission, having collected more information about Mars than all of the previous missions combined had acquired. "By any conceivable measure the scientific impact of Mars Global Surveyor has been extraordinary," said Global Surveyor Project Scientist Arden L. Albee. Since reaching the Red Planet in 1998, Global Surveyor had gathered data on Mars's climate, topography, and geology, as well as mapping the entire planet. The orbiter, which launched in November 1996, had provided a steady stream of invaluable data. Among the most significant findings of the primary mission had been the detection of significant evidence of liquid water, the detection of a magnetized crust on the planet's southern hemisphere, and the discovery of new information about seasonal changes on the planet. The spacecraft had gathered the data in the course of more than 8,500 orbits of the planet, during which it had collected 58,000 images. With Mars Global Surveyor still functioning effectively, NASA planned to extend its mission and continue its research.[12]

NASA's Near Earth Asteroid Rendezvous (NEAR) Shoemaker spacecraft completed its primary mission to the asteroid Eros. NEAR was the first spacecraft successfully to orbit an asteroid and to provide detailed data about it. Even in its first year, the NEAR spacecraft had exceeded expectations, gathering 10 times more data than scientists had forecast. Traveling more than 2 billion miles (3.2 billion kilometers), NEAR had captured 11 million laser pulses; x-ray, gamma-ray, and infrared readings; and approximately 160,000 images of Eros. With its initial objectives accomplished, the NEAR team focused on accomplishing another first—a controlled descent of the spacecraft onto the asteroid. Astronomers hoped that the landing would gather close-up images, otherwise impossible to obtain. With the low-cost and efficient spacecraft nearly out of fuel, NEAR Mission Director Robert W. Farquhar explained that NEAR's landing was a final attempt to glean as much as possible from the endeavor. Said Farquhar, "With the spacecraft just about out of fuel and our science objectives met, this is a great way to end a successful mission. It's all bonus science . . . at this point the only real risk is not taking one."[13]

NASA's Jet Propulsion Laboratory (JPL) announced that Charles Elachi would become Director of its 5,000-employee, US$1.3 billion research facility in Pasadena, California. Elachi, an expert in the field of remote sensing best known for developing radar systems, had assumed JPL's top post after 30 years of service with NASA. JPL had interviewed more than 70 candidates over eight months before selecting Elachi. Concerning JPL's challenge to encourage further exploration while meeting tight budgets, Elachi remarked, "It's basically striking a balance between faster implementation and cheaper implementation and making sure we have success." Having lost two separate spacecraft headed for Mars in 1999, JPL stood at a critical juncture as Elachi assumed control.[14]

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[12] NASA, "New Era Begins as Mars Global Surveyor Completes Prime Mission," news release 01-14, 31 January 2001.

[13] NASA, "NEAR Mission Completes Main Task, Now Will Go Where No Spacecraft Has Gone Before," news release 01-13, 31 January 2001.

[14] Associated Press, "New Director Named for NASA's Jet Propulsion Laboratory," 31 January 2001; Usha Lee McFarling, "30-Year Veteran of JPL Is Chosen as Its Leader," *Los Angeles Times*, 31 January 2001.

FEBRUARY 2001

2 February
NASA opened a new command and control center that would allow researchers on Earth to participate in scientific research conducted aboard the ISS. The new facility, located at NASA's Marshall Space Flight Center (MSFC) in Huntsville, Alabama, featured state-of-the-art communication and research technologies. Director of MSFC Arthur G. Stephenson described the new center as a significant part of NASA's ongoing plan to make space research more efficient and useful: "From this facility we will manage fundamental scientific research that can only be done in space—research that will lead to knowledge to benefit all humanity here on Earth." NASA planned to staff the 13,000-square-foot (1,200-square-meter) facility 24 hours per day to support research aboard ISS. In addition to its link to the ISS, the new facility was equipped to monitor payload resources, facilitate data transfer, and communicate with universities and research centers throughout the world. The new command post opened only days before Space Shuttle *Atlantis*'s scheduled trip into space to carry the *Destiny* research laboratory module to the ISS.[15]

7 February
Space Shuttle *Atlantis* STS-98/ISS-5A lifted off from NASA's Kennedy Space Center (KSC) in Cape Canaveral, Florida, carrying the most expensive and crucial component of the ISS—the United States–built *Destiny* science laboratory. Mark Stephenson of the Boeing Company, which had built the US$1.4 billion research module, called the vessel "the crown jewel" of the ISS. NASA had set high stakes on the *Destiny* laboratory, which was so expensive and complicated to build, that NASA could not afford to assemble a backup module. Therefore, any problem in the transport and connection of the *Destiny* module would set back the ISS several years. NASA had delayed *Atlantis*'s mission for three weeks when engineers discovered evidence that faulty wiring might compromise the Shuttle's safety. The vital mission brought the ISS closer to becoming the permanent and highly functional research station that NASA and the international space community had long awaited. The *Destiny* laboratory measured 28 feet (9 meters) long, weighed more than 30,000 pounds (13,600 kilograms), and held 13 computers. NASA expected to control the ISS using the computers and communications equipment built into *Destiny*. Because of the Space Shuttle's cargo, some officials speculated that *Atlantis*'s mission was the most important for NASA's research agenda ever undertaken. One NASA spokesperson called the *Destiny* module "the cornerstone for space-based research aboard the orbiting platform." The STS-98 crew consisted of Commander Kenneth D. Cockrell; Pilot Mark L. Polansky; and Mission Specialists Robert L. Curbeam Jr., Thomas D. Jones, and Marsha S. Ivins.[16]

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[15] NASA, "NASA Opens Space Station Command Post," news release 01-15, 2 February 2001; Shelby G. Spires, "MSFC Opens Science 'Mission Control' Today," *Huntsville Times* (AL), 2 February 2001.
[16] NASA, "Space Shuttle Mission Archives: STS-98," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-98.html* (accessed 2 February 2009); William Harwood, "Atlantis Heads for Space Station; Shuttle Flight No. 102 Will Transport $1.4 Billion Lab Module," *Washington Post*, 8 February 2001; Kelly Young, "Atlantis To Deliver Destiny," *Florida Today* (Brevard, FL), 7 February 2001; Associated Press, "Shuttle Totes Space Station's 'Crown Jewel'," 8 February 2001; Associated Press, "Countdown Begins for Launch of NASA Lab," 5 February 2001; NASA, "Atlantis Set To Deliver International Space Station's Destiny," news release 01-16, 5 February 2001.

Russian President Vladimir Putin appointed a new director of Russia's largest manufacturer of spacecraft and rockets, the Khrunichev State Research and Production Company. Putin selected Alexander I. Medvedev to succeed Anatoly Kiselyov, who had headed the company for 26 years. At the time of the change in leadership, Kiselyov had reported failing health. Companies with interests in Russian space exploration continued to adjust to postcommunist operations. The Khrunichev State Research and Production Company, providing much of the revenue to keep Russia's space projects alive, manufactured Proton booster rockets used to launch commercial and communication satellites.[17]

9 February

Lieutenant Governor of Florida Frank T. Brogan and Roy D. Bridges Jr., Director of NASA's KSC, broke ground on a new research facility located just south of KSC. The new project, officially named the Space Experiment Research and Processing Laboratory (SERPL), joined researchers from the state of Florida, NASA, the Florida Space Research Institute, and the University of Florida. The research center would devote significant resources to ISS research and to examining the commercial potential of space-related research. Bridges described the venture as widely beneficial, saying, "SERPL and the unprecedented opportunities for collaboration that it represents are key to Kennedy's evolution to a recognized center for technology development. We expect this partnership to pay dividends to NASA, the State of Florida, and the space industry well into the future.[18]

10 February

The crew of Space Shuttle *Atlantis* successfully installed the *Destiny* laboratory on the ISS. Using the Shuttle's robotic arm, astronaut Marsha S. Ivins moved the module from the Shuttle's payload area to its place on the side of the ISS. After patching up a small leak from one of the module's coolant lines, two spacewalking astronauts connected electrical, fluid, and data lines between the ISS and the *Destiny* laboratory. After carefully completing the installation, astronauts opened a hatch connecting the new module to the rest of the ISS. The additional 3,750 cubic feet (106 cubic meters) of space made the ISS the largest spacecraft ever. Astronaut Kenneth D. Cockrell—along with William M. Shepherd, the first to enter the *Destiny* module—reported, "The lab looks and feels and smells great, and looks like all the hard work has really paid off. It's a beautiful piece of hardware in here."[19]

12 February

The NEAR Shoemaker spacecraft landed on the 433 Eros asteroid, becoming the first probe ever to accomplish such a feat. The landing was a bonus. NEAR had already successfully completed a 1 billion-mile mission, which had provided pictures of Earth, comet Hoylake, and the asteroid 253 Mathilde. After a carefully scripted 5-hour descent, NEAR touched down safely, traveling at about 4 miles (6 kilometers) per hour. The spacecraft, which engineers had not designed for the impromptu landing mission, did not have a parachute to lessen its impact on the asteroid's

[17] Associated Press, "New Chief for Russia Space Company," 7 February 2001.
[18] M2 Presswire, "NASA and Florida Join Forces To Develop Space Science Facility," 9 February 2001.
[19] William Harwood, "Spacewalking Astronauts Attach Lab Module to Space Station," *Washington Post*, 11 February 2001; *USA Today*, "Space Station Module Gives Crew More Space," 12 February 2001; *Washington Post*, "Astronauts Open Hatch to Destiny Laboratory; Alpha Now Largest Orbiting Outpost," 12 February 2001; Associated Press, "Astronauts Install Lab on Station," 12 February 2001.

unknown surface. By firing the spacecraft's engines five times during descent, NASA controllers were able to slow the craft to a safe landing speed. As NASA's Chief Scientist Edward J. Weiler explained, "If you were an Erosian watching this thing come in, it should have a velocity about that of a walking individual." Scientists landed the craft to demonstrate that the landing was possible, as well as to gather additional information. NASA engineers reported detecting a faint signal from the probe even after it had landed. The environment is harsh on the asteroid, which measures 21 miles (34 kilometers) long and 8 miles (13 kilometers) wide. Moving through space at more than 40,000 miles (64,300 kilometers) per hour, Eros reaches a temperature of 400°F (204°C) daily and has only weak gravity. Researchers believed that the asteroid is composed of material older than Earth and might have been part of another planet at one time.[20]

14 February

Astronauts Thomas D. Jones and Robert L. Curbeam Jr. made their third and final spacewalk from Space Shuttle *Atlantis*, finishing the installation of the ISS's science laboratory *Destiny*. The spacewalk was the 100th in the history of U.S. space exploration. Two days earlier, Jones and Curbeam had conducted a spacewalk to install a window shutter for *Destiny*, allowing the astronauts residing inside the ISS an unparalleled view of Earth. Overall, the mission to install the vital and expensive *Destiny* module went smoothly. *Atlantis*'s crew worked quickly to connect the necessary cables, hatches, and wires to equip the new research center. The successful installation also allowed NASA to accept a transfer of leadership from the Russian Space Agency. Using the newly installed computers in the *Destiny* module, U.S. flight controllers took control of the ISS on 13 February 2001.[21]

NASA announced that it would extend the NEAR Shoemaker spacecraft mission by 10 days to make the most of the first successful landing of a spacecraft on an asteroid. After conducting a complicated landing sequence and arriving safely on the surface of the asteroid Eros, the NEAR spacecraft relayed its signal to excited scientists on Earth. Called the "Surprisingly Sturdy Little Spacecraft" by the *New York Times*, NEAR survived its landing mission, surprising space officials and enthusiasts. NEAR had already spent a year orbiting the Eros asteroid, when the craft had run low on fuel. NASA's mission team directed it to land on the asteroid's surface. After NEAR's successful landing, mission managers determined that the spacecraft merited additional funding. Although the details about where NEAR would touch down remained in doubt until the last moment, the craft had landed at a location ideal for Earth controllers to send and receive signals, facilitating an extended mission.[22]

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[20] Mike Toner, "Discover: Rendezvous with Eros Matchup Planned Monday for Asteroid, Spacecraft," *Atlanta Journal-Constitution* (GA), 11 February 2001; Reuters, "Space Probe Set To Land on Asteroid Eros," *Washington Post*, 12 February 2001; Dan Vergano, "Probe Lands on Gigantic Near-Earth Asteroid," *USA Today*, 13 February 2001; Regina Holtman, "Signals from Surface," *Washington Times*, 13 February 2001; Kathy Sawyer, "Spacecraft Lands on Asteroid; NASA Probe's Historic First May Yield Wealth of Data," *Washington Post*, 13 February 2001.
[21] Associated Press, "Atlantis Astronauts To Conduct 100th Spacewalk in U.S. History," 14 February 2001; *Los Angeles Times*, "Spacewalk Improves View from Space Station Lab," 13 February 2001; Dow Jones International News, "Window Shutter Gives US Spacewalkers Views of Earth," 12 February 2001.
[22] NASA, "Asteroid Mission Not Yet 'NEAR' an End," news release 01-20, 14 February 2001; Warren Leary, "Mission Extended for Surprisingly Sturdy Little Spacecraft," *New York Times*, 15 February 2001; Associated Press, "NASA Adds 10 Days to Asteroid Mission," 15 February 2001.

20 February
Space Shuttle *Atlantis* STS-98 landed at Edwards Air Force Base in California after three days of bad weather had prevented its planned landing at NASA's KSC in Cape Canaveral, Florida. The crew received a congratulatory call from President George W. Bush, praising their successful 13-day mission. By the time that *Atlantis* and its crew departed the ISS, the Shuttle had significantly boosted the space station's orbit, leaving the ISS orbiting at about 237 miles (381 kilometers) above Earth. While attached to the space station, *Atlantis* had used a series of engine bursts to push the ISS approximately 16 miles (26 kilometers) higher than its previous position. Shuttle crew had also unloaded food and supplies, including an enormous Russian carbon-dioxide removal unit, for the use of the three-person ISS crew during their visit.[23]

On the 15th anniversary of the launch of the *Mir* space station and with its doom imminent, Russian scientists and other space enthusiasts protested the plan to use a controlled descent to destroy the aging vessel. Once a point of pride for the Soviet space program, *Mir* had remained in use far beyond its planned lifespan and had fallen into disrepair. Russian Space Agency Chief Yuri Koptev attempted once again to explain why *Mir* had to come down: "The *Mir* has lived a wonderful life and must end it in a graceful way. We must discard it while we are still capable of controlling it, not turn its descent into roulette that threatens the entire global community." Russia had planned to initiate *Mir*'s final descent in mid-March 2001.[24]

22 February
A team of scientists led by Luann Becker of the University of Washington presented new evidence explaining what had precipitated the Permian-Triassic extinction of 250 million years ago, when 90 percent of life disappeared from Earth. Confirming a long-held hypothesis, the team of researchers had discovered, in ancient sediments spread across the planet, molecules of stardust that only could have come from space. This discovery led scientists to conclude that the impact of a massive comet had triggered the onset of dormancy of life on Earth. The scientists had examined samples from China, Japan, and Hungary, seeking to explain what had happened on Earth. NASA, which had contributed funding for the project, announced the team's findings at a panel presentation in Washington, DC.[25]

25 February
NASA's Ultra-Long Duration Balloon (ULDB), a huge research balloon designed to ascend to altitudes of more than 20 miles (32 kilometers), took off from Alice Springs, Australia. The size of a domed football stadium, the vessel was constructed of ultra-thin plastic material, enabling it to float above 99 percent of Earth's atmosphere. Scientists controlled the research craft from the ground, hoping that if it succeeded, this new type of balloon would provide a cost-effective method of gathering data. However, after a launch delay of several weeks, because of turbulent

[23] Associated Press, "Shuttle Back on Earth After Dismal Three Days," 21 February 2001; Associated Press, "Atlantis Leaves Space Station in a Higher Orbit," 16 February 2001.
[24] Associated Press, "Report: Russia Puts Off Dumping of Mir for a Week," 15 February 2001; Associated Press, "Russia Marks Mir's 15th Anniversary by Assuaging Fears of Its Demise," 19 February 2001; Associated Press, "Scientists Protest on Mir's 15th Anniversary," 20 February 2001.
[25] Luann Becker et al., "Impact Event at the Permian-Triassic Boundary: Evidence from Extraterrestrial Noble Gases in Fullerenes," *Science* 291, no. 5508 (23 February 2001): 1530–1533; Guy Gugliotta, "Comet Tied To a Mass Extinction; Sediments Show Earth Was Hit, Scientists Say," *Washington Post*, 23 February 2001; NASA, "Next Space Science Update: Trigger Found for Largest Mass Extinction," news release N01-10, 20 February 2001.

weather, the research balloon lasted aloft only a few hours before a leak forced it back to the ground. Once the balloon had reached 85,000 feet (26,000 meters), the flight controllers initiated a controlled descent, minimizing further damage to the craft and to the research instruments aboard. Engineers were optimistic that they could fix the balloon and that, once they had repaired and deployed it, the balloon would fly higher and longer than any previous research balloon. However, when the balloon landed approximately 132 miles (212 kilometers) away from its takeoff site, the launch-station director and crew remained uncertain of the nature and extent of the problem.[26]

MARCH 2001

1 March

NASA announced that it had canceled the X-33 rocket development project, an endeavor that many in the space industry had hoped would produce a vehicle to replace the Space Shuttle. NASA ended the five-year program after having invested nearly US$1 billion in developing a reusable launching vehicle. The X-33 program, contracted to Lockheed Martin Space Systems Company, had sought to build the world's most technologically advanced space vehicle—shaped like an arrowhead and protected by a heat-resistant metallic covering. Because of its capability to ascend to space without having to drop weight by discarding boosters after launch, the new vehicle would have significantly improved on the Shuttle. NASA officials had hoped that the X-33 would lead to development of the VentureStar vehicle, for transporting people and cargo into space. Operating at considerably less expense to NASA than the Space Shuttles, the VentureStar would permit more space missions per year. NASA's decision to cut funding for the X-33 was part of its general effort to reduce its budget. NASA officials in charge of the Space Launch Initiative (SLI) had determined that, although the X-33 program had yielded significant new knowledge, it had not advanced to a point at which NASA engineers could readily implement the new technology. Arthur G. Stephenson, the Director of NASA's MSFC, which had managed the program, called the decision to deny further funding "a very tough decision."[27]

2 March

Wallace D. Hayes, an aeronautical engineer and longtime Princeton University professor, died at age 82 after a long battle with Parkinson's disease. His colleagues referred to Hayes as "a giant in his field," Hayes had helped design the first planes that could safely break the sound barrier. Hayes's 1959 book *Hypersonic Flow Theory* had outlined the scientific principles behind hypersonic flight, as well as the necessary technology to accomplish it. Although decades passed before his theories produced functional aircraft, many consider Hayes the father of high-speed flight. According to Robert Probstein, a professor at the Massachusetts Institute of Technology, "Every supersonic aircraft, in my opinion, owes to him their design." Hayes had worked with NASA and a handful of elite American universities during his stellar career. In his association

[26] NASA, "NASA Aborts Space Research Balloon Flight," news release 01-28, 26 February 2001; Associated Press, "Leak Forces NASA Balloon To Land," 25 February 2001; Associated Press, "Giant Balloon Launched After Long Delay," 24 February 2001.

[27] NASA, "NASA Reaches Milestone in Space Launch Initiative Program; Also Announces No SLI Funding for X-33 or X-34," news release 01-31, 1 March 2001; Warren E. Leary, "NASA Ends Project on Rocket Meant To Replace Space Shuttle," *New York Times*, 2 March 2001; Kathy Sawyer, "NASA Kills $1.3 Billion Space Plane Project," *Washington Post*, 2 March 2001; *Los Angeles Times*, "NASA Ends X-33 Project that Sought To Cut Spaceflight Costs," 2 March 2001.

with NASA, he had worked to limit sonic booms from supersonic jets, an achievement that enabled supersonic jets to travel freely over populated areas.[28]

7 March

In preparation for the final descent of the *Mir* space station, the Russian Space Agency negotiated a US$200 million insurance policy covering any damage that might occur if pieces of the craft landed in populated areas. Russian officials planned to fire the engines of the cargo ship attached to the space station, thereby pulling *Mir* from orbit and sending the space station hurtling into Earth's atmosphere. Scientists predicted that intense heat would destroy most of the station during reentry, but that some fragments would hit Earth. Although space agencies had successfully deorbited many rockets and satellites to final resting places in the ocean, Russia faced increasing international consternation regarding the damage *Mir*'s reentry might cause. Japan was at higher risk from fragments of *Mir* than other countries, because the space station would pass over Japan in its final, low orbit.[29]

8 March

Space Shuttle *Discovery* STS-102/ISS-5.A.1—comprising Commander James D. Wetherbee, Pilot James M. Kelly, and Mission Specialists Andrew S. W. Thomas and Paul W. Richards—launched from NASA's KSC carrying the three-person crew of Expedition 2 to the ISS for their four-and-one-half-month stay. The members of Expedition 2—Russian cosmonaut Yury V. Usachev and NASA astronauts James S. Voss and Susan J. Helms—would replace the first ISS research team. The transfer also entailed a change of command aboard the orbiting research center. American William M. Shepherd, Commander during the first research period, had led a crew of two Russian cosmonauts in installing and calibrating ISS equipment. With many of the initial installation problems resolved, the second crew planned to devote more time to research. The Russian cosmonaut who was to take command aboard the ISS had plenty of space experience. Commander Usachev had spent 376 days on *Mir* and had performed numerous spacewalks. Although Voss and Helms had both flown on Shuttle missions before, this voyage was their first time traveling to space for a significant research period. The primary purpose of the Shuttle's 14-day mission was to deliver the new crew, but *Discovery* also carried, for the first time, the Leonardo Multi-Purpose Logistics Module (MPLM). The Italian Space Agency had constructed the module to serve as a "moving van" for carrying experiments and supplies back and forth between Earth and the ISS.[30]

11 March

Astronauts James S. Voss and Susan J. Helms conducted the longest spacewalk in NASA history—nearly 9 hours. After working to install hardware and equipment, the pair had to remain outside the ISS until NASA flight controllers had determined that the Italian module filled with

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[28] Mark Mueller, "Aerospace Pioneer Wallace Hayes Dies—Obituary," *Star-Ledger* (Newark, NJ), 11 March 2001.
[29] Vladimir Isachenkov, "Russia to Insure Mir Descent Negotiating $200 Million Spacecraft Policy," *Chicago Sun-Times*, 7 March 2001.
[30] NASA, "Discovery Returns Expedition One to Earth; Launches Second Crew," news release 01-34, 6 March 2001; NASA, "Space Shuttle Mission Archives: STS-102," *http://www.nasa.gov/mission_pages shuttle/shuttlemissions/archives/sts-102.html* (accessed 2 February 2009); Warren E. Leary, "Shuttle Primed for Crew-Exchange Mission to Station," *New York Times*, 7 March 2001; Marcia Dunn for Associated Press, "Discovery Blasts Off with Next Space Station Crew," 8 March 2001; Reuters, "USA: Corrected—Shuttle Discovery Launched on Space Station Mission," 8 March 2001.

supplies had found an ISS docking port. Voss and Helms spent 8 hours and 56 minutes on their spacewalk, eclipsing the record of 8 hours and 29 minutes set in 1992. The U.S astronauts conducted complex work, involving a series of slow, deliberate maneuvers. NASA's flight director commented that the lengthy endeavor required stamina, remarking that the spacewalk pushed the two astronauts "right to the edge" of what they could handle. Early in the spacewalk, Voss and Helms each mishandled pieces of equipment, causing one device to float off into space and slowing the process by about 1 hour.[31]

13 March

A team of astronomers released images taken by NASA's Chandra X-ray Observatory, revealing that black holes are present throughout the universe, across space and time, more pervasively than previously estimated. The researchers had found that black holes were even more common millions of years ago than they are today. The scientists had used new x-ray technology to examine galaxies several billion years old. The research had focused on a small sliver of the sky—a deep field—that the Chandra X-ray Observatory had probed looking for black holes and other bodies. Based on the findings in the relatively small sampling, the researchers had estimated that the universe might contain as many as 300 million black holes. Chandra had captured images using exposure times of up to 10 days and focusing on the same region of the sky for more than one year. The astronomers believed that their new images had exposed the early history of the universe, perhaps traveling as far back in time as 90 percent of the way to the Big Bang. In examining this distant patch of sky, the researchers had discovered black holes of all types and masses.[32]

14 March

The first changing of the guard took place aboard the ISS *Discovery* when the crew of Expedition 2, which included astronauts James S. Voss and Susan J. Helms and cosmonaut Yury V. Usachev, replaced the first ISS research team, Expedition 1. The new crew planned to spend four and one-half months aboard the space station, with Usachev serving as the outpost's Commander. With the official beginning of her mission on the ISS, Helms became the first long-term female occupant of the space station. The new crew anticipated working well together, having trained as a unit for nearly four years. Because the first crew had completed many of the ISS's final construction tasks, crew of Expedition 2 looked forward to having more research time than their predecessors had enjoyed.[33]

NASA astronomers linked the world's two largest telescopes, both located at the W. M. Keck Observatory in Hawaii. Using a process known as interferometry, the scientists used the two

[31] Marcia Dunn for Associated Press, "A Record Job, with Some Butterfingers," 13 March 2001; *CNN.com*, "Astronauts Set Out-of-This-World Record," *http://archives.cnn.com/2001/TECH/space/03/11/ space.shuttle.02/* (accessed 18 July 2008); Associated Press, "2 Astronauts Walk in Space Almost 9 Hours," 12 March 2001; Agence France-Presse, "Discovery Astronauts End Marathon Spacewalk To Add Leonardo to ISS Canvas," 12 March 2001.
[32] NASA, "Deepest X-rays Ever Reveal Universe Teeming with Black Holes," news release 01-37, 13 March 2001; Kathy Sawyer, "Young Cosmos Was Full of Black Holes," *Washington Post*, 14 March 2001; Associated Press, "X-ray Telescope Finds Heavens Brimming with Black Holes," 14 March 2001.
[33] Todd Halvorson, "Space Crews Ceremoniously Switch Places," *Florida Today* (Brevard, FL), 15 March 2001; NASA, "Space Station Shift—Change Set with Next Shuttle Launch," news release, 01-30, 28 February 2001; Marcia Dunn for Associated Press, "Space Station Alpha About To Get Its First Female Resident," 5 March 2001; Juan A. Lozano for Associated Press, "New Space Station Crew Moves into Orbiting Outpost," 14 March 2001.

telescopes to capture images of a faint star in the constellation Lynx. According to Anne L. Kinney, Director of NASA's Astronomical Search for Origins program, "combining the light from the two largest telescopes on Earth is a fabulous technical advancement." Using a tunnel that collects light waves that the telescopes have captured, to combine the images, the two telescopes worked together to allow astronomers to peer farther and more clearly into space than ever before. Scientists hailed the achievement as a significant step toward creating a new class of astronomical telescopes.[34]

16 March

NASA commemorated the 75th anniversary of the first successful launch of a liquid-fueled rocket. On 26 March 1926, Robert H. Goddard had launched a 10-foot-long (3-meter-long) rocket fueled by gasoline and liquid oxygen. The rocket flew just over 40 feet (12 meters) high using the same technology that would one day launch massive rockets carrying Space Shuttles and other research craft into space. NASA had named Goddard Space Flight Center (GSFC) after Robert H. Goddard. At the anniversary celebration, NASA's Chief Historian Roger D. Launius called Goddard the forefather of American space exploration: "Dr. Goddard was a true visionary, having already visualized flight in outer space by the time he was 21." Goddard had turned 21 in 1903, some 50 years before space exploration began in earnest. Even 75 years after Goddard's successful test, NASA continued to use liquid-propulsion systems to launch most of its spacecraft and satellites.[35]

17 March

Responding to the ongoing reductions in the budget for NASA and for the ISS, the Boeing Company announced that it would lay off 400 workers who had been working on the development of ISS modules, including those workers who would have built the living quarters for the space station's researchers. At the time of Boeing's cuts, NASA had trimmed nearly US$1 billion from its ISS funding.[36]

19 March

Russian cosmonauts training at NASA's Johnson Space Center (JSC) in Houston, Texas, staged a one-day walkout to protest NASA's rejection of millionaire Dennis A. Tito as a member of the Russian crew that would travel aboard the *Soyuz* to the ISS on 30 April. Space enthusiast Dennis Tito had paid the cash-strapped Russian Space Agency a reported US$20 million to make the trip. Russia's agreement with the untrained Tito had sparked debate over the proper use of the ISS and over so-called space tourism. Talgat A. Musabayev, the Kazakh cosmonaut who was to command Tito's crew, removed his men from the training program in Houston after learning that NASA would not allow Tito to participate in the exercises. NASA argued that allowing a person who had not trained as an astronaut to travel to space would pose safety risks, especially since the ISS remained a work-in-progress. Russian officials contended that they had the right to

[34] NASA, "An Astronomy First: Telescopes Double-Team Hawaiian Night Sky," news release 01-42, 14 March 2001; Associated Press, "World's Strongest Telescope Link Created," 15 March 2001.
[35] NASA, "March 16 Marks 75th Anniversary of First Liquid-Fueled Rocket Launch," news release 01-35, 12 March 2001.
[36] Associated Press, "Boeing Laying Off 400 on NASA's International Space Station," 17 March 2001.

transport aboard their spacecraft any person they deemed fit for the mission. Both sides pledged to find a resolution to the disagreement.[37]

21 March
NASA announced that its X-40A aircraft, built by the Boeing Company and on loan from the U.S. Air Force, had successfully passed a test flight, giving the X-37 program a major boost. NASA had designed the X-37, a reusable craft that could launch into space and return safely, for use in testing NASA technologies. To test the flight-control system planned for the X-37, an Army Chinook helicopter lifted the X-40A aircraft to 15,000 feet (4,570 meters) and then released it to a safe landing. NASA's director of the X-37 program called the successful test, "a cause for celebration," saying that incremental tests on prototype airplanes would ultimately make the X-37 program both cost-efficient and successful. Scientists hailed the safe landing of the X-40A as a triumph of cooperation among the U.S. military, NASA, and the Boeing Company, with each of the three playing a vital role in the development of the successful craft.[38]

Space Shuttle *Discovery* landed at NASA's KSC in Cape Canaveral, Florida, returning to Earth the crew of Expedition 1—Commander William M. Shepherd, Flight Engineer Sergei K. Krikalev, and *Soyuz* Commander Yuri P. Gidzenko. The Expedition 1 crew had lived and worked aboard the ISS since 31 October 2000. Commander James D. Wetherbee and Pilot James M. Kelly guided *Discovery* to a smooth night landing, the 17th night landing in the history of the Space Shuttle program and the 12th in the history of KSC.[39]

22 March
Members of the Landsat 7 project, involving scientists from NASA and the U.S. Geological Survey (USGS), announced that, in the course of mapping Antarctica, the team had discovered a giant new crack in one of the world's largest ice sheets. The team believed that the crack, formed within the past five weeks, would result in the calving of the Pine Island Glacier, creating a major new iceberg within 18 months. NASA had obtained the image from the Landsat 7 satellite, which had passed over Antarctica 16 times daily since its 1999 launch.[40]

23 March
After months of debate over whether Russia should bring *Mir* out of orbit and what damage the space station might cause when it fell to Earth, the 15-year-old *Mir* space station plunged into Earth's atmosphere, spraying some of its remnants into the Pacific Ocean. The splashdown marked the end of a 2.2 billion-mile journey for *Mir*. Witnesses in Fiji reported seeing streaks of gold and silver lights across the sky when *Mir* fell, but nobody reported any damage from pieces of the falling space station. U.S. officials at the Pentagon tracked the descent, while Japan's

[37] Kathy Sawyer, "Space Tourism Sparks U.S.-Russian Standoff," *Washington Post*, 20 March 2001; Warren E. Leary, "NASA Opposing Russian Plan for Tourist on Space Station," *New York Times*, 21 March 2001; Marcia Dunn, "Cosmonauts to NASA: Millionaire Comrade Trains with Us or Nobody Trains," 20 March 2001.
[38] NASA, "Successful X-40A Test Flight Gives Major Boost to NASA's X-37 Program," news release 01-51, 21 March 2001; M2 Presswire, "X-40A Flight Test Successful; Major Milestone in X037 Space Plane Project," 15 March 2001.
[39] NASA JSC, "STS-102, Mission Control Center Status Report # 27," 21 March 2001, *http://spaceflight.nasa.gov/spacenews/reports/sts102/STS-102-27.html* (accessed 2 February 2009).
[40] NASA, "NASA Image Reveals Giant Chip Off the Antarctic Ice Block," news release 01-50, 22 March 2001; Reuters, "Satellite Spies Crack in Antarctica Glacier, 23 March 2001.

public safety chief urged people to stay indoors to avoid falling debris. Anatoly Y. Solovyev, a Russian cosmonaut who had spent 651 days aboard *Mir*, remarked that he was sad to see the end of the pathbreaking space station: "An entire era of our Soviet space program is ending, into which we invested not only our money, but what is more important, our intellectual potential." Once *Mir* had descended safely, officials of the Russian Space Agency praised the precise sequence of maneuvers that had brought the space station safely from orbit.[41]

30 March
NASA Administrator Daniel S. Goldin received the Dr. Robert H. Goddard Memorial Trophy presented by the National Space Club, one of the United States' most prestigious space awards. Leaders from the aerospace industry, governmental space programs, and academics had selected Goldin for the award. "I am both honored and humbled by the award which validates and supports NASA's continuing mission to pioneer the frontiers of space," Goldin remarked upon receiving the honor.[42]

APRIL 2001

2 April
NASA announced that astronomers using the Hubble Space Telescope (HST) had discovered a supernova blast located farther away from Earth than any previously observed object. The discovery provided support for the theory that the universe might be expanding more rapidly than in the past. The supernova, approximately 10 billion light-years away from Earth, was relatively bright. According to Adam Riess of the Space Telescope Science Institute, the researcher who made the find, the discovery was significant because scientists would now be able, not only to observe the activities of the universe, but also to understand why it behaves as it does. "This supernova shows us the universe is behaving like a driver who slows down approaching a red stoplight and then hits the accelerator when the light turns green," Riess explained.[43]

3 April
At 4:51 p.m. Eastern Daylight Time (EDT), the Sun released one of the most powerful flares of the past 25 years. The flare originated from a region of the Sun known as active region 9393 and, almost immediately after its generation, began orbiting with the Sun. The flare, equal to the well-known X-20 flare of 16 August 1989, resulted from an explosion within the Sun's atmosphere. Both the 1989 and 2001 solar flares disrupted radio communications. The flare of 3 April 2001 caused an R4 radio blackout on the sunlit side of Earth and released energy equal to 1 billion megatons (907 trillion tonnes or 907 quintillion kilograms) of TNT. Had it occurred on the side of the Sun facing Earth, it would probably have caused major power failures on Earth. ESA's

[41] Patrick E. Tyler, "Mir Space Station Sizzles To Ending Over Pacific," *New York Times*, 23 March 2001; Vladimir Isachenkov for Associated Press, "Russian Space Officials Exultant After Flawlessly Bringing Down Mir," 23 March 2001; Peter Baker, "Mir's Fall to Earth Marks a Fiery End to Bumpy Mission," *Washington Post*, 23 March 2001; Associated Press, "Japan's Public Safety Chief Urges People To Stay Inside To Avoid Mir Debris," 16 March 2001; World Reporter, "Pentagon To Track Mir Station's Descent from Orbit," 10 March 2001.
[42] NASA, "NASA Administrator Receives Premier Space Honor," news release 01-61, 30 March 2001.
[43] NASA, "Farthest Supernova Ever Seen Sheds Light on Dark Universe," news release 01-58, 2 April 2001.

Solar and Heliospheric Observatory (SOHO) spotted the record-setting sun flare and several smaller X-class flares, which occurred during the following days.[44]

7 April

The Mars Odyssey spacecraft launched successfully aboard a Delta 2 rocket. The craft, built by Lockheed Martin Space Systems and controlled by scientists at NASA's JPL, had headed to orbit Mars in search of evidence of water on the Red Planet. NASA officials expected the trip to Mars to take more than six months and the data collection to continue for more than two years. NASA had designed Mars Odyssey—equipping it with a thermal-emissions imaging system, a gamma-ray spectrometer, and a radiation monitor—to investigate further the question of whether Mars might have once supported life. By collecting data about the climate and geology of Mars's surface, scientists hoped to explore theories regarding the planet's seemingly harsh climate change. NASA and members of the scientific community watched the US$300 million craft closely, hoping for success. In 1999 Mars Climate Orbiter and Mars Polar Lander had both failed to accomplish their missions. Upon the successful launch, NASA's chief Mars program scientist celebrated: "We've got a program! This is the next step . . . It's kind of like setting off on the Lewis and Clark voyage across North America. We're bound for a new frontier."[45]

18 April

India successfully launched its first experimental geosynchronous satellite (GSAT-1) aboard the Geosynchronous Satellite Launch Vehicle (GSLV). The successful test suggested that India was poised to launch its own communication satellites. In a previous trial, India had halted a GSLV launch only moments before liftoff, when sensors indicated that the booster had insufficient power. Subsequent tests remedied the problem, enabling the successful 18 April launch. The Indian government praised the mission as the culmination of a decade of research and development aimed at achieving Indian launch capability.[46]

19 April

Space Shuttle *Endeavour* STS-100/ISS-6A launched into orbit carrying a Canadian-built robotic arm for the ISS and one of the most diverse crews ever assembled. The Canadian Space Agency had developed and built Canadarm2 at a cost of nearly US$1 billion. With a reach extending to 57 feet (17 meters), Canadarm2 was the centerpiece of Canada's contribution to the ISS. Once in place, the new robotic arm would allow the ISS crew to lift spacewalkers to every part of the ISS's exterior to perform maintenance and repairs. During the mission, the crew planned to install the arm, as well as to transport to the ISS a logistics carrier developed by the Italian Space

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[44] NASA, "Sun Unleashes Record Superflare, Earth Dodges Solar Bullet," news release 01-66, 3 April 2001; NASA, "Sun Takes Another Solar Shot, This Time at Earth," news release 01-71, 11 April 2001.

[45] Lockheed Martin Space Systems, "Lockheed Martin-Built 2001 Mars Odyssey Successfully Launched, Begins Journey to Mars," news release, 7 April 2001, *http://www.lockheedmartin.com/news/press_releases/2001/LockheedMartinBuilt2001MarsOdysseyS.html* (accessed 28 January 2010); William Harwood, "Mars Odyssey Takes Off for Red Planet; NASA's Stalled Exploration Program Resumes with $297 Million Mission," *Washington Post*, 8 April 2001; Mark Carreau, "Flawless Odyssey Launch Fuels Hoe: Three-Year Mission to Mars Follows Pair of NASA Failures," *Houston Chronicle*, 8 April 2001; Marcia Dunn for Associated Press, "NASA Succeeds in Launching Craft To Survey Mars Anxious Time Ahead for Scientists," 8 April 2001.

[46] Indian Embassy, "GSLV Launched Successfully," news release, 18 April 2001, *http://www.indianembassy.org/press_release/2001/april/apr_18.htm* (accessed 1 July 2008); *Spacewarn Bulletin*, no. 570, 1 May 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx570.html* (accessed 24 July 2008).

Agency. The seven-person crew—Commander Kent V. Rominger, Pilot Jeffrey S. Ashby, and Mission Specialists Chris A. Hadfield, Scott E. Parazynski, John L. Phillips, Umberto Guidoni, and Yuri V. Lonchakov—included astronauts representing the space agencies of Canada, Europe, and Russia. STS-100 was the Shuttle's fifth flight in six months, setting a record for the most spaceflights performed during such a short period in NASA's history.[47]

NASA Administrator Daniel S. Goldin and President of the Italian Space Agency Sergio DeJulio signed a framework for cooperation agreement for the construction of the habitation module for the ISS. The ISS partners planned the module to house the ISS crew, providing a galley and a Treadmill Vibration Isolation System among other features. In exchange for designing and manufacturing the habitation module, the Italian Space Agency received a commitment from NASA to provide Italian astronauts with access to the Shuttle and the ISS, as well as to help train Italian astronauts for their time in space. The bilateral agreement continued the trend of cooperation among nations, making the ISS a truly international endeavor.[48]

23 April

The crews of Shuttle *Endeavour* and the ISS conducted the first successful test of the massive Canadarm2. Because of the size and weight of the robotic arm, the crew had never moved the completely assembled Canadarm2 until its arrival at the ISS. However, they installed the arm, composed of high-strength metals and weighing 3,618 pounds (1,640 kilograms), without any problems. Astronauts James S. Voss and Susan J. Helms, both in the middle of a four-month stay aboard the ISS, led the test of the new instrument. Voss explained that the robotic arm was vital to the station: "This was one of those linchpins that had to work, and it looks like it's going to work. We're looking forward to using it to keep building the station." As testing continued, the ISS crew was troubled with some computer malfunctions. However, cooperating with NASA's engineers, the astronauts eventually solved the problems.[49]

NASA released the first images taken by the recently launched Mars Odyssey spacecraft. Headed for the Red Planet, Odyssey pointed its camera Earthward to take calibrating shots as it traveled around the South Pole. Among the first images the vessel captured were the first thermal-infrared views ever taken of Earth and its Moon. The photographs demonstrated the technological sophistication of the instruments for the mission to Mars, which allowed close observation, producing images even with very little available light. The clarity of the images of Earth, particularly those of Antarctica, boded well for the success of the Mars mission. Mars Odyssey

[47] NASA, "Space Shuttle Mission Archives: STS-100," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-100.html* (accessed 2 February 2009); NASA, "Endeavour's International Crew Delivers Space Station Helping Hand," news release 01-73, 16 April 2001; Mark Carreau, "Endeavour Lifts Off To Attach Arm to Space Station," *Houston Chronicle*, 20 April 2001; NASA, "Endeavour's Mission Will Extend Space Station's Reach with Next-Generation Robotics; Launch Set for April 19," news release 01-67, 6 April 2001.
[48] NASA, "NASA Administrator Goldin and ASI President Dejulio To Sign Framework for Cooperation," news release N01-24, 19 April 2001; *NASA Watch*, "NASA/ASI International Space Station Habitation Module Project Framework for Cooperation," *http://www.nasawatch.com/iss/04.19.01.nasa.asi.hab.html* (accessed 24 July 2008).
[49] Marcia Dunn for Associated Press, "Space Station Robot Comes to Life: With 'Inchworm' Moves, 58-Foot Arm Passes Test," 24 April 2001; Marcia Dunn for Associated Press, "Astronauts Get Robot Arm Going After 4 Days," 29 April 2001.

measured surface temperatures in Antarctica as low as minus 58°F (14°C), similar in range to temperatures the craft would experience during its survey of Mars.[50]

24 April

The ISS Partnership agreed to allow space tourist Dennis A. Tito to travel to the ISS aboard the Russian *Soyuz* TM-32, scheduled to launch at the end of April. The agreement among the space agencies of Canada, Europe, Japan, Russia, and the United States followed months of disagreement regarding the safety and propriety of allowing the wealthy American businessman to purchase passage into space for US$20 million. Without conferring with NASA or with other members of the ISS Partnership, the Russian Space Agency had made an agreement with Tito permitting him to take a place on Russia's *Soyuz* spacecraft. NASA had protested against including an individual who was not a trained astronaut on the spaceflight at such an early point in the ISS's development. After Russia had reached the agreement with Tito, he had undergone months of training. The ISS Partnership required Tito to sign a waiver absolving NASA of any liability for his safety and required him to promise that he would pay for anything he damaged. The ISS Partnership also announced plans to formalize the criteria for future visits to the station.[51]

26 April

Engineers at NASA's KSC completed the installation of a new main engine for Space Shuttle *Atlantis*. Modifications of previous engine designs included a new high-pressure fuel turbopump, strengthened and made more durable by a casting process, rather than by welding. During the roughly 8½ minutes that the engines operate during a Shuttle launch, they must perform at temperatures reaching 6,000°F (3,300°C). The improvements continued NASA's practice of regularly updating the Shuttle's components.[52]

28 April

The Russian spacecraft *Soyuz* lifted off from the Baikonur Cosmodrome in Kazakhstan propelled by a Soyuz-U rocket. The spacecraft carried one of the most controversial space travelers in history—American businessman Dennis A. Tito. Tito had paid the Russian Space Agency for the opportunity to accompany cosmonauts Talgat A. Musabayev and Yuri M. Baturin on the mission to the ISS. Many space officials, regarding the endeavor as unsafe and capricious, had opposed Tito's presence on the flight. Only days before the launch, Tito had gained the final approval of the consortium of nations building the ISS, becoming the highest profile space tourist to fly into orbit.[53]

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[50] NASA, "Earth Day Portrait Is First One Snapped by NASA's 2001 Mars Odyssey," news release 01-81, 23 April 2001.

[51] Warren E. Leary, "Deal Reported in Long-Running Dispute on Putting Tourist on Space Station," *New York Times*, 21 April 2000; NASA, "International Space Station Partnership Grants Flight Exemption for Dennis Tito," news release 01-83, 24 April 2001; Marcia Dunn for Associated Press, "NASA Continues To Resist Visit by First Tourist," 15 April 2001; Kathy Sawyer, "Financier's Spaceflight Gets Final Clearance," *Washington Post*, 25 April 2001.

[52] NASA, "New Main Engine Promises Even Safer Shuttle Ride," news release 01-79, 26 April 2001.

[53] *Spacewarn Bulletin*, no. 570, 1 May 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx570.html* (accessed 24 July 2008); Warren E. Leary, "Russia Wins Fight To Be First Space Travel Agent," *New York Times*, 25 April 2001.

29 April
At the American Physical Society Spring Meeting, a team of cosmologists announced that they had discovered the "music of creation," using an extremely sensitive microwave telescope. The researchers presented their discovery of the sound waves that had rippled through the universe some 14 billion years ago. The team of the Balloon Observation of Millimetric Extragalactic Radiation and Geophysics (BOOMERANG) project had gathered the data from a telescope aboard a balloon, which circumnavigated Antarctica at an altitude of 23 miles (37 kilometers). According to Team Leader Paolo deBernardis, the beginning of the universe left behind a residue of light and sound, providing scientists with hints about the details of the Big Bang: "The early universe is full of sound waves compressing and rarefying matter and light, much like sound waves compress and rarefy air inside a flute or trumpet." The BOOMERANG team's findings provided a new means of examining the early universe and new evidence to use in calculating how it changed. Scientists praised the discoveries as "stunning and humbling" evidence that cosmologists were using the correct model to describe the early universe.[54]

30 April
The *Soyuz* spacecraft, carrying space enthusiast Dennis A. Tito, arrived safely at the ISS, having completed a two-day journey from Kazakhstan. The successful docking took place only 14 hours after Shuttle *Endeavour* left the ISS, with the crew having completed its mission of installing a Canadian-built robotic arm. Tito arrived at the ISS in good health. Appearing through grainy footage provided by the Russian Space Agency, Tito floated into the space station with arms outstretched and proclaimed, "I love space." The *Soyuz* mission mandated that the Russian-American crew remain aboard the ISS for six days.[55]

MAY 2001

1 May
Space Shuttle *Endeavour* STS-100 landed at Edwards Air Force Base in California, when wind and rain caused the diversion of the Shuttle and its seven-person crew from its planned landing at NASA's KSC in Florida. The completed mission had been unique, with NASA deliberately paring down its research goals because of the anticipated arrival during *Endeavour*'s stay at the ISS of the Russian *Soyuz* spacecraft carrying space tourist Dennis A. Tito. Shuttle Commander Kent V. Rominger greeted the press upon landing, commenting on the crew's installation of the ISS's robotic arm and the computer problems that had plagued the space station during the visit. Rominger explained that he and the other astronauts had worked with 500 computer experts on the ground to achieve partial restoration of the ISS's hard drives and software applications.[56]

[54] NASA, "New Boomerang Findings Reveal 'Music' of the Early Universe," news release 01-87, 29 April 2001; Kathy Sawyer, "Astronomy Peers into Face of Infant Universe," *Washington Post*, 30 April 2001.
[55] Mark Carreau, "Shuttle Leaves Space Station After 8 Days," *Houston Chronicle*, 30 April 2001; Marcia Dunn for Associated Press, "Tito's 'Taxi' Drops Fare at Station, 'I Love Space', Says the American Cosmonaut, Who Faces Strict NASA Limits," 30 April 2001.
[56] Warren E. Leary, "As Shuttle Returns to Earth, Tourist Adjusts to Space Station," *New York Times*, 2 May 2001; Associated Press, "Space Shuttle Diverted to California Due to Bad Weather," 1 May 2001; Mark Carreau, "Endeavour Lands in Clear California/Cloud Hangs Over Russia Relations," *Houston Chronicle*, 2 May 2001.

6 May

A research team led by John Bally of the University of Colorado and Henry Throop of the Southwest Research Institute announced that the team had used the HST to observe the first direct evidence of the snowballing theory of planet birth. According to the scholars' findings, later released in *Science*, dust grains in the midst of a cloud of dust and gas located in the Orion Nebula, which is approximately 1,500 light-years from Earth, had accreted into a single nucleus of gas and dust, thereby forming an embryonic planet. The researchers observing the occurrence speculated that a similar process might have formed the known planets of the universe. In describing the volatile environment in which the snowballing process occurs, Throop used the analogy of "trying to build a skyscraper in the middle of a tornado." The researchers surmised that, although snowballing may have caused many embryo planets to begin forming, the complete process of forming a full-fledged planet might have occurred more rarely than scientists previously had speculated.[57]

8 May

The American geosynchronous relay satellite XM 1, often referred to as Roll, launched into space aboard a Russian Zenit rocket, from a floating launchpad in the Pacific Ocean. The launch of Roll followed on the heels of the March 2001 delivery to space of XM 2, known as Rock. With both Rock and Roll in orbit, XM Satellite Radio became available to subscribing listeners in the United States. The president of the company XM Satellite Radio, based in Washington, DC, called Rock and Roll the "newest power couple" in Washington, DC, declaring that his firm was ready to compete with Sirius Radio for subscribers. Boeing Satellite Systems had designed and built the satellites.[58]

NASA collaborated with George Washington University's Space Policy Institute to host a symposium commemorating 40 years of human spaceflight, an era that had dawned with Alan B. Shepard Jr.'s 15-minute suborbital flight on 5 May 1961. NASA Administrator Daniel S. Goldin opened the conference, followed at the speaker's podium by astronauts and space experts. The conference, "Looking Backward, Looking Forward," provided a valuable forum, not only for discussing the accomplishments of the United States' space program, but also for considering space exploration's possible future evolution.[59]

NASA announced a partnership with John Deere and Company of Moline, Illinois, to allow farmers to use NASA's global positioning technology to navigate their fields and monitor their

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[57] Kathy Sawyer, "Astronomers Observe Forming of Infant Planet for First Time," *Houston Chronicle*, 6 May 2001; Henry B. Throop et al., "Evidence for Dust Grain Growth in Young Circumstellar Disks," *Science* 292, no. 5522 (1 June 2001): 1686–1689.

[58] The Boeing Company, "Sea Launch on a Mission To Launch XM's 'Roll' Satellite," 1 May 2001, *http://www.boeing.com/news/releases/2001/q2/news_release_010501s.html* (accessed 28 January 2010); *Spacewarn Bulletin*, no. 571, 1 June 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx571.html* (accessed 28 July 2008); Jim Banke, "Sea Launch Sends 'Roll' Spacecraft into Orbit for XM Satellite Radio," *Space.com*, 8 May 2001, *http://www.space.com/missionlaunches/launches/zenit_launch_010508.html* (accessed 28 July 2008).

[59] NASA, "NASA Conference To Commemorate 40 Years of Human Space Flight," news release N01-28, 1 May 2001; NASA and Space Policy Institute, "Looking Backward, Looking Forward: Forty Years of U.S. Human Spaceflight," (program, symposium organized by Space Policy Institute, Elliott School of International Affairs, George Washington University, in collaboration with NASA History Office, NASA Office of Policy and Plans, American Astronautical Society, and National Space Society, Washington, DC, 8 May 2001), *http://history.nasa.gov/40hsconf.pdf* (accessed 29 July 2008).

soil. Using a system developed at NASA's JPL, farmers would be able to access GPS data to locate points as small as 4 inches (10 centimeters) wide. Specifically, according to the agreement, NASA and John Deere's NavCom Technology Inc. had created a partnership to explore further the uses of GPS in farming. Scientists in NASA's Earth Science Enterprise believed that GPS might prove especially useful in the area of natural hazard monitoring, providing farmers with images of their land in the event of a tornado, fire, or other disaster. The pathbreaking agreement resulted from the activities of the Commercial Technology Office at JPL, which focused on exploring new ways that technologies developed by American space programs could benefit other American industries.[60]

11 May

With resident astronaut James S. Voss performing most of the work, the ISS crew completed repairs on the space station's computers and installed a replacement for the most damaged of the three command and control machines. With the repairs completed, the ISS regained the unfettered ability to steer, regulate, and communicate for the first time since the computer breakdown had occurred during the installation of the Canadian robotic arm in April 2001. NASA experts believed that the complex computer problems had stemmed from a failed hard drive but could not rule out software problems as the root cause. The computer outages had delayed testing of the new 57-foot (17-meter) arm; NASA resumed the testing only after officials had determined that they had corrected the computer malfunctions.[61]

17 May

NASA announced the first significant group of awards for its Space Launch Initiative (SLI)—a program dedicated to finding safer and more cost-effective modes of sending humans into space. NASA's SLI board had awarded a total of US$767 million in contracts to 22 groups. NASA clarified that the purpose of the contracts was to find a long-term solution to replace the costly Shuttle program. Therefore, NASA intended that grantees focus on conceptual designs rather than on vehicle specifics. NASA had designed the program to facilitate the development of a new space vehicle by the middle of the 21st century. Those receiving the funds had to meet ambitious standards; NASA wanted awardees to design a craft that would be 10 times safer than the Space Shuttle, with 100 times higher rates of crew survival, at a 10th of the cost of the current Shuttle program. The SLI board had consulted more than 100 experts to determine which proposals should receive funding.[62]

Continuing its effort to support science-related education, NASA announced that in May 2001 it would welcome to its facilities the first participants in the Undergraduate Student Research Program (USRP), designed to expose 100 students, selected from a pool of more than 1,000 applicants, to the level of math, science, and technological research necessary to propel new discoveries in space exploration. The Virginia Space Grant Consortium coordinated the pilot

[60] NASA, "NASA Satellite Technology Goes Down on the Farm," news release 01-62, 8 May 2001.
[61] Mark Carreau, "Astronauts Complete Repairs to Computers/ Station Equipment Back at Full Force," *Houston Chronicle*, 12 May 2001.
[62] *Marshall Star* (NASA MSFC), "NASA Awards $767 Million in SLI Contracts," 24 May 2001, 1, 6; Warren E. Leary, "NASA Begins Bid To Improve Its Launchings," *New York Times*, 18 May 2001.

program. Frank Owens, Director of NASA's Education Division, expressed optimism that the program would fuel increased interest in vital scientific fields.[63]

An international team of astronomers presented compelling new evidence that comet impacts had played a significant role in the formation of life on Earth. The researchers, led by Michael J. Mumma of NASA's GSFC and Hermann Boehnhardt, working at the European South Observatory in Chile, presented their findings in an issue of *Science* devoted to the burgeoning field of comet research. The astronomers had used orbiting space telescopes, as well as telescopes throughout the world, to provide unprecedented coverage of comets passing Earth. In the course of their observations, the team had witnessed the breakup of the Comet LINEAR, thereby gaining new knowledge about the organic materials contained in comets. This new understanding of the composition of comets led to new information about the impact of comets on Earth—especially during the collisions between comets and planets that occurred long ago. Mumma explained the significance of the new discoveries about the composition of comets: "The idea that comets seeded life on Earth with water and essential molecular building blocks is dramatic, and for the first time, we have seen a comet with the right composition to do the job." The researchers concluded that comets had formed from dust, ice, and glass, and that, in colliding with other celestial bodies, comets had transferred fundamental building blocks to them.[64]

21 May

The Russian cargo craft Progress M1-6 launched from Baikonur Cosmodrome, Kazakhstan, carrying 2.5 tons (2.3 tonnes or 2,300 kilograms) of supplies for the ISS crew. Along with food, research materials, and a new computer system to replace the damaged control machines, the cargo carrier also hauled 1 ton (0.9 tonnes or 907 kilograms) of extra fuel to the space station, so that Progress M1-6 could push the ISS into a higher orbit. Russian Space Agency officials planned for the spacecraft to dock with the ISS two days after launch. The launch was the first using the newly improved Soyuz-FG rocket, a booster designed to use 5 percent less fuel than previous models.[65]

24 May

NASA announced the inauguration of a program focused on designing a probe that could collide with a comet traveling at speeds of more than 22,000 miles (35,000 kilometers) per hour. Researchers had created the Deep Impact Mission program in the belief that the collision might enable measurement of the materials comprising the comet. The plan called for a 770-pound (349-kilogram) impactor, featuring cameras and an infrared spectrometer, to collect data from the comet. NASA selected Michael A'Hearn of the University of Maryland as Project Leader, with NASA's JPL and Ball Aerospace Technology Corporation as the designers of the probe. The effort targeted Comet Tempel 1, discovered in 1867, which orbits Earth every five and one-half years. Following in the wake of several comet-related discoveries, the Deep Impact Mission

[63] NASA, "NASA Introduces Pilot Undergraduate Student-Research Program," news release 01-95, 17 May 2001.
[64] Hermann Boehnhardt, "The Death of a Comet and the Birth of Our Solar System," *Science* 292, no. 5520 (18 May 2001): 1307–1308; NASA, "In Coming Apart, Comet Linear Exposes Its Deepest Secrets," news release 01-94, 17 May 2001; Peter N. Spotts, "Comets Give Clues to Solar System's Infancy: New Studies Chronicle the Break Up of a Comet That Sheds Light on Early Planet Information," *Christian Science Monitor*, 18 May 2001.
[65] *Spacewarn Bulletin*, no. 571; Mark Wade, "Progress M1," *Encyclopaedia Astronautica*, *http://www.astronautix.com/craft/proessm1.htm* (accessed 29 July 2008).

focused on analyzing the composition of comets and determining how they might have affected the rest of the universe. NASA had designated a budget of US$279 million for the project.[66]

25 May
Continuing to gather data long after it had completed its original mission, the Galileo spacecraft made the closest ever pass of Jupiter's largest moon, Callisto. Although regarded as the ugly duckling of Jupiter's moons because it does not appear to have ever had liquid water present, Callisto still interested scientists who hoped to gather enough data to determine the size and number of craters on the moon's surface. In the days leading up to the close pass of Callisto, problems with Galileo's cameras had worried NASA controllers. Galileo scientists had anticipated the complications, however, predicting that the flyby, within 100 miles (161 kilometers) of the moon, would expose the probe to strong gravitational pulls and radiation belts. Galileo had originally begun orbiting Jupiter in 1995 and had already made 30 flybys of Jupiter's largest moons.[67]

30 May
For the first time, NASA and the Canadian Space Agency made available the data gathered by the Terra spacecraft, carrying the technologically advanced Measurements of Pollution in the Troposphere (MOPITT) experiment. The data, released at the American Geophysical Union meeting, revealed more clearly than any previous readings the presence of immense clouds of carbon monoxide over Africa and South America. The readings also charted dense air-pollution plumes over Southeast Asia. The MOPITT data pointed to natural factors such as forest fires, as well as human contributors such as industrial pollution, as causes of the increased carbon-monoxide readings. The scientific community greeted the release of the new data, and the promise of more to come, with excitement, because the MOPITT data would be vital in the quest to understand Earth's changing climate. According to one researcher who was already mining the MOPITT data for an extensive study, the new data had the potential "to improve our understanding of the linkages between air pollution and global environment change."[68]

JUNE 2001

1 June
NASA announced that it would delay Shuttle Missions STS-104 and STS-105 for several weeks because of a series of computer problems on the ISS. The computer difficulties had limited the control of the new robotic arm delivered to the ISS in April 2001. Despite the efforts of the astronauts aboard the ISS and of hundreds of experts on the ground, the malfunctions had continued to render control of the Canadian-built robotic arm impossible. NASA officials had determined that, until the situation was resolved, NASA would have to delay an *Atlantis* mission, scheduled for 20 June, and a *Discovery* mission, scheduled for 12 July, both carrying cargo that

[66] NASA, "NASA Gives Green Light for Deep Impact Mission Development," news release 01-99, 24 May 2001.
[67] *SpaceRef.com*, "Galileo Millennium Mission Status," 24 May 2001, *http://www.spaceref.com/news/viewsr.html?pid=2913* (accessed 30 July 2001); NASA, "Galileo Gets One Last Close Encounter with Jupiter's Callisto," news release 01-97, 22 May 2001.
[68] NASA, "NCAR NASA/CSA Monitor Provides Global Air Pollution View from Space," news release 01-102, 30 May 2001.

the arm must move. The delay also meant that the ISS crew—Yury V. Usachev, James S. Voss, and Susan J. Helms—would remain aboard ISS longer than originally planned.[69]

Abe Silverstein, the former Director of NASA's Lewis Research Center (LeRC), died at age 92. Silverstein's work in the aerospace industry predated NASA itself; he had begun his research career in 1929, working for NASA's predecessor, the National Advisory Committee for Aeronautics. After serving in World War II, Silverstein had played a leading role in constructing the United States' first supersonic propulsion wind tunnel. He had contributed to the Mercury and Apollo missions before 1969, when he assumed the head position at LeRC, today known as Glenn Research Center (GRC). During his career, Silverstein had received the Guggenheim Medal for "technical contributions and visionary leadership in advancing technology of aircraft and propulsion performance." NASA Administrator Daniel S. Goldin called Silverstein one of NASA's "true founding members," who had made possible NASA's robotic and human space programs. NASA also remembered Silverstein for his naming of the Mercury and Apollo missions. In addition, Silverstein had successfully promoted the liquid propulsion techniques pioneered at LeRC for use in the Apollo missions. Two sons and five grandchildren survived him.[70]

2 June

NASA, conducting a test over the Pacific Ocean, aborted a planned attempt at the speed record for aircraft when the Pegasus rocket carrying a prototype X-43A jet veered out of control. NASA had employed a B-52 to carry the X-43A and the Pegasus rocket to 45,000 feet, where the test was to begin. According to the plan, the plane would release the Pegasus, which would then carry the X-43A to 100,000 feet (30,500 meters) before releasing the jet. Instead, however, the Pegasus rocket had gone out of control almost immediately after its release. NASA spokesperson Alan Brown explained: "The Pegasus went out of control. It appeared parts were breaking off of it." NASA ordered the Pegasus destroyed after only a few seconds, and the ensuing explosion resulted in the loss of the scramjet as well. NASA officials and flight enthusiasts had hoped that the US$185 million experimental plane would top speeds of Mach 7. Instead, engineers scrambled to determine the cause of the accident.[71]

5 June

At a meeting of the American Astronomical Society, NASA scientists Patricia T. Boyd and Alan P. Smale, both working at NASA's GSFC, announced that they had uncovered a predictable mathematical pattern governing the release of x-ray light from binary star systems. Boyd and Smale had tracked the emission of x-rays from three binary star systems over a period of several years, determining that the number of days between the low points of emission in each binary system was always based on multiples of a single constant number. The discovery countered the common perception among scientists that flares and bursts happen completely at random,

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[69] Warren E. Leary, "Problems with Space Station's Robotic Arm Delay Shuttle Visits," *New York Times*, 1 June 2001; Mark Carreau, "Glitch Postpones 2 Space Station Missions," *Houston Chronicle*, 31 May 2001.
[70] NASA, "Dr. Abe Silverstein, Early Architect of the Apollo Moon Landing, Dies," news release 01-109, 1 June 2001; Wolfgang Saxon, "Abe Silverstein, 92, Engineer Who Named Apollo Program," *New York Times*, 5 June 2001; Associated Press, "Abe Silverstein, 92, Pioneer in Space Research at NASA," 4 June 2001.
[71] Peter Pae, "Hypersonic Aircraft Test Fails; Plane Is Destroyed," *Los Angeles Times*, 3 June 2001; *New York Times*, "NASA Halts Scramjet Test," 3 June 2001; *Washington Post*, "NASA Aborts Bid for Speed Mark, Blows Up Rocket," 3 June 2001.

suggesting that a repeatable process occurs when swirling matter pours into a black hole, thereby creating an emission. According to Smale, the ongoing challenge would be to combine this knowledge of a pattern, while still considering the many random factors. "The interplay between periodic and random components in these systems is a puzzle," Smale concluded.[72]

6 June

NASA announced several new findings made possible by the Chandra X-ray Observatory. Farhad Zadeh of Northwestern University had used Chandra to locate "a cauldron of 60 million degree gas enveloping a cluster of young stars." The discovery marked the first time that scientists had located such high-energy x-rays surrounding young stars. Zadeh also noted that the newly discovered cluster, located some 25,000 light-years from Earth and estimated at 1 to 2 million years old, had provided evidence in support of the theory that stellar winds generated by stars can produce very hot gas. In addition to Zadeh's find, Andreas Zezas of the Harvard-Smithsonian Center for Astrophysics announced that his team of scientists had found new midmass black holes in several starburst galaxies—regions where stars form and explode frequently. Researchers had long hypothesized that such an environment might exist but had previously been able to locate only a few midmass black holes. Zezas credited the powerful Chandra X-ray Observatory with allowing astronomers to examine far-flung galaxies more closely than before. Kimberly A. Weaver of NASA's GSFC, who had contributed to Zezas's project, hypothesized that the concentration of midsize black holes could possibly lead eventually to the formation of a single, massive black hole.[73]

7 June

After months of deliberation and years of planning, NASA gave the official approval for developing a spacecraft for the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) mission. The plan called for the MESSENGER to launch in March 2004 and to begin orbiting Mercury in April 2009. NASA selected Sean C. Solomon of the Carnegie Institution of Washington as the "principal investigator and lead scientist" for the mission, choosing the Applied Physics Laboratory at Johns Hopkins University to build and operate the MESSENGER spacecraft. Preparations for the new mission had begun 26 years after NASA's last spacecraft had circled the Mercury in a 1975 flyby producing data for half of the planet. Moreover, some officials viewed the MESSENGER mission as the resumption of a long-stalled research endeavor. Solomon described the task ahead as "an opportunity to complete the detailed exploration of the inner solar system, on a planet where we've never even seen half the surface."[74]

NASA named Nelson H. Keeler Director of its Independent Verification and Validation Facility (IVVF) in Fairmont, West Virginia, giving Keeler the responsibility for safeguarding the facility's mission-critical software. Keeler also assumed the task of evaluating the cost-effectiveness of NASA's technology and software. Before joining NASA, Keeler had served in

[72] NASA, "Method Uncovered in Madness of Black Hole and Neutron Star Eruptions," news release 01-111, 5 June 2001.
[73] NASA, "Star Factory near Galactic Center Bathed in High-Energy X-rays," news release 01-113, 6 June 2001; John Noble Wilford, "Hot Stellar Winds Captured by X-ray Orbiter," *New York Times*, 12 June 2001; NASA, "Chandra Sees Wealth of Black Holes in Star-Forming Galaxies," news release 01-110, 6 June 2001.
[74] NASA, "NASA Gives Official Nod to First Mercury Orbiter Mission," news release 01-118, 7 June 2001.

the U.S. Coast Guard, amassing more than 6,000 flight hours in search-and-rescue and law-enforcement missions. During a stint at the U.S. Coast Guard's Research and Development Center, he had won the Legion of Merit medal. Keeler had served in NASA's Space Station Freedom program, in the NASA Office of Space Flight's Advanced Launch Technology and Advanced Flight Systems programs, as well is in private industry, before becoming Director of the IVVF.[75]

14 June

Herbert V. Frey of NASA's GSFC revealed a fundamental new finding about the complexion of Mars's surface. According to Frey and his team of researchers, data gathered by Mars Global Surveyor had corrected a commonly held belief about the topography of the Red Planet and the age of its crust. Most scientists had believed that the crust covering the relatively smooth northern lowlands of the planet was much younger than that of the rest of the planet. However, Frey's research using Surveyor's pathbreaking instruments had shown that the lowlands are not actually smooth at all. Using the measurements obtained by the spacecraft's laser altimeter, Frey and his team had documented more than 600 ancient craters lying just beneath a layer of dust on the lowlands, many of the craters larger than 30 miles (48 kilometers) in diameter. From this finding, the team had concluded that the crust of the northern lowlands is older than scientists had expected. According to James W. Head of Brown University, who was not a member of Frey's research contingent, the findings would "push the reset button" on ideas about how Mars had evolved as a planet.[76]

15 June

Shang-Ping Xie of the University of Hawaii's International Pacific Research Center and Meteorology Department and W. Timothy Liu of NASA's JPL published in the journal *Science* the results of their study of Hawaii's so-called tail, demonstrating that a strong ocean current connects Hawaii with Asia. The researchers had concluded that the current was the result of the wind whipping around the small Pacific Islands and creating wakes eastward toward Asia. Scientists had long recognized that the Hawaiian Islands cause an eastward current, but common knowledge had suggested that the current' reaches less than 200 miles (322 kilometers). However, using data from NASA's QuikSCAT satellite, the European Sensing Satellites, and the United States-Japan Tropical Rainfall Measuring Mission, Xie and Lie had traced the eastward-flowing current farther, discovering that it actually extends nearly 5,000 miles (8,000 kilometers). From an historical perspective, the discovery provided evidence in support of the tradition that early Hawaiian settlers had sailed to the islands from the Far East.[77]

21 June

NASA released new images gathered by the Terra satellite's instruments—Clouds and the Earth's Radiant Energy System (CERES)—which revealed shrinking glaciers, as well as the

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[75] NASA, "NASA Names Nelson Keeler Independent Verification and Validation Facility Director," news release 01-117, 7 June 2001.

[76] Robert C. Cowen, "Red Planet Still a Mystery, but Mars Global Surveyor Makes It Less So," *Christian Science Monitor*, 14 June 2001.

[77] Shang-Ping Xie et al., "Far-Reaching Effects of the Hawaiian Islands on the Pacific Ocean-Atmosphere System," *Science* 292, no. 5524 (15 June 2001): 2057–2060; NASA, "Satellites Reveal Hawaii's Long Tail of Wind and Water," news release 01-121, 14 June 2001.

most accurate global radiation measurements ever captured. Launched in December 1999, Terra monitored most of the world's major glaciers. The CERES instruments had captured the high-resolution images from 440 miles (708 kilometers) above Earth's surface. Initial analysis of the new data had revealed that most glaciers had shrunk considerably since previously measured. For example, the glaciers in the mountains of Patagonia had receded about 1 mile (1.6 kilometers) over the course of 13 years. CERES had also provided the first complete year of radiation readings since 1987, capturing readings from the May 2001 heat wave, which had produced record temperatures in the United States.[78]

27 June

An international team of astronomers led by Kailash C. Sahu of the Space Telescope Science Institute reported the discovery of what appeared to be planet-like celestial bodies clustered around a group of 10 million stars some 8,500 light-years from Earth. The team had used the HST to make their discovery, which formed the basis of their hypothesis that the strong gravitational force of the dense star cluster might have pulled the quasi-planets away from their parent stars. The researchers' article in *Nature* prompted both skepticism and praise. Stephen P. Maran, an American Astronomical Society spokesperson, summarized the reason for the excitement surrounding the find: "If it is confirmed, the finding suggests there is something big here that we don't understand." In addition, Sahu's research team reported that they had observed six microlensing events during their study, thereby focusing the attention of the scientific community on Albert Einstein's theory of microlensing— that the gravity of a celestial body can bend the light of a more distant object, thereby acting as a magnifying glass for space exploration.[79]

John F. Yardley, who had worked at the McDonnell Aircraft Corporation, serving as the Launch Operation Manager for the *Mercury* and *Gemini* spacecraft and the Technical Director for the Gemini program before joining NASA in 1974, died at the age of 76. NASA had awarded Yardley its Public Service Medal in 1963 and in 1966 for his work on the *Mercury* and the *Gemini*. From 1981 to 1989, Yardley had been President of McDonnell Douglas Astronautics Company. NASA Administrator Daniel S. Goldin called Yardley "as responsible as any individual for getting the Space Shuttle Program off the ground.[80]

30 June

The Microwave Anisotropy Probe (MAP) launched aboard a Delta 2 rocket from Cape Canaveral, Florida. MAP carried two Gregorian telescopes, designed to record temperatures in selected locations throughout the sky. MAP's broad mission was to provide further insight into how the universe formed. The spacecraft cost US$95 million to build.[81]

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[78] NASA, "NASA's Terra Satellite Captures a World of Sunlight and Heat," news release 01-123, 21 June 2001; Kenneth Chang, "Spacecraft's Supercamera Captures Earth in All Its Detail," *New York Times*, 19 June 2001.
[79] Kailash C. Sahu et al., "Gravitational Microlensing by Low-Mass Objects in the Globular Cluster M22," *Nature* 411, no. 6841 (28 June 2001): 1022–1024; Kathy Sawyer, "A Dim Discovery in a Bend of Light; Celestial Orbs Detected Through Microlensing May Hold Clues to Stars' Birth," *Washington Post*, 28 June 2001.
[80] NASA, "John F. Yardley, Human Space Flight Pioneer, Dies," news release 01-130, 27 June 2001; Wolfgang Saxon, "John Yardley, 76, Dies; Had Central Role in Space Flight," *New York Times*, 28 June 2001.
[81] The Boeing Company, "Boeing Delta II Helps Unlock Secrets of the Universe," news release, 30 June 2001, *http://www.boeing.com/news/releases/2001/q2/news_release_010630h.html* (accessed 28 January 2010); Peter N. Spotts, "Latest NASA Launch Aims To Take Cosmic Baby Picture," *Christian Science Monitor*, 29 June 2001;

JULY 2001

6 July
Researchers based at the Stanford Linear Accelerator Center announced that they had delineated the mechanism by which the universe favors matter instead of empty space. The team of scientists had used Stanford University's 1,200-ton (1,090-tonne or 1.1 million-kilogram) particle detector to study the process of charge-party violation (CP violation) —the interactions and relationships between matter and antimatter. Although scientists had long believed that matter and antimatter are distinctly different, obtaining proof of this had proved difficult. The new discovery provided significant support for the hypothesis, exciting the scientific community. As physicist Stewart Smith, spokesperson for the research group, explained: "After 37 years of searching for further examples of CP violation, physicists now know that there are at least two kinds of subatomic particles that exhibit this puzzling phenomenon, thought to be responsible for the great preponderance of matter in the universe."[82]

11 July
NASA announced that images provided by the Submillimeter Wave Astronomy Satellite (SWAS), which NASA had launched in December 1998, showed new evidence that extra-planetary systems contain water. In particular, astronomers had studied the giant IRC+10216 star, also known as CW Leonis, and had located water vapor surrounding the celestial body. Scientists had never considered the giant star, located some 500 light-years from Earth, as a likely host of water because of its high levels of carbon. Gary Melnick of the Harvard-Smithsonian Center for Astrophysics led the SWAS study, which concluded that the most viable explanation for the "substantial concentrations of water vapor" around the star was that the star's gravity had pulled the water vapor from the icy surfaces of nearby comets. The discovery had broad implications for scientists' theories about how Earth might eventually end. "We think we are witnessing the type of apocalypse that will ultimately befall our own planetary system," said one SWAS researcher. "Several billion years from now, the Sun will become a giant star and its power output will increase five thousand fold. As the luminosity of the Sun increases, a wave of water vaporization will spread outwards through the solar system, starting with Earth's oceans and extending well beyond the orbit of Neptune."[83]

12 July
Space Shuttle *Atlantis* STS-104/ISS7A lifted off from NASA's KSC in Cape Canaveral, Florida, bound for the ISS. Steven W. Lindsay served as Flight Commander, Charles O. Hobaugh piloted the spacecraft, and Mission Specialists Janet L. Kavandi, Michael L. Gernhardt, and James F. Reilly rounded out the crew. The launch was the first using NASA's upgraded hydrogen turbopumps in the Shuttle's three main engines. The pump was the last in a series of Shuttle improvements that NASA had made to reduce maintenance and improve safety of the Shuttle.

Spacewarn Bulletin, no. 572, 1 July 2001, *http://nssdc.gsfc.nasa.gov/ spacewarn/spx572.html* (accessed 4 August 2008).
[82] Kathy Sawyer, "New Insight into Reason Matter Exists; Studies Confirm Cosmic Mechanism," *Washington Post*, 7 July 2001.
[83] Gary J. Melnick et al., "Discovery of Water Vapour Around IRC+10216 as Evidence for Comets Orbiting Another Star," *Nature* 412, no. 6843 (12 July 2001): 160–163; NASA, "Stellar Apocalypse Yields First Evidence of Water-Bearing Worlds Beyond Our Solar System," news release 01-140, 11 July 2001.

The mission called for the astronauts to attach the new American-made Joint Airlock to the ISS and to conduct important repairs to the station during three separate spacewalks. The design of the new airlock permitted the ISS crew access to and from space, wearing either Russian or American spacesuits. During the days leading up to the launch, Mission Specialist Michael L. Gernhardt explained: "The term Joint Airlock means that it's applicable to both the U.S. [space]suit, the EMU [Extravehicular Mobility Unit], and to the Russian suit, the Orlan suit. The main objectives of our flight are to install four High Pressure Gas Tanks—that would be two oxygen, two nitrogen—to activate and check out the airlock and then to make the first spacewalk from the Joint Airlock and demonstrate the viability of the whole process and sort of usher in the space station era of EVA."[84]

16 July

Crew members of Space Shuttle *Atlantis* accomplished the primary objective of Mission STS-104, successfully installing the Joint Airlock on the ISS. The crew used the space station's massive, Canadian-made robotic arm, which had not operated properly for several months, to hoist the enormous entryway out of the Shuttle's cargo bay and to move it into position for installation. Astronaut Susan J. Helms commanded the robotic arm, while spacewalking astronauts Michael L. Gernhardt and James F. Reilly helped line up the hatch for its final installation. The robotic arm successfully accomplished its first construction task, drawing applause from NASA's Mission Control, as did the opening of the US$164 million Joint Airlock. Although the ISS Partnership planned improvements and additions to the space station far into the future, the mission marked the end of a major stage of assembly for the ISS.[85]

19 July

Daniel Wang, a University of Massachusetts professor and leader of a study team of astronomers, announced that his team had discovered a giant halo of hot gas spiraling a galaxy similar to the Milky Way and relatively near Earth. The researchers had used the Chandra X-ray Observatory and the HST to observe galaxy NGC 4631, some 25 million light-years from Earth. The discovery not only revealed the increasing power of the astronomical tools at the disposal of scientists, but also contributed to astronomers' knowledge about the structure and evolution of galaxies. Wang explained the significance of the discovery: "Scientists have debated for over 40 years whether the Milky Way has an extended corona, or halo, of hot gas . . . by studying similar galaxies like NGC 4631, we can get an idea of what's going on within our own galaxy." The study's results also provided new information about how energy and mass spin around galaxies, as well as about the possible effects of rapid star formation.[86]

Arthur F. Davidsen, an astrophysicist who had helped found the Space Telescope Science Institute at Johns Hopkins University in Baltimore, Maryland, died at age 57. Davidsen had served for many years as a professor of physics and astronomy at Johns Hopkins, focusing much of his research on the missing mass or dark matter of the universe. His findings had led to the

[84] *Spacewarn Bulletin*, no. 573, 1 August 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx573.html* (accessed 11 August 2008); William Harwood, "Atlantis Heads for Space Station; Crew To Install Airlock, Expanding Capabilities," *Washington Post*, 13 July 2001; NASA, "NASA Prepares To Open a New Doorway to Space," news release 01-138, 9 July 2001.
[85] *New York Times*, "2nd Entry Installed on Space Station," 16 July 2001.
[86] NASA, "Chandra Detects Halo of Hot Gas Around Milky Way–Like Galaxy," news release 01-146, 19 July 2001.

development of the theory that, because of the reflecting light of other bodies, we are able to observe only about 1 percent of the universe's matter. Davidsen's work indicated that, although the remaining matter exists, it remains hidden from us. Not only had Davidsen led his colleagues in establishing the Space Telescope Science Institute, but he had also encouraged the Institute to participate in operating the HST. In his later years, Davidsen had even begun planning for the instrument that would eventually supplant the HST as the world's foremost astronomical tool. Davidsen had trained at Princeton University and at the University of California at Berkeley. In 1979 he had won the American Astronomical Society's Helen B. Warner Prize for his work using a rocket to obtain the first ultraviolet spectrum of a quasar.[87]

20 July
NASA commemorated the 25th anniversary of Viking 1 Lander's safe descent to the surface of Mars. The successful mission, marking the first time that humankind had sent a spacecraft to the Red Planet and the first landing of an American probe on another planet, inaugurated a series of research-oriented missions to Mars. In celebrating this banner day in its history, NASA looked forward to new challenges and opportunities for the study of Mars. NASA Administrator Daniel S. Goldin delivered a keynote address, "Continuing the Quest—Celebrating Viking and Looking to the Future of Mars Exploration," at the National Geographic Society's Grosvenor Auditorium in Washington, DC. Viking 1 Lander had remained on Mars for six years, gathering images and data invaluable for scientists. Following up on the success of the first probe, Viking 2 Lander had arrived on Mars's Plain of Utopia in September 1976. The two probes had taken more than 4,500 pictures while slowly crawling over Mars's surface. Perhaps as significant as the finds of Viking 1 and 2 on Mars was the fact that the probes did not find any evidence of life on the Red Planet. NASA's Langley Research Center (LaRC) had equipped both probes with biological sensors, setting a precedent for future probes to other planets to continue the search for signs of life outside of Earth. As NASA celebrated the pathbreaking Viking missions, the 2001 Mars Odyssey traveled toward the Red Planet to continue the tradition of exploring Mars's hostile but fascinating landscape.[88]

23 July
In the midst of increased concerns over the long-term effects of the depletion of Earth's ozone layer and concerns over global warming, scientists learned that Mars's average global temperature had increased 50°F (10°C) in one month. A research team at Arizona State University analyzed and made public data that Mars Global Surveyor had collected, indicating the planet's drastic change in climate. Scientists concluded that a massive dust storm, originating in Mars's lower latitudes, had caused the increase in temperature. The researchers believed that the dust had trapped sunlight, eventually causing a heat wave to envelope the Red Planet; they predicted, however, that the planet's temperature would cool when the dust particles began reflecting sunlight.[89]

Diplomats from 178 nations reached a compromise agreement to enact the Kyoto Protocol, a pact designed to reduce emissions of carbon dioxide and other gases, which scientists believed

[87] Martin Weil, "Hopkins Astrophysicist Arthur Davidsen Dies," *Washington Post*, 22 July 2001; *Los Angeles Times*, "Obituaries: Arthur Davidsen; Astrophysicist Led Work To Build Knowledge of Universe," 23 July 2001.
[88] NASA, "NASA Celebrates 25th Anniversary of Mars Landing," news release 01-143, 17 July 2001.
[89] *Los Angeles Times*, "Science File in Brief; Global Warming Strikes Another Planet: Mars," 23 July 2001.

were contributing to global warming. The United States, represented by Undersecretary of State Paula J. Dobriansky, had rejected the final agreement. Calling the agreement "fatally flawed," President George W. Bush expressed concern over the effect of the treaty on the U.S. economy. Although Russia and Japan had also expressed major reservations, the two countries had eventually signed the Kyoto Protocol when negotiators included language in the final draft delaying the date of compliance. The treaty called for industrialized nations to limit the emissions released by automobiles, plants, and factories, but the mechanisms for enforcement defied easy solutions. However, according to final rules, each nation must reduce its carbon-dioxide emissions or pay fines for violations. Nations throughout the world criticized the United States' rejection of the treaty. For example, the chief negotiator for the European Union expressed disappointment at the United States' decision, saying, "Almost every single country stayed in the protocol. There was one that said the Kyoto Protocol was flawed." Although an international consensus had emerged, the treaty still required the ratification of the 55 nations responsible for 55 percent of the world's carbon-dioxide emissions in 1990.[90]

24 July

After a one-day delay because of rain, Space Shuttle *Atlantis* STS-104 landed safely at KSC in Cape Canaveral, Florida, having completed its mission successfully. The crew had installed a new hatch, allowing spacewalkers easier access in and out of the ISS. Officially called the ISS Airlock and also known as the Joint Airlock, the new pressurized unit gave ISS spacewalkers a portal that oxygen-nitrogen tanks could quickly pressurize. NASA planned for all future spacewalks on ISS to begin and end at the new site. In addition to installing the airlock, *Atlantis*'s crew delivered to the ISS the EarthKAM, a new camera that U.S. high school and middle school students could direct from the ground, enabling them to take pictures of some 2,000 points of interest on Earth, thus, participating in ISS research.[91]

25 July

Scientists at NASA's JPL became the first researchers to observe a star spinning so rapidly that its midsection had stretched out. Using an ultra-high–resolution telescope located at Palomar Mountain in California, the JPL team measured the shape of the star Altair and found that it was not round. Although scientists had often suspected that the revolutions of a star might cause its shape to change, the JPL team was the first to take measurements to confirm the hypothesis. Altair's diameter at its equator measured about 14 percent greater than the diameter at the poles. The findings had implications far beyond determining the shape of one star. As Charles A. Beichman, Chief Scientist on the project explained, "Determining the shape of another star helps us learn about the forces that control the shape and structure of all stars, including our star, the Sun. This tells us more about the Sun's behavior and ultimate fate."[92]

31 July

A research team announced the results of a NASA-funded study using microgravity to investigate the properties of everyday materials. Led by Jennifer A. Lewis, the team of

[90] Traci Watson, "Compromise Rescues Kyoto Protocol; Nations Hope Global Warming Treaty Will Take Effect in 2002; U.S. Says Pact 'Is Not Sound Policy'," *USA Today*, 24 July 2001; Peter N. Spotts, "Global Climate Treaty Moves Ahead, Without US," *Christian Science Monitor*, 24 July 2001.
[91] *Spacewarn Bulletin*, no. 573; *Washington Post*, "Shuttle Lands After Extra Day in Space," 25 July 2001.
[92] NASA, "Star with Midriff Bulge Eyed by Astronomers," news release 01-150, 25 July 2001.

researchers had pioneered a new approach to stabilizing particles in fluids, a process they termed nanoparticle haloing. By suspending movement of fine particles in fluids such as paint, Lewis and her colleagues had succeeded in manipulating the complexion of the liquid. Perhaps of greater significance, they had been able to ensure that the fluid did not break down as quickly as it would have done otherwise. The researchers believed that nanoparticle haloing would have wide application, such as in making the fluids more useful and long lasting. As Lewis said, "This designer capability will assist us in developing improved materials." NASA's Office of Biological and Physical Research (OBPR) made the project possible, offering grants for studies that might benefit from the use of a microgravity or low-gravity environment to examine the fundamental states and characteristics of materials.[93]

Russia launched the Coronas-F solar observatory satellite aboard a Tsiklon 3 rocket. The launch took place from the Plesetsk Cosmodrome in northern Russia. Engineers had designed the satellite to monitor light intensity, solar bursts, and several solar radii. The satellite carried 13 separate instruments, to gather data as the spacecraft orbited while pointing toward the Sun. The Coronas-F satellite was Russia's second attempt to place in orbit such a complicated research craft. The Coronas-I, launched in 1994, had operated for only a couple of months before a control failure had caused it to lose its functionality.[94]

AUGUST 2001

2 August
NASA and the National Commission for Space Activities of the Argentine Republic signed a 15-year extension of an existing agreement on cooperation in civil uses of space. Originally signed in August 1991, the accord had established the framework for the United States and Argentina to collaborate on space research projects in fields such as Earth science and global climate change.[95]

7 August
NASA announced the selection of six new members and eight new consultants for the Aerospace Safety Advisory Panel (ASAP). The U.S. Congress had created ASAP to advise NASA on ways it could improve its safety performance, tasking ASAP with submitting annual reports of its findings to both NASA and Congress. The six newly selected members of the panel were Otto K. Goetz, Sidney M. Gutierrez, Shirley C. McCarty, J. Paul Reason, Roger D. Schaufele, and Robert B. Sieck. The new consultants were Wanda M. Austin, Richard R. Bruckman, Ulf G. Goranson, Bernard A. Harris Jr., Nancy G. Leveson, Forrest S. McCartney, and C. Julian May.[96]

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[93] NASA, "Suspended in Space: Researchers Make Important Discovery About Materials," news release 01-154, 31 July 2001.
[94] *Spacewarn Bulletin*, no. 573.
[95] NASA, *Aeronautics and Space Report of the President: Fiscal Year 2001 Activities* (Washington, DC, 2002), pp. 24–25, *http://history.nasa.gov/presrep01/2001report.pdf* (accessed 29 July 2002); NASA, "U.S. and Argentina Sign Space Cooperation Agreements," news release 91-126, 8 August 1991.
[96] NASA, "NASA Announces New Aerospace Safety Advisory Panel Members," news release 01-159, 7 August 2001; NASA, "Aerospace Safety Advisory Panel," *http://www.hq.nasa.gov/office/oer/asap/ index.html* (accessed 7 November 2008).

8 August

NASA launched the Genesis solar research spacecraft from Cape Canaveral Air Force Station in Florida. Genesis would collect samples of solar wind to assist scientists in studies of the formation of Earth's solar system. Scientists believed that the plasma in solar wind might contain material similar to or identical with the material that formed the solar system. The 633-kilogram (1,400-pound) spacecraft was equipped with four instruments: a wide-angle ion collector, a concentrated ion collector, an ion spectrometer, and an electron spectrometer. Donald S. Burnett of California Institute of Technology was Principal Investigator and Project Scientist for Genesis.[97]

NASA suspended indefinitely the launch of the climate-monitoring satellite Triana, which NASA had designed to provide imagery of entire hemispheres from nearly 1 million miles away in space. By contrast, weather satellites often remain in low Earth orbit and, therefore, are only able to provide images of continents. Triana was also called GoreCam or GoreSat, because former Vice President Gore had originated the project. Gore had conceived of the satellite in March 1998, choosing to name it in honor of Rodrigo de Triana, the sailor on Columbus's ship who had first sighted land. NASA had planned to launch the US$120 million Earth-observation satellite by the end of 2001. However, the Republican-controlled U.S. House of Representatives had voted to eliminate the project's funding from NASA's fiscal year (FY) 2000 appropriation. A conference committee of the House and the Senate had later agreed to suspend funding for Triana and to delay its launch, so that the National Academy of Sciences could review the project's merits. Although the National Academy of Sciences had strongly endorsed the project, NASA had decided to shelve the satellite project indefinitely, as part of its effort to prioritize scientific expenditures and concentrate its resources on projects such as the HST and the ISS.[98]

9 August

NASA and the Russian Space Agency agreed to allow the transport of space tourists to the ISS. Although the two agencies did not sign a formal agreement on the matter, media reported that they had agreed to the procedures and standards that spaceflight participants—individuals who are not professional astronauts or cosmonauts—must satisfy when they visit the space station. NASA and the Russian Space Agency agreed that such visitors must demonstrate foreign language ability, undergo specified physical training, and pass a personal suitability test. The issue of spaceflight participants had become a source of contention between NASA and the Russian Space Agency after American businessman Dennis A. Tito had paid the Russian Space Agency to transport him to the ISS in April 2001.[99]

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[97] *Spacewarn Bulletin*, no. 574, 1 September 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx574.html* (accessed 7 November 2008); NASA JPL, "Genesis, Search for Origins: Why Study the Sun?" *http://genesismission.jpl.nasa.gov/gm2/science/solarwind.htm* (accessed 7 November 2008).

[98] Joel Achenbach, "For Gore Spacecraft, All Systems Aren't Go; Earth Observation Satellite Shelved," *Washington Post*, 8 August 2001.

[99] Peter Baker, "U.S., Russia Agree To Allow 'Space Tourists'," *Washington Post*, 10 August 2001; ESA, Multilateral Crew Operations Panel, "Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers" (statement of criteria, Paris, November 2001), *http://esamultimedia.esa.int/docs/isscrewcriteria.pdf* (accessed 5 November 2008).

10 August

NASA launched Space Shuttle *Discovery* STS-105/ISS-7A.1 at 4:10 p.m. Central Daylight Time (CDT). Shuttle crew consisted of Mission Commander Scott J. Horowitz, Pilot Frederick W. "Rick" Sturckow, Mission Specialists Daniel T. Barr and Patrick G. Forrester; and Expedition 3 crew members, Frank L. Culbertson Jr., Vladimir N. Dezhurov, and Mikhail Tyurin. One of the main purposes of the mission was to transport the Expedition 3 crew to the ISS, returning Expedition 2 crew members to Earth. Another objective was to use an Italian-built, 9,000-pound (4,100-kilogram) Multi-Purpose Logistics Module (MPLM) called Leonardo to deliver supplies to the ISS. Leonardo would deliver six resupply stowage racks, four resupply stowage platforms, and two scientific experiment racks for the station's laboratory. *Discovery*'s payload also included NASA's scientific project, the Materials International Space Station Experiments (MISSE).[100]

Gerard A. Kriss of Johns Hopkins University led a group of astronomers using NASA's Far Ultraviolet Spectroscopic Explorer (FUSE) satellite to obtain the best observations to date of helium gas remaining from the Big Bang. The observations provided information about the universe's architecture millions of years ago, giving empirical support for theories about how matter in the expanding universe had condensed into a structure that permeated space between galaxies. The FUSE satellite had observed the light of the distant quasar HE2347-4342, and scientists had used the data it produced to make comparative analyses of the light's absorption by helium and hydrogen gas on its trajectory to Earth. The astronomers had compared the ionization of the helium and hydrogen, the result of the gases' absorption of light, to determine the most likely source of the energy that had heated the universe during its early formation. They concluded that, most likely, a combination of quasars and newly formed stars had produced the ionization of helium and hydrogen gases. Moreover, the presence of helium, in regions with no hydrogen, supported the theory that the universe's architecture resulted from extensive gravitational instabilities during the chaos after the Big Bang.[101]

14 August

NASA's Helios aircraft set a world record for the highest altitude ever attained by an aircraft without rocket power. The solar-powered, propeller-driven aircraft reached an altitude of 96,500 feet (30,000 meters), eclipsing the previous record by more than 10,000 feet (3,000 meters). The remotely piloted aircraft took off from the U.S. Navy's Pacific Missile Range Facility (PMRF) in Hawaii at 8:48 a.m. local time on 13 August, staying aloft for nearly 17 hours before landing at 1:43 a.m. on 14 August. Fuel cells on the aircraft's wings provided electrical power during the daylight hours, when the aircraft achieved the record altitude; at night, the plane's propellers acted as generators, providing electrical power to control the aircraft. According to NASA, an aircraft operating at such an altitude would be able to monitor the environment, improve

[100] NASA, "STS-105: A New Crew Arrives at the International Space Station," *http://spaceflight.nasa.gov/shuttle/archives/sts-105/* (accessed 7 November 2008); NASA KSC, "STS-105," *http://science.ksc.nasa.gov/shuttle/missions/sts-105/mission-sts-105.html* (accessed 7 November 2008).

[101] NASA, "New View of Primordial Helium Traces Structure of Early Universe," news release 01-160, 9 August 2001; G. A. Kriss, "Resolving the Structure of Ionized Helium in the Intergalactic Medium with the Far Ultraviolet Spectroscopic Explorer," *Science* 293, no. 5532 (10 August 2001): 1112–1116.

communications on Earth, and simulate the conditions of flight within the atmosphere of Mars.[102]

15 August

Astronomers led by Debra A. Fischer of the University of California at Berkeley announced the discovery of a planetary system similar to Earth's solar system, located in the Big Dipper. The team of astronomers had found a planet about the size of Jupiter, orbiting the star 47 Ursae Majoris. Scientists had already known about one planet orbiting 47 Ursae Majoris, but the second planet's discovery provided the first example of two planets orbiting in near-perfect circles around a single star outside of Earth's solar system. Astronomers had previously discovered other planets orbiting stars outside of Earth's solar system, but those planets either were orbiting perilously close to the host star or had eccentric orbits. The astronomers had used University of California's Lick Observatory near Santa Cruz, California, to find the planets, which they had detected by observing the planets' gravitational effects upon the star 47 Ursae Majoris.[103]

16 August

During the first spacewalk for Mission STS-105, astronauts Daniel T. Barry and Patrick F. Forrester affixed an ammonia coolant canister and two boxes containing hundreds of samples of prospective spacecraft materials to the exterior of the ISS. The ammonia canister would function as a backup coolant system in the event of a problem with the ISS's primary coolant system. The samples, part of the MISSE experiment, would remain attached to the ISS for almost two years, so that scientists could examine how the materials performed during prolonged exposure to solar storms, cosmic radiation, and other aspects of the space environment. The experiment was a cooperative research effort of Boeing Phantom Works, the Materials Laboratory at the U.S. Air Force Research Library, and several NASA centers.[104]

17 August

NASA announced the selection of crew members for three missions to the ISS scheduled for 2002. Mission STS-112, scheduled for launch in July 2002, would comprise Commander Jeffrey S. Ashby and crew members Sandra H. Magnus, Pamela A. Melroy, Piers J. Sellers, David A. Wolf, and Fyodor N. Yurchikhin. The crew for STS-113, scheduled to depart in August 2002, would consist of Commander James D. Wetherbee and crew members John Bennett Herrington, Michael Lopez-Alegria, and Christopher J. Loria. The mission would also transport Expedition 6 crew members Valery G. Korzun, Sergei Y. Treschev, and Peggy A. Whitson to the ISS, returning to Earth Expedition 5 crew members Kenneth D. Bowersox, Nikolai M. Budarin, and Donald A. Thomas. Finally, the crew of STS-114 would include Commander Eileen M. Collins and crew members James M. Kelly, Soichi Noguchi, and Stephen K. Robinson. STS-114,

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[102] NASA, "NASA Solar Aircraft Sets Altitude Record; Communications, Environmental Breakthroughs Expected," news release 01-165, 14 August 2001.

[103] John Noble Wilford, "Planet System with Earth-Like Orbits Is Found," *New York Times*, 16 August 2001; Debra A. Fischer et al., "A Second Planet Orbiting 47 Ursae Majoris," *Astrophysical Journal* 564, no. 2 (10 January 2002): 1028–1034.

[104] Marcia Dunn, "Spacewalking Astronauts Attach Ammonia Canister, Science Experiments to Space Station," Associated Press, 16 August 2001; NASA, "Materials International Space Station Experiment: Introduction," *http://misseone.larc.nasa.gov/* (accessed 13 November 2008).

scheduled to leave for the ISS in November 2002, would transport Expedition 7 crew members Edward T. Lu, Yuri I. Malenchenko, and Sergei I. Moschenko.[105]

18 August
During the second spacewalk for Mission STS-105, astronauts Daniel T. Barry and Patrick G. Forrester attached two 45-foot (13.7-meter) power cables and two handrails to the exterior of the ISS's *Destiny* laboratory module. The cables would provide a secondary power supply for a 44-foot (13.4-meter) external truss, scheduled for installation in 2002. The truss, which would contain a satellite navigation system and other electronic components, would be the first of several parts of the ISS's Integrated Truss Structure, which would support new components, such as solar arrays.[106]

21 August
The ISS Management and Cost Evaluation Task Force (IMCE) held its first meeting on 20 and 21 August at NASA Headquarters. NASA Administrator Daniel S. Goldin had created the IMCE in July 2001 to consider the ISS program's budget and management challenges and to determine a more efficient and effective method for NASA and its partners to construct the orbiting space station. Goldin had appointed A. Thomas Young, former president of Martin Marietta, to chair the 20-member Task Force, composed of Nobel Laureates and a highly regarded surgeon. In addition, a Financial Management Team and a Cost Analysis Support Team would support the IMCE in its efforts. On 1 November 2001, the Task Force would report its findings to the NASA Advisory Council, which would, in turn, present its recommendations to the NASA Administrator for NASA's official response.[107]

The Russian Space Agency launched a crewless logistics and resupply mission to the ISS. The Progress automatic cargo spacecraft launched from Baikonur Cosmodrome in Kazakhstan at 9:32 a.m., Universal Time (UT),[108] on a Soyuz-U rocket. The mission, officially designated as M-45, carried to the ISS 2.5 tonnes (2,500 kilograms, 2.8 tons, or 5,512 pounds) of fuel, oxygen, equipment, and other supplies.[109]

22 August
Space Shuttle *Discovery* landed at NASA's KSC in Cape Canaveral, Florida, at 1:23 p.m. (CDT), marking the end of Mission STS-105. During the mission, the Shuttle crew had delivered supplies and equipment to the ISS, carried Expedition 3 crew members to the ISS, and transported the Expedition 2 crew back to Earth. In addition, astronauts Daniel T. Barry and

[105] NASA JSC, "NASA Names 23 Astronauts and Cosmonauts to Shuttle Flights in 2002," news release H01-167, 17 August 2001.
[106] NASA, "Mission Archives: STS-105," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-105.html* (accessed 13 November 2008); Mark Carreau, "Discovery Astronauts Connect Power Flow During Spacewalk," *Houston Chronicle*, 19 August 2001.
[107] NASA, "Space Station Program Review Team To Meet Aug. [20–21]; Reporters Invited To Attend," news release N01-047, 16 August 2001; NASA, "NASA Administrator Announces Distinguished Team To Review International Space Station Program," news release 01-152, 31 July 2001.
[108] NASA GSFC Solar System Exploration Division, "Time Zones and Universal Time," *http://eclipse.gsfc.nasa.gov/SEhelp/TimeZone.html* (accessed 5 December 2008).
[109] *Spacewarn Bulletin*, no. 574; Jesco von Puttkamer, "Space Flight 2001: The Year in Review," *http://spaceoperations.nasa.gov/2001/yearinrev/01YearReview.html* (accessed 10 November 2008).

Patrick G. Forrester had each performed two spacewalks to attach equipment to the exterior of the ISS, spending a total of 11 hours and 45 minutes outside the space station. STS-105's total duration was 11 days, 21 hours, and 13 minutes.[110]

29 August
Japan's National Space Development Agency (NASDA) launched the first of its HII-A vehicles at 4:00 p.m., Japan Standard Time (JST), from Tanegashima Space Center. The HII-A carried two payloads, the Doppler Ranging Equipment and the Laser Ranging Equipment, both instruments designed to monitor the rocket during and after launch. Observers regarded the launch as a major success for the Japanese space program, which had designed the rocket as the country's primary large-scale launch vehicle.[111]

31 August
Scientists led by Ken Ebisawa of NASA's GSFC published research that helped resolve a long-standing question about whether the emission of x-rays from the plane of the Milky Way Galaxy was truly diffuse or derived from numerous discrete sources. The scientists had used the Chandra X-ray Observatory to carry out an unprecedented survey of a region of the galactic plane that had no known x-ray point sources, in the deepest examination ever made of hard x-rays in the region referred to as the zone of avoidance. Chandra had revealed 36 new x-ray point sources and an area of diffuse emission. Properties of the new point sources had indicated that they were probably located outside the Milky Way. In addition, Chandra's survey had indicated that the diffuse x-ray emission revealed the galactic omnipresence of hot plasma with a higher energy density than any other substance in interstellar space.[112]

SEPTEMBER 2001

4 September
The National Academy of Sciences released a report criticizing a White House proposal directing NASA to assume responsibility for research in astronomy and astrophysics managed by the National Science Foundation (NSF). The White House had made the proposal as a cost-reduction measure in its proposed budget for FY 2002. At the request of NASA and the NSF, a National Research Council (NRC) panel had assessed the proposal and concluded that NASA should not assume this responsibility. According to the panel, the NSF's relations with the academic community and its commitments to investigator-initiated and interdisciplinary research made the NSF better suited than NASA to sponsor ground-based astronomy and astrophysics research. The panel also concluded that the federal government could maximize the benefits of astronomy and astrophysics research by creating an interagency astronomy and astrophysics planning board to develop an integrated research strategy. The NRC panel's report suggested that such a strategy should include ways of supporting ground- and space-based facilities and

[110] NASA, "STS-105: A New Crew Arrives at the International Space Station," *http://spaceflight.nasa.gov/shuttle/archives/sts-105/* (accessed 10 November 2008).
[111] Puttkamer, "Space Flight 2001"; Japan Aerospace Exploration Agency (JAXA), "H-IIA Launch Vehicle," *http://www.jaxa.jp/projects/rockets/h2a/index_e.html* (accessed 10 November 2008); JAXA, "LRE (Laser Ranging Equipment)," *http://god.tksc.jaxa.jp/lr/lre.html* (accessed 10 November 2008).
[112] NASA, "Astronomers Go Behind the Milky Way To Solve X-ray Mystery," news release 01-161, 9 August 2001; Ken Ebisawa et al., "Origin of the Hard X-ray Emission from the Galactic Plane," *Science* 293, no. 5535 (31 August 2001): 1633–1635.

missions, and that NASA and the NSF should create formal mechanisms to implement the planning board's recommendations.[113]

5 September

For the first time, astronomers detected a supermassive black hole consuming material in the Milky Way. Frederick K. Baganoff of the Massachusetts Institute of Technology and a team of scientists using NASA's Chandra X-ray Observatory to observe a source of radio emissions called Sagittarius A* had noticed a rapid rise and decline in x-ray emissions in its vicinity. The scientists, who believed that Sagittarius A* is connected to a black hole in the center of the galaxy, speculated that the emissions emanate from matter falling into the black hole. The Chandra observations had provided the best view yet of the area just outside of the black hole's event horizon—the point of no return for all matter falling into a black hole. The discovery added significantly to previous research indicating that the Milky Way Galaxy contains a black hole or some other large, dark object.[114]

6 September

Lockheed Martin confirmed that the U.S. Department of Defense (DOD) had decided not to fund the company's development of the X-33 space plane, a possible replacement vehicle for the Space Shuttle. Since 1996, Lockheed Martin had been developing a pilotless prototype of the X-33, a reusable spacecraft that would be able to launch without shedding fuel tanks or boosters and to land like an airplane. However, the development of lightweight fuel tanks had taken the project off schedule and over budget, and NASA had decided in March 2001 to forego continued funding for the X-33, although it was, reportedly, 75 percent complete. When Lockheed Martin had subsequently attempted to secure another government sponsor for the project, the U.S. Air Force had expressed interest in the project and submitted to the Pentagon a proposal to fund the space plane. However, the DOD had since determined that the project was too costly to undertake.[115]

The U.S. Senate Commerce, Science, and Transportation Subcommittee on Science, Technology, and Space held a hearing on safety and workforce issues related to NASA's Space Shuttle Program. According to newspaper reports, much of the testimony addressed the effects of budget cuts on the safety improvements for the Space Shuttles. Subcommittee members and witnesses reportedly were critical of the budget cuts and concerned about their possibly detrimental effects on Shuttle safety. Individuals providing testimony at the hearing were NASA Deputy Associate Administrator William F. Readdy, Allen Li of the General Accounting Office (GAO), Michael James McCulley of United Space Alliance, Richard D. Blomberg, chair of the ASAP, and Bryan D. O'Connor, former chair of the NRC's Committee on Space Shuttle Upgrades.[116]

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[113] NRC, *U.S. Astronomy and Astrophysics: Managing an Integrated Program* (Washington, DC: National Academy Press, 2001); James Glanz, "Report Warns Against Plan for Changes in Astronomy," *New York Times*, 5 September 2001.

[114] NASA, "Chandra Catches Milky Way Monster Snacking," news release 01-179, 5 September 2001.

[115] Michael Cabbage, "Air Force Decides Not To Revive Lockheed's X-33 Space Plane," *Orlando Sentinel* (FL), 7 September 2001.

[116] U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, *Shuttle Safety,* 107th Cong., 1st sess., 6 September 2001; Tamara Lytle, "Experts Fear for Shuttle Safety as NASA Budget Is Trimmed," *Orlando Sentinel* (FL), 7 September 2001.

11 September
Terrorists hijacked four U.S. planes, subsequently crashing them in New York City, Pennsylvania, and Washington, DC. The incidents led to the deaths of nearly 3,000 people. The federal government immediately responded by grounding all commercial air traffic, and NASA closed its major facilities throughout the country.[117]

13 September
U.S. Secretary of Transportation Norman Y. Mineta allowed commercial aircraft to resume flying in the national airspace system, the first time that the Department of Transportation had permitted aircraft to fly since the terrorist attacks of 11 September 2001. However, Secretary Mineta also announced that the government would permit airports to reopen and flights to resume only on a case-by-case basis, pending airports' implementation of stricter security measures. Before reopening, airports would have to clear all individuals from terminals and conduct security searches. After reopening, airports would have to increase the number of law enforcement personnel at their facilities. Secretary Mineta had made the decisions after consulting with the White House and with intelligence and law enforcement officials. On the previous day, he had only allowed aircraft to use the nation's airspace if flight controllers had diverted them from their original destination or had repositioned them so that they could resume flying upon government approval.[118]

14 September
The Russian Space Agency launched a module of the ISS designed to expand the space station's size and provide other capabilities. The module, called Docking Compartment One (DC-1) or *Pirs* (Russian for *pier*), launched at 11:44 p.m. (UT), on a Soyuz-U rocket, from Baikonur Cosmodrome in Kazakhstan. A cargo craft called Progress M-SO1 would transport the module to the ISS. The Russian Space Agency intended the DC-1 to provide additional stowage space for the ISS, an airlock for spacewalks, and an additional docking port for future *Soyuz* and Progress vehicles. The 8,000-pound (3,600-kilogram), 16-foot-long (4.9-meter-long) module would increase the total mass of the space station to 303,500 pounds (138,000 kilograms).[119]

U.S. Secretary of Transportation Norman Y. Mineta allowed privately owned and operated aircraft to use the nation's airspace as part of a phased restoration of the national airspace system. However, the Department of Transportation would allow this category of aircraft—often referred to as general aviation—to resume flights only if they complied with certain restrictions. For example, general aviation flights would have to operate according to the Instrument Flight Rules, which required certified pilots to operate under direction from air traffic controllers subsequent to filing specific flight plans with the U.S. Federal Aviation Administration (FAA).

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[117] Mark Carreau, "Cautious NASA Shuts Down Johnson Space Center, Other Major Facilities," *Houston Chronicle*, 12 September 2001; U.S. Department of Transportation, "Statement of Secretary of Transportation Norman Y. Mineta," news release 93-01, 11 September 2001.
[118] Federal Aviation Administration (FAA), "Statement of U.S. Secretary of Transportation Norman Y. Mineta," news release, 13 September 2001, *http://www.faa.gov/news/press_releases/news_story.cfm?newsid=5431* (accessed 28 January 2010).
[119] Puttkamer, "Space Flight 2001"; *Spacewarn Bulletin*, no. 575, 1 October 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx575.html* (accessed 14 November 2008).

In addition, the Department of Transportation would not permit general aviation flights to fly within 25 nautical miles of New York City or Washington, DC.[120]

16 September
A group of scientists led by Liming Zhou of Boston University published research indicating that substantial portions of the northern hemisphere had experienced effects of global warming. The scientists, who were studying the responses of vegetation to temperature changes, had used satellite data collected from July 1981 to December 1999 and had found a persistent increase in the length of the growing season in the majority of vegetated areas in the northern latitudes of Asia and Europe. A similar trend was evident in North America, but in a relatively lower proportion of land area. The data had also revealed declines in vegetated area in Alaska, Canada, and some parts of Asia, which may have resulted from temperature-induced drought in those areas. In addition, the scientists discovered a statistically significant relationship between changes in vegetated area and increasing land surface temperatures, indicating that climatic changes may have led to changes in vegetative activity in much of the world.[121]

21 September
A rocket carrying a NASA satellite and other payloads failed to reach orbit. The 91-foot (27.7-meter) Taurus rocket launched at 11:49 a.m. Pacific Daylight Time (PDT) from Vandenberg Air Force Base in California, and within minutes, NASA observed indications of problems with the rocket, including a skewed trajectory near the time of the first-stage separation. The rocket's manufacturer Orbital Sciences Corporation was uncertain about the exact details of the launch problem but presumed that the rocket had not reached orbit. The rocket was carrying NASA's ozone-analyzing Quick Total Ozone Mapping Spectrometer (QuikTOMS) satellite, a private imaging satellite called OrbView-4, and a private payload with the cremated remains of individuals who had paid to have their remains launched into orbit.[122]

26 September
At a news conference, NASA scientists announced the preliminary findings of Deep Space 1's 22 September flyby of Comet Borrelly, a type of comet that originates in a region near Pluto. NASA's Deep Space 1 spacecraft, operating two years past its planned mission duration, had passed within 1,400 miles (2,250 kilometers) of Borrelly, returning the best images and data of a comet ever captured. The encounter was only the second time that a spacecraft had come within such a distance of a comet's nucleus, as well as the first close flyby of a comet of Borrelly's type. In 1986 ESA's Giotto spacecraft had flown within 373 miles (600 kilometers) of Halley's comet, which belongs to a category of comets that originate from outside Earth's solar system. In addition, NASA scientists reported that the data captured by Deep Space 1 had substantially enhanced existing scientific knowledge of comets. Scientists found a number of Deep Space 1's observations surprising, including the discoveries that the comet's icy jets discharge in tall

[120] FAA, "Secretary Mineta Re-opens Skies to General Aviation," news release DOT 97-01, 14 September 2001, *http://www.faa.gov/news/press_releases/news_story.cfm?newsid=5432* (accessed 28 January 2010).
[121] NASA, "Earth's Becoming a Greener Greenhouse," news release 01-178, 4 September 2001; L. Zhou et al., "Variations in Northern Vegetation Activity Inferred from Satellite Data of Vegetation Index During 1981 to 1999," *Journal of Geophysical Research* 106, no. D17 (16 September 2001): 20069–20083.
[122] Associated Press, "Rocket Launch with NASA, Orbital Sciences Payload Goes Awry, Satellites Probably Lost," 21 September 2001.

columns rather than in a diffuse spray, that a cloud of charged particles emanates from off the comet's center, and that solar wind flows asymmetrically around the particle cloud.[123]

27 September
The *New York Times* revealed that, in the wake of the terrorist attacks of 11 September, the U.S. government had changed the rules of engagement regarding the circumstances in which the U.S. military could shoot down civilian aircraft. The newspaper had interviewed U.S. Air Force General Ralph E. Eberhart, who had provided some cursory details of the military's rules of engagement for civilian aircraft. Before 11 September, the DOD had no formal rules concerning military engagement of a hijacked airplane when the flight had originated within the United States. However, on an unnamed date after 11 September, White House officials and the Joint Chiefs of Staff had approved new rules, stipulating that the U.S. military could down an aircraft that presented a security threat, but that the President of the United States or one of four specified U.S. Air Force generals must authorize such an action. The new rules also detailed measures taken by the North American Aerospace Defense Command (NORAD) and the FAA for better joint surveillance of the nation's airspace. Those measures included NORAD's positioning of mobile ground radars around the country and a direct telephone line between the two agencies.[124]

29 September
NASA launched the Kodiak Star from Kodiak Island in Alaska at 2:40 a.m. (UT), NASA's first mission ever launched into Earth orbit from that location. The Kodiak Star's payload consisted of four small satellites: PCSAT, PICOSat 9, Sapphire, and Starshine 3. The PCSAT and Starshine 3 would serve amateur radio operators; Sapphire carried a voice synthesizer to convert text messages into human voice; and PICOSat 9 would test electronic components and systems in space conditions. NASA had funded the Starshine 3, and the DOD had sponsored the other three satellites.[125]

OCTOBER 2001

3 October
NASA announced the selection of Lockheed Martin to construct Mars Reconnaissance Orbiter (MRO), scheduled to launch in August 2005. Under the US$145 million contract, Lockheed Martin would be responsible for building the orbiter and for integrating and testing six scientific instruments and two engineering payloads. In addition, Lockheed Martin would provide operations support for spacecraft during its five and one-half year mission. Odyssey, designed for low-altitude remote sensing of Mars, would include an atmospheric sounder; a context imager; a high-resolution camera; a shallow, subsurface, sounding radar; a visible, near-infrared imaging spectrometer; and a wide-angle color imager. NASA engineers planned to use Odyssey's images to help determine landing sites for future Mars missions. NASA also planned

[123] Warren E. Leary, "Probe Sends Postcards from Comet's Core," *New York Times*, 26 September 2001; NASA, "Deep Space 1," *http://nmp.nasa.gov/ds1/* (accessed 17 November 2008).
[124] Eric Schmitt, "Generals Given Power To Order Downing of Jets," *New York Times*, 27 September 2001.
[125] *Spacewarn Bulletin*, no. 575; NASA KSC, "Kodiak Star Scheduled for Launch from Alaska Sept. 17," news release 101-01, 22 August 2001.

for the spacecraft to provide telecommunications and navigation relay capability for future missions to the planet.[126]

8 October
Russian cosmonauts Vladimir N. Dezhurov and Mikhail Tyurin performed a spacewalk outside of the ISS, the first time ISS crew had walked in space without a Shuttle present. Two tethers attached each cosmonaut to the ISS as the pair departed and reentered the station through the 16-foot (4.9-meter) Russian module *Pirs*, added to the ISS in September 2001. During the 5-hour spacewalk, the two cosmonauts hooked up a 40-foot (12.2-meter) crane, a ladder, handrails, and other equipment to the exterior of the ISS. American astronaut Frank L. Culbertson Jr. monitored the two cosmonauts' work from inside the station, and Mission Control Center in Moscow supervised the spacewalk.[127]

9 October
The Royal Swedish Academy of Sciences awarded the Nobel Prize in Physics to former NASA scientist Wolfgang Ketterle and two other scientists, Eric A. Cornell and Carl E. Wieman. Ketterle was a professor at the Massachusetts Institute of Technology and Principal Investigator for NASA's Office of Biological and Physical Research (OBPR) in Washington, DC. The three scientists received the Nobel Prize for their work in discovering a new state of matter called Bose-Einstein condensate (BEC), named after the two physicists who had made the initial theoretical calculations of such matter. BEC consists of atomic particles that all have the same energy and that researchers can oscillate in a controlled manner. Cornell and Wieman had created a pure condensate of rubidium atoms, and Ketterle had independently produced BEC with sodium atoms. However, Ketterle's condensates had also enabled further investigation of the new type of matter, because his condensates contained more atoms than those of Cornell and Wieman. In addition, Ketterle had produced other research that further advanced understanding of the phenomenon.[128]

11 October
NASA Administrator Daniel S. Goldin announced that, to honor the victims of the 11 September terrorist attacks, NASA would carry American flags into space and give the flags to survivors of the attacks and families of the victims. NASA called the memorial to the people who had lost their lives in the events of 11 September "Flags for Heroes and Families." Space Shuttle *Endeavour*, scheduled to launch on 29 November 2001, would carry nearly 6,000 flags. NASA would later have the flags mounted on specially designed memorial certificates and would distribute them to survivors and to victims' families.[129]

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[126] NASA, "NASA Selects Spacecraft Contractor for 2005 Mars Mission," news release c01-w, 3 October 2001; Lockheed Martin, "Lockheed Martin Chosen by NASA and JPL to Build the 2005 Mars Reconnaissance Orbiter," 3 October 2001, *http://www.lockheedmartin.com/news/press_releases/2001/LockheedMartinChosenByNASAJPLBuild2.html* (accessed 28 January 2010).
[127] Marcia Dunn, "Cosmonauts Work Outside on Station; Spacewalk from New Module Is First Without Shuttle Present," *Washington Post*, 9 October 2001.
[128] Nobel Foundation, "The Nobel Prize in Physics 2001," *http://nobelprize.org/nobel_prizes/physics/laureates/2001/press.html* (accessed 23 November 2008).
[129] NASA, "NASA Administrator Launches 'Flags for Heroes and Families' Campaign," news release 01-195, 11 October 2001.

NASA revealed time-lapse images of the biggest dust storm on Mars to occur in nearly 30 years. The HST and Mars Global Surveyor had captured the images, which showed that the storms had begun as a local event in the Hellas region of Mars and had rapidly propagated throughout the planet. The storms had obscured the surface of Mars and dramatically affected temperatures in the planet's atmosphere, including heating the upper portions of its atmosphere to as much as 80°F (26.7°C). NASA scientists hoped that data about the storms would help them learn more about sediments on Mars, as well as helping them plan future missions to the Red Planet.[130]

17 October

NASA Administrator Daniel S. Goldin announced his resignation, effective 17 November 2001. Goldin, who had become the head of NASA on 1 April 1992, was NASA's longest-serving Administrator. During his tenure, Goldin had overseen numerous successes for NASA, including the launch of Mars Pathfinder, the repair of the HST, and the redesign of the ISS. Goldin stated that he was leaving for personal reasons and that he had accepted an interim position at the Council on Competitiveness, an organization promoting U.S. economic competitiveness, both at home and abroad. However, newspapers noted that Goldin had made the announcement during a time of budgetary difficulties for NASA. Moreover, media reported that White House officials had already sought candidates to replace Goldin, although, according to NASA, President George W. Bush had not yet selected his replacement.[131]

NASA formally accepted the Tracking and Data Relay Satellite–H (TDRS-H) from Boeing Satellite Systems. TDRS-H was part of a constellation of satellites that formed a communication-signal relay system, providing tracking and data-acquisition services between low Earth-orbiting spacecraft and ground-based control and data-processing facilities. The TDRS satellites served the HST, the ISS, and other NASA programs. Boeing had built TDRS-H under contract from NASA, which had launched the satellite in June 2000. However, NASA had delayed its formal acceptance of the spacecraft, after Boeing engineers had found that the satellite's multiple-access, phased-array antenna did not meet contractually specified performance standards. On 10 August 2001, NASA and Boeing had announced that they had tentatively agreed to a settlement and were finalizing negotiations for NASA to accept the satellite.[132]

20 October

Scientists reported that, for the first time, they had used an innovative technique known as gravitational lensing, combined with data that telescopes had obtained, to observe light from extremely distant stars, which may have formed in the early stages of the universe's creation. Gravitational lensing is a technique of detecting distant and otherwise unobservable objects by observing light from these distant background objects, while the gravity of galaxy clusters in the viewable foreground magnifies the background objects' emitted light. The team of scientists, led

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[130] William Harwood, "Mars Wearing Veil of Dust; Biggest Storm in Three Decades Obscures Surface, Alters Temperatures," *Washington Post*, 12 October 2001; NASA, "Scientists Track 'Perfect Storm' on Mars," news release 01-193, 11 October 2001.

[131] NASA, "NASA Administrator Daniel S. Goldin Announces Resignation," news release 01-191, 17 October 2001; William Harwood, "NASA Chief to Step Down," *Washington Post*, 18 October 2001.

[132] The Boeing Company, "NASA To Take Control of TDRS-H Satellite," news release 10 August 2001, *http://www.boeing.com/news/releases/2001/q3/nr_010810t.html* (accessed 28 January 2010); NASA, "Media Kit: TDRS-J Mission," *http://www.gsfc.nasa.gov/gsfc/earth/pictures/20021127tdrs_j/tdrs_jmedia.htm* (accessed 25 November 2008).

by Richard S. Ellis of the California Institute of Technology, had combined the natural magnifying power of galaxy cluster Abell 2218 with observations from the HST and the W. M. Keck Observatory in Hawaii to execute the technique successfully. As a result, the team had been able to detect faint light emitted by a small cluster of stars located nearly 13.4 billion light-years from Earth. Based on detectable characteristics of the stars, the scientists believed that a star cluster in its early formation stages had produced the detected light, and that, during the early formation of the universe, the infant star cluster may have combined with other star groups to create galaxies.[133]

21 October

The Russian Space Agency launched the *Soyuz* TM-33 to the ISS on a Soyuz-U rocket from Baikonur Cosmodrome in Kazakhstan at 4 a.m. (CDT). The mission's crew members consisted of Russian cosmonauts Viktor M. Afanasyez and Konstantin M. Kozeev and French astronaut Claudie André-Deshays Haigneré; Afanasyez was also Mission Commander. The spacecraft carried supplies and equipment for the ISS. The crew members planned to conduct joint operations and scientific research with the crew of Expedition 3. In addition, one of the main purposes of the mission, designated Soyuz 3 Taxi Flight, was to deliver the *Soyuz* spacecraft to the ISS, so that the ISS crew could use it as an emergency escape vehicle. The new *Soyuz* would remain at the ISS, and the spacecraft's crew would return to Earth in the older *Soyuz* TM-32, which was already docked at the station.[134]

22 October

A team of European and American astronomers announced that they had obtained the first observations of energy leaving a black hole. The scientists, who had used ESA's XMM-Newton satellite to observe a supermassive black hole in the center of galaxy MCG-6–30–15, had detected an x-ray glow emanating from iron gas that was moving at half the speed of the light that was close to the black hole. The scientists believed that the x-ray glow resulted from friction produced by matter rotating around a black hole before falling into it. Because the black hole's gravity is sufficiently intense to wrap magnetic field lines around it, the entwined magnetic fields tighten around the black hole, slowing its rotation, and, as a result, increasing the temperature of the region surrounding the black hole. Observed gravity-stretching particles of light in the iron gas, the scientists had discovered unexpectedly that the total energy output of the gas was too high for only gravity and the descent of matter into the black hole to be providing the power source. The scientists had concluded that an additional power source must be increasing the energy output of the gas to the observed intensity.[135]

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[133] Richard Ellis et al., "A Faint Star-Forming System Viewed Through the Lensing Cluster Abell 2218: First Light at $z \sim 5.6$?" *Astrophysical Journal Letters* 560, no. 2 (20 October 2001): L119–L122; William Harwood, "Pre-Galactic Star Cloud Is Discovered," *Washington Post*, 6 October 2001.

[134] NASA, "Soyuz 3 Taxi Flight Crew," *http://spaceflight.nasa.gov/station/crew/exp3/taxi3/index.html* (accessed 26 November 2008); *Spacewarn Bulletin*, no. 576, 1 November 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx576.html* (accessed 26 November 2008).

[135] NASA, "New Energy Source 'Wrings' Power from Black Hole Spin," news release 01-200, 22 October 2001; Jörn Wilms et al., "XMM-EPIC Observation of MCG-6-30-15: Direct Evidence for the Extraction of Energy from a Spinning Black Hole," *Monthly Notices of the Royal Astronomical Society: Letters* 328, no. 3 (11 December 2001): L27–L31.

23 October
NASA's Mars Odyssey spacecraft maneuvered into Mars's orbit after a six-month, 286 million-mile (460 million-kilometer) voyage from Earth. Newspapers described the event as a major success for NASA, which had lost three previous spacecraft destined for Mars during the years from 1993 to 1999. NASA planned for Odyssey to orbit Mars for two and one-half years, mapping the mineral composition of Mars and searching for evidence of water ice beneath the planet's surface. Toward the end of Odyssey's orbital reconnaissance mission, the spacecraft would also function as a communications satellite for two robotic landers that NASA planned to launch to Mars in 2003.[136]

26 October
Spain's Prince of Asturias Foundation granted the Prince of Asturias Award for International Cooperation to the ISS partnership, in recognition of the cooperation among the partnering space agencies that had created the orbiting space station. The Prince of Asturias Felipe de Borbón was the heir to the throne of Spain. The foundation granted the Award for International Cooperation to recognize the cultural, humanitarian, scientific, social, and technical efforts of individuals, groups, and institutions. The prince presented the award to officials representing the space agencies participating in the ISS, namely the Canadian Space Agency, ESA, NASA, Japan's NASDA, and the Russian Space Agency. Earlier in the day, the prince had called the astronauts at the ISS to congratulate them on their efforts.[137]

The Pentagon selected an international team of contractors, led by Lockheed Martin, to build the Joint Strike Fighter (JSF), a multi-role fighter plane that the United States, the United Kingdom, and other countries planned to use. The Pentagon planned for the JSF to function as a single, fungible, low-maintenance replacement for the various aircraft that different military branches in the United States and elsewhere had been using. The program, valued at approximately US$200 billion, included three versions of the JSF, to fulfill the different requirements of the various military branches in the United States and Europe. All of the versions would have stealth and supersonic capabilities. BAE Systems, Lockheed Martin, and Northrop Grumman would initially produce 22 aircraft during the system design and development phase; the companies expected to construct nearly 3,000 aircraft under the program.[138]

31 October
NASA's Mars Odyssey provided its first image from its orbit around the Red Planet. Odyssey took the image as part of a calibration process for the spacecraft's thermal-emission imaging system, which NASA had designed to observe the surface of Mars in both light and darkness. The initial image, a thermal infrared image of the planet's southern polar carbon-dioxide ice cap,

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[136] Mark Carreau, "Odyssey Slips into Orbit, Breaks String of Failures," *Houston Chronicle*, 24 October 2001; *New York Times*, "At Last a Success on a Mars Mission," 24 October 2001.
[137] NASA, "International Space Station Receives 2001 Prince of Asturias Award," news release 01-206, 26 October 2001; Fundación Príncipe de Asturias, "The Aims of the Foundation," *http://www.fundacionprincipedeasturias.org/ing/00/objetivos.html* (accessed 28 November 2008).
[138] Lockheed Martin, "Lockheed Martin Team Wins Joint Strike Fighter Competition, Pledges Full Commitment to This Cornerstone of Future Defense Capability," news release, 26 October 2001, *http://www.lockheedmartin.com/news/press_releases/2001/LockheedMartinTeamWinsJointStrikeFi.html* (accessed 28 January 2010).

covered an area greater than 6,500 kilometers (3,900 miles) at a resolution of approximately 5.5 kilometers (3.4 miles) per pixel.[139]

The government of France named NASA Administrator Daniel S. Goldin as Officer of the Legion of Honor, the country's highest award. Napoleon had created the Legion of Honor in 1802 to honor civil and military service to France. The award honored Goldin for his contribution to the cooperation of France and the United States in space endeavors. NASA and the French space agency, Centre National d'Études Spatiales, had collaborated on Earth observation and Mars exploration, and French astronauts had flown on the Space Shuttle. Ambassador François Bujon de l'Éstang presented the award to Goldin at the residence of the French Ambassador.[140]

NOVEMBER 2001

1 November
The Task Force assigned to assess NASA's management of the ISS program released a report of its findings and recommendations. NASA and the Office of Management and Budget (OMB) had established the ISS Management and Cost Evaluation (IMCE) Task Force to analyze the space station's cost, budget, and management and to recommend how the numerous space agencies supporting the project could derive maximum benefit from their investment. The Task Force's report stated that, although the ISS program's technical achievements to date had been extraordinary, problems concerning the program's budget, management, and other matters threatened future development of the ISS. In addition, the IMCE Task Force recommended numerous changes to establish a core-complete program for the ISS, including altering program management; identifying and applying additional funding; and implementing more clearly defined programs to build the ISS so that its crew would be able to conduct high-priority research at the space station. With regard to maximizing research under the proposed FY 2002 budget, the Task Force recommended establishing research priorities, implementing a plan to execute them, and allocating more ISS crew time to high-priority research.[141]

5 November
Researchers from NASA and the National Oceanic and Atmospheric Administration (NOAA) published research indicating that, during the 20th century, the world's average temperatures had increased, and the United States' average temperatures had declined. Using data from satellites and 7,200 weather stations worldwide, NASA and NOAA scientists had found that the global mean surface air temperature had increased by 1ºF (0.6ºC) during the 20th century. However, temperatures had not increased consistently but had undergone successive periods of warming (from 1900 to 1940), cooling (1940 to 1965), and warming again (1965 to 2000). The evidence also indicated that these temperature changes had not been uniform throughout Earth. For example, although the average surface air temperature in the United States had increased during

[139] NASA, "Mars Odyssey's First Look at Mars Is All Treat, No Trick," news release 01-214, 31 October 2001.
[140] NASA, "NASA Administrator Daniel S. Goldin Receives French Legion of Honor Award," news release 01-202, 31 October 2001.
[141] NASA, "Report by the International Space Station Management and Cost Evaluation (IMCE) Task Force to the NASA Advisory Council" (report, Washington, DC, 1 November 2001*)*, *http://history.nasa.gov/youngrep.pdf* (accessed 26 November 2008).

the latter part of the 20th century, it had remained at a level comparable to average U.S. temperatures during the 1930s. In addition, the researchers had discovered evidence that humans had influenced surface air temperatures on a local scale in large urban areas, suburbs, and even in small towns. However, the data also indicated that this effect had been of modest magnitude and might reflect problems with data measurement.[142]

6 November

A group of scientists from Stanford University and NASA's GSFC published research providing the first clear evidence of the causes of sunspots. Sunspots are large dark areas on the surface of the Sun that can last for weeks or longer. The scientists had used the Solar and Heliospheric Observatory (SOHO)—a project of NASA and ESA—to conduct an acoustic tomography of a large sunspot on 18 June 1998. This technique, much like medical ultrasound diagnostics, had enabled the scientists to conduct subsurface observations of the sunspot, whereas previous research had relied only on surface observations. Researchers had already known that material flows out of sunspots and that the magnetic field below sunspots obstructs the upward flow of energy from the solar interior, thus making the sunspot cooler than its surroundings. However, the SOHO data revealed that material also flows into sunspots, because the cooler material at the sunspot's top condenses and flows downward, pulling the surrounding plasma and magnetic field inward with it. This concentration of material leads to further cooling of plasma, which, in turn, flows downward and draws in more plasma in a self-perpetuating cycle. These findings also clarified the previously unexplained attraction of magnetic fields with like polarities in sunspots. This characteristic had puzzled scientists because such magnetic fields generally repel rather than draw towards each other.[143]

7 November

Scientists announced the first confirmed observation of the optical afterglow of a gamma-ray burst (GRB). GRBs are the most energetic phenomenon in the universe. NASA's High Energy Transient Explorer (HETE) had observed a GRB—dubbed GRB 010921—occurring nearly 5 billion light-years from Earth in the constellation Lacerta. The astronomers had coordinated the HETE data with observations that Italy's BeppoSAX satellite and ESA's Ulysses spacecraft had captured, enabling them to find the afterglow in optical light and to measure its redshift—the warping of electromagnetic radiation by gravity. The measurement of the redshift helped them determine the GRB's distance from Earth. The observation was a special opportunity to obtain information on GRBs. Scientists hoped that with additional observations they could begin to understand the causes of this frequent, but enigmatic phenomenon.[144]

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[142] J. Hansen et al., "A Closer Look at United States and Global Surface Temperature Change," *Journal of Geophysical Research* 106, no. D20 (2001): 23947–23963; NASA, "Satellites Shed Light On Warmer World," news release 01-212, 5 November 2001.

[143] Junwei Zhao, Alexander G. Kosovichev, and Thomas L. Duvall Jr., "Investigation of Mass Inflows Beneath a Sunspot by Time-Distance Helioseismology," *Astrophysical Journal* 557, no. 1 (10 August 2001): 384–388; NASA, "The Sun's Dark Secret: How Sunspots Pull Themselves Together," news release 01-216, 6 November 2001.

[144] NASA, "NASA's HETE Spots Rare Gamma-Ray Burst Afterglow," news release 01-218, 7 November 2001; P. A. Price et al., "GRB 010921: Discovery of the First *High Energy Transient Explorer* Afterglow," *Astrophysical Journal Letters* 571, no. 2 (1 June 2002): L121–L125; G. Ricker et al., "GRB 010921: Localization and Observation by the *High Energy Transient Explorer* Satellite," *Astrophysical Journal Letters* 571, no. 2 (1 June 2002): L127–L130.

10 November
Maxwell W. Hunter II, one of the world's leading rocket designers and space engineers, died at the age of 79. Hunter had graduated from the Massachusetts Institute of Technology in 1944 and had worked for Douglas Aircraft. While at Douglas, he had designed several of the company's missiles, including the Nike and the Thor, as well as many of its space projects, including the Delta rocket and the Saturn S-IV stage of the Apollo Moon rocket program. Hunter had later worked for Lockheed Missiles and Space Company. Among his achievements with Lockheed was the design of the Space Shuttle. Hunter had also advised Presidents John F. Kennedy and President Lyndon B. Johnson on space programs and space policy and had been a noted proponent of nuclear-powered spacecraft and a space-based laser defense program. In addition, Hunter had authored nearly 60 technical papers and had received the National Space Society's Wernher von Braun Memorial Award in recognition of his contributions to the development of missiles, rockets, and spaceflight.[145]

12 November
Two members of the ISS crew performed a spacewalk to complete installation of the Russian *Pirs* docking compartment. During the 5-hour spacewalk, American astronaut Frank L. Culbertson Jr. and Russian cosmonaut Vladimir N. Dezhurov connected communications cables between the *Pirs* module and the adjoining crew-habitation and command module. The pair also tested an external construction crane and photographed an askew solar array attached to the crew-habitation module, so that ground-based experts in Russia could determine whether the array would require repair in the future.[146]

14 November
President George W. Bush nominated Sean O'Keefe to succeed Daniel S. Goldin as NASA's Administrator. At the time of his nomination, O'Keefe was Deputy Director of OMB and had previously served as Secretary of the Navy for former President George H. W. Bush. Major newspapers emphasized that O'Keefe had received the nomination because of his experience in financial management and that, during his tenure at OMB, O'Keefe had worked on a task force that had recommended scaling back the ISS because of NASA's inability to manage the project within budget. If confirmed by the U.S. Senate, O'Keefe, who was 45 years old at the time of the nomination, would be the youngest person to serve as NASA Administrator.[147]

15 November
Roy Estess, Acting Director of NASA's JSC, appointed Randy Stone as Deputy Director of JSC. As Deputy Director, Stone would be responsible for planning, organizing, and controlling activities necessary to meet the Center's goals and objectives. Stone had worked for Mission Control in Houston and for JSC for 34 years and, before his appointment as Deputy Director, had served as JSC's Acting Associate Director of Management. He had begun his career with NASA in 1967, developing equipment for the lunar landings of the Apollo program. During his tenure

[145] Dennis McLellan, "Maxwell Hunter II, 79; Pioneer Rocket Scientist," *Los Angeles Times*, 17 November 2001.
[146] Mark Carreau, "International Crew Completes Cable Task on Final Spacewalk," *Houston Chronicle*, 13 November 2001.
[147] Mark Carreau and Karen Masterson, "Bush Names 'Key Advisor' To Lead NASA," *Houston Chronicle*, 15 November 2001; Kristen Mack and Mark Carreau, "Senate Approves O'Keefe as NASA Administrator, Hammond as NEA Head," *Houston Chronicle*, 21 December 2001.

with NASA, he had worked on numerous programs, including Skylab, the Space Shuttle, and the ISS.[148]

19 November
NASA named Daniel R. Mulville as Acting Administrator, to serve until the U.S. Senate had officially confirmed a new Administrator. Mulville was to replace previous NASA Administrator Daniel S. Goldin while Sean O'Keefe—President George W. Bush's nominee for the position—was awaiting Senate confirmation. Before becoming Acting Administrator, Mulville had served as Associate Deputy Administrator for NASA since the beginning of 2000. Mulville, who had a PhD in structural mechanics, had begun working at NASA in 1986.[149]

26 November
The Russian Space Agency launched an automatic cargo carrier to the ISS from Baikonur Cosmodrome in Kazakhstan at 6:24 p.m. (UT). A Soyuz-FG booster lifted the Progress M1-7 cargo carrier. Progress M1-7 was to deliver 2.5 tonnes (2.8 tons or 5,511 pounds) of equipment, food, and fuel to the space station, as well as a microsatellite called Klibri, which the crew would release after the carrier had docked with the ISS.[150]

27 November
A team of astronomers using the HST published results of the first direct detection and chemical analysis of the atmosphere of a planet located outside of the solar system. The scientists had used Hubble to examine the planet's atmosphere as it passed in front of its parent star—called HD 209458—a technique that enabled them to see the star's light filtered through the planet's atmosphere. During the analysis, the astronomers had detected sodium in the planet's atmosphere. They hoped that the observation was a harbinger of a new phase in analyses of extrasolar planets, often referred to as exoplanets. Scientists also hoped that this type of analysis would enable them to measure any unusual abundance of atmospheric gases created by living organisms, thereby offering them a method of acquiring direct evidence of life on other planets.[151]

The GAO released a generally positive assessment of NASA's efforts to meet its FY 2002 performance plan—as required by the Government Performance and Results Act (GPRA) of 1993—and to overcome its major management challenges, which GAO and NASA's Office of Inspector General (OIG) had previously identified. The GPRA required each government agency to develop an annual plan, which must include its performance goals, the resources required to achieve them, and the measures it would use to assess its performance. In its examination of NASA's FY 2002 performance plan, GAO had determined that NASA had successfully met its stated goals. NASA's goals for the fiscal year had included expanding commercial development of space and deploying and operating the ISS safely and cost-effectively. However, GAO's

[148] NASA JSC, "Mission Control Veteran Randy Stone Named Johnson Space Center Deputy Director," news release J01-111, 15 November 2001.
[149] NASA History Division, "Biographies of NASA Administrators: Daniel R. Mulville," *http://www.hq.nasa.gov/office/pao/History/mulville.htm* (accessed 19 December 19, 2008).
[150] *Spacewarn Bulletin*, no. 577, 1 December 2001, *http://nssdc.gsfc.nasa.gov/spacewarn/spx577.html* (accessed 12 December 2001).
[151] NASA, "Hubble Measures Atmosphere on World Around Another Star," news release 01-232, 27 November 2001.

report also stated that NASA's performance plan had not explained the reasons that NASA had changed its previous performance goals to those stated in the FY 2002 performance plan. In addition, GAO questioned NASA's measurements of its performance in meeting the stated goals and gave mixed assessments of NASA's performance in the areas of human-capital management and information security. In its response to the report, NASA concurred with GAO's findings but it also defended the explanations and measurements of its performance goals, as outlined in its FY 2002 performance plan.[152]

29 November
Konrad Dennerl, of the Max Planck Institute for Extraterrestrial Physics in Germany, and his team of astronomers announced that they had performed the first x-ray observations of the planet Venus. The team had used NASA's Chandra X-ray Observatory to conduct the observations, which revealed new information about the planet's atmosphere. The x-ray observations of Venus were different from views of the planet made in visible light, because fluorescence, rather than reflection, produced the x-rays from the planet. Most of the fluorescent x-rays come from oxygen and carbon atoms located 120 to 140 kilometers (74 to 87 miles) above the surface of Venus, whereas clouds that are 50 to 70 kilometers (31 to 43 miles) above the surface reflect optical light. The observations represented a technological breakthrough. Other x-ray astronomy satellites had been unable to point steadily in the direction of Venus, because the planet's relative proximity to the Sun had prevented them from locking onto guide stars that were visually distinct from the Sun.[153]

DECEMBER 2001

3 December
Cosmonauts Vladimir N. Dezhurov and Mikhail Tyurin performed a spacewalk outside of the ISS to clear an obstruction that had prevented the pilotless Progress Russian supply ship from docking securely to the space station. The crew believed that the obstruction was a rubber seal from a supply ship that had left the ISS on 22 November. NASA had delayed the launch of Space Shuttle *Endeavour* for five days because of concern that *Endeavour*'s arrival at the space station could cause the insecurely docked supply ship to wobble, possibly damaging the ISS. However, Dezhurov and Tyurin were able to remove the obstruction during their 3-hour spacewalk, thereby clearing the way for *Endeavour* to launch on 5 December.[154]

5 December
Space Shuttle *Endeavour* STS-108/UF-1 launched at 5:19 p.m. Eastern Standard Time (EST) from NASA's KSC in Cape Canaveral, Florida. The crew members were Commander Dominic L. Gorie, Pilot Mark E. Kelly, and Mission Specialists Linda M. Godwin and Daniel M. Tani; and ISS Expedition 4 crew members, Daniel W. Bursch, Carl E. Walz, and Yuri I. Onufrienko. One of the main objectives of the mission was to transport the Expedition 4 crew to the ISS and

[152] U.S. General Accounting Office, "NASA: Status of Plans for Achieving Key Outcomes and Addressing Major Management Challenges" (report no. GAO-02-184, Washington, DC, November 2001), *http://www.gao.gov/new.items/ d02184.pdf* (accessed 8 December 2008).
[153] NASA, "Chandra Captures Venus in a Whole New Light," news release 01-236, 27 November 2001.
[154] Warren E. Leary, "Endeavour Is Set for Launching After Docking Problem Is Solved," *New York Times*, 4 December 2001; *Los Angeles Times*, "With Space Debris Cleared, Shuttle Launch Set," 4 December 2001.

return Expedition 3 crew members to Earth. Another mission objective was to transport approximately 3 tons (2.7 tonnes or 2,700 kilograms) of supplies to the ISS. Much of the payload was contained in an Italian-built Multi-Purpose Logistics Module (MPLM) called Raffaello. In addition, *Endeavour* carried a host of scientific payloads, including some experiments created by schools and universities in the United States and numerous other countries.[155]

7 December

NASA launched the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft on a Delta 2 rocket from Vandenberg Air Force Base in California. The purpose of the mission was to study a region called the Mesosphere and Lower Thermosphere/Ionosphere (MLTI), located 40 to 110 miles (60 to 180 kilometers) above Earth. The Johns Hopkins University Applied Physics Laboratory had designed the spacecraft to produce the first set of comprehensive, global measurements of the MLTI, a region that scientists had not yet thoroughly analyzed, in which electrical currents surge and auroras create a glow over the northern and southern hemispheres of Earth. TIMED, which launched on the same rocket as the Jason-1 oceanography satellite, was the first in a series of six spacecraft that NASA intended to send to observe the MLTI from a 388-mile (625-kilometer) orbit of Earth. NASA's GSFC would manage the TIMED spacecraft for the Office of Space Science in Washington, DC; the Johns Hopkins University Applied Physics Laboratory would operate the spacecraft for NASA during the mission.[156]

NASA launched the Jason-1 oceanography satellite from Vandenberg Air Force Base in California. The satellite launched on the same rocket as the TIMED spacecraft, but the two spacecraft were part of separate missions. Jason-1 belonged to a joint U.S.-French mission to monitor global climate interactions between Earth's atmosphere and seas, continuing the mission that the TOPEX/Poseidon spacecraft had begun in 1992. The 500-kilogram (1,100-pound) Jason-1 weighed about 1/5th of the TOPEX/Poseidon and carried its predecessor's main instrument—the Poseidon 2 altimeter—as well as other, more advanced instruments that would provide Jason-1 with improved operational utility.[157]

NASA researchers with the Scripps Institution of Oceanography of the University of California at San Diego published research indicating that particles from human-produced pollution might significantly contribute to weakening the planet's hydrological cycle. The hydrological cycle is the circulation of water between Earth's atmosphere and its surface water and soils. Specifically, water precipitates from the atmosphere into surface water or soils and later evaporates from surface water, soils, and plants back into the atmosphere. The researchers had examined satellite data indicating aerosol distribution in the Indian Ocean region and had found that the aerosols,

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[155] NASA KSC, "STS-108 (107)," *http://science.ksc.nasa.gov/shuttle/missions/sts-108/mission-sts-108.html* (accessed 12 December 2008); NASA KSC, "Space Shuttle, Mission Archives: STS-108," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-108.html* (accessed 12 December 2008).

[156] NASA, "It's About TIMED: NASA Spacecraft Will Use Lofty Perch To Study Gateway to Space," news release 01-226, 19 November 2001; Johns Hopkins University Applied Physics Laboratory, "TIMED: A Mission To Explore One of the Last Frontiers in Earth's Atmosphere: Mission," *http://www.timed.jhuapl.edu/WWW/mission/mission.php* (accessed 6 January 2009).

[157] NASA, "NASA/French Ocean-Observing Satellite Set To Soar," news release 01-225, 19 November 2001; NASA JPL, "Ocean Surface Topography from Space: Missions—Jason-1 Launch,"29 July 2008, *http://topex-www.jpl.nasa.gov/mission/jason-1-launch.html* (accessed 12 December 2008).

primarily composed of black carbon, could weaken the hydrological cycle in two ways. The aerosols could reduce the amount of sunlight reaching the ocean, thereby decreasing the amount of water evaporating into the atmosphere. In addition, when particulates enter clouds, they reduce the size of cloud droplets, thereby reducing the amount of rain over polluted regions. The particulates in aerosols comprise a mixture of substances formed by the burning of fossil fuels and rural biomass. The new research was significant because it suggested that aerosols might be more environmentally harmful than scientists had previously understood and that air pollution is both an urban and a rural phenomenon.[158]

10 December

Endeavour crew members Linda M. Godwin and Daniel M. Tani completed a 4-hour spacewalk to repair the rotating mechanisms on the solar arrays attached to the outside of the ISS. The solar-powered module provided electrical power for the space station's communications, life-support, and steering systems, as well as for scientific experiments conducted aboard the ISS. However, flight-control personnel had found that the solar arrays were consuming more electrical power than expected. Project engineers attributed this to temperature-induced contraction and expansion in the bearings within the motors that rotated the solar arrays. Contraction and expansion was occurring because of the temperatures outside of the ISS, which ranged from 200ºF to 200º below 0ºF (93.3ºC to -128.9ºC), during each orbit of Earth. Therefore, Godwin and Tani were installing insulation around the motors in an effort to stop the bearings from undergoing contraction and expansion.[159]

11 December

Crew members aboard Space Shuttle *Endeavour* and the ISS held a brief ceremony to mark the three-month anniversary of the 11 September terrorist attacks. The tribute included playing both the Russian and U.S. national anthems in the Space Shuttle and at ISS Mission Control Centers at NASA's JSC in Houston. Moreover, *Endeavour* carried U.S. flags and Marine Corps flags that had flown at the World Trade Center, the Pentagon, and the Pennsylvania State Capitol; shields and patches worn by New York City police officers; a New York Fire Department flag; and a poster with pictures of the firefighters who had died in the attacks. Also aboard the Shuttle were 6,000 American flags, which *Endeavour* would return to Earth, and NASA would distribute to the victims of the 11 September terrorist attacks and their families.[160]

17 December

Space Shuttle *Endeavour* landed at NASA's KSC in Cape Canaveral, Florida, at 12:55 p.m. (EST), bringing to an end Mission STS-108. During the mission, *Endeavour* had transported crew members of Expedition 4 to the ISS to begin their residency on the orbiting space station and had returned to Earth the Expedition 3 crew members, ending their 117-day stay aboard the ISS. In addition, astronauts Linda M. Godwin and Daniel M. Tani had completed numerous tasks during a 4-hour spacewalk, including installation of insulation on mechanisms that rotated the

[158] NASA, "Tiny Pollution Particles May Carry Large Consequences for Earth's Water Supply," news release 01-239, 6 December 2001; V. Ramanathan, "Aerosols, Climate, and the Hydrological Cycle," *Science* n.s. 294, no. 5549 (7 December 2001): 2119–2124.
[159] Mark Carreau, "Astronauts Make Breathtaking Repair Trip," *Houston Chronicle*, 11 December 2001.
[160] NASA, "Shuttle, Station Crewmembers To Honor September 11 Victims," news release N01-74, 10 December 2001.

station's main solar arrays. The crews of *Endeavour* and the ISS had collectively transferred more than 5,000 pounds (2,270 kilograms) of crew provisions, experiments, and other supplies to the ISS from *Endeavour*'s mid-deck and from the Raffaello MPLM. The mission's total duration had been 11 days, 19 hours, and 55 minutes.[161]

18 December

NASA officially ended the operation of spacecraft Deep Space 1 when engineers at NASA's JPL sent a signal to the spacecraft to shut down its engine and cease communications with Earth. NASA had launched Deep Space 1 in October 1998, to test 12 technologies for use in future spacecraft. Although NASA had planned for the spacecraft's mission to conclude in September 1999, NASA had continued operating Deep Space 1 for more than two additional years with results that were highly beneficial and sometimes unexpected. Most notably, during a close flyby of the Comet Borrelly on 25 September 2001, Deep Space 1 had provided the most detailed pictures ever taken of a comet. In addition, experts stated that, at a cost of approximately US$160 million, the spacecraft's mission had been the least expensive interplanetary mission ever conducted by the United States.[162]

Researchers published findings from an unprecedented analysis of NASA-produced satellite data of carbon absorption by northern hemisphere forests. The researchers had used the satellite data to study the extent to which forests had absorbed carbon released into Earth's atmosphere in the form of carbon dioxide from fossil-fuel combustion. Many scientists consider atmospheric accumulation of carbon dioxide to be a primary cause of global climate change, because forests act as "sinks," absorbing carbon dioxide, thereby reducing its atmospheric accumulation. The researchers had found that forests in Europe, Russia, and the United States annually absorbed almost 700 million tonnes (771 million tons or 1.5 trillion pounds) of carbon from 1981 to 1999. They had also found geographic variations in carbon absorption, with Russian forests accounting for nearly 40 percent of the carbon sink and Canadian forests losing carbon. The findings were significant, because they indicated which forests had lost carbon and which had stored it. The findings also validated relationships between satellite measurements and ground-based measurements of carbon absorption, demonstrating the crucial importance of satellites in monitoring forests. NASA's Earth Science Enterprise, dedicated to understanding human-induced and natural changes in Earth's environment, had funded the research.[163]

19 December

In a letter to Acting NASA Administrator Daniel Mulville, NASA Advisory Council (NAC) issued its recommendations on the management and future development of the ISS. NAC provided the recommendations two weeks after it had received an assessment created by the ISS Management and Cost Evaluation (IMCE) Task Force. NASA and the OMB had created the IMCE to perform an independent external review of the ISS. In its letter, NAC stated that NASA needed to resolve budgetary and management problems with the space station. NAC also

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[161] NASA KSC, "Space Shuttle, Mission Archives: STS-108," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-108.html* (accessed 12 December 2008).
[162] Warren E. Leary, "Deep Space 1 Ends Mission, but Triumphs Are Clear," *New York Times*, 19 December 2001.
[163] NASA, "Satellite Data Help Researchers Track Carbon in Northern Hemisphere Forests," news release 01-242, 11 December 2001; Ranga B. Myneni, "A Large Carbon Sink in the Woody Biomass of Northern Forests," *Proceedings of the National Academy of Sciences* 98, no. 26 (18 December 2001): 14784–14789.

recommended that NASA clarify its scientific priorities for the ISS and focus on a reduced configuration of the ISS that could serve three crew members. However, NAC also recommended that NASA continue funding components of the ISS that could serve a larger crew, such as a lifeboat vehicle and crew quarters.[164]

20 December
The U.S. Senate confirmed Sean O'Keefe as NASA's Administrator. With the confirmation, O'Keefe replaced Daniel S. Goldin as Administrator and, at the age of 45, became the youngest person ever to lead NASA. Before becoming NASA's Administrator, O'Keefe had served as Deputy Director of OMB, a post he had held since March 2001. O'Keefe had also served as Secretary of the Navy under former President George H. W. Bush.[165]

21 December
NASA announced the selection of two missions as part of its Discovery Program, which had as its objective low-cost, highly focused scientific missions using innovative methods to enhance scientific understanding of the solar system. One of the missions NASA had selected was Dawn, a spacecraft that would orbit the solar system's two largest asteroids, Vesta and Ceresto, to help scientists understand early planetary formation in the solar system. The other mission, Kepler, was a space-based telescope that would search for Earth-like planets outside of the solar system, to help scientists learn more about planetary formation and the possibility of life on other planets. NASA had selected the missions—both scheduled to launch in 2006—from a pool of 26 proposals made earlier in 2001.[166]

JANUARY 2002

3 January
Arnold Torres retired as Senior Manager of NASA's Wallops Flight Facility (WFF) and Director of NASA's GSFC Suborbital and Special Orbital Projects Directorate, positions that he had held since January 1995. Among the changes that had occurred under Torres's tenure, WFF had begun to manage small payloads for Space Shuttles and had developed the Ultra-Long Duration Balloon (ULDB), capable of flying for 100 days. Torres had begun working at NASA in 1978 as an atmospheric scientist, and in 1985 GSFC had awarded him an Exceptional Achievement Award.[167]

6 January
Burton I. Edelson, who influenced NASA's space science and Earth science programs, died at the age of 75. Edelson had served as NASA's Associate Administrator for Space Science and

[164] *New York Times*, "NASA Report Endorses Cuts at Space Station," 21 December 2001; NASA, "NASA Advisory Council Releases Space Station Recommendations," news release N01-76, 20 December 2001.
[165] Kristen Mack and Mark Carreau, "Senate Approves O'Keefe as NASA Administrator, Hammond as NEA Head," *Houston Chronicle*, 21 December 2001.
[166] NASA, "NASA Selects Missions To Explore Two Large Asteroids and Search for Earth-Like Planets," news release 01-254, 21 December 2001; NASA Discovery Program, "Discovery Mission: Kepler," *http://discovery.nasa.gov/kepler.html* (accessed 19 December 2008).
[167] *Inside Wallops*, "Congratulations to Our Newest Retirees," 14 January 2002, *http://www.nasa.gov/centers/wallops/news/newsletters_archive.html#y2002* (accessed 28 July 2008); NASA Goddard Space Flight Center, "Wallops Senior Manager Announces Retirement," news release W01-29, 13 July 2001.

Applications from 1982 to 1986, and in 1987 NASA had awarded him its Exceptional Service Medal. He had helped to establish and direct several programs at NASA, including missions to explore Mars and a program developing instruments for the HST. After leaving NASA, Edelson had managed the COBE (Cosmic Background Explorer) satellite program, which had received international acclaim when it began measuring radiation from the Big Bang. Edelson had won several major awards, as well as the high regard of his peers and the public, for founding international space programs such as the Japan-United States Science Technology and Space Applications Program.[168]

8 January

Using images from NASA's Chandra X-ray Observatory, scientists found evidence that an ancient eruption had burst through a cluster of galaxies, which could explain why those galaxies act like massive magnetic fields. Scientists believed that the universe's largest known structures bounded by gravity—called galaxy clusters—might be the source of highly energetic and recurring explosions, which cause the clusters to behave like huge cosmic magnets. Chandra's images of the galaxy cluster Abell 2597 had revealed a cloud of hot gas with two dark circular cavities called ghost cavities, containing little x-ray or radio emissions. The images suggested that powerful explosions around a black hole in the cluster's center might have occurred when these ghost cavities expelled material from the black hole's vicinity, creating gaps in the cluster's hot gas. Scientists believed that these cavities might eventually move to the edge of the cluster, similar to the movement of air bubbles to the surface of water, thereby transporting magnetic fields to the cluster gas. The images suggested that these explosions are recurring. If the recurring explosions continue to create more cavities, this could explain the strong magnetic field of the extremely hot gas throughout the cluster.[169]

Using the most sensitive images ever taken by the HST, scientists found new evidence of star creation, challenging the findings of much of the existing research on the origin of the universe. Although the HST had captured images of portions of the skies that appear empty to the naked eye, the images revealed nearly 5,000 galaxies. Led by Kenneth M. Lanzetta of the State University of New York at Stony Brook, a team of scientists had examined approximately 150 of those galaxies spectroscopically, inferring from color variations their actual distance from Earth, as well as the properties of less visible light from even fainter and more distant galaxies. The scientists had also conducted spectroscopic analysis of remote quasars to measure the early universe's gas density, because high gas density implies high creation rates of stars, which are the building blocks of galaxies and the birthplaces of solar systems. The new images indicated that countless stars had begun forming at a period closer to the birth of the universe than previous research had suggested. Although the HST had captured the images in 1995 and 1998, using the most advanced available technology, the findings suggested that the peak of star creation had occurred earlier than Hubble's ability to detect it. However, the scientists believed that they could date the peak of star creation to within a few hundred million years after the Big Bang.[170]

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[168] NASA, "Death of Burt Edelson Highlights His NASA Legacy," news release 02-06, 9 January 2002; Anahad O'Connor, "Burton I. Edelson Dies at 75; NASA Space Science Leader," *New York Times*, 14 January 2002.
[169] NASA, "Chandra Finds Ghosts of Eruption in Galaxy Cluster," news release 02-02, 8 January 2002.
[170] NASA, "Hubble Suggests First Stars Opened in a Blaze of Glory," news release 02-01, 8 January 2002; William Harwood, "Stars May Have Brightened Infant Universe," *Washington Post*, 9 January 2002.

9 January

Researchers at NASA's JPL successfully demonstrated the first use of robotic rovers capable of cooperating to perform tasks together while navigating uneven natural terrain. The researchers hoped that the rovers would be able to perform sustained research on Mars and to assemble and maintain orbiting spacecraft. In outdoor tests, JPL researchers had used two rovers to simulate the deployment of a solar power station. In these simulations, the two robots had grasped and carried a container measuring 2.5 meters (8 feet) long, for more than 50 meters (160 feet). The project had used new software called the Control Architecture for Multi-Robot Planetary Outposts, which equipped the rovers with a distributed and autonomous intelligence producing instinctively reactive behaviors, shared sense and control, and collective decision making. This new technology, along with other innovations, had developed rovers—referred to as the Robotic Work Crew—capable of sharing both work and thinking. Project scientists hoped these capabilities would enable the rovers to collaborate in performing designated tasks, while coping with the unknown and unpredictable surface of Mars and encountering other scenarios unforeseen by scientists on Earth.[171]

10 January

In an article in the journal *Nature*, scientists reported that they had used images from NASA's Chandra X-ray Observatory to reveal how objects in the most active area of the Milky Way Galaxy affect each other and other parts of the galaxy. The scientists had used 30 separate images from Chandra to construct a montage of the Milky Way's central regions, revealing hundreds of white dwarf stars, neutron stars, and black holes, shrouded by the extremely hot gas around a massive black hole. The researchers found that emissions from highly ionized iron, previously attributed to diffuse hot gas, had actually originated from discrete sources in the Milky Way's white dwarf stars, neutron stars, and black holes. The findings helped clarify the relative contributions of diffuse and discrete sources of x-rays emitted from the galaxy.[172]

13 January

NASA appointed John H. Campbell as Senior Manager at WFF and Director of GSFC Suborbital and Special Orbital Projects Directorate. In 1987 Campbell had begun his NASA career as a Systems Engineering Manager for the Flight Systems Software Branch, at GSFC in Greenbelt, Maryland. In the years before his appointment at WFF, NASA had awarded Campbell its Distinguished Service Medal, Outstanding Leadership Medal, and Exceptional Achievement Medal.[173]

16 January

The United States launched the fifth Milstar satellite on a Titan 4B-Centaur from Cape Canaveral, Florida, completing a fleet of communications satellites designed to provide

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[171] NASA, "Robotic Construction Crew Rolls Up Its Sleeves," news release 02-04, 9 January 2002; NASA JPL, "Technology—Feature: Researchers Toy with New Rover Designs," 21 December 2001, *http://jpl.nasa.gov/news/features.cfm?feature=489* (accessed 28 July 2008).

[172] NASA, "Chandra Takes In Bright Lights, Big City of Milky Way," news release 02-03, 9 January 2002; Q. D. Wang, E. V. Gotthelf, and C. C. Lang, "A Faint Discrete Source Origin for the Highly Ionized Iron Emission from the Galactic Centre Region," *Nature* 415, no. 6868 (10 January 2002): 148–150.

[173] *Inside Wallops*, "Wallops Senior Manager Appointed," 14 January 2002, *http://www.nasa.gov/centers/wallops/news/newsletters_archive.html#y2002* (accessed 29 July 2002).

government leaders and military troops with jam-resistant transmission nearly anywhere on Earth.[174]

17 January
NASA's Galileo spacecraft took its last pictures, images of Io, a planet-sized moon orbiting Jupiter. Galileo had launched in 1989 from Space Shuttle *Atlantis* and had entered Jupiter's orbit six years later. The spacecraft had eventually made 33 orbits around Jupiter, capturing nearly 14,000 images of the planet and the objects around it.[175]

18 January
NASA and the USGS announced a partnership to acquire data from the Earth Observing-1 (EO-1) satellite and to provide that data to the private sector for applications such as land-cover analysis, ecosystem monitoring, and petroleum prospecting. NASA and the USGS made the announcement one year after the launch of EO-1, a year in which the spacecraft's nine breakthrough instruments had all successfully satisfied test objectives. The instruments included Earth-viewing technologies, such as a hyperspectral imager that could view Earth's surface with unprecedented spectral discrimination and an Advanced Land Imager that could provide better views of Earth than NASA's Landsat, at a lower cost. Under the terms of the agreement, NASA would maintain command and control of the EO-1, and the USGS would take orders for spacecraft data at prices set to cover the nearly US$5 million annual cost of operating the satellite, processing data, and interacting with customers.[176]

21 January
A NASA scientific balloon established a new flight-duration record of 31 days and 20 hours in a flight that included two orbits of the South Pole. The previous record for long-duration balloon flight was 26 days. Weighing 3,687 pounds (1,670 kilograms) and expanding to a diameter of nearly 424 feet (130 meters), the balloon was larger than a football field and taller than the Washington Monument but constructed of a polyethylene material of the same thickness as ordinary sandwich wrap. The pilotless, helium-filled balloon carried the 2-ton (1.8-tonne or 1,814-kilogram) Trans-Iron Galactic Element Recorder (TIGER) experiment to approximately 125,000 feet (38,000 meters), traveling nearly 8,800 miles (14,000 kilometers) before landing 284 miles (4,460 kilometers) from its launch point in McMurdo Station, Antarctica. NASA had designed TIGER to search for the origin of cosmic rays and their propagation throughout the galaxy.[177]

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[174] NASA, *Aeronautics and Space Report of the President: Fiscal Year 2002 Activities* (Washington, DC, 2002), p. 114, *http://history.nasa.gov/presrep2002.pdf* (accessed 29 July 2002); Jesco von Puttkamer, "Space Flight 2002: The Year in Review," NASA, *http://spaceoperations.nasa.gov/2002/yearinrev/ 02YearReview.html* (accessed 23 July 2002).
[175] NASA, "Farewell, Io; Galileo Paying Last Visit to a Restless Moon," news release 02-10, 15 January 2002; NASA, "Solar System Exploration—Galileo: Overview," *http://solarsystem.nasa.gov/galileo/ /index.cfm* (accessed 31 July 2008); Andrew Bridges, "NASA Awaits Last Photographs from Jupiter Probe's Long Trip," *Houston Chronicle*, 16 January 2002.
[176] NASA, "Technology Mission Accomplished, NASA Goes for More," news release 02-12, 18 January 2002.
[177] NASA, "NASA Balloon Makes Record-Breaking Flight," news release 02-13, 22 January 2002; Warren E. Leary, "Shuttle's Cameras Offer New Views of the World," *New York Times*, 29 January 2002.

22 January
Scientists from NASA's JPL announced the release of high-resolution topographic data of the continental United States acquired during the Shuttle Radar Topography Mission (SRTM) on Space Shuttle *Endeavour* in February 2000. Project scientists planned to process the digital-elevation-model (DEM) data, sampled at an interval of one measurement every 30 meters (98 feet), into the most detailed three-dimensional topographic maps ever made of Earth. The SRTM data would eventually include 1 trillion measurements, representing nearly 80 percent of Earth's landmass between 60° north and 56° south of the equator, a mapped area in which nearly 95 percent of the world's population resides. SRTM project scientists anticipated that the maps produced from the mission would provide the most valuable and universally beneficial data produced by any scientific mission. Scientists would be able to use the data in applications ranging from flood control to transportation and urban planning.[178]

29 January
In a meeting with reporters, newly appointed NASA Administrator Sean O'Keefe emphasized that, although he wanted NASA to remain at the forefront of science and technology, he also wanted to address NASA's financial and management problems. O'Keefe, who had received the U.S. Senate's confirmation on 20 December 2001, said he would spend the next few months learning about NASA. Explaining that he wanted both to refocus NASA and to keep it within its budget, O'Keefe did not rule out the possibility of closing field centers and laying off employees to achieve his objectives. However, he stressed that he considered the budgetary problems of the ISS his immediate concern, and that he would first devote his attention to implementing the ISS Management and Cost Evaluation Task Force's (IMCE's) recommendation to scale back the ISS, at least temporarily, to reduce costs.[179]

30 January
GAO released a report examining NASA's established mechanisms for learning lessons from past failures. The report, "NASA: Better Mechanisms for Sharing Lessons Learned," noted that NASA's investigations of its past failures and its evaluations of its programs had led it to establish various mechanisms to ensure that NASA's personnel had learned from past successes and failures and had applied their knowledge to future programs and projects. These mechanisms included a Web-based database of lessons learned, program reviews, and the development of a business strategy called knowledge management. However, GAO's report also noted that, according to interviews with NASA managers, NASA's established policies, procedures, and systems were not facilitating the use of lessons learned. GAO indicated that this was largely because managers faced challenges, such as lack of time to note, submit, and share lessons learned, and cultural barriers, such as reluctance to discuss mistakes for fear of their colleagues' disapproval. Among the report's main recommendations were that NASA develop a strong

[178] NASA, "Pictures from the Real Edge: NASA Posts U.S. Topography Data," news release 02-15, 22 January 2002.
[179] Warren E. Leary, "New NASA Administrator Says Money Troubles Are Solvable," *New York Times*, 9 January 2002; William Harwood, "Panel Urges Space Station Reforms," *Washington Post*, 3 November 2001; NASA, "People: Former NASA Administrator Sean O'Keefe," *http://www.nasa.gov/about/highlights/AN_Feature_Administrator.html* (accessed 31 July 2008).

managerial commitment to sharing knowledge and create technological systems capable of facilitating access to this information.[180]

NASA's Extreme Ultraviolet Explorer (EUVE) reentered Earth's atmosphere nearly 10 years after its launch on 7 July 1992. NASA had initially planned for the spacecraft to operate for only three years but had extended the EUVE's scientific mission twice, ending operations on 26 January 2001. The EUVE did not have an on-board propulsion system, and NASA scientists had not designed it to survive reentry intact. Thus, in February 2001, mission engineers had left the spacecraft in a decaying orbit, so that it would destruct upon reentering Earth's atmosphere. The EUVE, the first astrophysics mission to explore the extreme ultraviolet spectrum (the energy range between 70 and 760 Å), had examined nearly 1,000 sources near Earth, including three-dozen objects outside of the Milky Way Galaxy.[181]

31 January
The United States, Russia, and other partners and sponsoring agencies of the ISS released a nine-page document, "Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers," defining the partners' agreed-upon procedures for staffing the ISS. Among the acceptable categories of ISS crew members, the international partners included nonprofessional spaceflight participants, such as American space tourist Dennis A. Tito, who had reportedly paid the Russian Space Agency US$12 to US$20 million to visit the ISS. Tito's visit had created tension among ISS partners, who hoped that the new agreement would clarify the selection criteria for individuals traveling to the ISS, while continuing to enable space programs to raise funds from nonprofessional space travelers.[182]

FEBRUARY 2002

5 February
NASA's KSC launched the Reuven Ramaty High Energy Solar Spectroscopic Imager (HESSI) on a Pegasus XL rocket from a Lockheed L-1011 aircraft. The purpose of HESSI's two-year mission was to analyze particle acceleration and explosive energy released in solar flares, using imaging and spectroscopic instruments. Solar flares can release in a few minutes, or even just a few seconds, an amount of energy nearly equal to that released by the explosion of 1 billion megatons (907 trillion tonnes or 907 quintillion kilograms) of TNT, disrupting communications

[180] U.S. General Accounting Office, "NASA: Better Mechanisms Needed for Sharing Lessons Learned" (report no. GAO-02-195, Washington, DC, January 2002), *http://www.gao.gov/new.items/d02195.pdf* (accessed 31 July 2002).
[181] NASA, "Aging NASA Spacecraft To Reenter Earth's Atmosphere," news release 02-16, 29 January 2002; NASA, "EUVE Spacecraft Re-enters Earth's Atmosphere," news release 02-19, 31 January 2002; NASA Goddard Space Flight Center, "EUVE Guest Observer Facility—The Extreme Ultraviolet Explorer Mission," *http://heasarc.gsfc.nasa.gov/docs/euve/euvegof.html* (accessed 30 July 2002).
[182] ESA, Multilateral Crew Operations Panel, "Principles Regarding Processes and Criteria for Selection, Assignment, Training and Certification of ISS (Expedition and Visiting) Crewmembers"; William Harwood, "NASA Approves Space Visitor Rules," *Washington Post*, 1 February 2002; Mark Carreau, "New NASA Policy Opens the Way for More People To Go into Space," *Houston Chronicle*, 1 February 2002.

satellites and power grids. Scientists at the University of California at Berkeley, which would manage the US$85 million mission, had designed the 645-pound (290-kilogram) probe.[183]

The Office of Space Flight at NASA Headquarters decided that Palmdale Manufacturing Facility in California would no longer perform major modifications to Space Shuttle orbiters. Instead, NASA's KSC, already responsible for preparing the Shuttles for launching, would also provide the modifications. The Palmdale facility had served as the manufacturing site for all orbiters since the Space Shuttle program's inception, as well as providing periodic maintenance and safety upgrades. Based on cost and risk assessments, the Office of Space Flight had determined that maintaining two modification facilities for four Shuttle orbiters was no longer financially feasible, and that performing such work at KSC would minimize associated costs and risks. The change was part of NASA's effort to absorb President George W. Bush's proposed budget cuts. Because it overhauled one of the four Shuttle orbiters every two to three years, NASA estimated that transferring this work to KSC would save approximately US$30 million per overhaul.[184]

7 February
NASA awarded Boeing Information, Space, and Defense Systems a US$936 million modification to its contract for the ISS. Under the contract, which had commenced in 1995, Boeing was providing construction, integration, and operations for the ISS. The modification extended Boeing's integration and operation work until 31 December 2003 and increased the total contract value to US$10.7 billion.[185]

12 February
Administrator Sean O'Keefe selected astronaut Shannon W. Lucid as NASA's Chief Scientist. In this post, Lucid became responsible for ensuring that NASA's programs were of scientific merit. At the time of the selection, Lucid was a spacecraft communicator supporting the Space Shuttle and ISS missions. A veteran of five Space Shuttle flights, Lucid had been one of the first six women selected to become an astronaut and the only woman awarded the Congressional Space Medal of Honor. Lucid replaced Kathie L. Olsen, who had occupied the position since May 1999. Olsen had accepted an appointment as the Associate Director of the Office of Science and Technology Policy in the Executive Office of the President.[186]

15 February
Scientists found that a bright blue ring of dust surrounds Earth's solar system, beginning outside of Saturn's orbit and extending beyond the orbit of Neptune. However, viewed from outside the solar system, this band of dust appears to surround the Sun. The discovery of the dust ring provided empirical support for the idea that this feature around a mature star indicates that the star harbors a planetary system. Therefore, researchers planning missions would be able, based on whether the star has a dust ring, to narrow down the list of which stars to study in their search

[183] *Houston Chronicle*, "New NASA Probe To Analyze High-Energy Flares from Sun," 5 February 2002; Puttkamer, "Space Flight 2002."
[184] NASA, "Kennedy Space Center To Perform Shuttle Modifications," news release 02-22, 5 February 2002; Mark Carreau, "NASA To Overhaul Shuttles in Florida," *Houston Chronicle*, 6 February 2002.
[185] NASA, "NASA Awards $936 Million Modification to Boeing Space Station Contract," news release c02-d, 7 February 2002.
[186] NASA, "NASA Astronaut, Dr. Shannon Lucid, Selected as Chief Scientist," news release 02-27, 12 February 2002.

for planets and planetary systems. ESA scientist Markus Landgraf had led the research team, which had made the discovery using data collected by Pioneer 10 and 11.[187]

16 February
The American Association for the Advancement of Science named Senior Research Scientist David Halpern of NASA's JPL a fellow, in recognition of his work on air-sea interactions in tropical oceans and on satellite measurements of ocean-surface quantities.[188]

22 February
The United States and Europe began incorporating data about wind speed and direction into their operational global weather analysis and forecast systems. NASA's Quick Scatterometer (QuikSCAT) spacecraft had gathered the data, which forecasters would use to predict, 6 to 12 hours earlier than before, hazardous weather events occurring over the oceans. QuikSCAT was orbiting Earth every 100 minutes, using its SeaWinds scatterometer to collect approximately 400,000 measurements over 90 percent of Earth's surface within each 24-hour period. Although the spacecraft had launched in 1999, a series of collaborative research efforts, among organizations including NASA, NOAA, and numerous European agencies, had only recently enabled scientists to take advantage of the data's full potential. The QuikSCAT program's participants included the European Centre for Medium-Range Weather Forecasts and the National Centers for Environmental Prediction, a branch of the National Weather Service.[189]

25 February
The American Institute of Aeronautics and Astronautics, the world's leading professional society in the field, elected Charles Elachi, Director of NASA's JPL, as a fellow in the society. In his research concerning geological analysis of Earth, Elachi had developed 45 flight missions and instruments, including radar remote-sensing techniques used to study Venus.[190]

26 February
NASA named 16 crew members for two Space Shuttle missions to the ISS, scheduled for 2003. Mission STS-115 would carry Commander Brent W. Jett Jr. and crew members Daniel C. Burbank, Christopher J. Ferguson, Steven G. MacLean, Heidemarie M. Stefanyshyn-Piper, and Joseph R. Tanner. Mission STS-116 would carry Commander Terrence W. Wilcutt and the crew—American astronauts Robert L. Curbeam Jr. and William A. Oefelein, and Swedish ESA astronaut Christer Fuglesang. NASA planned for STS-115 to deliver a second port truss segment to the ISS. Later, crew would attach the second port truss segment to a third port truss, which STS-116 would deliver. STS-116 would also involve rotation of the crew: the Shuttle would carry ISS Expedition 8 Commander C. Michael Foale, astronaut William S. McArthur, and Russian cosmonaut Valery I. Tokarev to the ISS, for a long-term stay, and would return ISS

[187] ESA, "ESA Scientist Discovers a Way To Shortlist Stars That Might Have Planets," ESA news release SNR 1-2002, 15 February 2002.
[188] NASA JPL, "JPL Researcher Honored by Largest Scientific Discovery," news release, 28 February 2002.
[189] NASA, "NASA's QuikSCAT Spacecraft Turns Operational," news release 02-33, 22 February 2002; NASA JPL, "Missions—SeaWinds on QuikSCAT," *http://winds.jpl.nasa.gov/ missions/quikscat/index.cfm* (accessed 1 August 2008).
[190] NASA JPL, "JPL Director Honored by Leading Aeronautic Institute," news release, 25 February 2002.

Expedition 7 Commander Yuri I. Malenchenko and crew members Edward T. Lu and Sergei I. Moschenko to Earth.[191]

27 February
Administrator Sean O'Keefe testified before the U.S. House Committee on Science and Technology concerning NASA's FY 2003 budget. Administrator O'Keefe also reported a recent independent audit of NASA's finances, which NASA planned to release to the public the next day. According to newspaper reports, the lawmakers questioned O'Keefe in a tone that was frequently skeptical and even critical. At the time of O'Keefe's testimony, NASA was already under public scrutiny regarding its budget overruns and financial accounting procedures, and critics had proposed reductions in its budget for human space travel.[192]

For the first time, scientists made combined internal and external observations of Jupiter's magnetosphere, the biggest object with distinct boundaries within the solar system. In the first conjunction of two spacecraft at an outer planet, the Galileo spacecraft conducted observations from inside Jupiter's magnetosphere, a comet-shaped region of space filled by the planet's magnetic field. Meanwhile, on the outside of the magnetosphere, the Cassini-Huygens spacecraft monitored the effects of solar wind—particles that flow from the Sun through the solar system. Scientists augmented the data gathered during these observations with data from near-simultaneous observations collected from radio telescopes on Earth and from spacecraft orbiting Earth, namely the HST and the Chandra X-ray Observatory. Researchers found that, although Jupiter's magnetosphere deflects solar winds, shock waves carried by solar winds compress the magnetosphere, stimulate radio emissions from within it, and brighten auroras at the planet's poles. The observations helped bolster researchers' confidence in their understanding of Earth's own protective magnetosphere.[193]

Researchers using data from NASA's Chandra X-ray Observatory found a substantial, pulsating source of x-rays in Jupiter's atmosphere near the planet's north magnetic pole. Existing theories could not explain either the pulsations or the location of the x-ray source. Scientists had posited that energetic oxygen and sulfur ions steadily precipitate from Jupiter's inner magnetosphere, entering the planet's polar regions and producing a northern aurora of x-rays. However, images from Chandra revealed that most of Jupiter's northern auroral x-rays originate at latitudes that only ions precipitating from Jupiter's outer magnetosphere could reach. In addition, researchers found that the hot-spot source of the x-rays was pulsating at 45-minute intervals, contradicting scientists' theory that the x-ray emissions originate from a steady precipitation of ions in the inner magnetosphere. Although this discovery invalidated previous theories, scientists were not yet able to explain the process they had observed. Specifically, according to Chandra's measurements, the researchers found insufficient energetic oxygen and sulfur ions within the required distance of the ion source—at least 30 times Jupiter's radius—to account for the observed x-ray emissions.[194]

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[191] NASA, "Astronauts Named to Key Space Station Missions," news release 02-35, 26 February 2002.
[192] Karen Masterson, "Skeptical Lawmakers Quiz NASA Chief About Budget," *Houston Chronicle*, 28 February 2002.
[193] NASA JPL, "Solar Wind Buffets Vast Jupiter Region, Team Approach Reveals," news release, 27 February 2002; Thomas W. Hill, "Magnetic Moments at Jupiter," *Nature* 415, no. 6875 (28 February 2002): 965–966.
[194] NASA, "Jupiter Hot Spot Makes Trouble for Theory," news release 02-34, 28 February 2002; G. R. Gladstone et al., "A Pulsating Auroral X-ray Hot Spot on Jupiter," *Nature* 415, no. 6875 (28 February 2002): 1000–1003.

28 February
NASA released two reports of an audit conducted by the independent firm Pricewaterhouse-Coopers, noting several problems with NASA's system of financial management and record keeping. In one report, PricewaterhouseCoopers stated that NASA had not provided auditors with timely and sufficient documentary evidence of its financial transactions. Thus, auditors could not determine the accuracy and completeness of NASA's reported financial obligations, expenses, and equipment, including those related to the ISS and Space Shuttle programs. The audit did not state that waste or fraud characterized NASA's financial management; rather, the report concluded that NASA's incomplete financial records obviated any definitive assessment of its finances. In the second report, the auditors enumerated several problems with NASA's internal controls over financial reporting, but also stated that they would not provide an opinion on the merit of those internal controls.[195]

MARCH 2002

1 March
Space Shuttle *Columbia* launched from NASA's KSC in Cape Canaveral, Florida, at 6:22 a.m. (EST). Weather, mechanical issues, and other concerns had prompted NASA to postpone *Columbia*'s launch several times, from its original launch date of 19 November 2001. Officially designated STS-109, the mission's objective was to service the HST, the fourth such mission (designated Mission SM3B) for the HST. The payload consisted of various technology updates for the HST, including a new camera and solar arrays. In addition, *Columbia* carried seven crew members: Mission Commander Scott D. Altman and astronauts Duane G. Carey, Nancy J. Currie, John M. Grunsfeld, Richard M. Linnehan, Michael J. Massimino, and James H. Newman.[196]

ESA launched the environmental satellite Envisat on an Ariane-5 rocket. The primary mission of Envisat, designed to provide continuous monitoring of Earth's atmosphere, ice caps, and land, was to measure sea color in coastal areas and in oceans. To perform this monitoring, Envisat was equipped with 10 optical and radar instruments, including the Advanced Synthetic Aperture Radar and the Medium Resolution Imaging Spectrometer. ESA planned for the satellite to orbit Earth every 100 minutes, examining each region of Earth once every 35 days.[197]

Engineers succeeded in returning NASA's Far Ultraviolet Spectroscopic Explorer (FUSE) spacecraft to full operational status. Some of the satellite's guidance components had failed in December 2001, and engineers had feared that the mission would terminate prematurely. Mission engineers on Earth had been able to revive FUSE with a new, innovative guidance system, which

[195] Karen Masterson and Mark Carreau, "NASA Bookkeeping in Disarray," *Houston Chronicle*, 1 March 2002; PricewaterhouseCoopers, "Report of Independent Accountants" (report, Washington, DC, 22 February 2002), *http://www.hq.nasa.gov/office/oig/hq/igfy01fsaudit.pdf* (accessed 5 August 2008); PricewaterhouseCoopers, "Report of Independent Accountants on Internal Control" (report, Washington, DC, 22 February 2002), *http://www.hq.nasa.gov/office/oig/hq/lrreport022602.pdf* (accessed 5 August 2008).
[196] NASA, "STS-109," *http://science.ksc.nasa.gov/shuttle/missions/sts-109/mission-sts-109.html* (accessed 10 August 2008); William Harwood, "Cooling Glitch Mars Shuttle's Hubble Trip," *Washington Post*, 2 March 2002.
[197] Puttkamer, "Space Flight 2002"; ESA, "Envisat Overview," *http://www.esa.int/esaEO/SEMWYN2VQUD_index_0_m.html* (accessed 10 August 2008).

used the satellite's electromagnets to push and pull on Earth's magnetic field, thereby pointing the satellite in the desired direction. Engineers had originally developed the innovative guidance system as a contingency for a failure of this type, but NASA had never before used the system to navigate a satellite with the accuracy required for scientific observations.[198]

2 March
Scientists with NASA's JPL made contact with Pioneer 10, the first object made by humans to leave the solar system. NASA scientists had last made contact with the space probe on 9 July 2001 but had lost contact with Pioneer 10 from August 2000 to April 2001. Pioneer 10, launched on 2 March 1972, had been the first spacecraft to pass through an asteroid belt, the first to make direct observations of Jupiter, and in 1983, became the first object made by humans to leave the solar system. After Pioneer 10's mission had ended on 31 March 1997, scientists with JPL's Deep Space Network had continued to track the spacecraft's signal as part of a study of communications technology. In addition, NASA had used the probe for training flight controllers in the acquisition of radio signals from space.[199]

8 March
James Bock, an astrophysicist at NASA's JPL, received the Presidential Early Career Award for Scientists and Engineers. Bock had begun his career with JPL in 1994, developing detectors and instruments for far-infrared, millimeter-wave astrophysics. The award is the U.S. government's highest honor for scientists and engineers commencing their careers.[200]

NASA successfully launched the second spacecraft for its Tracking and Data Relay Satellite (TDRS) fleet—called the TDRS-9 or TDRS-I—from Cape Canaveral, Florida, at 10:59 p.m. (UT). The TDRS satellite system provided tracking and data-acquisition services between low Earth-orbiting spacecraft and ground-based control and data-processing facilities. In addition, the TDRS satellite system served numerous NASA programs, including the HST, the ISS, and the Space Shuttle. NASA had launched the first TDRS satellite in 1983.[201]

9 March
Crew of Space Shuttle *Columbia* STS-109 finished installing several new instruments on the 12-year-old HST and sent the observatory back into orbit. During a series of five spacewalks conducted in as many days, *Columbia*'s crew had installed a new power-shunting unit, an improved solar panel, and a cooling unit that would restore the Near-Infrared Camera and Multi-Object Spectrometer (NICMOS) to operational status. In addition, *Columbia*'s crew had installed

[198] NASA, "NASA's FUSE Satellite Lit Again," news release 02-45, 6 March 2002; Johns Hopkins University Department of Physics and Astronomy, "Fuse Mission Status Report" (mission status report no. 56, Johns Hopkins University, Baltimore, MD, 25 March 2002), *http://fuse.pha.jhu.edu/facts/ miss_rep56.html* (accessed 10 August 2008).
[199] NASA, "An Early NASA Pioneer Still on the Job in Deep Space," news release 02-44, 4 March 2002.
[200] NASA JPL, "JPL Astrophysicist Receives Presidential Award," news release, 8 March 2002.
[201] *Spacewarn Bulletin*, no. 581, 1 April 2002, *http://nssdc.gsfc.nasa.gov/spacewarn/spx581.html* (accessed 31 October 2008); NASA Goddard Space Flight Center, National Space Science Data Center, "NASA's Tracking and Data Relay Satellites (TDRS)," *http://nssdc.gsfc.nasa.gov/multi/tdrs.html* (accessed 31 October 2008).

a new main camera, the Advanced Camera for Surveys (ACS), which NASA had designed to give the telescope unprecedented ability to observe distant galaxies and other objects.[202]

12 March
Space Shuttle *Columbia* STS-109 landed at NASA's KSC in Cape Canaveral, Florida, at 4:32 a.m. (EST). During the 11-day mission, the Shuttle crew had conducted five spacewalks and performed several significant modifications of the HST, including the installation of an ACS and an experimental cryocooler, which had restored the operation of the NICMOS. The mission's total duration was 10 days, 22 hours, and 11 minutes.[203]

13 March
The White House informed NASA Administrator Sean O'Keefe that it was withdrawing Major General Charles F. Bolden as its nominee for NASA's Deputy Administrator. According to a White House spokesperson, President George W. Bush had withdrawn the nomination so that Bolden could serve the military in the war on terrorism. At the time of the nomination, Bolden, a former astronaut, was the commanding general for the Third U.S. Marine Aircraft Wing, which had nearly 11,000 U.S. Marines in Afghanistan as part of Operation Enduring Freedom.[204]

17 March
Two spacecraft comprising the Gravity Recovery and Climate Experiment (GRACE) launched on a single rocket vehicle from Russia's Plesetsk Cosmodrome. The five-year mission's main purpose was to map variations in Earth's gravity field, using the GPS and a microwave ranging system to measure the distance between the mission's two identical satellites—nicknamed Tom and Jerry. The two craft were to monitor each other while flying in a polar orbit 500 kilometers (311 miles) above Earth. This mission, to study measurements of gravity variations, could help scientists understand better the changes in the transport of mass around the planet. Changes in mass, such as ocean currents, ground-water storage, and mass within Earth, can affect climate and other aspects of the planet's environment. The GRACE mission was a partnership between NASA and the Deutsche Zentrum für Luft- und Raumfahrt (the German Aerospace Center).[205]

18 March
Citing terrorism concerns, NASA officials stated that NASA planned to change the manner in which it released information about launch times to the public. NASA officials said that NASA would no longer publicize launch times until 24 hours before liftoff, at which time NASA would announce a 4-hour time slot during which liftoff would occur. The change was a reversal of NASA's previous practice of announcing specific launch times months in advance of liftoff.[206]

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[202] Warren E. Leary, "Hubble Returning to Mission Able To Peer Deeper Into Space," *New York Times*, 10 March 2002.
[203] NASA, "STS-109," *http://science.ksc.nasa.gov/shuttle/missions/sts-109/mission-sts-109.html* (accessed 11 August 2002); Puttkamer, "Space Flight 2002."
[204] NASA, "Deputy Administrator Nomination Withdrawn," news release 02-49, 13 March 2002; Mark Carreau and Bennett Roth, "Nomination Is Withdrawn for Deputy's Post at NASA," *Houston Chronicle*, 14 March 2002.
[205] University of Texas Center for Space Research, "GRACE: Mission Overview," *http://www.csr.utexas.edu/grace/overview.html* (accessed 11 August 2002); Warren E. Leary, "New Satellites To Map Gravity More Precisely," *New York Times*, 19 March 2002.
[206] Steve Siceloff, "NASA To Withhold Shuttle Launch Times," *Florida Today* (Brevard, FL), 19 March 2002.

NASA announced the assignment of three crew members to begin training for the ninth expedition to the ISS. The three were Station Commander Gennady I. Padalka and crew members E. Michael Fincke and Oleg D. Kononenko. NASA assigned American astronaut Daniel M. Tani to serve as backup for his fellow compatriot Fincke and selected cosmonauts Alexander F. Poleschuk and Roman Y. Romanenko to serve as backups for fellow Russians Kononenko and Padalka.[207]

20 March

The U.S. House Government Reform Subcommittee on Government Efficiency, Financial Management, and Intergovernmental Relations held a hearing, "Financial Management at NASA: What Went Wrong?" Stephen Varholy and Alan Lamoreaux of NASA and Gregory D. Kutz and Allen Li of GAO provided testimony to the Subcommittee. The hearing focused on NASA's methods of financial accounting and on the role of its former auditor, Arthur Andersen LLP, in assessing those methods. Kutz reported that NASA's system of accounting had made it difficult for GAO to assess NASA's financial records and questioned Arthur Andersen LLP's ability to assess those records accurately.[208]

23 March

Thomas J. Kelly, designated by NASA as father of the lunar module, died at the age of 72 in Cutchogue, New York. Kelly had led a team of engineers at Grumman Aircraft Corporation in designing and building the Lunar Excursion Module known as the *Eagle*. *Apollo 11* astronauts had used the *Eagle* to land on the Moon and to return to the orbiting command module for the trip back to Earth. In 1972 NASA had awarded Kelly with its Distinguished Public Service Medal for his work on the Apollo program. Kelly's wife, six children, and 10 grandchildren survived him.[209]

27 March

The National Weather Service Aviation Weather Center in Kansas City, Missouri, placed in operation a computer-based warning system called the Current Icing Potential (CIP), designed to alert aviation controllers to the potential for icing along flight routes. The National Center for Atmospheric Research had developed the warning system with funding from the FAA. The CIP used information from satellite data, ground observations, and other sources to produce information on the likelihood of airplanes experiencing icing along flight routes. The FAA had supported the development of the CIP to improve flight planning and aircraft safety.[210]

29 March

NASA Administrator Sean O'Keefe announced his selection of an independent task force to assess the productivity and priorities of the research produced by NASA's Office of Biological

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[207] NASA, "Astronauts Assigned for Space Station Expedition Training," news release 02-55, 18 March 2002.
[208] U.S. General Accounting Office, "National Aeronautics and Space Administration: Leadership and Systems Needed to Effect Financial Management Improvements" (testimony of Gregory D. Kutz and Allen Li before U.S. House Committee on Government Reform, Subcommittee on Government Efficiency, Financial Management, and Intergovernmental Relations; report no. GAO-02-551T, Washington, DC, 20 March 2002), *http://www.gao.gov/new.items/d02551t.pdf* (accessed 12 August 2002).
[209] Warren E. Leary, "T. J. Kelly, 72, Dies; Father of Lunar Module," *New York Times*, 27 March 2002.
[210] *Federal Aviation Administration's R&D Review*, Spring 2003, 2, 6, 11, *http://www.airporttech.tc.faa.gov/RD/2003_spring.pdf* (accessed 3 March 2009).

and Physical Research (OBPR) and to provide a report to the NASA Advisory Council. O'Keefe expected the task force, designated the Research Maximization and Prioritization Task Force (ReMAP), to recommend strategies the OBPR could use to achieve its research goals and still remain within President George W. Bush's requested budget. In addition, O'Keefe requested the task force to offer assessments and recommendations to guide NASA in maximizing the scientific returns of the ISS's missions and of its other programs. O'Keefe selected Rae Silver, the Helene L. and Mark N. Kaplan Professor of Natural and Physical Sciences at Columbia University, as the chairperson of ReMAP.[211]

APRIL 2002

1 April
Jefferson Davis Howell Jr. became the eighth Director of NASA's JSC, replacing Acting Director Roy S. Estess, who resumed his position as Director of NASA's Stennis Space Center (SSC). Before assuming the post, Howell had worked for Science Applications International Corporation (SAIC) administering its safety, reliability, and quality-assurance contract with NASA, to provide safety and mission assurance for the Space Shuttle and ISS programs.[212]

4 April
In an article in the journal *Nature*, astronomers at ESA reported that they had found evidence indicating which specific type of stellar object produces gamma-ray bursts (GRBs), the universe's most energetic phenomena. Prevailing hypotheses had posited that, either GRBs originate from the merger of two neutron stars, or they form from the collapse of one massive star, but researchers had discovered no conclusive proof to support either of these ideas. However, based on their analysis of the speed, temperature, and chemical elements of a GRB that had occurred on 11 December 2001, ESA astronomers found evidence supporting the latter hypothesis. The research team examined two sequential observations of the GRB, both taken by ESA satellites: the BeppoSAX satellite had made the first observation, and, nearly 11 hours later, the XMM-Newton satellite had made the second. The team had found large quantities of argon, calcium, magnesium, silicon, and sulphur, moving at 1/10th the speed of light. These findings supported the idea that a supernova explosion from a single massive star produces GRBs. If the merger of two neutron stars had produced the burst, astronomers would have expected the stars to produce large amounts of elements other than those observed—particularly iron—and to emit those elements at a slower velocity.[213]

5 April
NASA's JPL researchers identified a 1-kilometer-long (0.62-mile-long) asteroid that might possibly crash into Earth in the future—although such an event would be highly unlikely. In the report published in the journal *Science*, the scientists suggested that asteroid 1950 DA would come close to Earth in 2880, but that the probability of a collision would be low. The study had

[211] NASA, "NASA Administrator Names Task Force To Review Biological and Physical Research Programs," news release 02-61, 29 March 2002.
[212] NASA JSC, "Jefferson Davis Howell Jr. Named as Johnson Space Center Director," news release J02-17, 12 February 2002.
[213] J. N. Reeves et al., "The Signature of Supernova Ejecta in the X-ray Afterglow of the γ-ray Burst 011211," *Nature* 416, no. 6880 (4 April 2002): 512–515; ESA, "ESA's X-ray Space Telescope Proves Supernovae Can Cause Mysterious Gamma-Ray Bursts," ESA news release 22-2002, 4 April 2002.

incorporated radar and optical measurements of the asteroid collected over 51 years and had used analytical techniques unprecedented in asteroid-trajectory predictions and hazard studies. Based on their analysis, JPL scientists had identified a 20-minute window on 16 March 2880, in which "there could be a non-negligible probability of the 1-kilometer [0.62-mile] object colliding with Earth." However, they clarified that the odds of a collision were at most 1 in 300 and possibly even more remote, considering how little they knew about the asteroid. The research results indicated that, despite the remote possibility of such a collision, 1950 DA poses a relatively greater potential hazard to Earth than any other known asteroid.[214]

8 April

Space Shuttle *Atlantis* STS-110 lifted off at 4:44 p.m. (EST) from NASA's KSC in Cape Canaveral, Florida. The object of STS-110/ISS Assembly Flight 8A was to attach to the ISS a 43-foot-long (13-meter-long) truss structure called the Starboard Zero (S Zero or S0). The mission's payload included several science payloads, the S0 Truss, and the Mobile Transporter (MT). NASA had designed the MT to move the completed truss and to act as a work platform for a mechanical arm, which the crew would install in the future. The crew included Mission Commander Michael J. Bloomfield and astronauts Stephen N. Frick, Lee M. E. Morin, Ellen Ochoa, Jerry L. Ross, Steven L. Smith, and Rex J. Walheim.[215]

10 April

Two separate teams of astronomers reported that NASA's Chandra X-ray Observatory and the HST had observed two stars, possibly composed of a form of matter unknown to scientists. Researchers examining data from Chandra and the HST had noted that the neutron star RX J1856.5–3754 was far smaller than expected and, therefore, had concluded that the star might be composed, not of neutrons, but of quarks—components of protons and neutrons that scientists had never before observed outside of the nucleus of an atom in laboratories on Earth. Another team of astronomers had analyzed Chandra's observations of neutron star 3C 58 and had found that the star's temperature was less than 1,000,000°C (1,800,032°F), a far lower temperature than scientists would expect for a star composed of pure neutrons. Thus, that star also appeared to be composed, either of quarks, or of another form of matter unknown to scientists.[216]

In a letter to the congressional committees overseeing NASA's budget requests, the GAO stated that it could not verify NASA's accounting of amounts charged against cost limits for the ISS and Space Shuttle programs, as reported to Congress in NASA's FY 2003 budget. Federal law required GAO to provide verification of these amounts to the U.S. House Committee on Science and Technology and to the U.S. Senate Committee on Commerce, Science, and Transportation. However, GAO said that NASA's lack of an integrated financial management system had

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[214] J. D. Giorgini, "Asteroid 1950 DA's Encounter with Earth in 2880: Physical Limits of Collision Probability Prediction," *Science* 296, no. 5565 (5 April 2002): 132–136; NASA JPL, "Radar Pushes Limits of Asteroid Impact Prediction," news release, 4 April 2002.

[215] NASA, "Framework for Expanding Station Research: STS-110," press kit, 20 March 2001, *http://www.shuttlepresskit.com/STS-110/spk-110.pdf* (accessed 12 August 2008); William Harwood, "Shuttle on Haul to Space Station," *Washington Post*, 9 April 2002.

[216] NASA, "Cosmic X-rays Reveal Evidence for New Form of Matter," news release 02-65, 10 April 2002; Jeremy J. Drake, "Is RX J1856.5-3754 a Quark Star?" *Astrophysical Journal* 572, no. 2 (20 June 2002): 996–1001; Patrick O. Slane, David J. Hefland, and Stephen S. Murray, "New Constraints on Neutron Star Cooling from *Chandra* Observations of 3C 58," *Astrophysical Journal Letters* 571, no. 1 (20 May 2002): L45–L49.

prevented NASA from providing GAO with details of costs charged against these programs. GAO reported that NASA's 10 centers operated separate accounting systems, each with its own policies and practices, and that some centers could not provide complete and detailed documentation of accounts covering several fiscal years. GAO also reported that NASA officials had responded that NASA's accounts were verifiable, stating that the verification problems lay in GAO's auditing methodology rather than in NASA's system of accounting.[217]

11 April

Astronauts aboard Space Shuttle *Atlantis* STS-110 attached a 44-foot (13-meter) truss, containing computers, coolant lines, electrical cables, and other components to the ISS. The 27,000-pound (12,250-kilogram) beam, dubbed Starboard Zero or S0, was the first of nine truss segments that would form a 356-foot (110-meter) exterior spine, supporting new solar arrays, heat radiators, and laboratory modules. The installation, involving the first use of the 58-foot (18-meter), Canadian-built robotic arm designed for the station, required two separate spacewalks, performed by two different pairs of astronauts.[218]

U.S. Navy officials announced that the Navy had been using NASA satellite data in combat, the first time the military had done so. The officials stated that the Navy had used unclassified NASA data to help guide ships and planes engaged in combat operations in Afghanistan. Major media reported that members of Congress had voiced mixed reactions to the announcement, with some members expressing their concern that the cooperation between NASA and the military would overstep the bounds of NASA's civilian charter.[219]

12 April

In his first major speech as NASA's Administrator, Sean O'Keefe announced his strategic vision for the future of NASA. In his speech, "Pioneering the Future," at Syracuse University's Maxwell School of Citizenship and Public Affairs, O'Keefe stated that NASA's new vision was "to improve life here, to extend life to there, and to find life beyond." In addition, O'Keefe said that NASA's mission was "to understand and protect our home planet, to explore the universe and search for life, to inspire the next generation of explorers . . . as only NASA can." O'Keefe also emphasized that NASA would carry out its mission with a commitment to fiscal responsibility and to working with academia, government agencies, and private industry.[220]

NASA Administrator Sean O'Keefe announced that, after international partners had completed certain portions of the ISS, former schoolteacher Barbara R. Morgan would fly on a Space Shuttle mission to the station. NASA had selected Morgan as a mission specialist in the astronaut class of 1998. She had subsequently worked in ISS Mission Control, relaying instructions between ISS Mission Control and the crew of Expedition 4 aboard the ISS. Morgan had previously served as a backup candidate for the Teacher in Space Program, training with Christa McAuliffe and the STS-51L crew of Space Shuttle *Challenger*. At the time of O'Keefe's

[217] U.S. General Accounting Office, "NASA Space Station Cost Limits" (report no. GAO-02-504R, Washington, DC, 10 April 2002), *http://www.gao.gov/new.items/d02504r.pdf* (accessed 12 August 2008).
[218] Warren E. Leary, "Major Component of Space Station Is Attached," *New York Times*, 12 April 2002; Puttkamer, "Space Flight 2002."
[219] *Houston Chronicle*, "NASA Satellite Guides Navy Warplanes, Ships," 12 April 2002.
[220] NASA, "Administrator Unveils Future NASA Vision and a Renewed Journey of Learning," new release 02-66, 12 April 2002.

announcement, Morgan was part of a new Educator Astronaut Program administered by NASA and the Department of Education, designed to attract students to engineering, math, and science.[221]

14 April

James S. Martin, former NASA Manager of the Viking missions to Mars, died at the age of 81. Martin had led the nationwide team of 750 engineers, scientists, and technicians that had developed the Viking 1 and Viking 2 spacecraft. The two craft had launched in 1975 and landed on Mars a year later, making Viking the first mission to successfully soft-land on the surface of another planet. Martin had joined NASA in 1964 as an Assistant Project Manager for the Lunar Orbiter, and in 1967 he had received NASA's Exceptional Service Medal for his contribution to that project. He had departed from NASA in 1976 to work for Martin Marietta Aerospace, and in 2000 NASA had asked him to leave retirement to lead its effort to restructure its Mars Exploration Program.[222]

17 April

NASA Administrator Sean O'Keefe testified before the U.S. House Appropriations Subcommittee on VA, HUD, and Independent Agencies, which has primary jurisdiction for setting NASA's annual funding levels. The subcommittee hearing was held in preparation for markup of FY 2003 appropriations legislation. Major media reported that subcommittee members were critical of NASA's plans to eliminate certain programs to achieve President George W. Bush's proposed reduction of US$1 billion in funding from NASA's human spaceflight programs. In response to the comments of some members of the subcommittee, O'Keefe noted that, because NASA planned to complete its review of human spaceflight programs later in the year, he could not yet identify the programs that the budget cuts would affect. O'Keefe also said that NASA would provide Congress with a review of its scientific priorities by June and an independent cost assessment by August.[223]

18 April

Using images from the HST, astronomers reported their analysis of a new class of objects in the solar system. The researchers reported that Kuiper Belt object 1998 WW31 is binary—composed of two objects that orbit around a common center of mass as they both orbit the Sun—with a highly eccentric orbit and a long period. However, they had found that 1998 WW31 is very different from the Pluto/Charon system, which was previously the only known binary in the Kuiper Belt. The Kuiper Belt is the region of space that extends from Neptune, at 30 AU (astronomical units)—the approximate mean distance between Earth and the Sun) to more than 100 AU. Since its discovery in 1992, the Kuiper Belt has helped scientists understand the solar system's formation. Although scientists had discovered 1998 WW31 in 1998, they had reported it as a single Kuiper Belt object. However, analysis of observations made in 2000 indicated that

[221] NASA, "Press Briefing Scheduled with NASA Administrator and Astronaut Barbara Morgan," news release N02-28, 15 April 2002; William Harwood, "McAuliffe's Backup Will Go to Space in 2004," *Washington Post*, 13 April 2002.
[222] NASA, "Mars Viking Leader, James S. Martin Jr. Dies," news release 02-72, 18 April 2002.
[223] Karen Masterson, "DeLay Calls Plans for NASA 'Timid'," *Houston Chronicle*, 18 April 2002; U.S. Congress, House of Representatives, Committee on Apropriations, Subcommittee on VA, HUD, and Independent Agencies, *Departments of Veterans Affairs and Housing and Urban Development and Independent Agencies Appropriations for 2003, Part I*, 107th Cong., 2nd sess., 17 April 2002.

the object might contain two components. Further analysis, using ground-based and HST observations made in 2001 and 2002, confirmed 1998 WW31's binarity.[224]

19 April

Space Shuttle *Atlantis* STS-110 landed at NASA's KSC in Cape Canaveral, Florida, at 10:27 a.m. (EST). While in orbit, the Shuttle's crew had performed four spacewalks to connect the S0 Truss to the ISS and to prepare the MT—a track-mounted platform—for use. The crew had used the robotic arms of both *Atlantis* and the ISS to install the truss. STS-110 was the first mission in which the crew had used the ISS's robotic arm to maneuver crew members around the station as they performed spacewalks. In addition, it was the first mission in which the crew's base for all of its spacewalks was the ISS's Quest Airlock. The Shuttle's crew had also engaged in joint operations with the ISS's Expedition 4 crew. The total duration of STS-110 was 10 days, 19 hours, and 42 minutes.[225]

24 April

Scientists announced an estimate of the universe's age based on new HST images of very faint white dwarf stars in Messier 4 (M4), a cluster of stars in the constellation Scorpius. The researchers had closely examined M4's white dwarf stars—low-mass stars that have exhausted their fuel sources for thermonuclear fusion. Although white dwarfs cool at a predictable rate, enabling scientists to estimate their age, they become progressively fainter as they cool, making them difficult to observe. The HST had provided the first deep exposures of these dim stars, which the astronomers discovered were M4's oldest white dwarf stars, at around 12 to 13 billion years old. Earlier Hubble observations had revealed that the first stars in the universe had formed less than 1 billion years after the universe's emergence from the Big Bang. Thus, the researchers had discovered that the age of these M4 white dwarfs supported the previous estimates that the universe's age is 13 to 14 billion years old. The use of this new methodology to estimate the universe's age represented a major departure from those used previously.[226]

25 April

The Russian *Soyuz* TM-34 launched from Baikonur Cosmodrome in Kazakhstan at 6:27 a.m. Greenwich Mean Time (GMT)—1:27 a.m. (EST). The mission, designated Soyuz 4 Taxi Flight, carried three crew members—Commander Yuri P. Gidzenko of Russia, Italian astronaut Roberto Vittori, and South African businessman Mark Shuttleworth. The mission's main purpose was to deliver a new *Soyuz* spacecraft to the ISS for use as an emergency lifeboat for the ISS's permanent three-member crew. In addition, major media noted that Shuttleworth had paid the Russian Space Agency a fee of approximately US$20 million to fly on *Soyuz* to the ISS.[227]

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[224] Christian Veillet, "The Binary Kuiper-Belt Object 1998 WW31," *Nature* 416, no. 6882 (18 April 2002): 711–713; NASA, "Hubble Hunts Down Odd Couples at the Fringes of Our Solar System," news release 02-70, 17 April 2002.

[225] NASA, "STS-110 Extravehicular Activities," *http://spaceflight.nasa.gov/shuttle/archives/sts-110/eva/index.html* (accessed 12 August 2002); NASA, "STS-110: A Framework for Station Expansion," *http://spaceflight.nasa.gov/shuttle/archives/sts-110/* (accessed 12 August 2002).

[226] NASA, "Hubble Uncovers Oldest 'Clocks' in Space To Read Age of Universe," news release 02-73, 24 April 2004; Brad M. S. Hansen et al., "The White Dwarf Cooling Sequence of the Globular Cluster Messier 4," *Astrophysical Journal* 574, no. 2 (1 August 2002): L155–L158.

[227] NASA, "Soyuz 4 Taxi Flight Crew," *http://spaceflight.nasa.gov/station/crew/exp4/taxi4/index.html* (accessed 12 August 2002); *Houston Chronicle*, "Space Tourist No. 2," 25 April 2002.

30 April
NASA released the first four images taken by the HST's newly installed Advanced Camera for Surveys (ACS). During Mission STS-109 in March 2002, astronauts had installed the ACS, capable of providing images with double the area and resolution of those provided by the Wide Field Planetary Camera 2, which the ACS had replaced. The ACS had captured images of a turbulent galaxy, which scientists called Tadpole because of its long tail of stars; of two colliding spiral galaxies known as the Mice; of the Cone Nebula, which looks like a red volcano; and of the M17 Swan Nebula, a richly colored, cloudy-looking nebula containing newly forming planetary systems.[228]

MAY 2002

3 May
NASA awarded a US$1.14 billion contract to the Boeing Company's Rocketdyne Propulsion and Power division for maintenance and support of the Space Shuttle's main engine during the ensuing five years. Under the terms of the contract, Rocketdyne was to provide flight and test engineering; engine refurbishment; and manufacture, assembly, test, and delivery of three additional Space Shuttle main engines. The contract also required Rocketdyne to provide engineering support for NASA's main engine facilities at NASA's KSC and SSC. From 1972 until the company signed the contract, Rocketdyne had assembled 106 main engines for NASA's Shuttles.[229]

4 May
The Earth observation satellite Aqua launched aboard a Delta 2 rocket from Vandenberg Air Force Base in California. The satellite Aqua was a component of the Earth Observing System (EOS), which also included the Terra satellite launched in December 1999. Aqua's primary purpose was to acquire information about the effects of climate change on the water cycle. The satellite would also collect data to help scientists examine biological systems dependent upon water and improve long-term forecasts of weather and climate. Brazil, Japan, and the United States planned for their joint project Aqua to continue for six years.[230]

7 May
In an article published in the journal *Geophysical Research Letters*, scientists using data from NASA's high-altitude research balloon reported a discovery that, potentially, could improve the research methodology for studying gases that contribute to ozone-layer depletion. Although scientists already knew that reactive hydrogen gases destroy stratospheric ozone and were able to detect hydrogen peroxide from space, they had problems with computer models used to analyze hydrogen-peroxide concentration in the atmosphere. However, in the reported study, researchers funded by NASA's Earth Science Enterprise had compared a new predicted rate of hydrogen-

[228] NASA, "Hubble's New Camera Delivers Breathtaking Views of the Universe," news release 02-74, 30 April 2002; Warren E. Leary, "Telescope Opens Window on Dawn of the Universe," *New York Times*, 1 May 2002.
[229] NASA, "NASA Awards $1.14 Billion Space Shuttle Main Engine Contract to Boeing Rocketdyne," news release c02-h, 3 May 2002.
[230] NASA JPL, "Aqua Launched To Study Earth's Water Cycle," news release, 4 May 2002; Warren E. Leary, "NASA To View Interaction of Earth's Water and Climate," *New York Times*, 30 April 2002.

peroxide formation with the levels of the gas measured by two instruments on board NASA's high-altitude research balloons. The new data had revealed a high degree of agreement between the actual and the predicted measurements. The researchers noted that, although their newly discovered rate of hydrogen-peroxide formation had no appreciable impact on rates of stratospheric ozone loss, they expected the findings would help to analyze the deleterious effects on Earth's ozone of other, less easily measured, hydrogen gases.[231]

8 May

The U.S. Senate Commerce Subcommittee on Science, Technology, and Space began hearings on legislation to reauthorize NASA programs. Subcommittee chairman Ron Wyden (D–OR) expressed concern about the agency's financial management, particularly cost overruns for the ISS. He also urged NASA to maintain the excellence of the Shuttle program while research continued on a next-generation space vehicle. Members of the subcommittee heard testimony from NASA Administrator Sean O'Keefe, who addressed them for the first time, and from William F. Readdy, Deputy Associate Administrator of the NASA Office of Space Flight. The members of the subcommittee questioned O'Keefe about his vision for NASA and his plans to reduce NASA's budget by ending particular programs. In his prepared statement, O'Keefe discussed the status of the ISS and Space Shuttle programs.[232]

10 May

Using data from NASA's Deep Space 1, astronomers uncovered unexpected findings about the surface of comets, suggesting that comets might have brought to Earth material necessary for the beginning of life. The astronomers had examined images gathered in 2001, during the spacecraft's flyby of the 8-kilometer-long (5-mile-long) comet 19P/Borrelly, the only other comet besides 1P/Halley that a spacecraft had examined at such close proximity. Borrelly, the first comet of its type examined in this manner, is a short-period comet of the Jupiter family, compositionally different from intermediate-period comets such as 1P/Halley. The research, published in the journal *Science*, revealed no water ice or hydrated minerals on the comet's surface, which scientists had unexpectedly found to be hot and dry. Deep Space 1 had also revealed that a dark dust, possibly containing biological material, covered the comet, which had a far darker surface than most objects in the inner solar system. According to the scientists, this finding suggested that comets might have provided a transport mechanism, supplying the organic materials required for the beginning of life on Earth.[233]

12 May

NASA officials stated that NASA had used Web sites such as Yahoo! and eBay to find discontinued electronic equipment. NASA had continued to use electronic components such as 8-inch-floppy-disc drives, circuit boards, and computer chips, not in the Space Shuttles

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[231] NASA JPL, "NASA Study Leads to Better Understanding of Ozone Depletion," news release, 9 May 2002; L. E. Christensen et al., "Kinetics of $HO_2 + HO_2 \rightarrow H_2O_2$: Implications for Stratospheric H_2O_2," *Geophysical Research Letters* 29, no. 9 (7 May 2002): 1299.

[232] U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, *NASA Reauthorization,* 107th Cong., 2nd sess., 8 May 2002; Karen Masterson, "JSC Mission May Hit Detour," *Houston Chronicle*, 9 May 2002.

[233] L. A. Soderblom, "Observations of Comet 19P/Borrelly by the Miniature Integrated Camera and Spectrometer Aboard Deep Space 1," *Science* 296, no. 5570 (10 May 2002): 1087–1091; NASA JPL, "NASA Spacecraft Finds Comet Has Hot, Dry Surface," news release, 5 April 2002.

themselves, but in equipment used to service and support the Shuttles. For example, NASA had purchased outdated medical equipment to acquire the increasingly scarce Intel 8086 computer chip, a variant of the chip used in IBM's first personal computers in 1981. NASA had continued to use the Intel 8086 chip in diagnostic equipment for the Space Shuttle booster rockets, also developed in the early 1980s. Although NASA planned to develop various systems with new hardware, some crucial systems remained dependent on antiquated electronic parts.[234]

14 May

NASA selected the National Consortium for Aviation Mobility (NCAM)—a consortium of more than 100 public and private entities involved in transportation issues—as its partner in a joint venture to develop air-mobility technologies for small aircraft and small airports. By mid-2005 NASA and NCAM intended to create a flight demonstration, called a proof-of-concept, of NASA's Small Aircraft Transportation System (SATS). Engineers planned for the system to provide on-demand, point-to-point transportation with 4- to 10-passenger aircraft operating from nearly 5,400 public-use landing facilities. NASA officials hoped SATS would improve the affordability, efficiency, reliability, and safety of small aircraft servicing small communities throughout the United States. However, NASA wanted to determine the project's feasibility and to share its costs through partnerships with public and private entities. NASA expected that funding from the Department of Transportation and other federal agencies, along with its own contributions, would total nearly US$40 million for research over four years.[235]

NASA Administrator Sean O'Keefe named Michael C. Kostelnik as Deputy Associate Administrator for the ISS and Space Shuttle, a newly established senior management position in the Office of Human Space Flight. Kostelnik assumed responsibility for corporate-level management of the two programs' budgetary, performance, safety, and scheduling requirements. Before his retirement from the U.S. Air Force, Kostelnik had served as commander of the Air Armament Center at Eglin Air Force Base in Florida.[236]

16 May

The International Astronomical Union announced that astronomers had found 11 new moons around the planet Jupiter. The discovery increased the total number of known satellites around Jupiter to 39, more than any other planet in the solar system. Using the Canada-France-Hawaii telescope, astronomers from Cambridge University and the University of Hawaii had first detected the moons in December 2001. At 1- to 2-miles (1.6- to 3.2-kilometers) across, the newly discovered moons were far smaller than some of Jupiter's other moons, which are thousands of miles (or kilometers) wide. In addition, the astronomers had discovered that the satellites have irregular orbits and, unlike the planet's largest moons, spin in the opposite direction of Jupiter. The moons' irregular orbits around Jupiter indicate that they may have originally orbited the Sun.[237]

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[234] William J. Broad, "For Parts, NASA Boldly Goes . . . on Ebay," *New York Times*, 12 May 2002.
[235] NASA, "NASA Selects Partner for Aviation Research," news release 02-89, 14 May 2002.
[236] NASA, "NASA Administrator Names New Deputy Associate Administrator for International Space Station and Space Shuttle," news release 02-79, 14 May 2002; *Florida Today* (Brevard, FL), "NASA Chief Creates New Space Station Post," 16 May 2002.
[237] Usha Lee McFarling, "11 New Moons of Jupiter Found," *Los Angeles Times*, 17 May 2002; NASA JPL, "Astronomers Discover 11 More Small Moons of Jupiter," news release, 17 May 2002.

21 May

NASA and U.S. Air Force officials announced that they had agreed with a study team's recommendation that NASA and the Air Force continue to assess the construction of a joint reusable launch vehicle (RLV) demonstrator. After spending 120 days examining the two organizations' shared requirements and their technologies to access space, the team's most critical recommendation had been that NASA and the Air Force should cooperate in assessing the construction of an RLV demonstrator for their joint operations. In addition, the study team had recommended that engineers eventually develop the demonstrator into a crew-operated vehicle for NASA and a cargo vehicle for the Air Force. NASA and the Air Force also agreed that experienced Air Force personnel should continue to work with NASA in joint study efforts, to refine their concepts of operations, requirements, and figures of merit, and to design reference missions.[238]

23 May

In an article in the journal *Nature*, scientist Paul M. Schenk provided evidence that Jupiter's moon Europa might not be able to support life, challenging many scientists' previous assessments about the potential for life on the moon. Astrobiologists had theorized that Europa might be able to support life, based on the possibility that it might possess a heat source, liquid water, and organic material, all necessary for life to exist. However, researchers had also known that Europa is covered with a shell of ice, which might be sufficiently thick to prevent sunlight and oxygen from reaching water below the icy surface, thereby impeding Europa's ability to support life. Using data obtained from NASA's Galileo and Voyager spacecraft, Schenk had calculated the thickness of Europa's ice shell by comparing the depths of impact craters on Europa with those on Callisto and Ganymede, two other moons of Jupiter. Schenk's analysis indicated that Europa's ice shell is at least 19-kilometers (12-miles) thick—nearly twice that suggested by previous studies and thick enough to prevent the existence of life.[239]

24 May

Radar images of near-Earth asteroid 2000 DP107 revealed that it is a binary system, composed of two objects orbiting each other. The finding suggested that many near-Earth asteroids could be binaries. The images, taken by NASA's Goldstone telescope facility and the National Science Foundation's Arecibo Observatory, revealed that the asteroid was not one, but two objects, a nearly 800-meter-diameter (2,625-foot-diameter) primary and an almost 300-meter-diameter (985-foot-diameter) secondary, revolving around their common center of mass. The researchers suggested that approximately 16 percent of near-Earth asteroids larger than 200 meters (655 feet) in diameter could be binary systems. In addition, the analysis suggested that binaries with similar orbits might result from a close encounter of an asteroid and a planet, in which the planet's gravitational pull breaks off a portion of the asteroid. Scientists consider binary asteroids potential hazards to Earth and worthy of further study.[240]

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[238] NASA, "NASA and Air Force Forge Ahead with Reusable Launch Technology," news release 02-87, 21 May 2002.

[239] Usha Lee McFarling, "Life on Jupiter Moon Likely on Thin (or Thick) Ice," *Los Angeles Times*, 23 May 2002; Paul M. Schenk, "Thickness Constraints on the Icy Shells of the Galilean Satellites from a Comparison of Crater Shapers," *Nature* 417, no. 6887 (23 May 2002): 419–421.

[240] J. L. Margot et al., "Binary Asteroids in the Near-Earth Object Population," *Science* 296, no. 5572 (24 May 2002): 1445–1448; NASA JPL, "Some Asteroids Have Astronomers Seeing Double," news release, 11 April 2002.

28 May
Using data gathered by NASA's Mars Odyssey spacecraft, scientists discovered direct evidence of water ice on Mars. NASA scientists were using the Odyssey to measure and map soils in Mars's polar regions when the spacecraft's gamma-ray spectrometer detected hydrogen, indicating the presence of substantial, subsurface water ice in the upper meter of soil in a region surrounding Mars's south pole. Scientists had already suspected that Mars possessed large quantities of water near its surface, but the Odyssey's new information was the first direct evidence supporting this hypothesis. Scientists also found that large areas in Mars's low and middle latitudes contained "slightly enhanced amounts of hydrogen." However, their report did not indicate whether the hydrogen was in the form of water ice or chemically bound to minerals in the soil.[241]

JUNE 2002

3 June
The leaders of the space agencies participating in the ISS met at ESA's headquarters in Paris to discuss the program's status. The attendees included representatives of NASA, the Canadian Space Agency, ESA, Japan's NASDA, and the Russian Space Agency. All of the agencies reaffirmed their commitment to work on developing, assembling, and using the ISS for both applied and scientific research. In addition, the agencies agreed on a timeline for the next measures they would undertake to ensure that the construction and operation of the ISS met system engineering and safety requirements, so that participants could use it for various research objectives.[242]

5 June
Space Shuttle *Endeavour* STS-111 launched from NASA's KSC in Cape Canaveral, Florida, at 5:22 p.m. (EDT). NASA had originally scheduled the mission to lift off on 30 May but had delayed the launch because of mechanical and weather concerns. The Shuttle's crew included Commander Kenneth D. Cockrell and astronauts Franklin R. Chang-Diaz, Valery G. Korzun, Paul S. Lockhart, Philippe Perrin, Sergei Y. Treschev, and Peggy A. Whitson. Korzun, Treschev, and Whitson were also members of ISS Expedition 5, which was to remain at the ISS when *Endeavour* returned to Earth. STS-111 had several objectives. The Shuttle was transporting to the ISS the Multi-Purpose Logistics Module (MPLM), which contained racks for experiments, stowage, and resupply. The crew would also install a component called the Mobile Base System (MBS) to service the ISS's robotic arm. Both the MPLM and the MBS were part of the payload of the mission, also designated ISS Utilization Flight 2. A further objective of the mission was to transport the crew of Expedition 5 to the ISS and to return the members of Expedition 4 to Earth.[243]

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[241] NASA, "Odyssey Finds Water Ice in Abundance Under Mars's Surface," news release 02-99, 28 May 2002.
[242] NASA, "Joint Statement: International Space Station Heads of Agency Meeting," news release 02-105, 3 June 2002.
[243] NASA, "STS-111 (110)," *http://science.ksc.nasa.gov/shuttle/missions/sts-111/mission-sts-111.html* (accessed 17 August 2008); NASA, "STS-111: A New Crew for the International Space Station," *http://spaceflight.nasa.gov/shuttle/archives/sts-111/* (accessed 17 August 2008).

NASA announced the release of the first test images from the HST's recently reactivated Near-Infrared Camera and Multi-Object Spectrometer (NICMOS). The test images of galaxies in various stages of development included the NGC 4013 and the Cone Nebula galaxies. The NICMOS had remained inactive for three years, until the crew members of Space Shuttle *Columbia* STS-109 had installed a new cooling system for the instrument on 3 March 2002 as part of HST Servicing Mission 3B. The new NICMOS Cooling System (NCS) had been a joint project of NASA and the U.S. Air Force; NASA's GSFC and the Creare Corporation had built the NCS.[244]

10 June

NASA announced the selection of the instrument and science teams that would provide instruments for NASA's Next Generation Space Telescope (NGST), the intended successor of the HST. The team selected to provide the primary near-infrared science camera comprised engineers and scientists from the project team's leader, the University of Arizona at Tucson, as well as from Lockheed Martin Advanced Technology Center, EMS Technologies of Canada, and COM DEV Limited, also of Canada. The team selected to build the NGST's mid-infrared instrument included engineers and scientists from NASA's JPL, NASA's Ames Research Center (ARC), ESA, the University of Illinois at Urbana-Champaign, and the University of Arizona at Tucson. In addition to the principal instrument scientists, NASA had selected scientists to serve on the NGST Science Working Group, including Heidi B. Hammel, Simon Lilly, Jonathan Lunine, Mark McCaughrean, Massimo Stiavelli, and Rogier Windhorst.[245]

12 June

NASA announced the extension of its existing six-year contract with Lockheed Martin Space Systems to build 35 super-lightweight external tanks for the Space Shuttle program. The modified agreement extended the contract to September 2008, adding US$341 million to the original contract of US$1.15 billion, which NASA had awarded to Lockheed Martin in October 2000. Under the contract, Lockheed Martin would construct, test, and deliver the tanks; maintain and operate NASA's Michoud Assembly Facility in New Orleans; and provide services at NASA's KSC and its MSFC. Furthermore, under the terms of the extension, Lockheed Martin agreed to provide at least six tanks per year, instead of the eight tanks per year stipulated in the original agreement. [246]

13 June

Scientists announced the discovery of a planetary system with architecture similar to Earth's solar system, including multiple planets revolving around a parent star, at great distances and in nearly circular orbits. The discovery, the first confirmation that other planetary systems had evolved much like Earth's solar system, also raised the possibility of the existence of other Earth-like planets in the universe. The scientists who had spearheaded the research effort—Geoffrey W. Marcy of the University of California at Berkeley and R. Paul Butler of the

[244] NASA, "Hubble's Infrared Camera Is Back in Business—New Images Released," news release 02-104, 5 June 2002; NASA, "SM3B," *http://hubble.nasa.gov/missions/sm3b.php* (accessed 17 August 2008).
[245] NASA, "NASA Selects Instruments and Science Team for Next Generation Space Telescope," news release 02-109, 10 June 2002.
[246] NASA, "NASA Extends Shuttle External Tank Contract with Lockheed Martin to September 2008," news release c02-m, 12 June 2002.

Carnegie Institute of Washington—announced the discovery of a planet nearly the size of Jupiter, orbiting a star at approximately the same distance as that of Jupiter from the Sun. Just as significantly, the astronomers reported that the planet was orbiting its parent star at a distance relatively farther than that of most planets previously observed. In addition, they had found that the newly discovered planet has a circular orbit like Jupiter, whereas most other planets observed had elongated, eccentric orbits. The planet was the second discovered orbiting the star 55 Cancri. The scientists explained that, although the planetary system they had observed was not directly analogous to Earth's solar system, its discovery signaled that they were closer to finding a system similar to that of Earth.[247]

Two astronauts from Space Shuttle *Endeavour* undertook an extravehicular activity (EVA) to repair the ISS's robotic arm, Canadarm2. American astronaut Franklin R. Chang-Diaz and French astronaut Philippe Perrin replaced one of seven joints on the US$600 million, Canadian-built robotic arm, which was critical to the continued construction of the ISS. To repair Canadarm2, the astronauts first removed its 450-pound (205-kilogram), hand-like, latching-end effector (LEE); loosened six bolts connecting the problematic "wrist roll" joint to the arm; and disconnected power, data, and video lines. They then installed the replacement joint, tightened the bolts to secure the new joint to the arm, restored the power and other lines, and reaffixed the LEE. Subsequent tests of the Canadarm2 confirmed the success of the repairs. The EVA, lasting 7 hours and 17 minutes, was the third for Mission STS-111.[248]

15 June

NASA Administrator Sean O'Keefe named Jeremiah F. Creedon, Director of NASA's LaRC, as the new Associate Administrator for the Office of Aerospace Technology at NASA Headquarters. Creedon had begun working at LaRC in June 1963 as an engineer, eventually succeeding Paul F. Holloway to become LaRC's seventh director. Delma C. Freeman Jr., LaRC's Deputy Director, became its Acting Director.[249]

19 June

Space Shuttle *Endeavour* landed at Edwards Air Force Base in California at 2:58 p.m. (EDT), ending a mission of 13 days, 20 hours, and 35 minutes. During STS-111, the crew had used the ISS's robotic arm, Canadarm2, to move the MBS from *Endeavour* to the Mobile Transporter (MT) on the ISS's *Destiny* laboratory module. In addition, crew members Franklin R. Chang-Diaz and Philippe Perrin had performed three EVAs lasting a total of 19 hours and 31 minutes. During the first EVA, the astronauts had installed a Power and Data Grapple Fixture to the ISS's P6 Truss, the sixth truss segment on the port side of the ISS's Integrated Truss Structure, and moved six micrometeoroid debris shields from the Shuttle to a portion of the ISS called the PMA-1 (Pressurized Mating Adapter-One) for eventual installation on the Russian-made *Zvezda* service module. During the second spacewalk, the crew had connected data, power, and video cables between the MT rail car and the MBS; positioned the Payload Orbital Replacement Unit

[247] NASA, "Newfound Planetary System Has 'Hometown' Look," news release 02-111, 13 June 2002.
[248] William Harwood, "Spacewalkers Continue Space Station Repairs; Joint on Robotic Arm Is Replaced," *Washington Post*, 14 June 2002; NASA JSC, "STS-111, Mission Control Center Status Report no. 18," 13 June 2002, *http://spaceflight.nasa.gov/spacenews/reports/sts111/STS-111-18.html* (accessed 18 August 2008).
[249] NASA LaRC, "NASA Administrator Names Langley Director Associate Administrator of Aerospace Technology," news release 02-037, 14 May 2002; NASA History Division, "NASA Center Directors," *http://www.hq.nasa.gov/office/pao/History/director.html* (accessed 18 August 2008).

Accommodation (POA) on the MBS; and completed the installation of the MBS platform. In the final EVA, Chang-Diaz and Perrin had performed repairs on the ISS's Canadarm2, restoring the instrument to full operational status. In addition, STS-111 had returned the members of Expedition 4—Daniel E. Bursch, Yuri I. Onufrienko, and Carl W. Walz—to Earth.[250]

24 June
NOAA's Polar Orbiting Environmental Satellite (POES), NOAA-M, launched on a Titan 2 rocket from Vandenberg Air Force Base in California. NOAA intended the satellite, which was renamed NOAA-17 upon reaching orbit, to collect meteorological data to improve weather forecasting. The satellite was the third in a series of five satellites collectively referred to as the POES system. NOAA planned to transmit the satellite's data to its National Weather Service, as well as to organizations in other countries. Lockheed Martin Space Systems had built and launched the satellite for NOAA, with NASA's GSFC managing the project and providing technical guidance.[251]

25 June
NASA announced that it had grounded all four Space Shuttles because of newly discovered mechanical problems, postponing indefinitely the launch of Space Shuttle *Columbia*. Previously, NASA had scheduled *Columbia*'s launch for 19 July 2002. According to NASA officials, engineers had found small fissures in metal liners within the fuel pipes of the main engines of Shuttles *Atlantis* and *Discovery*. If left unrepaired, the cracks could cause pieces of the liners to break off, possibly damaging a Shuttle's engine while in flight.[252]

27 June
NASA's Office of Space Science announced that it had selected one team to lead the development of an advanced ion-propulsion system and another to develop advanced ion optics. The Office of Space Science had selected NASA's GRC to develop the NASA Evolutionary Xenon Thruster (NEXT) system, which would use xenon gas and electrical power to drive spacecraft. NASA intended the NEXT system as an alternative to conventional chemical propulsion systems. Furthermore, NASA had selected Boeing Electron Dynamic Devices to lead the development, fabrication, and testing of carbon-based ion optics, important components of ion engines, which, historically, had possessed limited thruster lifetimes.[253]

28 June
President George W. Bush signed National Security Presidential Directive-15 (NSPD-15), initiating a review of all U.S. space policies. According to NSPD-15, the review's purpose was

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[250] NASA, "Space Shuttle Mission Archives: STS-111," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-111.html* (accessed 18 August 2008); NASA, "Continuing the Human Presence in Space: STS-111," press kit, 16 May 2001, 24–29, *http://www.jsc.nasa.gov/history/shuttle_pk/ pk/Flight_110_STS-111_Press_Kit.pdf* (accessed 2 January 2009).
[251] NASA, *Aeronautics and Space Report of the President: Fiscal Year 2002*, p. 46; NOAA, "NOAA-M Environmental Satellite Successfully Launched," 24 June 2002, *http://www.noaanews.noaa.gov/stories/s929.htm* (accessed 18 August 2008); NOAA, "Polar Operation Environmental Satellite: Polar Orbiting Satellites," *http://www.oso.noaa.gov/poes/* (accessed 18 August 2008).
[252] Warren E. Leary, "Shuttle Fleet Is Grounded To Fix Cracks," *New York Times*, 26 June 2002.
[253] NASA, "NASA Selects Teams To Lead Development of Next-Generation Ion Engine and Advanced Technology," news release 02-118, 27 June 2002.

to update the country's National Space Policy—last revised in 1996—to better address domestic and international developments affecting the nation's space capabilities. The review provided recommendations in three specific areas: commercial remote sensing and foreign access to remote-sensing space capabilities; space transportation policy; and existing national policy statements related to space activities. The National Security Council (NSC) was to chair the review with support from the Office of Science and Technology Policy. In addition, the NSC had established the Space Policy Coordinating Committee (Space PCC), which would include representatives from federal agencies with roles in the formation of U.S. space policy, such as the International Trade Administration and NOAA.[254]

JULY 2002

1 July

NASA announced the extension of its existing contract with ATK Thiokol Propulsion for the production and refurbishment of reusable solid rocket motors (RSRM) for the Space Shuttle program. Shuttle launches required two RSRMs and three main engines to provide sufficient thrust for the Shuttle to attain orbit. Under the modified agreement, ATK Thiokol would produce and refurbish 70 RSRMs and three flight-support motors. The US$429 million modification extended to May 2007 the original US$2.4 billion contract, which NASA and ATK Thiokol had agreed on in October 1998. The original contract had been the sixth agreement between ATK Thiokol Propulsion and NASA's MSFC in Huntsville, Alabama.[255]

The FAA announced a major operational enhancement to its Automatic Dependent Surveillance Broadcast (ADS-B), a surveillance technology enabling aircraft pilots and air flight controllers to share a common picture of airspace and air traffic. The FAA announced that it had selected new surveillance data links for the ADS-B, including a Universal Access Transceiver link for general aviation users and a 1,090 megahertz Extended Squitter ADS-B link for air carriers and for both commercial and private aviation operators. The FAA's selection of these data links was part of an effort to coordinate ADS-B operations between the United States and Europe.[256]

3 July

NASA launched Comet Nucleus Tour (CONTOUR) on a Delta 2 rocket from Cape Canaveral Air Station in Florida. NASA scientists had created CONTOUR—scheduled to make close approaches to comets Encke, Schwassmann-Wachmann-3, and d'Arrest—to analyze the composition of comets. Engineers had designed the spacecraft to capture 4-meter-resolution (13-foot-resolution) images of the comets' nuclei during its encounters and to perform spectral mapping of the nuclei at resolutions of 100 to 200 meters (328 to 656 feet). Astronomers planned to supplement the data obtained through CONTOUR's observations with data captured by Earth-

[254] NASA, *Aeronautics and Space Report of the President: Fiscal Year 2002*, p. 43; U.S. National Security Professional Development Integration Office, "National Space Policy Review: Fact Sheet" (report, National Security Presidential Directive/NSPD-15, Arlington, VA, 2002), *http://www.nspd.gov/rawmedia_repository/4ff02489171c66d9a66ae29824384025.pdf* (accessed 18 August 2008).
[255] NASA, "NASA Extends Reusable Solid Rocket Motor Contract with ATK Thiokol Through May 2007," news release c02-q, 1 July 2002.
[256] FAA, "FAA Announces Automatic Dependent Surveillance-Broadcast Architecture," news release APA 27-02, 1 July 2002.

based or Earth-orbital telescopes. In addition, NASA planned for CONTOUR to collect data on gas and dust from the environment near the comets' nuclei.[257]

9 July

NASA announced the selection of two proposals for space missions for its Earth System Science Pathfinder small-satellite program, developed to research Earth's carbon cycle and the relationship of climate change and oceans. Specifically, the selected proposals would support the Orbiting Carbon Observatory (OCO), which would provide global measurements of carbon dioxide in the atmosphere, and the Aquarius mission, which would map salt concentrations on oceans' surfaces to learn how they affect ocean circulation and global heat redistribution. NASA planned to provide up to US$175 million for each of the two proposals selected for the program. NASA appointed David Crisp of JPL as Principal Investigator for the OCO mission and Chester J. "Chet" Koblinsky of GSFC as Principal Investigator for the Aquarius mission. NASA had numerous university, corporate, and international collaborators for both missions, including the Argentine Space Program, a significant partner in the Aquarius mission.[258]

ESA reported research indicating that the universe might be older than scientists had previously estimated and that a common method of estimating the age of celestial bodies might be incorrect. A group of scientists had analyzed the XMM-Newton satellite's x-ray observations of the distant but exceptionally luminous quasar APM 08279+5255 and found that the quasar contains three times more iron than the Sun. Because exploding stars release iron, which increases across the universe over time, the scientists had expected APM 08279+5255 to have less iron than Earth's relatively older solar system. The scientists noted that the surprising quantity of iron in the distant quasar could be the result of an unknown phenomenon that produces iron very efficiently. However, they suggested that the more likely explanation for the finding was that the conventional method of measuring the age of celestial objects by estimating the objects' redshift—a property of the light emitted by such objects—was flawed.[259]

Data from NASA's Quick Scatterometer (QuikSCAT) satellite provided support for a decades-old, unproven theory that winds converge in two large areas near Earth's equator, driving ocean circulation south of the equator. The two areas, known as the northern and southern portions of the Intertropical Convergence Zone, are part of a belt circling Earth near the equator, where trade winds of both the northern and southern hemispheres converge. The region affects north-south atmospheric circulation, significantly influencing precipitation and temperatures in many regions of the globe. Previously, researchers had identified the double Intertropical Convergence Zone as a limited seasonal phenomenon. However, since 1969 the zone's existence, location, and seasonality had remained controversial. The QuikSCAT data confirmed, not only that the double Intertropical Convergence Zone exists all year long, but also that it is more extensive than scientists had suspected. The finding provided important information about how Earth's

[257] NASA, *Aeronautics and Space Report of the President: Fiscal Year 2002*, p. 116; NASA Science Mission Directorate, "Missions: CONTOUR," *http://nasascience.nasa.gov/missions/contour* (accessed 22 August 2008).
[258] NASA, "Pathfinder Missions To Enhance Our Understanding of Earth," news release 02-121, 9 July 2002.
[259] ESA, "Is the Universe Older Than Expected?" ESA news release, 10 July 2002; Günther Hasinger, Norbert Schartel, and Stefanie Komossa, "Discovery of an Ionized Fe K Edge in the z=3.91 Broad Absorption Line Quasar APM 08279+5255 with *XMM-Newton*," *Astrophysical Journal Letters* 573, no. 2 (10 July 2002): L77–L80.

atmosphere and oceans interact near the equator, data that could assist scientists in climate modeling and weather forecasting.[260]

10 July
The Research Maximization and Prioritization Task Force (ReMAP) presented the executive summary of its external review to the NASA Advisory Council. NASA Administrator Sean O'Keefe had created ReMAP in March 2002 to recommend strategies that NASA's Office of Biological and Physical Research (OBPR) could use to achieve its research goals within budgetary limits. Among its recommendations, ReMAP suggested that the ISS include a chief science officer on board, and that NASA increase the ISS's equipment, the ISS crew's work time, and the frequency of Shuttle flights, to enable the crew to conduct first-rate research aboard the station.[261]

11 July
NASA signed an agreement with the National Imagery and Mapping Agency (NIMA) to provide researchers with mapping data collected during the Shuttle Radar Topography Mission (SRTM) in 2000. Specifically, the two agencies agreed to provide 90-meter-resolution (295-foot-resolution), digital-elevation-model (DEM) data for areas outside of the United States and 30-meter-resolution (98-foot-resolution) data for the continental United States. According to the agreement, only qualified researchers would have access to the DEM data, although the public would have access to certain selected data. NASA's JPL would process the 90-meter-resolution (295-foot-resolution) data into DEM data, and NIMA would provide additional finishing before sending it to the USGS's Earth Resources Observation Systems Data Center for archiving and distribution. In addition, NASA and NIMA would process requests for the data. With regard to the 30-meter-resolution (98-foot-resolution) data, the two agencies agreed that NASA would have access to the data for scientific research, and that NIMA, at its discretion, would make the data available to other agencies.[262]

13 July
NASA announced that it would keep all four Space Shuttles grounded until at least September 2002 because of potentially dangerous fractures discovered in the fuel lines of all four Shuttles. NASA officials also reported that engineers now considered the cracks less of a safety concern than they had feared when NASA first discovered them in June 2002.[263]

17 July
The GAO submitted a report to Congress examining the reasons for the increasing costs of the ISS and the potential effects of those costs on the station's ability to conduct scientific research. The report stated that changes in the program, scheduling delays, and other issues had

[260] NASA JPL, "Satellite Sees Double Zone of Converging Tropical Winds Around the World," news release, 9 July 2002; W. T. Liu and X. Xie, "Double Intertropical Convergence Zones—A New Look Using Scatterometer," *Geophysical Research Letters* 29, no. 22 (30 November 2002): 2072.
[261] NASA, "ReMaP Task Force Recognized by NASA Administrator and NASA Advisory Council Chair," news release 02-123, 10 July 2002; Warren E. Leary, "Panel Asserts Reduced Space Station Plans Will Limit Scientific Work," *New York Times*, 11 July 2002.
[262] NASA, "Seeing Clearly Now: Sharp New NASA Maps To Improve Lives Everywhere," news release 02-122, 11 July 2002.
[263] William Harwood, "NASA Grounds Space Shuttle Fleet over Fuel Line Cracks," *Washington Post*, 13 July 2002.

substantially increased the program's costs, and that NASA's management had not taken steps to address cost growth. Consequently, the ISS's scientific research capabilities had diminished, raising concerns among the station's international partners. Although GAO made no formal recommendations, it cited NASA's own newly established management and cost-estimation reforms, noted challenges NASA faced in implementing those reforms, and suggested that NASA develop a credible budget to complete the ISS. NASA formally responded that the report reasonably portrayed the problems with the ISS, as well as NASA's efforts to address them.[264]

18 July

The House Science Subcommittee on Space and Aeronautics held a hearing—*NASA Workforce and Management Challenges*—to garner information about NASA's efforts to address concerns regarding its human capital, competitive sourcing for the Space Shuttle program, and other matters. Committee members heard testimony from NASA Administrator Sean O'Keefe; David M. Walker, Comptroller General of the United States; and Mark D. Roth, General Counsel of the American Federation of Government Employees. O'Keefe discussed NASA's Strategic Human Capital Plan, a systemic method of managing human capital according to NASA's vision and mission. In addition, O'Keefe announced the termination of the comprehensive Strategic Resources Review initiated during the Clinton administration to create a blueprint for NASA's future facility, missions, and workforce requirements. Roth argued that, because NASA expected a high number of retirements in the near future, its existing and proposed personnel policies were inadequate to address the resulting loss in human capital. Walker discussed methods NASA could use to strengthen its human capital and to address its difficulties with contract management, as well as the increasing expense of the ISS program and of space exploration.[265]

20 July

NASA officials announced the delay of the launch of Space Shuttle *Endeavour* STS-113, scheduled for 21 July. Engineers had discovered fuel-line cracks, the same problem that had previously led NASA to ground some Space Shuttles. At the time of the announcement, NASA officials remained uncertain of the new date of *Endeavour*'s launch, suggesting that, although the Shuttle would be ready to fly by September 2002, NASA might delay the launch until at least the end of 2002.[266]

22 July

The FBI and NASA's Office of Inspector General (OIG) announced the arrest of three students employed at NASA's JSC. The FBI had charged the students with the theft of lunar and meteorite samples. According to the FBI, the three student employees and another man had

[264] U.S. General Accounting Office, "Space Station: Actions Under Way To Manage Cost, But Significant Challenges Remain" (report no. GAO-02-735, Washington, DC, 17 July 2002), *www.gao.gov/cgi-bin/getrpt?GAO-02-735* (accessed 26 September 2008).
[265] U.S. Congress, House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, *NASA Workforce and Management Challenges*, 107th Cong., 2nd sess., 18 July 2002, *http://science.house.gov/publications/hearings_markups_details.aspx?NewsID=1424* (accessed 21 August 2008 through Lexis-Nexis Congressional); Larry Wheeler, "O'Keefe Scraps Review of NASA," *Florida Today* (Brevard, FL), 19 July 2002.
[266] Warren E. Leary, "Delay Likely for Shuttle Mission with Israeli," *New York Times*, 20 July 2002.

stolen a safe containing the samples and had attempted to sell the specimens. JSC had notified the FBI and NASA's OIG of the possible theft on 15 July.[267]

26 July
NASA announced that Donald R. Pettit, a backup member of the crew of the Expedition 6 Mission to the ISS, would replace Donald A. Thomas on the mission. NASA had reassigned Thomas, a veteran of four Space Shuttle flights, because of medical issues affecting his qualification for long-duration spaceflight. Pettit, a chemical engineer who had joined the astronaut corps in 1996, had previously served as a staff scientist at Los Alamos National Laboratory in New Mexico.[268]

AUGUST 2002

1 August
The U.S. Senate confirmed Frederick D. Gregory as NASA's Deputy Administrator, making Gregory the first African American to serve as NASA's second-in-command. Before becoming Deputy Administrator, Gregory had served as NASA's Associate Administrator for Space Flight from December 2001 to August 2002 and as Associate Administrator for the Office of Safety and Mission Assurance from June 1992 to December 2001. In addition, Gregory had been an astronaut on three Shuttle missions and had served in the U.S. Air Force for 30 years.[269]

Analyzing observations of the dwarf galaxy NGC 1569, a group of astronomers led by Crystal L. Martin of the University of California Santa Barbara found the first evidence that such galaxies produce most of the heavy elements in the universe. Heavy elements, defined as all elements other than hydrogen and helium, are essential for planet formation and can strongly influence astronomical phenomena such as the rate of galaxy formation. Scientists had theorized that, during the early development of the universe, heavy elements emanating from dwarf galaxies played a dominant role in enriching the intergalactic gas that formed other galaxies. Data from NASA's Chandra X-ray Observatory enabled Martin and her team to test this idea. They found that NGC 1569 emitted large quantities of heavy elements in extremely hot x-ray winds, the first direct evidence of metal-enriched winds from dwarf galaxies. The researchers noted that the findings left open the question of whether or not dwarf galaxies or other galaxies dominate the intergalactic metallic enrichment process.[270]

2 August
NASA scientists published research challenging prominent theories about the growth of the gravitational field at Earth's equator, a phenomenon that began in 1998. Researchers had suggested that atmospheric change, or the melting of glaciers and polar ice, had caused a

[267] NASA, "NASA Cooperating in Investigation of Theft," news release 02-133, 22 July 2002; *Los Angeles Times*, "4 Charged in Theft of NASA Moon Rocks," 23 July 2002.
[268] NASA, "Backup Crew Member Assigned to Expedition Six," news release 02-139, 26 July 2002.
[269] Kelly Young, "Senate Names New NASA Official," *Florida Today* (Brevard, FL), 3 August 2002; NASA, "NASA Deputy Administrator Frederick D. Gregory," *http://www.nasa.gov/about/ highlights/gregory_bio.html* (accessed 26 September 2008).
[270] NASA, "Dwarf Galaxies Give Universe a Breath of Fresh Oxygen," news release 02-134, 23 July 2002; Crystal L. Martin, Henry A. Kobulnicky, and Timothy M. Heckman, "The Metal Content of Dwarf Starburst Winds: Results from *Chandra* Observations of NGC 1569," *Astrophysical Journal* 574, no. 2 (1 August 2002): 663–692.

geographic shift in the planet's gravitational field, with a decline in upper latitudes and a corresponding increase in lower latitudes. However, NASA scientists Christopher M. Cox and Benjamin F. Chao discovered that the quantity, rate, and timing of atmospheric change and ice melt did not correspond to the magnitude and rate of gravitational shift. Based on their analysis of data that 10 satellites had acquired between 1979 and 2002, Cox and Chao found a more probable explanation of this phenomenon. The data suggested that the oceans had been rapidly transporting substantial quantities of water and ice from higher to lower latitudes, thereby shifting Earth's mass and causing a corresponding alteration in the planet's gravitational field from the higher to the lower latitudes. The scientists noted, however, that additional data and analysis were necessary to determine whether their interpretation of the data was correct.[271]

5 August

Lockheed Martin, NASA, and the state of Mississippi opened the Lockheed Martin Mississippi Space and Technology Center at NASA's SSC. Officials planned for the 220,000-square-foot (20,440-square-meter) facility to commence operations by the end of 2002. Lockheed Martin announced that its new facility would include a center for production of propulsion and thermal systems for spacecraft, as well as an integrated metrology center. The company also announced that it would provide engineering and manufacturing services at the facility. Lockheed Martin officials cited the location of NASA's Center of Excellence for propulsion testing at SSC as a critical factor in their decision to consolidate the company's capabilities at the single facility.[272]

NASA announced that its Stardust spacecraft had begun collecting interstellar dust grains—extremely small particles of solid matter that permeate the Milky Way Galaxy, providing clues to the galaxy's formation and development. For use in comparative analyses, the spacecraft would collect both ancient dust grains, found in the interior of comets, and relatively young dust particles, produced by the current generation of stars. Stardust would encounter comet Wild 2 in early 2004. Project scientists, who planned to analyze the dust grains after the spacecraft's scheduled return to Earth in 2006, hoped that their study would yield evidence about the composition of the early galaxy and its subsequent evolutionary changes.[273]

15 August

NASA announced that it had lost contact with the US$159 million comet-exploring spacecraft Comet Nucleus Tour (CONTOUR), launched on 3 July 2002. Ground controllers had lost contact with CONTOUR after a scheduled ignition of its solid-propellant rocket engine, designed to propel the spacecraft out of Earth-orbiting space and into a heliocentric trajectory where it would eventually encounter comets Encke, Schwassmann-Wachmann, and d'Arrest. At the time

[271] NASA, "Satellites Reveal a Mystery of Large Change in Earth's Gravity Field," news release 02-147, 1 August 2002; Christopher M. Cox and Benjamin F. Chao, "Detection of Large-Scale Mass Redistribution in the Terrestrial System Since 1998," *Science* 297, no. 5582 (2 August 2002): 831–833.
[272] Lockheed Martin, "Lockheed Martin Mississippi Space and Technology Center Opens Doors at John C. Stennis Space Center, MS," news release, 5 August 2002, *http://www.lockheedmartin.com/news/press_releases/2002/LockheedMartinMississippiSpaceTechn.html* (accessed 28 January 2010).
[273] NASA JPL, "Stardust Spacecraft Reaches for Cosmic Dust," news release, 6 August 2002.

of its scheduled ignition, the spacecraft was orbiting Earth approximately 140 miles (225 kilometers) above the Indian Ocean.[274]

Boeing and the U.S. Air Force signed a US$9.7 billion contract for 60 C-17 Globemaster III transport aircraft. The contract, an extension of previous agreements between the Air Force and Boeing, would increase the number of C-17s in the Air Force fleet to 180. The Air Force had been using C-17s to transport personnel, equipment, and supplies in support of combat and humanitarian missions.[275]

ESA announced that an international group of astronauts would attend a training session at the European Astronaut Centre in Cologne, Germany, to prepare for missions to the ISS. The specific objective of the training was to prepare the astronauts for the tasks they would need to accomplish when a Japanese experiment module and ESA's *Columbus* laboratory docked with the ISS. Upon completing the training, the international ISS partners planned to assign the astronauts to specific, long-duration ISS missions. The training session, scheduled to last from 26 August to 6 September, would include ESA astronauts Pedro Duque, Léopold Eyharts, Paolo A. Nespoli, and Thomas Reiter; Japan's NASDA astronauts Takao Doi, Satoshi Furukawa, Aikihiko Hoshide, and Koichi Wakata; and NASA astronauts Nicole Passonno Stott and Stephanie D. Wilson.[276]

20 August

NASA's Voyager 2 spacecraft completed its 25th year of operation. As the probe reached its anniversary, Voyager 2 was 6.3 billion miles (10 billion kilometers) from the Sun and moving toward the edge of the solar system at more than 35,000 miles per hour (56,000 kilometers per hour). Since its launch on 20 August 1977, Voyager 2 had provided photographs of planets Jupiter, Saturn, Uranus, Neptune, and their respective moons, as well as other data. At 25 years old, the spacecraft continued to send data to Earth. Scientists estimated that Voyager 2 could reach the boundary of the solar system in another seven to 21 years. However, they also expected that, by 2020, the spacecraft might not have sufficient power to maintain contact with Earth.[277]

21 August

The first Evolved Expendable Launch Vehicle (EELV), the product of a long-term program designed to provide military and other satellites with enduring, reliable access to space, launched from Cape Canaveral Air Force Station in Florida. Lockheed Martin had developed the rocket, called the Atlas 5. The EELV placed the European television satellite Hot Bird 6 in its preliminary orbit 31 minutes after its launch, and the satellite's thrusters later maneuvered it into its final orbit. The EELV program had resulted from the U.S. government's research into the 1986 *Challenge*r disaster. The U.S. Air Force had reportedly paid Lockheed Martin and the Boeing Company more than US$500 million each to design an EELV. The U.S. Air Force had

[274] Warren E. Leary, "Comet-Exploring Spacecraft Has Disappeared, NASA Says," *New York Times*, 16 August 2002; NASA National Space Science Data Center, "CONTOUR," *http://nssdc.gsfc.nasa.gov/nmc/masterCatalog.do?sc=2002-034A* (accessed 26 September 2008).
[275] The Boeing Company, "Boeing and U.S. Air Force Sign $9.7 Billion C-17 Contract," news release, 15 August 2002, *http://www.boeing.com/news/releases/2002/q3/nr_020815m.html* (accessed 2 February 2010).
[276] ESA, "Ten Astronauts Train in Europe for the International Space Station," ESA news release 56-2002, 19 August 2002.
[277] William Harwood, "Voyager Celebrates 25 Years of Space Discovery," *Washington Post*, 19 August 2002.

requested an EELV that was an advanced version of existing rockets, rather than an entirely new system, estimating that, through 2020, the EELV could reduce the cost of placing military satellites into orbit by approximately US$10 billion. France-based Eutelsat (European Telecommunications Satellite Organization) owned the Hot Bird 6 broadcast satellite, which Alcatel Space had built.[278]

A team of NASA scientists using uninhabited aerial vehicles (UAVs) to research electrical storms achieved a flight-duration milestone. The research was part of the Altus Cumulus Electrification Study (ACES), a project that examined the causes of electrical storms and their effects on the planet. The ACES research team employed Altus II UAVs to study thunderstorms over Florida, capping off four weeks of research flights with the study's longest flight, lasting for 6 hours and 32 minutes and monitoring four successive thunderstorms. General Atomics Aeronautical Systems had built the Altus II, which could fly near thunderstorms for hours, at altitudes of up to 65,000 feet.[279]

25 August
William W. Parsons Jr. replaced Roy S. Estess as Director of SSC. Parsons had joined NASA in 1990 as a Launch Site Support Manager at NASA's KSC, later serving in various positions at NASA's KSC, SSC, and JSC. Estess had come to SSC in 1966 as a test engineer and had served as the Center's Director from 1989 to 2002.[280]

29 August
NASA's KSC awarded the Boeing Company the checkout, assembly, and payload-processing services (CAPPS) contract for the Space Shuttle and the EELV. The CAPPS contract had a four-year base period of performance valued at US$332 million. In addition, the contract had two three-year extension options, which could increase the contract's total value to US$810 million. Under the contract, Boeing would perform payload-processing tasks, such as ensuring that payloads were compatible with launch vehicles and loading payloads into launch vehicles. Boeing had also held KSC's previous payload-processing agreement, called the payload ground-operations contract.[281]

30 August
NASA scientists Eric J. Rignot and Robert H. Thomas published results of one of the most detailed and widespread examinations of polar ice sheets ever performed. Researchers had already determined that changes in the thickness of polar ice correlated with changes in sea level

[278] William Harwood, "Into Space, A New Kind of Rocket," *Washington Post*, 22 August 2002; Lockheed Martin, "Inaugural Atlas V Scores Success for ILS, Lockheed Martin," news release, 21 August 2002, *http://www.lockheedmartin.com/news/press_releases/2002/InauguralAtlasVScoresSucceslForILSL.html* (accessed 28 January 2010).
[279] NASA MSFC, National Space Science and Technology Center, "NASA Lightning Study Achieves Flight-Duration Milestone, Monitoring Four Storms in Single Mission," news release N02-011, 23 August 2002.
[280] NASA, "NASA Center Directors," *http://www.hq.nasa.gov/office/pao/History/director.html* (accessed 26 September 2008); NASA SSC, "William (Bill) W. Parsons Jr. Director, 2002–2003," *http://www.ssc.nasa.gov/about/history/personalities/parsons.html* (accessed 26 September 2008); NASA SSC, "Roy S. Estess, Director, 1989–2002," *http://www.ssc.nasa.gov/about/ history/personalities/estess.html* (accessed 26 September 2008).
[281] The Boeing Company, "Boeing Wins Major Space Payload Processing Contract," news release, 29 August 2002.

but disagreed about the extent to which the thickness of the ice sheets was changing. Analyzing recent remote-sensing measurements of ice sheets in Greenland and Antarctica, Rignot and Thomas discovered that the thickness of the ice sheets was changing more rapidly than previously thought. Although the data was indeterminate concerning changes in some parts of the ice sheets, Rignot and Thomas found clear evidence that large regions of the polar ice sheets were rapidly changing, with accumulation of ice in some areas and attrition in others. Despite such variations, the scientists found that, overall, the major polar ice sheets were losing mass. Specifically, Greenland's ice sheet was losing 50 cubic kilometers (12 cubic miles) of mass annually, and the West Antarctic ice sheet appeared to be losing nearly 48 cubic kilometers (11.5 cubic miles) of mass per year.[282]

The ReMAP Task Force of NASA's Office of Biological and Physical Research (OBPR) presented its final report to the NASA Advisory Council. NASA had charged the ReMAP Task Force with evaluating the research productivity and priorities of NASA's OBPR and with providing a framework for prioritizing a research program for the OBPR and the ISS. ReMAP's 173-page report identified two major goals of these programs: research enabling human exploration of space and basic research of intrinsic scientific interest. In addition, the report made several recommendations, for example, that NASA increase the ISS's facilities and equipment for scientific research, as well as the amount of time that ISS crew members dedicated to scientific operations. The report stated that, if NASA did not make these and other enhancements to the ISS, then NASA "should cease to characterize the ISS as a science driven program."[283]

SEPTEMBER 2002

3 September
The Defense Advanced Research Projects Agency awarded the Boeing Company a contract to design a fuel cell–based propulsion system for a pilotless, ultra-long-endurance UAV. According to Boeing, the UAV's propulsion system would incorporate existing automotive–fuel cell technology, to create a vehicle with a variety of commercial and military applications.[284]

9 September
The FAA announced plans to establish public use of a new method of air navigation that would significantly increase the capacity and efficiency of airways in the United States. The Required Navigation Performance (RNP) method would rely upon aircraft's use of advanced, automated guidance technologies, both in terminal areas and en route. Specifically, RNP would incorporate advanced technologies in areas within a 40-mile (64-kilometer) radius of an airport, as well as in high-altitude areas. The use of RNP would have several potential benefits, including precise approach and departure paths at airports, accurate vertical and lateral guidance, and increased airspace capacity. In the United States, Alaska Airlines had pioneered the use of RNP in air

[282] NASA JPL, "NASA Study Finds Rapid Changes in Earth's Polar Ice Sheets," news release, 30 August 2002; Eric Rignot and Robert H. Thomas, "Mass Balance of Polar Ice Sheets," *Science* 297, no. 5586 (30 August 2002): 1502–1506.
[283] NASA ReMAP Task Force, "Report by the NASA Biological and Physical Research Maximization and Prioritization (ReMAP) Task Force to the NASA Advisory Council" (report, Washington, DC, August 2002).
[284] The Boeing Company, "Boeing Receives Contract for UAV Advanced Propulsion System," news release, 3 September 2002, *http://www.boeing.com/news/releases/2002/q3/nr_020903m.html* (accessed 2 February 2010).

carrier operations. The FAA stated that it was committed to establishing public RNP airspace and procedures over the United States.[285]

The Russian Space Agency notified NASA that it had abandoned its plan to transport singer Lance Bass of the popular music group 'N Sync to the ISS. Television producers had intended to sponsor Bass, featuring him in a television documentary about his trip to the ISS. However, the sponsors had failed to raise the estimated US$20 million needed to cover the singer's fare. Therefore, Russian officials had decided to withdraw Bass as a member of the *Soyuz* crew scheduled to leave for the ISS on 28 October 2002. If the 23-year-old Bass had gone on the *Soyuz* mission, he would have become the youngest person ever to travel in space, as well as the third space tourist.[286]

10 September

NASA announced the appointment of two senior managers as part of its new approach to program management. James W. Kennedy, Deputy Center Director of NASA's MSFC, became Deputy Center Director of NASA's KSC, and David A. King, Director of Shuttle Processing at KSC, assumed the post of Deputy Center Director of MSFC. The appointments were the result of Administrator Sean O'Keefe's "One NASA" approach, a method of program management emphasizing enhanced collaboration, communication, and coordination among NASA's facilities, to attain common goals. Deputy Center Directors Kennedy and King would share management responsibilities with the center directors of their respective facilities.[287]

NASA scientist Zdenek Sekanina published new findings challenging existing ideas about comets. Existing theory had posited that comets rarely break up and that, when they do, the fragmentation usually occurs in close proximity to the Sun. However, basing his research on the analysis of images taken by the Solar and Heliospheric Observatory (SOHO), operated jointly by NASA and ESA, Sekanina had discovered that comets fragment throughout their lifetimes, often at distances far from the Sun. Moreover, Sekanina had found that such fragmentation generally occurs in a somewhat orderly pattern, with a single comet fragmenting into clusters of smaller comets. Sekanina had analyzed a type of very small comet called a sungrazer and discovered that sungrazers are actually fragments of other comets that have broken apart during a previous encounter with the Sun. Moreover, he had found that sungrazers continue to break into pieces throughout their orbits around the Sun. Sekanina had also examined another type of comet—57P/du Toit-Neujmin-Delaporte, finding that this type of comet shows the same pattern of fragmenting into smaller comets as it moves farther from the Sun.[288]

NASA announced the selection of TRW Inc. to lead the team to build the HST's successor, a new space-based observatory planned to launch in 2010. NASA planned to call the new satellite

[285] FAA, "FAA To Establish New Air Navigation Concept Within a Year," news release APA 39-02, 9 September 2002.
[286] Marcia Dunn, "It's Official: Russia Faxes NASA To Confirm Bass off Space Flight," *Houston Chronicle*, 10 September 2002.
[287] NASA, "NASA Senior Official Appointments Emphasize 'One NASA' Management Approach," news release 02-172, 10 September 2002.
[288] NASA, "Comets Break Up Far and Near," news release 02-158, 5 September 2002; Zdenek Sekanina, "Runaway Fragmentation of Sungrazing Comets Observed with the *Solar and Heliospheric Observatory*," *Astrophysical Journal* 576, no. 2 (10 September 2002): 1085–1089.

the James Webb Space Telescope (JWST), in honor of former NASA Administrator James E. Webb. Under the US$824.8 million contract, TRW and its partner organizations would build an observatory capable of viewing deeper into space than the HST. The telescope's main mirror would unfold to a diameter of at least 20 feet (6.1 meters), thereby providing six times more light-gathering area than the HST, which had an 8-foot (2.4-meter) primary mirror. The telescope would also have instruments highly sensitive to infrared light, which would help astronomers understand the universe's creation and evolution. In addition, NASA planned for the new telescope to orbit 940,000 miles (1.5 million kilometers) from Earth, within the second Lagrange point or L2, where a spacecraft maintains a balance between the gravity of the Sun and of Earth. Although the L2 orbit would be too far from Earth to allow astronauts to service the observatory, it would enable the observatory to cool to very low temperatures without the use of complex refrigeration equipment.[289]

12 September

The Indian Space Research Organisation (ISRO) announced its first successful launch of a satellite into a geosynchronous transfer orbit. ISRO launched METSAT, a meteorological satellite, from Satish Dhawan Space Center in Sriharikota, Andhra Pradesh, India, using it own rocket, the Polar Satellite Launch Vehicle (PSLV). The new version of the PSLV reflected a significant enhancement of the rocket's capabilities and a substantial improvement in ISRO's overall launch capabilities. Previous versions of the PSLV had been capable of placing 900-kilogram (2,000-pound) satellites in a 900-kilometer (560-mile), polar Sun–synchronous orbit, whereas the PSLV-C4 had placed the 1,055-kilogram (2,325-pound) METSAT in a highly elliptical orbit with an apogee (the farthest point from Earth) of 34,700 kilometers (21,600 miles).[290]

15 September

The China National Space Administration's (CNSA's) Kaituozhe 1 rocket failed during launch, for reasons that remained unclear. Kaituozhe 1 was the first of the CNSA's new all-solid-fuel, four-stage launch vehicles. CNSA and other Chinese government agencies apparently provided no information to the public about the event or about the reason the launch had failed.[291]

16 September

NASA Administrator Sean O'Keefe announced that Peggy A. Whitson would be NASA's first ISS Science Officer. In the future, NASA planned to assign one of its astronauts to the post for each ISS expedition crew. The objective of the assignment was to increase the ISS's emphasis on research. According to NASA, the ISS Science Officer would focus initially on U.S. research conducted on the ISS. As the station's research capabilities expanded in the future, NASA would discuss with the ISS's international partners the possibility of expanding the ISS Science Officer's role. NASA's ISS Science Officer would be responsible for working with the U.S. research community on the requirements and objectives of ISS experiments, acting as the point-of-contact between ISS crew and NASA-sponsored principal investigators, payload developers,

[289] NASA, "NASA Announces Contract for Next-Generation Space Telescope Named After Space Pioneer," news release 02-171, 10 September 2002.
[290] ISRO, "PSLV-C4 Launch Successful—Places METSAT in Orbit," news release, 12 September 2002, *http://www.isro.org/pressrelease/Sep13_2002.htm* (accessed 3 October 2008); Puttkamer, "Space Flight 2002."
[291] Puttkamer, "Space Flight 2002."

and other ISS stakeholders. As a crew member of Expedition 5 in June 2002, Whitson, who had a PhD in biochemistry, would become the first resident scientist on the ISS.[292]

17 September

Observations from the HST revealed the existence of medium-sized black holes. According to scientists, the discovery provided important information about the creation of many types of celestial bodies. Scientists were surprised to find that the black holes in the cores of globular star clusters—bright clusters of stars that orbit galaxies, including the Milky Way—are nearly 10,000 times less massive than galaxies. The HST data revealed that black holes in globular star clusters are proportionally smaller than massive black holes found in galaxies, demonstrating that the mass of a black hole is proportional to its stellar surroundings. The results also indicated that when the globular star clusters had formed they had black holes, suggesting that, to form large star clusters, black holes must act as gravitational anchors. Scientists believed these findings might illuminate the process by which galaxies and globular clusters formed. The discovery also suggested that black holes are more ubiquitous than scientists had previously thought.[293]

The GAO submitted a report to the House Science Subcommittee on Space and Aeronautics on NASA's progress toward developing a reusable launch vehicle (RLV), under the Space Launch Initiative (SLI) program, to replace the Space Shuttle. According to GAO, NASA needed to complete ongoing reassessment of its overall space transportation plans and of the future of the ISS. NASA also needed to determine whether it would develop the SLI program in cooperation with the DOD. To address these concerns, GAO recommended that NASA reassess the schedule for defining the SLI's requirements and reach a consensus with the DOD on the program's priorities and objectives. The report also recommended that NASA finalize the SLI's basic requirements before implementing management controls on the program's costs and risks. In its response, NASA concurred with GAO's recommendations and outlined plans to implement them.[294]

18 September

The National Research Council (NRC), the research arm of the National Academy of Sciences, released a report on the ISS, outlining NASA's efforts to limit cost overruns on the project. The report concluded that, if NASA proceeded with its plans to halt construction, once the ISS's core was complete, and to limit the station's crew, equipment, and other components, the ISS would be unlikely to become a first-class laboratory. NRC reported that capping the crew to three persons would have a highly detrimental impact on the quality of scientific research conducted on board the ISS, because a crew of such a small size would have to devote most of its time to station maintenance and operation. In addition, NRC stated that NASA had made its decision to cancel or delay equipment for experiments without assessing scientific priorities or determining which research plans the curtailments would affect most. NASA's official representative

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[292] NASA, "NASA Administrator Names Whitson First NASA ISS Science Officer," news release 02-175, 16 September 2002.

[293] NASA, "Hubble Discovers Black Holes in Unexpected Places," news release 02-174, 17 September 2002; William Harwood, "Finding May Connect Dots on How Galaxies Form; Mid-size Black Holes Are Discovered," *Washington Post*, 18 September 2002.

[294] U.S. General Accounting Office, "Space Transportation: Challenges Facing NASA's Space Launch Initiative" (report no. GAO-02-1020, Washington, DC, 17 September 2002), *http://www.gao.gov/ new.items/d021020.pdf* (accessed 10 October 2008).

responded that NASA was committed to building the ISS beyond the core-complete stage. Moreover, NASA intended to continue developing the ISS based on decisions concerning the station's scientific priorities and planned to take any steps necessary to achieve those goals—for example, increasing the size of the station's crew.[295]

19 September
G. Scott Hubbard replaced Henry McDonald as Director of NASA's ARC. Hubbard, ARC's Deputy Director of Research at the time of the appointment, had served in a number of management roles at the Center since the beginning of his career with NASA in 1987. In addition, he had helped establish NASA's Astrobiology Institute at ARC and had originated the Mars Pathfinder program. McDonald, who had served as Director of ARC from 1996 to 2002, had left the Center to become a professor of computational engineering at the University of Tennessee in Chattanooga.[296]

The General Services Administration (GSA) presented the Federal Aviation Award to the Aircraft Operations Division (AOD) of NASA's JSC. The AOD, which provided astronauts with spaceflight training, had an exemplary safety record. In addition, GSA gave Chief of AOD Robert J. Naughton an Honorable Mention for the Federal Aviation Professional Award. GSA's awards recognized effectiveness, efficiency, and safety in federal aviation operations, in the hope that honoring outstanding federal aviation programs and professionals would promote excellence in government aviation.[297]

23 September
NASA awarded Boeing Space and Communications Group a US$200 million contract to perform payload and mission operations for the ISS. The contract, formally known as the ISS payload-integration contract (IPIC), stipulated that Boeing perform payload engineering integration, mission integration, and payload operations at NASA's JSC and MSFC. Previously, Boeing had performed those operations under two separate contracts. The new IPIC contract covered operations until 30 September 2004, with an option to extend through 30 September 2005.[298]

26 September
NASA announced an agreement with the National Institute of Aerospace Associates (NIAA), an organization of universities and nonprofit organizations engaged in aerospace research, to create the National Institute of Aerospace (NIA) at NASA's LaRC. NASA described the agreement with NIAA as a long-term commitment to expand its collaboration with universities, industry, and other entities. The new NIA would host advanced aerospace and atmospheric research and the development of related technologies, offering graduate degrees in engineering and science, facilitating the growth of new business opportunities, and stimulating the commercialization of

[295] Warren E. Leary, "Cuts Lessen Space Station's Value to Science, Report Says," *New York Times*, 20 September 2002.
[296] NASA History Division, "NASA Center Directors," *http://www.hq.nasa.gov/office/pao/History/ director.html* (accessed 3 October 2008); NASA ARC, "G. Scott Hubbard Named NASA Ames Research Center Director," news release 02-103AR, 19 September 2002.
[297] NASA JSC, "JSC's Aircraft Operations Division Wins Top Federal Aviation Award," news release J02-93, 19 September 2002.
[298] NASA, "NASA Awards Contract to Boeing," news release c02-dd, 8 October 2002.

new intellectual property. The basic five-year cooperative agreement was valued at US$69 million, and the contract's total value could increase to US$379 million with the acceptance of three five-year options.[299]

30 September
NASA awarded contracts to four companies to develop technology to prevent the flammability of airliner fuel tanks. The research plan was a response to the National Transportation Safety Board's (NTSB's) findings concerning the problem of flammability and explosiveness in the center wing tanks of airplanes, a vulnerability that had destroyed airliners such as TWA Flight 800. NASA's GRC awarded the contracts to Creare Engineering, Essex Cryogenics, Honeywell Environmental Controls Systems, and Valcor Engineering, stipulating that the companies research how they might replace the oxygen in fuel tanks with a noncombustible gas. The companies would determine the feasibility of improving the methods of on-board systems of inert gas generation and of on-board oxygen generation. If the researchers found potential means of improving the systems, the awardees would fabricate and test hardware during the contract's second phase.[300]

The FAA released an enhanced version of the Emissions and Dispersion Modeling System (EDMS), a computer program that the FAA had developed in the mid-1980s to assess the effects of aircraft, ground-support equipment, and other sources of airport emissions on air quality. The new version, referred to as EDMS 4.1, included a number of features enabling analysts better to examine local concentrations of pollutants, including diagrams of specific airports and mathematical models of aircraft-exhaust dispersion.[301]

OCTOBER 2002

4 October
Astronomers used images from NASA's Chandra X-ray Observatory and Rossi X-ray Timing Explorer to observe, for the first time, the life cycles of x-ray jets ejected from a black hole. Scientists considered x-ray jets an extremely important phenomenon to understand, because they could reveal information about the dynamics of matter that accumulates in intense gravitational fields. From 1998 to 2002, the two satellites had collected the images showing the progressive changes of two jets of high-energy particles emitted from a black hole, microquasar XTE J1550-564. The images revealed that the jets had initially traveled at nearly half the speed of light, later decelerating and eventually disappearing. Astronomers were surprised to discover that the x-ray

[299] NASA, "NASA Selects Corporation To Lead Innovative Research Institute," news release c02-aa, 26 September 2002.
[300] NASA, "Studies Aim to Reduce Airliner Fuel Tank Flammability," news release 02-186, 30 September 2002.
[301] *Federal Aviation Administration's R&D Review*, Spring 2003, 14, *http://www.airtech.tc.faa.gov/RD/2003_spring.pdf* (accessed 3 March 2009); FAA, "EDMS Reference Manual Supplement—Model Changes between EDMS 4.05 and EDMS 4.1" (manual, Washington, DC, September 30, 2002), *http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/previous_edms/media/410-sup_rev.pdf* (accessed 3 March 2009).

jet farthest from Earth was three times brighter than the jet that traveled closer to Earth, a finding that was not explained by existing models of x-ray jets.[302]

7 October

Space Shuttle *Atlantis* STS-112 launched from NASA's KSC in Cape Canaveral, Florida, at 2:46 p.m. (CDT). The Shuttle's crew included Commander Jeffrey S. Ashby, Pilot Pamela A. Melroy, and crew members Sandra H. Magnus, Piers J. Sellers, David A. Wolf, and Fyodor N. Yurchikhin. STS-112's major objective was to deliver and install the Starboard One (S1) Truss, the second segment of the ISS's Integrated Truss Structure. Astronauts Sellers and Wolf planned to make three spacewalks during the installation mission—designated ISS Assembly Mission 9A—to install and activate the truss. Other mission objectives included transferring experiments and payloads from *Atlantis* to the ISS, deploying the station's second S-Band communications system, and installing external camera systems.[303]

Scientists from California Institute of Technology announced that they had used NASA's HST to measure the true size of an orbiting, planet-like body beyond Pluto. The sphere was the most distant object that a telescope had measured within Earth's solar system. Like its neighbor Pluto, the object, which is nearly 4 billion miles (6.4 billion kilometers) from Earth, lies in the Kuiper Belt, an icy debris field that extends 7 billion miles (11.3 billion kilometers) beyond the orbit of Neptune. Using the HST, scientists Michael E. Brown and Chadwick A. Trujillo were able to determine several properties of the sphere, including its diameter of 780 miles (1,250 kilometers). Although too small to be a planet, the sphere, which Brown and Trujillo named Quaoar—after a creation deity of the Native American Tongva people—has planet-like traits that Pluto lacks. For example, Brown and Trujillo found that Quaoar has a circular orbit around the Sun and is in the same plane as the other planets in Earth's solar system. Brown and Trujillo announced their findings at the annual meeting of the American Astronomical Society's Division for Planetary Sciences.[304]

8 October

Astronomer Riccardo Giacconi received the Nobel Prize in physics for research on cosmic x-ray radiation. Giacconi's projects had included NASA-funded research leading to his discovery of cosmic x-ray sources. A professor at Johns Hopkins University, Giacconi had been the first scientist to discover a source of x-rays outside Earth's solar system and the first to prove that the universe contained background radiation of x-ray light. In addition, many astronomers believed that x-ray sources Giacconi had discovered contained black holes. Giacconi had also been responsible for the conception and design of the first x-ray satellite and the first operating x-ray telescope. Together with Harvey Tananbaum, he had proposed the design of the x-ray telescope that eventually became NASA's Chandra X-ray Observatory. Moreover, Giacconi had been the first Director of the Hubble Space Telescope Science Institute and the Principal Investigator for

[302] NASA, "Chandra Discovers the History of Black Hole X-ray Jets," news release 02-189, 3 October 2002; S. Corbel et al., "Large-Scale, Decelerating, Relativistic X-ray Jets from the Microquasar XTE J1550-564," *Science* n.s. 298, no. 5591 (4 October 2002): 196–199.

[303] NASA, "STS-112: Extending the Space Station's Backbone," *http://spaceflight.nasa.gov/shuttle/ archives/sts-112/* (accessed 17 October 2008); NASA, "STS-112 Overview," *http://spaceflight.nasa.gov/ shuttle/archives/sts-112/mm-sts-112.pdf* (accessed 17 October 2008).

[304] NASA, "Hubble Spots an Icy World Far Beyond Pluto," news release 02-190, 7 October 2002; Usha Lee McFarling, "Pluto's Not So Alone Out There, It Appears," *Los Angeles Times*, 8 October 2002.

the Chandra Ultra-Deep Survey, which had obtained the deepest x-ray exposures with a millionth-second observation.[305]

NASA Administrator Sean O'Keefe and U.S. Air Force Undersecretary Peter Teets jointly announced that NASA and the DOD would have closer links, beginning with the FY 2004 budget. Major media reported that the two officials had not provided specific details concerning the association between NASA and the DOD. Although O'Keefe remarked that the collaboration might not require a formalized plan, the two officials stated that NASA and the DOD would integrate research and development efforts on projects such as space-based radar, communications satellites, and the Strategic Launch Initiative (SLI) to develop a reusable launch vehicle (RLV) to replace the Space Shuttle.[306]

10 October

Crew members of Space Shuttle *Atlantis* STS-112 and the ISS installed the first Starboard truss segment, the S1 Truss, connecting it with the ISS's Integrated Truss Structure. Installation of the 45-foot-long (13.7-meter-long) S1 Truss was the mission's main objective. Astronauts David A. Wolf and Piers J. Sellers accomplished the task during three spacewalks, with astronauts Peggy A. Whitson and Sandra H. Magnus operating the ISS's robotic arm to attach the S1 to the central truss segment, the S0 Truss. The astronauts also installed the Crew and Equipment Translation Aid, a cart that runs on rails along the top of the truss.[307]

15 October

A Russian Space Agency launch failed, when an uncrewed Soyuz-U rocket exploded after the rocket's engine automatically shut down, 29 seconds after liftoff from Plesetsk Cosmodrome in Russia. The rocket was carrying a Foton-M1 spacecraft with 44 microgravity experiments that ESA, Japan, Russia, and the United States had intended for the ISS. ESA stated that it planned to rebuild the Foton-M1 spacecraft for a later launch.[308]

16 October

NASA engineers completed a successful demonstration of a solar-powered UAV for remote-sensing applications. Engineers with NASA's Suborbital Airborne Sciences programs had guided the Pathfinder-Plus UAV throughout a flight lasting nearly 4 hours, during which the aircraft had captured more than 300 high-resolution digital images of a coffee plantation on the Hawaiian island of Kauai. NASA had developed the UAV for Earth science research, but project engineers described the flight demonstration as evidence that their integration of the UAV technology with decision-support systems would have additional practical applications. For example, project engineers hoped that the UAV technology might eventually enable farmers and ranchers to produce harvests more effectively and efficiently. The solar-powered UAV had a

[305] NASA, "Nobel Physics in Physics Awarded to Astronomer for NASA-Funded Research," news release 02-197, 8 October 2002; Nobel Foundation, "Advanced Information on the Nobel Prize in Physics 2002," news release, 8 October 2002, *http://nobelprize.org/nobel_prizes/physics/laureates/2002/phyadv02.pdf* (accessed 17 October 2008).
[306] Gwyneth K. Shaw, "Military Influence To Grow at NASA," *Orlando Sentinel* (FL), 9 October 2002.
[307] Warren E. Leary, "Astronauts Install Girder on Space Station," *New York Times*, 11 October 2002; NASA, "ISS Assembly Mission 9A," *http://www.nasa.gov/mission_pages/station/structure/ iss_assembly_9a.html* (accessed 17 October 2008).
[308] ESA, "Foton," *http://www.spaceflight.esa.int/users/index.cfm?act=default.page&level=11&page=facfoton* (accessed 6 January 2009); Puttkamer, "Space Flight 2002."

ground-controlled aerial imaging system. In fact, an undergraduate student nearly 2,500 miles (4,000 kilometers) away at California State University in Monterey Bay controlled one of the craft's digital cameras during the demonstration.[309]

17 October

ESA launched the International Gamma Ray Astrophysics Laboratory (INTEGRAL) observatory from Baikonur Cosmodrome, Kazakhstan, at 10:41 a.m., local time—12:41 a.m. (EST). ESA had designed the satellite, and Italy's Alenia Spazio had developed it, with support from more than 30 European firms. INTEGRAL would study dense objects that are sources of high-energy radiation, such as neutron stars and black holes. Project scientists hoped that INTEGRAL would produce images that would help confirm the presence of black holes at the center of galaxies, beginning with the Milky Way. INTEGRAL had two main instruments for analyzing gamma-ray sources: the Spectrometer on INTEGRAL, or SPI spectrometer, and the Imager on Board the INTEGRAL Satellite, or IBIS imager. The spectrometer and imager had an extremely sharp angular resolution, enabling them to conduct spectral analyses with an energy resolution 40 times better than that provided by any previous satellite. INTEGRAL also carried an x-ray imager and a charged-coupled device (CCD) imager that operated within the visible spectrum waveband. Using the combined data from the four instruments, project scientists would be able to make simultaneous observations of high-energy phenomena, from visible light to gamma rays.[310]

NASA appointed Michael U. Rudolphi as Deputy Director for NASA's SSC. NASA administrators stated that the selection was part of the "One NASA" initiative of enhancing partnerships among NASA's various centers. Rudolphi would assume the post after the launch of Space Shuttle *Endeavour* on STS-113, scheduled for liftoff in November 2002. Since January 2000, Rudolphi had managed the Reusable Solid Rocket Motor Project at NASA's MSFC. He had begun his career with NASA in 1998 as Facility Manager for MSFC's Advanced Solid Rocket Motor Project. Before joining NASA, Rudolphi had been a manager of the contractor plant for the Solid Rocket Booster Project at NASA's KSC.[311]

18 October

Space Shuttle *Atlantis* landed at NASA's KSC in Cape Canaveral, Florida, at 10:44 a.m. (CDT), marking the end of STS-112. During the mission, *Atlantis*'s crew had conducted joint operations with the ISS Expedition 5 crew, including the installation of the S1 Truss to the ISS's Integrated Truss Structure. Astronauts Piers J. Sellers and David A. Wolf had performed three spacewalks to install the truss. In addition, the Shuttle's crew members had transferred cargo to the ISS and had used the Shuttle's thruster jets to raise the station's orbit. The mission's total duration was 10 days, 19 hours, and 58 minutes.[312]

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[309] NASA, "NASA Mission Demonstrates Practical Use of UAV Technology," news release 02-200, 16 October 2002.
[310] ESA, "Europe Opens a Window onto a Violent Universe," ESA news release 66-2002, 17 October 2002, *http://www.esa.int/esaCP/ESAKXQTHN6D_index.0.html* (accessed 2 February 2010).
[311] NASA, "NASA Announces New Stennis Space Center Deputy Director," news release 02-201, 17 October 2002.
[312] NASA, "STS-112: Extending the Space Station's Backbone," *http://spaceflight.nasa.gov/ shuttle/archives/sts-112/* (accessed 17 October 2008).

22 October
NASA announced that it would delay the selection of designs for the RLV that would replace the Space Shuttle under the US$4.8 billion SLI program. NASA had planned to select a pool of proposed designs in November 2002, eventually limiting the pool to two designs before 2006. However, a NASA official said that NASA had slowed the selection process while awaiting the results of studies on various unresolved issues with the SLI program. The results of those studies could affect the program's objectives, as well as the design of the RLV that NASA planned.[313]

25 October
A group of astronomers, including NASA's Christophe Dumas, announced the discovery of a new moon orbiting the planet Uranus. S/2001 U 1 was Uranus's 21st confirmed moon, one of six Uranian moons with an irregular orbit on a different orbital plane from that of the planet's other moons. Moons with irregular orbits are hard to find, because they tend to be very distant from the planet they orbit and are so faint that they are difficult to distinguish from stars. The six Uranian moons with irregular orbits were the planet's smallest moons, ranging in size from 10 to 20 kilometers (6 to 12 miles) in diameter. Scientists theorized that these smaller moons were the result of collisions that had occurred during the early stages of planetary formation.[314]

28 October
The ISS's international partners made several decisions during a meeting held in Houston, Texas. The meeting's purpose was to discuss the provision of crew return vehicles (CRVs) for the ISS and plans for the station's construction, through 2008. NASA announced that the collaborating space agencies had agreed to a modified launch schedule for components provided by Canada, Japan, and ESA. In addition, they had discussed the possibility of Russia's continuing to provide *Soyuz* CRVs until NASA had completed the construction of a replacement vehicle.[315]

31 October
The Russian Space Agency launched the *Soyuz* TMA-1 from Baikonur Cosmodrome, Kazakhstan, at 8:11 a.m., local time—10:11 p.m. (EST). The launch was officially designated ISS Mission 5S. *Soyuz* TMA-1 was the first of a newly modified version of the *Soyuz* spacecraft, offering improved safety features and accommodation for crew members of a larger range of sizes. In addition, *Soyuz* TMA-1 was an automatic passenger craft intended to replace *Soyuz* TM-34 as the ISS's escape craft. The Russian Space Agency had been sending *Soyuz* vehicles to the ISS every six months as CRVs for scientists residing on the ISS. *Soyuz* TMA-1's crew consisted of Commander Sergei V. Zalyotin and two crew members, Russian cosmonaut Yuri V. Lonchakov and Belgian ESA astronaut Frank De Winne. The mission's primary purpose was to provide a CRV for the ISS; however, *Soyuz* TMA-1's crew also planned to conduct scientific experiments with the ISS Expedition 5 members. ISS crew would conduct most of these experiments under a commercial contract between Russia and ESA.[316]

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[313] Gwyneth K. Shaw, "NASA Taps Brakes on Shuttle Replacement," *Orlando Sentinel* (FL), 23 October 2002.
[314] NASA JPL, "Scientists Boost Tally at Uranus," news release, 25 October 2002.
[315] John Kelly, "International Space Station Partners OK Modified Launch Schedule," *Florida Today* (Brevard, FL), 29 October 2002.
[316] Puttkamer, "Space Flight 2002"; NASA Mission Control Center, "Report #48," *http://quest.nasa.gov/news/space/2002/10-29a.txt* (accessed 17 October 2008).

NOVEMBER 2002

6 November
Scientists obtained the first measurements ever taken of the dimensions and compositional matter of a neutron star, providing important new information about the fundamental nature of matter and energy. Using ESA's XMM-Newton space telescope, Jean Cottam of NASA's GSFC and other researchers captured the first measurements of the gravitational redshift of a neutron star. Gravitational redshift occurs when an intense gravitational field such as that of a neutron star warps light or other electromagnetic radiation. Thus, by calculating the star's redshift, the scientists were able to estimate its gravity, compositional material, and other characteristics. The researchers found that the star EXO 0748-676 is likely composed of normal nuclear matter, as scientists had previously theorized. The researchers' observations regarding neutron stars, specifically, and matter and energy, generally, occurred under conditions that scientists are unable to replicate on Earth. The researchers thought that the findings might reveal new information about the creation of the universe, because, theoretically, the temperature and pressure of neutron stars is similar to the temperature and pressure that was present just one second after the Big Bang.[317]

7 November
George W. S. Abbey, Special Assistant to NASA's Administrator and former Director of NASA's JSC, announced his retirement from NASA effective 3 January 2003. Abbey had begun his career at JSC in 1964 as a U.S. Air Force officer. He had served as Director of JSC and had become a high-level manager for the ISS project. In 2001 he had left the post because of the soaring costs of the ISS.[318]

11 November
The U.S. Air Force chose Boeing Integrated Defense Systems to produce the first three satellites for the GPS IIF satellite program. The U.S. Air Force had designed the GPS IIF program to provide new capabilities for civilian and military GPS users—a new civilian signal within the protected Aeronautical Radio Navigation System frequency band and secure operational military codes for military aircraft. The Air Force had also intended the GPS IIF to be compatible with the U.S. Air Force's Evolved Expendable Launch Vehicle (EELV). Boeing had designed the GPS IIF to accommodate incremental technology upgrades, enabling the satellites to serve both the immediate needs of the GPS IIF program and the long-term needs of the planned next generation satellite system, GPS III.[319]

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[317] ESA, "XMM-Newton Closes In on Space's Exotic Matter," ESA news release 69-2002, 6 November 2002, *http://www.esa.int/esaCP/ESAK117708D_index_0.html* (accessed 2 February 2010); NASA, "Exotic Innards of a Neutron Star Revealed in a Series of Explosions," news release 02-214, 6 November 2002; Jean Cottam, Frederik Paerels, and Mariano Mendez, "Gravitationally Redshifted Absorption Lines in the X-ray Burst Spectra of a Neutron Star," *Nature* 420, no. 6911 (7 November 2002): 51–54.
[318] NASA JSC, "Statement by General Jefferson D. Howell Jr. on the Retirement of Former JSC Director George W. S. Abbey," news release J02-111, 7 November 2002; *Houston Chronicle*, "Longtime NASA Official Retires," 8 November 2002.
[319] The Boeing Company, "Boeing Receives GPS IIF Production Approval," news release, 11 November 2002, *http://www.boeing.com/news/releases/2002/q4/nr_021111t.html* (accessed 28 January 2010); U.S. Coast Guard

13 November

President George W. Bush released details of NASA's new Integrated Space Transportation Plan (ISTP) in an amendment to his budget request for FY 2003. The ISTP included a number of changes in NASA's spaceflight programs that, together, would encompass a comprehensive effort to coordinate NASA's investments in the ISS, the Space Shuttle program, and the replacement vehicle for the Shuttle. The new plan would provide more resources for completing the assembly of the ISS, as well as an increase in the number of annual Shuttle flights to the ISS. Shuttle flights to the ISS would increase from four to five flights annually, enabling transport of more researchers and more science-based payloads. Moreover, the ISTP would restructure the Space Launch Initiative (SLI), making the program's immediate objective the development of the Orbital Space Plane (OSP), rather than development of a replacement vehicle for the Space Shuttle. The OSP, which would be smaller than the Shuttle, would function as both the crew transport vehicle and the emergency escape vehicle for the ISS, and NASA would use the Shuttles for heavy cargo delivery. NASA stressed that, although the ISTP would change NASA's five-year budget plan, the program's costs would remain within the original FY 2003 budget.[320]

18 November

The Commission on the Future of the United States Aerospace Industry released its final report on the industry's health and future well-being. President George W. Bush had created the Commission, composed of aerospace industry executives, lawyers, and policy analysts, to analyze the U.S. aerospace industry's stability, financial health, and relationship to national security. The Commission had concluded that the United States should establish a national aerospace policy; create a government-wide framework to implement that policy; reduce legal and regulatory barriers, to enable the industry to grow and become more internationally competitive; and increase investments in the nation's aerospace industrial base, infrastructure, personnel, and long-term research. In addition, the Commission's report provided numerous recommendations to the industry concerning how to meet those objectives, such as increasing and sustaining public and private investment in the aerospace industry and aerospace technologies, transforming the nation's air transportation system, and enhancing the defense industrial base.[321]

19 November

Astronomers discovered a phenomenon that they had previously postulated in theory, but had never actually observed—a black hole in motion, likely propelled by the explosion of a supernova. Using the HST, I. Felix Mirabel, of France's Atomic Energy Commission and Argentina's Institute of Astronomy and Space Physics, and other scientists had determined that the black hole GRO J1655-40 was traveling toward Earth at approximately 250,000 miles per hour (400,000 kilometers per hour) as it consumed a companion star locked in gravitational orbit around the black hole. Although astronomers could not observe the black hole directly, they were

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Navigation Center, "The Global Positioning System," *http://www.gps.gov/ systems/gps/index.html* (accessed 12 December 2008).

[320] NASA, "NASA's Integrated Space Transportation Plan Released," news release 02-220, 13 November 2002; Warren E. Leary, "NASA To Delay Decision on Shuttle Replacement," *New York Times*, 14 November 2002.

[321] Commission on the Future of the United States Aerospace Industry, *Final Report* (Arlington, VA, November 2002); The Boeing Company, "Boeing Supports Recommendations of U.S. Aerospace Commission," news release, 18 November 2002, *http://www.boeing.com/news/releases/2002/q4/nr_021118a.html* (accessed 28 January 2010).

able to infer its velocity, orbit, and other characteristics by observing its companion star and the effects of the black hole's immense gravity on that star. The scientists were able to use the calculations of the black hole's velocity and orbit to determine that a supernova explosion was most likely the event that had propelled the black hole into motion.[322]

20 November
NASA awarded SLI contracts to Boeing and Lockheed Martin for flight-demonstrator technologies. The flight-demonstrator contracts would support development of the future OSP, which would serve as both the transport vehicle and the escape vehicle for astronauts assigned to the ISS. NASA awarded a contract valued at US$301 million (including options through 2006) to Boeing's Phantom Works Division, to continue developing its X-37 test vehicle. The purpose of the X-37 was to test technologies that, eventually, NASA could use in the OSP. NASA awarded another contract worth US$53 million (including options through 2006) to Lockheed Martin, to develop a reusable, launchpad-abort demonstrator. The demonstrator, an escape module capable of recognizing problems and evacuating crew within seconds, would assist crews to escape emergencies occurring on the launchpad.[323]

Boeing successfully launched its first Delta 4 rocket, which the U.S. Air Force would use in 2003 in the EELV program. The purpose of the EELV program was to develop reliable and cost-efficient launch capabilities for commercial and government payloads. The launch occurred at 5:39 p.m. (EST) at Cape Canaveral Air Force Station in Florida. The Delta 4, a "Medium+" configuration of Boeing's five-member Delta 4 family of rockets, deployed Eutelsat's (European Telecommunications Satellite Organization's) commercial telecommunications satellite W5 into geosynchronous transfer orbit. During the next scheduled Delta 4 launch—the first mission for the EELV program—the Air Force planned to use a Delta 4 Medium rocket to deploy the DSCS III A3 satellite for the Defense Satellite Communication System.[324]

23 November
Space Shuttle *Endeavour* STS-113 launched from NASA's KSC in Cape Canaveral, Florida, at 6:50 p.m. Central Standard Time (CST). The Shuttle's crew members comprised Commander James D. Wetherbee and astronauts Kenneth D. Bowersox, Nikolai M. Budarin, John Bennett Herrington, Paul S. Lockhart, Michael Lopez-Alegria, and Donald R. Pettit. The primary objective of STS-113, also designated as Station Assembly Flight 11A, was to transport the crew of Expedition 6—Bowersox, Budarin, and Pettit—to the ISS and return the crew of Expedition 5 to Earth. Another major objective was to install the Port 1 (P1) Truss segment on the ISS's Integrated Truss Structure. The structure would eventually house the ISS's solar arrays and would carry power, data, and temperature controls for the station's electronics. In addition, STS-

[322] William Harwood, "Black Hole's Velocity Links It to Supernova," *Washington Post*, 19 November 2002; I. F. Mirabel et al., "The Runaway Black Hole GRO J1655-40," *Astronomy and Astrophysics* 395, no. 2 (19 November 2002): 595–599.
[323] NASA, "NASA Awards Contracts for Flight Demonstrators," news release c02-gg, 20 November 2002; Chris Kidler, "NASA Awards X-37 Contracts," *Florida Today* (Brevard, FL), 27 November 2002.
[324] The Boeing Company, "Successful First Launch for Boeing Delta IV," news release, 20 November 2002, *http://www.boeing.com/news/releases/2002/q4/nr_021120s.html* (accessed 28 January 2010); U. S. Air Force, "U.S. Air Force Fact Sheet: Evolved Expendable Launch Vehicle," *http://www.au.af.mil/au/awc/space/factsheets/eelv.htm* (accessed 28 October 2008).

113 would transport several experiments to the ISS, returning to Earth with several experiments that the crew of Expedition 5 had conducted.[325]

26 November
NASA completed an agreement with California Institute of Technology for the university to continue operating NASA's JPL. The cost-plus-award-fee contract, valued at approximately US$8 billion, extended an existing agreement with California Institute of Technology for five years beyond its planned expiration date of 30 September 2003. The agreement also contained a provision to extend the contract performance period for an additional five years based on performance reviews. In addition, NASA and the California Institute of Technology restored full management of the Deep Space Network to JPL, allowing JPL to review and comment on any of NASA policies that affected JPL's performance. According to NASA, the new contract reflected its "One NASA" initiative, intended to align JPL's policies and procedures more closely with those of other NASA centers.[326]

28 November
A Russian Kosmos-3M rocket launched the first Algerian spacecraft, AlSAT-1, from Plesetsk Cosmodrome in Russia. The Algerian Space Agency (Agence Spatiale Algérienne) had designed the 92-kilogram (202-pound), imaging microsatellite to provide multispectral, medium-resolution images for remote-sensing purposes, particularly the monitoring of natural disasters. The Algerian Space Agency intended AlSAT-1 as the first of five microsatellites for a program called the Disaster Monitoring Constellation.[327]

30 November
Crew members of STS-113 completed the installation of the P1 Truss segment, attaching it to the ISS's Integrated Truss Structure. The installation entailed the use of the Shuttle's and the ISS's robotic arms, as well as three spacewalks, which astronauts John Bennett Herrington and Michael Lopez-Alegria performed. STS-113's crew attached the 45-foot-long (13.7-meter-long), 14-ton (12,700-kilogram or 12.7-tonne) P1 Truss to the port side of the Starboard Zero (S0) Truss, the centerpiece of the Integrated Truss Structure. The P1 was the third segment of planned ISS equipment that would eventually include 11 contiguous truss structures. This particular truss segment contained the ISS's Active Thermal Control System, scheduled for activation in 2003; one of two Ultra High Frequency Communications systems on the ISS; and a Thermal Radiator Rotary Joint intended to provide mechanical and electrical energy to rotate the ISS's heat-rejecting radiators.[328]

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[325] NASA, "STS-113: A New Crew for the International Space Station," *http://spaceflight.nasa.gov/shuttle/archives/sts-113/* (accessed 29 October 2008); NASA, "STS-113 Shuttle Press Kit" press kit, 25 October 2002, *http://www.shuttlepresskit.com/STS-113/SPK_sts-113.pdf* (accessed 29 October 2008).
[326] NASA, "NASA Awards JPL Contract," news release c02-hh, 26 November 2002.
[327] Agence Spatiale Algérienne [Algerian Space Agency], "Lancement AlSAT-1," *http://www.asal-dz.org/lancement.php* (accessed 29 October 2008); Agence Spatiale Algérienne [Algerian Space Agency], "Mission AlSAT-1," *http://www.asal-dz.org/mission.php* (accessed 29 October 2008).
[328] NASA, "STS-113 Overview," *http://spaceflight.nasa.gov/shuttle/archives/sts-113/mm-sts-113.pdf* (accessed 29 October 2008); Puttkamer, "Space Flight 2002."

DECEMBER 2002

1 December

The U.S. Department of Commerce's Office of Space Commercialization (OSC) published a report on potential markets for suborbital reusable launch vehicles (RLVs). The study was a follow-up to earlier OSC efforts concerning commercial space opportunities, efforts that had identified suborbital space transportation as a potentially viable market. The report examined 14 different suborbital RLVs and the existing and emerging markets those systems could create. The authors had determined that the advent of an operational suborbital RLV could create numerous new markets in fields such as military surveillance and commercial Earth-imaging. In addition, the advent of suborbital RLVs with dual-use capabilities could serve multiple emerging markets, offering customers significantly lower costs. Moreover, the expansion of such markets could contribute to lower operating and manufacturing costs for RLVs. The Aerospace Corporation had written the report under contract with the OSC, submitting it in October 2002.[329]

Astronomers from the Harvard-Smithsonian Center for Astrophysics and the European Southern Observatory published research detailing their discovery of a diffuse emission of x-rays from a cluster of forming stars known as RCW 38. The new discovery contrasted with astronomers' conventional understanding of bodies that commonly emit high-energy particles, namely supernovas and exploding stars in the intense magnetic fields surrounding neutron stars and black holes. The astronomers, using NASA's Chandra X-ray Observatory, had discovered that neither type of body was evident in the RCW 38 stellar region, which is, instead, an area of active star formation. Although the scientists remained uncertain about the source of the x-rays, as well as the effects of the x-rays on the star cluster, they hypothesized that these x-rays could affect the chemistry of the bodies that would form planets around the stars in the cluster.[330]

3 December

NASA announced that Russian cosmonaut Alexander Y. Kaleri would replace Sergei I. Moschenko as a member of the ISS Expedition 7 crew. Russian officials had proposed the change to the Multilateral Crew Operations Panel, which formally certified and assigned ISS crew, and the panel had formally approved the proposal on 10 October 2002. Kaleri had served three separate missions on the Russian space station *Mir* between 1992 and 2000. In addition to Kaleri, the Expedition 7 crew would include U.S. astronaut Edward T. Lu and Russian cosmonaut Yuri I. Malenchenko.[331]

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[329] J. C. Martin and G. W. Law, "Suborbital Reusable Launch Vehicles and Applicable Markets" (report, Aerospace Corporation for Office of Space Commercialization, U.S. Department of Commerce, Washington, DC, October 2002), *http://www.space.commerce.gov/library/reports/2002-10-suborbital-LowRes.pdf* (accessed 5 November 2008); NASA, *Aeronautics and Space Report of the President: Fiscal Year 2003 Activities* (Washington, DC, 2003), p. 51, *http://history.nasa.gov/presrep2003.pdf* (accessed 5 November 2008).

[330] NASA, "Young Star Cluster Found Aglow with Mysterious Cloud," news release 02-251, 18 December 2002; Scott J. Wolk et al., "Discovery of Nonthermal X-ray Emission from the Embedded Massive Star-Forming Region RCW 38," *Astrophysical Journal Letters* 580, no. 2 (1 December 2002): L161–L165.

[331] NASA, "Expedition Five Backup Crewmember Named to Expedition Seven," news release 02-235, 3 December 2002; NASA, "Memorandum of Understanding Between the National Aeronautics and Space Administration of the United States of America and the Russian Space Agency Concerning the Cooperation on the Civil International Space Station" (MOU, Washington, DC, 29 January 1998), Article 11.3, *ftp://ftp.hq.nasa.gov/pub/pao/reports/1998/nasa_russian.html* (accessed 5 November 2008).

4 December
NASA successfully launched the third replenishment spacecraft for its Tracking and Data Relay Satellite (TDRS) fleet. The TDRS-J satellite launched aboard an Atlas 2A rocket from Cape Canaveral, Florida, at 9:42 p.m. (EST). TDRS satellites comprised a communication-signal relay system providing tracking and data-acquisition services between low Earth-orbiting spacecraft and ground-based control and data-processing facilities. The TDRS satellite system served numerous NASA programs, including the HST, the ISS, and the Space Shuttle. NASA had launched the first TDRS satellite in 1983.[332]

6 December
The five partner space agencies of the ISS—the Canadian Space Agency, ESA, NASA, Japan's NASDA, and the Russian Space Agency— approved the 2002 Program Action Plan for the ISS at a meeting held in Tokyo, Japan. The partner agencies agreed to expand the station's capabilities, to increase the number of permanent ISS crew members, and to provide additional crew rescue vehicles. They also agreed to a process for selecting an ISS configuration, once the ISS had accommodated the remaining components. In this process, each of the station's partner agencies would make additional programmatic and technical assessments, cost estimations, and internal budget reviews. In addition, the agencies announced that they would approve a station configuration option by March 2003, select a revised configuration by June or July 2003, and agree upon a final configuration by December 2003.[333]

NASA announced the selection of Boeing's Delta 2 expendable launch vehicle to launch medium-class payloads between 2006 and 2009. The selection was part of an existing NASA launch-services contract with Boeing that had a maximum value of US$1.2 billion, if NASA exercised all options. The procurement contract called for 12 definite launches, with options for an additional seven. Boeing's rockets would launch both NASA's payloads and NASA-sponsored payloads.[334]

7 December
Space Shuttle *Endeavour* landed at NASA's KSC in Cape Canaveral, Florida, at 1:37 p.m. (CST), marking the end of Mission STS-113. During the mission, *Endeavour*'s crew had attached the Port 1 (P1) Truss to the ISS's Integrated Truss Structure, in an installation that included three spacewalks by crew members John Bennett Herrington and Michael Lopez-Alegria. Shuttle and Expedition crews had also transferred 4,340 pounds (1,969 kilograms) of cargo between the Shuttle and the ISS. In addition, *Endeavour* had transported the Expedition 6 crew to the station, returning the crew of Expedition 5 to Earth. The total duration of STS-113 was 13 days, 18 hours, and 47 minutes.[335]

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[332] The Boeing Company, "Boeing-Built NASA Tracking and Data Relay Satellite Successfully Launched," news release, 4 December 2002, *http://www.boeing.com/news/releases/2002/q4/nr_021204s.html* (accessed 28 January 2010); National Space Science Data Center, "NASA's Tracking and Data Relay Satellites (TDRS)," *http://nssdc.gsfc.nasa.gov/multi/tdrs.html* (accessed 31 October 2008).
[333] NASA, "Space Station Action Plan Approved," news release 02-241, 6 December 2002.
[334] NASA, "NASA Picks Delta II To Launch Medium-Class Payloads," news release C02-ii, 6 December 2002.
[335] NASA, "STS-113: A New Crew for the International Space Station," *http://spaceflight.nasa.gov/shuttle/archives/sts-113/* (accessed 31 October 2008).

12 December
NASA announced the selection of crew members for three ISS missions scheduled for 2003 and 2004. The crew of STS-118 would include Mission Commander Scott J. Kelly and crew members Charles O. Hobaugh, Barbara R. Morgan, Lisa M. Nowak, Scott E. Parazynski, and Dafydd Rhys Williams. Morgan, who had trained as Christa McAuliffe's backup for the ill-fated *Challenger* Shuttle, would be the first teacher in space under NASA's new Educator Astronaut Program. NASA hoped that the program would inspire students to become space explorers. The second mission, STS-119, would comprise Commander Steven W. Lindsey and U.S. astronauts Michael L. Gernhardt, Mark E. Kelly, and Carlos I. Noriega. STS-119 would also include ISS Expedition 9's Station Commander Gennady I. Padalka and crew members E. Michael Fincke and Oleg D. Kononenko. Crew for STS-120 would be Commander James D. Halsell and astronauts Michael J. Foremen, Wendy B. Lawrence, Alan G. Poindexter, Piers J. Sellers, and Stephanie D. Wilson.[336]

17 December
NASA announced that, although they were continuing inspections, technicians had found no similar cracks in other Shuttles after they had discovered a crack in one of Shuttle *Discovery*'s parts. Engineers had discovered the first crack during standard inspections of *Atlantis* and *Discovery* in June 2002. The fissures were in small metal balls, a component of a liquid oxygen line. According to a NASA spokesperson, engineers had completed inspections of *Atlantis*, but inspections of *Discovery* would remain on hold until inspectors had finished examining *Endeavour*. However, NASA had no plans to inspect *Columbia*.[337]

20 December
After several unsuccessful attempts to contact the Comet Nucleus Tour (CONTOUR) satellite, NASA and Johns Hopkins University Applied Physics Laboratory concluded that CONTOUR was lost. The objectives of the CONTOUR mission had been to maneuver to a distance of 60 kilometers (100 miles) from at least two comets, capturing high-resolution images and performing various compositional analyses of the comets' near-nucleus-environment compositional material. NASA had launched CONTOUR on 3 July 2002 but had lost contact with the satellite on 15 August 2002 after a maneuver intended to shift CONTOUR from Earth orbit to an orbit in which it would encounter the comet Encke.[338]

21 December
A combined U.S. Air Force and Lockheed Martin crew engaged in the first flight of a C-5 Galaxy modified under the Avionics Modernization Program (AMP). AMP was the first phase of an overall C-5 modernization program to upgrade the plane's communications, navigation, and air-traffic-control surveillance equipment. The program's objectives were to improve the C-5's reliability and to satisfy emerging air-traffic-management requirements, so that the C-5 would be able to operate in global airspace without restrictions. During the 5-hour test flight, the crew

[336] NASA, "Astronauts Named for Future Space Station Missions," news release 02-249, 12 December 2002; NASA, "NASA's Educator Astronaut Assigned First Flight," news release 02-250, 12 December 2002; William Harwood, "Teacher Ready To Fulfill Space Legacy," *Washington Post*, 13 December 2002.
[337] Chris Kidler, "NASA Inspections Find No More Shuttle Cracks," *Florida Today* (Brevard, FL), 17 December 2002.
[338] NASA, "Discovery Mission: CONTOUR," *http://discovery.nasa.gov/contour.html* (accessed 31 October 2008).

demonstrated the craft's basic flying qualities and navigational system, verified new primary flight displays, and engaged in initial testing of stability-augmentation operations. Lockheed Martin planned to introduce additional components of the new, automatic flight-control system and the Global Air Traffic Management–compliant systems. After completing installation of the AMP components, Lockheed Martin planned to commence the second phase of the C-5 modernization, known as the Reliability Enhancement and Re-engining Program.[339]

23 December

NASA announced the backup crew members for ISS Expedition 10, including Jeffrey N. Williams, acting as backup for the ISS station commander, Russian cosmonaut Konstantin M. Kozeev, and U.S. astronaut Sunita L. Williams. The primary crew members for Expedition 10 were ISS Commander Leroy Chiao, U.S. astronaut John L. Phillips, and Russian cosmonaut Salizhan S. Sharipov.[340]

With the aid of NASA's High Energy Transient Explorer (HETE), scientists were able to capture the first images ever taken of an unusual gamma-ray burst (GRB) that signals the birth of a new black hole. With the exception of the Big Bang, GRBs are the most powerful type of explosion known. The bursts last for only a few seconds, yet their afterglows can last for days or even longer. However, scientists had been unable to detect an optical afterglow produced by a fast-fading type of dark GRB—until the HETE indicated that such a burst was occurring. NASA had created the satellite to alert ground-based observatories to GRBs. On 11 December 2002, HETE had detected a GRB and, within 22 seconds, had notified observatories of the event's location. In the following minutes, ground-based telescopes captured images of the burst's afterglow, which disappeared in 2 hours. The event was a rare subcategory of dark GRBs known as a transitional burst—a burst with an afterglow lasting longer than that of the short-duration type, but shorter than that of a long-duration burst. Moreover, these transitional bursts are the rarest type of GRB. Scientists hoped the images would help them learn more about the causes of GRB in general, as well as providing specific data indicating the reason that dark bursts have no detectable afterglow.[341]

31 December

The Space Shuttle Competitive Source Task Force released its final report on the potential for private-sector operation of the Shuttle program. NASA had commissioned the Task Force to analyze the roles of NASA and its contractors with regard to Space Shuttle operations. More specifically, the Task Force had assessed various scenarios in which NASA would focus primarily on spaceflight research and development, outsourcing to the private sector the operation of the planned replacements of the Shuttles for routine transit to low Earth orbit. The Task Force had concluded that, although NASA faced numerous challenges to competitive sourcing for the Shuttle program, it should pursue some form of this option. Moreover, the panel

[339] Lockheed Martin, "Initial C-5 Upgraded Under the Avionics Modernization Program Makes Its First Flight," news release, 23 December 2002, *http: //www.lockheedmartin.com/news/press_releases/2002/InitialC5UpgradedUnderAvionicsModer.html* (accessed 28 January 2010); William Knight and Christopher Bolkcom, "Strategic Airlift Modernization: Analysis of C-5 Modernization and C-17 Acquisition Issues," (report, Congressional Research Service, Washington, DC, 15 April 2008), CRS-4–CRS-5.
[340] NASA, "Space Station Expedition Backup Crew Named," news release 02-258, 23 December 2002.
[341] NASA, "Scientists Catch Their First Elusive 'Dark' Gamma-Ray Burst," news release 02-257, 23 December 2002.

suggested that the most likely scenario for successful private-sector involvement in the Shuttle program would not involve private operation of the program, but rather a transfer of program assets to private entities at highly deflated prices. Another option would entail the restructuring of existing contracts, perhaps taking steps to expand the pool of program suppliers beyond the existing duopoly of Boeing and Lockheed Martin. In addition, as a first step to privatization, NASA could establish a space authority to operate the Shuttle, as well as future human transportation vehicles.[342]

JANUARY 2003

5 January
A reentry section of the People's Republic of China's *Shenzhou 4* spacecraft landed in Inner Mongolia after *Shenzhou 4* had orbited Earth for nearly a week. Phillip Clark, a U.K. observer of China's space program, remarked that the *Shenzhou 4* mission was key to flying Chinese astronauts in the future, noting that orbital control of the craft during this flight had been far tighter than in the two preceding tests. Furthermore, during two back-to-back *Shenzhou* launches, the Chinese had completed all the maneuvers necessary for a rendezvous and docking mission, indicating that China would progress quickly to an orbital docking. Clark predicted that either *Shenzhou 7* or *Shenzhou 8* would complete a nose-to-nose docking.[343]

6 January
After a series of delays, a Titan 2 rocket carried into orbit the U.S. military's Coriolis research satellite, launching from the Vandenberg Air Force Base in California. The refurbished Titan 2 intercontinental ballistic missile placed the spacecraft in orbit 5½ minutes after launch, and the rocket's second stage deployed its payload approximately 1 hour later. The US$224 million Coriolis mission carried the Navy's Windsat microwave polarimetric radiometer and the Air Force's Solar Mass Ejection Imager. The U.S. military had designed Windsat to measure wind speed and direction at or near the surface of Earth's seas, providing improved weather forecasting to assist in planning naval operations. The Air Force intended the Solar Mass Ejection Imager to provide "an early warning of coronal mass ejections from the Sun that impact Earth, disrupting communications and power grids."[344]

The Arianespace Flight 157 Inquiry Board submitted its report to Arianespace, establishing the most probable cause of the failure of an Ariane 5 ECA on the night of 11/12 December 2002. The Board had analyzed all measurements recorded during Flight 157 and had reviewed all documentation concerning production, quality, and technical records for the Ariane 5 ECA—which used a Vulcain 2 engine—as well as the documentation for all Ariane 5 flights to date. The Board had identified a leak in the Vulcain 2 nozzle's cooling circuit during the first flight phase. The leak had caused critical overheating of the nozzle, a loss of integrity, and a major imbalance in the thrust of the Vulcain 2 engine, leading to the loss of control over the

[342] Space Shuttle Competitive Sourcing Task Force, "Alternative Trajectories: Options for Competitive Sourcing of the Space Shuttle Program" (Final Report, Science and Technology Policy Institute, Rand Corporation, Arlington, VA, December 2002), *http://www.rand.org/scitech/stpi/NASA/index.html* (accessed 30 December 2009).
[343] Leonard David, "After Shenzhou—China's Space Plans Boosted Following Successful Mission," *Space.com*, 5 January 2003, *http://www.space.com/missionlaunches/after_shenzhou4_030105.html* (accessed 28 July 2008).
[344] Justin Ray, "Coriolis Launched To Track Ocean Winds, Solar Storms," *Spaceflight Now*, 6 January 2003.

launcher's trajectory. The Board concluded that two aggravating factors, occurring simultaneously, had caused the failure: "degraded thermal condition of the nozzle due to fissures in the cooling tubes" and "non-exhaustive definition of the loads to which the Vulcain 2 engine is subjected during flight." Although its review of the operating data from the Vulcain 1 engine's successful flights identified no weakness in the functioning and resistance of the nozzle, the Board recommended a thorough review of the Ariane 5. Upon learning the factors involved in the failure of Ariane 5 ECA, Arianespace decided to create a board to study the upcoming 14 January launch of Rosetta. ESA had timed the mission to enable Rosetta to rendezvous with the comet Wirtanen.[345]

7 January

NASA announced that the Advanced Camera for Surveys (ACS) aboard the HST had used "a natural 'zoom lens' in space to boost its view of the distant universe," revealing remote galaxies previously beyond HST's reach. For more than 13 hours, the camera had concentrated on one of the most massive known galaxy clusters, Abell 1689, located more than 2.2 billion light-years away. In combination with dark matter, Abell 1689's gravity behaves as a 2 million light-year–wide lens in space, bending and magnifying the light of the galaxies behind it. The HST image captured hundreds of galaxies—10 times more arcs than a ground-based telescope could reveal—"smeared by the gravitational bending of light into a spider-web tracing of blue and red arcs of light." Scientists intended to use the image map to study the distribution of dark matter in galaxy clusters and to trace the history of star formation in the universe over the past 13 billion years. NASA deemed the image "an exquisite demonstration of Albert Einstein's prediction that gravity warps space and therefore distorts a beam of light."[346]

GenCorp Inc.'s company Aerojet, a member of the Rocket Based Combined Cycle Consortium (RBC3), announced that NASA and RBC3 had successfully completed the first in a series of tests of a full-scale rocket thrust. Conducted at Aerojet facilities in Sacramento, California, the test demonstrated the first successful hot fire of a thruster using a mix of decomposed peroxide, liquid peroxide, and JP-7 jet fuel to generate combustion—a key milestone in NASA's Integrated System Test of an Air-breathing Rocket (ISTAR) program. The ISTAR program sought to flight-test a self-powered hypersonic flight vehicle at more than six times the speed of sound by the end of the decade. The program was part of NASA's effort to develop hypersonic technologies by 2025, to create flight vehicles that could provide safe, routine, and affordable space access and air transportation to anywhere on the globe in less than 2 hours.[347]

9 January

U.S. Representative William L. Jenkins (R-TN) announced that NASA had awarded East Tennessee State University a grant valued at US$363,310 to study light patterns of stars located

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[345] ESA, "Arianespace Flight 157—Inquiry Board Submits Findings," *http://www.esa.int/esaCP/ESA7198708D_index_0.html* (accessed 28 July 2008).
[346] NASA, "Biggest 'Zoom Lens' in Space Extends Hubble's Reach," news release 03-003, 7 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-003.txt* (accessed 9 July 2008).
[347] Aerojet, "NASA, Industry Consortium Successfully Test Full-Scale Hypersonic Engine Thruster," news release, 7 January 2003, *http://www.aerojet.com/program/news/nr_010703_nasa_industry_consortium_successfully_tests_thruster.htm?program_ID=45* (accessed 30 July 2008); "NASA, "NASA Tests Environmentally Friendly Rocket Fuel," news release 03-010, 13 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-010.txt* (accessed 9 July 2008).

hundreds of light-years away. The award would grant researchers of the university's physics and astronomy department access over the next five years to data from COBE—the Cosmic Background Explorer satellite. The scientists would use the COBE data to study the infrared variability of asymptotic giant branch stars, "older stars with shells of gas and dust around them." During its mission in 1989 and 1990, the COBE satellite had surveyed the sky on 10 infrared wavelengths, observing the cosmic backlight of the universe, as well as asymptotic giant branch stars. Although astronomers in the field had conducted significant research on the backlight data, they had done little with COBE's infrared data on the stars.[348]

12 January

A Delta 2 rocket carried NASA's Ice Cloud and Land Elevation Satellite (ICESat) into orbit, launching from Vandenberg Air Force Base in California. ICESat was one in a series of Earth Observing System (EOS) spacecraft to follow the Terra satellite, launched in December 1999, and the Aqua satellite, launched in May 2002. NASA had designed the 661-pound (299.8-kilogram) craft to measure the ice sheets of Greenland and Antarctica, so that scientists could determine whether global sea levels were rising or falling. The craft's only instrument, the Geoscience Laser Altimeter System, would beam rapid pulses of laser light to the icy surface, and the ice sheets would reflect the light back to the satellite, acting like radar. The GPS would determine the ICESat's location as it fired its laser, enabling program scientists to measure the ice sheets' topography. The rocket also carried a second, smaller craft into orbit—CHIPSat, NASA's 131-pound (59-kilogram), University Explorer Class probe, the Cosmic Hot Interstellar Plasma Spectrometer. CHIPSat would gather data on the origin, physical processes, and properties of the hot gas between stars. The CHIPSat mission was the first U.S. mission to use end-to-end satellite operations over the Internet, treating the craft "something like a node on the Internet."[349]

13 January

NASA announced that a two-year collaboration between researchers at Stanford University and NASA's ARC had resulted in a successful test of an alternative paraffin-based rocket fuel intended to increase operational safety, reduce costs as compared to solid fuels, and, eventually, to provide the fuel in Space Shuttle booster rockets. The researchers had developed a nontoxic, easily handled fuel, producing as by-products carbon dioxide and water, rather than the aluminum oxide and acidic gases that conventional rocket fuel produces. Arif Karabeyoglu had led Stanford University's contribution to the fuel research, developing the theory of a fast-burning, low-cost, paraffin-based fuel in his doctoral thesis, which Stanford and NASA had partially funded. The testing series had begun on 24 September 2001 at ARC's Hybrid Combustion Facility, a heavy-duty test chamber capable of accommodating pressures of up to 60 atmospheres. The first phase of the testing program had consisted of approximately 40 runs.[350]

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[348] Sam Watson, "NASA Grant To Fund ETSU Study of Stars," *Johnson City Press* (TN), 9 January 2003.
[349] NASA, "NASA Successfully Launches ICE and CHIPS Satellites," news release 03-011, 13 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-011.txt* (accessed 22 July 2008); Associated Press, "Rocket Carrying NASA Satellites Launched," 12 January 2003; Jim Banke, "Boeing Launches Pair of Science Research Satellites for NASA," *Space.com*, 12 January 2003, *http://www.space.com/missionlaunches/delta2_launch_030112.html* (accessed 22 July 2008).
[350] NASA, "NASA Tests Environmentally Friendly Rocket Fuel," news release 03-010, 13 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-010.txt* (accessed 9 July 2008).

14 January

Arianespace and ESA announced that, because of the failure of Ariane 5 Flight 157, they had postponed the launch of the Rosetta spacecraft. Arianespace had designed Rosetta to rendezvous with the comet Wirtanen, in a mission that would have included a journey lasting eight years, followed by a two-year study of the comet. Rosetta's launch had presented several challenges, requiring the Ariane 5 rocket's upper stage to "undertake its first-ever ballistic coast phase before being ignited, a [2]-hour-long sequence." Although launch officials had not planned to launch the spacecraft aboard an Ariane 5 ECA, the type of rocket that had exploded shortly after launch in December 2002, Rosetta's launch vehicle was not standard. Arianespace had modified its equipment bay and electrical system. The postponement would cause Rosetta to miss the launch window for the rendezvous with Wirtanen; therefore, mission scientists would search for a new comet for the study and would redesign the mission.[351]

15 January

NASA announced that scientist David Atlas of NASA's GSFC and University of Colorado scientist Christopher Williams had created the first "full-body scan" of an evolving tropical thunderstorm, using data collected from an unusual storm over the Amazon rain forest, which had occurred in February 1999. At that time, a team of scientists from NASA, NOAA, the National Center for Atmospheric Research, and several universities had used sensitive radar equipment, such as scanning Doppler and vertically oriented Doppler, to detect and measure different types of particles from the storm's base to its top, approximately 8.7 miles (14 kilometers) above the rainforest floor. Participants from the University of North Dakota had operated a jet aircraft to gather some of the data. One of the study's goals had been validating the Tropical Rainfall Measuring Mission (TRMM) satellite measurements, to help plan the TRMM's successor, the Global Precipitation Mission. TRMM had provided data about how such storms operate, thus enabling scientists to understand how wind circulates in the upper atmosphere. The research, which Atlas and Williams had published in the American Meteorological Society's *Journal of Atmospheric Sciences*, provided new insight into the intense and hazardous conditions within storms. Scientists expected the research to improve forecasts, helping aircraft avoid dangerous storms and making air travel safer, and to improve satellite measurements of precipitation.[352]

As part of Expedition 6, American astronauts Donald D. Pettit and Kenneth R. Bowersox undertook a spacewalk outside the ISS, each spacewalking for the first time, while their Russian colleague Nikolai M. Budarin monitored their work from inside the station. Pettit had replaced Budarin in the spacewalk lineup because NASA doctors were concerned about Budarin's known cardiovascular issues. In the summer of 2003, Pettit had served as backup for another astronaut in an ISS mission, because NASA doctors were worried about that astronaut's radiation exposure. NASA had decided to replace Budarin even though Russian doctors disagreed, because NASA was in charge of this spacewalk. During the 7-hour spacewalk, the two astronauts successfully completed their primary tasks—releasing locks on a recently installed radiator and

[351] Reuters, "Rosetta Space Launch Set Back by Further Delay," 15 January 2003.
[352] NASA Goddard Space Flight Center, "NASA Scientists Take First 'Full-Body Scan' of Evolving Thunderstorm," news release 03-07, 15 January 2003, *http://www.gsfc.nasa.gov/news-release/releases/2003/03-07.htm* (accessed 28 July 2008); Reuters, "NASA Takes First 'Full-Body Scan' of Thunderstorm," 15 January 2003; Lee Bowman for Scripps Howard News Service, "Probing the Inner Workings of Storm Clouds," 16 January 2003.

cleaning a docking ring. However, they were unable to erect a light on a boom, because a protruding pin prevented the boom from swinging out of its stowed position.[353]

16 January

Space Shuttle *Columbia* launched on STS-107 from NASA's KSC in Cape Canaveral, Florida, at 10:39 a.m. (EST). NASA had postponed the launch, originally scheduled for July 2001, because of technical and scheduling problems. Flying an orbital mission, a rare event since the ISS partners had begun construction of the space station in 1998, STS-107 was a "pure research mission." The crew would conduct scientific investigations in two 12-hour shifts each day in the laboratory module of the Shuttle's cargo bay. The crew included Shuttle Commander Rick D. Husband; Pilot William C. McCool; Payload Commander Michael P. Anderson; Payload Specialist Ilan Ramon, Israel's first astronaut and a fighter pilot with the rank of colonel in Israel's Air Force; Mission Specialist Kalpana Chawla, an aerospace engineer originally from India; and Mission Specialists David M. Brown and Laurel B. Clark, both physicians. The launch occurred under exceptionally tight security with more than 300 dignitaries and guests from Israel in attendance.[354]

17 January

The U.S. National Imagery and Mapping Agency (NIMA) announced that it had awarded a five-year contract worth up to US$500 million to the Colorado-based companies Space Imaging and DigitalGlobe. Under the contract, which stipulated a base performance period of three years with two additional one-year options, NIMA agreed to purchase a minimum of US$72 million worth of data from DigitalGlobe and a minimum of US$120 million from Space Imaging during the first three years. The contract and accompanying agreements marked "the Pentagon's strongest commitment yet to buy products and services from the U.S. commercial satellite imaging industry." Space Imaging, based in Thornton, Colorado, operated the Ikonos satellite launched in September 1999, which was capable of distinguishing ground objects as small as 1 meter. DigitalGlobe, based in Longmont, Colorado, operated the QuickBird satellite, launched in October 1999, which, under certain conditions, was capable of distinguishing objects as small as 0.61 meter.[355]

21 January

NASA launched a nationwide campaign to recruit elementary, middle, and high school classroom teachers for its astronaut corps, building on the legacy of its Teacher in Space Project of 1985. NASA had selected Christa McAuliffe and Barbara R. Morgan from among 12,000 applicants for the first project, which had ended tragically when Space Shuttle *Challenger* exploded shortly after launching on 28 January 1986 with McAuliffe on board. McAuliffe's

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[353] Associated Press, "Astronauts Take Spacewalk, Including a Late Substitute Who Frees the Space Station's Sticky Hatch," 15 January 2003.

[354] Broward Liston for Reuters, "Space Shuttle Launches with First Israeli Astronaut," 16 January 2003; Warren E. Leary, "Columbia Takes Off Under Tight Security," *New York Times*, 16 January 2003.

[355] NIMA, "NIMA Partners with Remote Sensing Industry," media release 03-05, 17 January 2003, *http://www.nga.mil/NGASiteContent/StaticFiles/OCR/nima0305.pdf* (accessed 24 July 2008); Warren Ferster, "NIMA Awards Lucrative Contracts to U.S. Satellite Imaging Firms," *Space News*, 17 January 2003; Satellite Imaging Corporation, "About the Ikonos Satellite," *http://www.satimagingcorp.com/ satellite-sensors/ikonos.html* (accessed 24 July 2008); Satellite Imaging Corporation, "About the QuickBird Satellite Sensor," *http://www.satimagingcorp.com/satellite-sensors/quickbird.html* (accessed 24 July 2008).

backup Barbara R. Morgan had rejoined NASA in 1998 to train and qualify as a mission specialist. In December 2002, NASA Administrator Sean O'Keefe had announced Morgan's assignment to a November assembly mission to the ISS. NASA planned for the new recruitment campaign to extend the legacy of McAuliffe and the work of Morgan, making future educator-astronauts as much a part of the astronaut corps as test pilots, engineers, physicians, astronomers, geologists, and scientists from other disciplines. To accomplish this goal, NASA planned to train teachers with proven technical skills, making them eligible for missions ranging from 12-day Shuttle flights to months-long residencies aboard the ISS. Because of their ability to communicate with students in the classroom more effectively than traditional NASA astronauts, the educator-astronauts would be a critical part of an educational initiative to "make math and science as inspiring to youngsters as pop music and sports."[356]

23 January

Officials from Boeing and Finmeccanica, an Italian aerospace corporation, signed a Memorandum of Understanding (MOU) in a joint ceremony held in Rome and at the Italian Embassy in Washington, DC. The purpose of the MOU was to explore joint initiatives and to pursue growth opportunities in aerostructures and commercial aircraft, aircraft modification, UAVs, satellite systems, navigation, launch services, missile defense, space infrastructure, and avionics. The MOU called for the creation of an executive steering committee to investigate the possibilities of collaborative activity in space navigation, satellite services, launch services, and services to the ISS. The committee would make the final decision about which activities the partnership would pursue.[357]

24 January

NASA launched SORCE—its Solar Radiation and Climate Experiment satellite—from a Pegasus XL rocket dropped from a jet plane 140 miles offshore over the Atlantic Ocean. On board the satellite were five instruments designed to help scientists better understand how the Sun affects Earth's climate. SORCE's high-precision instruments could measure total radiation from the Sun, and its spectrometers could analyze light in all its various wavelengths, capturing information that scientists hoped would help them build a long-term data set that future generations would use.[358]

28 January

The crew aboard Space Shuttle *Columbia* joined Mission Control for a moment of silence at 11:39 a.m. (EST), the exact time that *Challenger* had exploded after launch 17 years before. The astronauts also remembered the three astronauts killed in a launchpad fire in their *Apollo* spacecraft on 27 January 1967. Airwaves also fell silent on the ISS, as the crew of two American astronauts and one Russian cosmonaut aboard the space station paused to remember the tragedies.[359]

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[356] Mark Carreau, "NASA Seeking a Few Good Teachers," *Houston Chronicle*, 22 January 2003.
[357] *UV Online.com*, "Finmeccanica and Boeing To Collaborate on UAVs," 23 January 2003, *http://www.shephard.co.uk/news/category/1/uvonline/*.
[358] NASA, "NASA's SORCE Satellite Soars into Space To Catch Some Rays," news release 03-022, 27 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-022.txt* (accessed 9 July 2008); Associated Press, "NASA Launches Satellite To Measure Sun's Radiation," 25 January 2003.
[359] Marcia Dunn for Associated Press, "Astronauts Honor Challenger Victims," 28 January 2003.

29 January
Alain Bensoussan, president of the French space agency, announced that he was resigning from his post because he no longer had the support he needed to continue his job. Bensoussan had been the "target of increasingly bitter attacks" lodged by frustrated employees who no longer perceived a clear direction in the agency's mission. Bensoussan had also faced the failure of a new Ariane 5 rocket and an agency budget that had decreased steadily since 1997, despite the addition of new programs. Moreover, the French government had commissioned a report evaluating the space agency's current status and future direction, and the report had been "lukewarm in its assessment" of Bensoussan. Following the publication of the report, France's space minister Claudie Haignere had stated that the agency had not yet made a decision about its future management. The commission's findings and the space minister's statement had not provided a strong message of support for Bensoussan's leadership.[360]

A Delta 2 rocket launched, carrying a GPS-2R8 satellite and an Experimental Spacecraft System (XSS-10) microsatellite into orbit. The U.S. Air Force was launching the GPS-2R8 to replace the 22nd GPS satellite, which had launched 10 years earlier, joining a constellation of 26 operational GPS spacecraft. Although the military GPS created in the 1970s had generated a commercial industry with sales in excess of US$6 billion, the system had continued to exist primarily to serve the U.S. military. The U.S. Air Force was launching the 62-pound (28-kilogram) XSS-10 spacecraft to test new guidance and navigation software and to demonstrate new technologies, such as a miniature communications system, a lightweight propulsion system, and advanced lithium polymer batteries.[361]

NASA announced its collaboration with Japan's NASDA and the Japanese Meteorological Research Institute to study snowfall over Wakasa Bay, Japan. The study would use NASA's EOS Aqua satellite in conjunction with research aircraft, which would gather data for the study using the coastal radar systems. NASA had begun the Wakasa Bay Field Campaign on 3 January 2003, scheduling the study to run through 14 February 2003. Although, historically, scientists had found it difficult to quantify contributions to the global hydrologic cycle from the northern Pacific Ocean, they expected that the new satellite instruments, which could detect precipitation over water, would provide data needed to interpret the effect of Pacific Ocean hydrology on the world.[362]

30 January
Israeli scientists announced that, while traveling aboard Space Shuttle *Columbia*, astronaut Ilan Ramon had successfully captured images of smoke from a burning rain forest, a dust storm above the Mediterranean Ocean, and a small dust plume off the African coast over the Atlantic Ocean. Operating a twin-camera multispectral instrument in *Columbia*'s payload bay, Ramon had scanned dust and other aerosol particles, which storms had blown from deserts and high winds had carried across the globe. The instrument had also operated during the night, capturing images of the tops of thousands of thunderstorms. The team of scientists from Tel Aviv

[360] Peter B. de Selding, "French Space Agency Chief To Resign," *Space News*, 29 January 2003.
[361] Jim Banke, "Delta 2 Rolls, Launches GPS and Experimental Satellites," *Space.com*, 29 January 2003, *http://www.space.com/missionlaunches/delta2_launch_030129.html* (accessed 23 July 2008).
[362] NASA, "NASA Joins Snow Study over the Sea of Japan," news release 03-025, 29 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-025.txt* (accessed 29 July 2008).

University's Mediterranean Israeli Dust Experiment (MEIDEX) intended to use the images to develop a better understanding of climate change, one of the goals of *Columbia*'s research flight, which had encountered two years of delays. Joachim Joseph, a principal researcher on the project, remarked that the experiment had gathered "very good data, very unique data." The purpose of the US$2 million experiment was to "provide a better understanding of how migrating dust plumes affect climate." [363]

31 January
NASA announced that it had settled negotiations with United Space Alliance, increasing the value of its two-year extension of the spaceflight operations contract (SFOC) by US$59.91 million. The finalized SFOC extension supporting the Space Shuttle Program brought the total value of the two-year contract to US$2.90 billion. The extended contract would run through 30 September 2004.[364]

FEBRUARY 2003

1 February
After completing a 16-day orbital science mission that NASA judged a success, the crew of STS-107 perished when Space Shuttle *Columbia* broke apart above Texas during reentry. NASA's Mission Control lost communication with *Columbia* at 9:00 a.m. (EST) and immediately switched to the contingency plan to preserve all flight-activity information. NASA had scheduled the landing for 9:16 a.m. (EST). NASA Administrator Sean O'Keefe issued a statement describing all the steps NASA had taken after the loss of the Shuttle. NASA officials had spoken with President George W. Bush and Secretary of Homeland Security Tom Ridge; met with family members of the crew; assembled an internal mishap investigation team; and appointed a mishap investigation board. The board comprised an external group of people independent from NASA, charged with examining all the information that Mission Control had locked down when it lost communication with *Columbia*.[365]

2 February
Progress M-47 launched atop a Soyuz-U rocket from Baikonur Cosmodrome one day after the loss of Space Shuttle *Columbia* "threw future missions to the orbiting complex in doubt." The launch, scheduled long in advance, took place as "stunned Russian space officials offered condolences to their American colleagues." Russian officials also expressed concern that the loss of *Columbia* and the ensuing suspension of Shuttle missions might place Russia's "cash-strapped space program under more pressure to deliver crews and supplies to the station." Sergei

[363] NASA, "Shuttle's Desert Dust Experiment Delivers," news release N03-010, 29 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/note2edt/2003/n03-010.txt* (accessed 9 July 2003); Associated Press, "Astronaut Photographs Dust Storm," 31 January 2003; Warren E. Leary, " Space Shuttle Crew Completes Israeli Dust and Cloud Studies," *New York Times*, 31 January 2003.
[364] NASA, "NASA Finalizes Contract with United Space Alliance," news release C03-001, 31 January 2003, *ftp://ftp.hq.nasa.gov/pub/pao/contract/2003/c03-001.txt* (accessed 15 July 2008).
[365] NASA, "NASA Statement on Loss of Communications with Columbia," news release 03-030, 1 February 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-030.txt* (accessed 15 July 2008); NASA, "Statement by NASA Administrator Sean O'Keefe," news release 03-032, 1 February 2003, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-032.txt* (accessed 15 July 2008); *Washington Post*, "The Columbia Catastrophe," 2 February 2003.

Gorbunov, a spokesperson for the Russian Space Agency, explained that Russia had no reserve of *Soyuz* spacecraft. He pointed out that if the U.S. space program intended to use Russian craft to transport crews to the ISS, NASA would need to buy Russian *Soyuz* TMAs, the type of craft designed to carry cosmonauts to the ISS. Russia had routinely built only two *Soyuz* spacecraft per year.[366]

NASA Administrator Sean O'Keefe announced the members of the Space Shuttle Mishap Interagency Investigation Board, also known as the Gehman Board. To chair the Board, NASA had appointed retired U.S. Navy Admiral Harold W. Gehman Jr., who had cochaired the independent commission that investigated the attack on the USS Cole in Aden, Yemen, on 12 October 2000. Other members included Rear Admiral Stephen A. Turcotte of the U.S. Naval Safety Center; Major General John L. Barry of the Wright-Patterson Air Force Base in Ohio; Major General Kenneth W. Hess of Kirtland Air Force Base in New Mexico; James N. Hallock of the U.S. Department of Transportation; Steven B. Wallace of the FAA; and Brigadier General Duane W. Deal of the 21st Space Wing at Peterson Air Force Base in Colorado. Several senior-level NASA leaders were also named to the panel: G. Scott Hubbard, Director of NASA's ARC; Bryan D. O'Connor, NASA's Associate Administrator for Safety and Mission Assurance and a former astronaut; and Theron M. Bradley Jr., NASA's Chief Engineer. NASA intended the Gehman Board to make a parallel investigation, complementing NASA's own internal investigation. The Board would have access to the same scientific information and to the cooperation of the same agencies as NASA.[367]

4 February

Progress M-47/ISS-10P docked with the ISS, delivering 2.75 tons (2.5 tonnes or 2,495 kilograms) of supplies, which would enable the Expedition 6 crew to remain at the station until June without Shuttle support. The crew—Russian cosmonaut Nikolai M. Budarin and American astronauts Kenneth D. Bowersox and Donald R. Pettit—had served at the outpost for 73 days, and NASA had scheduled their return to Earth on Shuttle *Atlantis* for 1 March. However, in the wake of the *Columbia* disaster, NASA had grounded all Shuttles indefinitely. Although the suspension of Shuttle flights did not place the ISS crew in danger, it did affect the schedule of space station construction and interrupted NASA's plan to install a high-speed gyroscope at the station in March, to replace one that had broken down in June 2002. With only three operational gyroscopes, the ISS would continue to drift, but NASA did not consider the matter a time-critical problem.[368]

Telesat Canada selected Astrium, Europe's largest space company, to manufacture a replacement for its Anik F1 satellite—the Anik F1R. Engineers had determined that the Anik F1, based on the 702 platform of Boeing Satellite Systems, was defective. Several of the Boeing-built 702 satellites were "afflicted with a solar panel malady" expected to shorten each craft's operational

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[366] Associated Press, "Russians Send Supply Ship on Way to Space Station," 2 February 2003.
[367] NASA, "NASA Announces Space Shuttle Columbia Accident Investigation Board (The Gehman Board)," news release 03-034, *ftp://ftp.hq.nasa.gov/pub/pao/pressrel/2003/03-034.txt* (accessed 15 July 2008); David Arnold, "Specialist Panel Convenes, Begins Search for Cause," *Boston Globe*, 4 February 2003.
[368] Todd Ackerman, "Cargo Craft Resupplies Outpost Crew Hanging in Orbit," *Houston Chronicle*, 5 February 2003; NASA, "Spaceflight 2003: International Space Station Goals and Objectives," *http://www.nasa.gov/directorates/somd/reports/2003/iss.html* (accessed 13 November 2009).

lifetime. Telesat planned to base the Anik F1R, which would carry 24 C-band and 32 Ku-band transponders, on Astrium's Eurostar 3000 platform.[369]

7 February

NASA notified SPACEHAB Inc. that NASA had not renewed SPACEHAB's contracts for building and maintaining the Space Vehicle Mockup Facility (SVMF), the facility with ISS mockups at NASA's JSC, and for operating the Neutral Buoyancy Laboratory (NBL) facility, where astronauts simulate spacewalks in a swimming pool. Instead, NASA had awarded the multiyear contract, valued at up to US$78.97 million, to Raytheon Technical Services of Houston. SPACEHAB's subsidiary Johnson Engineering had operated the NBL for approximately 10 years. In 1998 SPACEHAB had acquired Johnson Engineering and had continued to operate the NBL. SPACEHAB had depended on Johnson Engineering and the NBL/SVMF contract for about half of its US$100 million in annual revenues. The loss of the contract followed SPACEHAB's loss of one of its major flight articles, the Research Double Module, a pressurized science facility that had made its debut during STS-107 on the ill-fated Space Shuttle *Columbia*. SPACEHAB had insured the module for only US$17.7 million of its US$62.7 million value. SPACEHAB expected to contract with NASA to fly additional modules, which would enable the company to recoup its investment in the hardware.[370]

12 February

Senator John McCain (R-AZ), chair of the U.S. Senate Committee on Commerce, Science and Transportation, and U.S. Representative Sherwood Boehlert (R-NY), chair of the U.S. House Science Subcommittee on Space and Aeronautics, cochaired a joint hearing of congressional leaders, focusing on the Space Shuttle *Columbia* accident. Recommendations resulting from the hearing prompted NASA Administrator Sean O'Keefe to issue a second amendment to the charter of the Space Shuttle Accident Investigation Board, an independent panel led by retired U.S. Navy Admiral Harold W. Gehman Jr. and known as the *Columbia* Accident Investigation Board (CAIB) or, informally, as the Gehman Board. The amendment removed any requirement, real or perceived, instructing Gehman to "coordinate or await approval from NASA for any dimension of the panel's investigation."[371]

13 February

NASA announced that it had positively identified the remains of all seven members of STS-107 at Dover Air Force Base in Delaware, and that officials in Angelina County, Texas, had signed the death certificates. Eileen Hawley, spokesperson for NASA's JSC in Houston, said that officials had released the crew members' remains to their families for private memorial services.

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[369] Telesat, "Telesat Selects European Manufacturer for New Anik F Satellite," news release, 4 February 2003, *http://www.telesat.ca/news/releases/2003/03-02-e.asp* (accessed 12 August 2008); Sam Silverstein, "Telesat Canada Selects Astrium to Replace Anik F1," *Space News*, 4 February 2003.

[370] NASA, "NASA Buoyancy Laboratory, Space Vehicle Mockup Facility Contract Awarded," news release, 7 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_c03004_bb_030207.html* (accessed 16 July 2008); Brian Berger, "Double Whammy: Spacehab Loses NASA Contract," *Space News*, 12 February 2003; Brian Berger, "$100 Million Commercial Science Lab Lost on Columbia Was Insured," *Space News*, 2 February 2003.

[371] NASA, "Joint Congressional Hearing Results in Second Charter Amendment for Gehman Board Columbia Accident Briefing," news release 03-069, 12 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_03069.html* (accessed 16 July 2008).

NASA had already returned the remains of Israeli astronaut Ilan Ramon to Israel, where burial services had taken place on 11 February.[372]

NASA issued a statement on behalf of the CAIB announcing that preliminary analysis performed by a NASA working group indicated that the temperature level in *Columbia*'s left wheel well during reentry indicated the presence of plasma. Heat transfer related to a missing tile in the structure would not have been sufficient to elevate the temperature to the level revealed in the preliminary analysis.[373]

18 February
NASA announced the Level 1 requirements for the Orbital Space Plane (OSP) system, the next-generation system of space vehicles designed to transport crews to and from the ISS and to provide rescue missions. NASA Administrator Sean O'Keefe had proposed the concept in November 2002 "as a way to take some of the pressure off the aging space shuttle fleet." NASA had envisioned a simple craft, easier to launch and with greater maneuverability in orbit. However, NASA had not intended the OSP system as a substitute for the Shuttle, the only U.S. spacecraft able to haul heavy cargo into space. The OSP concept was to include in its first design an escape pod for the ISS, ready for use by 2010. Its second version, intended for completion by 2012 would be a craft capable of transporting people.[374]

NASA released a newly revised charter for the CAIB, permitting the Board's chairperson to replace its executive secretary with someone not working for NASA. The revision was the third attempt to quell congressional concerns about the Board's independence. Legislators had mixed reactions to the new revision—some saw it as an improvement, but others maintained that the charter did little to guarantee a credible inquiry and argued that its provisions might deter whistleblowers. U.S. Representative Bart Gordon (D-TN) remarked that the revision had not addressed the fundamental problems: NASA had appointed the commission members; NASA had staffed the commission; and the commission reported to NASA.[375]

19 February
NASA's Deputy Chief of Staff Scott Pace announced that NASA would not seek a waiver to the Iran Non-Proliferation Act of 2000 (Pub.L.No.106-178) The law prohibited NASA from purchasing space hardware from Russia unless Russia certified that Russian aerospace companies had not aided Iranian missile programs for at least a year. If the White House did not grant a waiver, NASA would be unable to buy Russian Progress and *Soyuz* vehicles—the United States' only viable means of reaching the ISS after the suspension of Shuttle flights. Pace explained that NASA would not press the White House for a waiver, because NASA did not

[372] NASA JSC, "Columbia Astronaut Remains Identified," news release H03-070, 13 February 2003, *http://www.nasa.gov/centers/johnson/news/releases/2003/h03-070.html* (accessed 14 August 2008); Associated Press, "Remains of All Shuttle Astronauts Identified," 14 February 2003.
[373] NASA, "Statement by the Columbia Accident Investigation Board," news release 03-072, 13 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_03072.html* (accessed 16 July 2008).
[374] NASA, "Initial Requirements Set for Orbital Space Plane System," news release 03-073, 18 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_03073.html* (accessed 16 July 2008); Gwyneth K. Shaw, "NASA Views Space Plane as Helpmate to Shuttles," *Orlando Sentinel* (FL), 19 February 2003.
[375] Richard A. Oppel Jr., "New Charter for Shuttle Board, But Critics Are Not Appeased," *New York Times*, 19 February 2003.

intend "to make foreign policy," acknowledging that the White House or the U.S. Department of State was responsible for seeking changes in the Iran Non-Proliferation Act, if appropriate.[376]

20 February

President George W. Bush signed into law an omnibus appropriations bill (Pub.L.No.108-7), setting aside US$50 million to help NASA fund its investigation of the Space Shuttle *Columbia* disaster. Taking into account that NASA's costs could exceed US$50 million to cover the investigation and to correct the problems with the Shuttle program, the law allowed NASA to seek additional funding if necessary. U.S. Senator Bill Nelson (D-FL) initiated discussion about the need for additional funding for the *Columbia* accident investigation, urging senior members of the Senate responsible for appropriations to include enough money to help NASA avoid further erosion of the already depleted Shuttle funds. The *Challenger* accident investigation had cost the United States US$75 million.[377]

25 February

Having received a very weak signal from the Pioneer 10 spacecraft on 22 January 2003, NASA announced that it would make no further attempts to contact the craft. On 2 March 1972, NASA had launched Pioneer 10, built by TRW Inc., on a three-stage Atlas-Centaur rocket. In just 12 weeks, Pioneer 10 had traveled beyond Mars, had become the first spacecraft to pass through the asteroid belt, and had continued to travel beyond Jupiter into deep space, "venturing into places where nothing built by humanity had ever gone before." Pioneer 10 had last returned telemetry data on 27 April 2002. In the previous three attempts of JPL's Deep Space Network to contact it, Pioneer 10 had emitted very weak response signals, and in the last attempt at contact on 7 February, the Deep Space Network had detected no signal from the spacecraft. Engineers reported that Pioneer 10's radioisotope power source had decayed. Originally, NASA had designed Pioneer 10 for a 21-month mission, but the spacecraft had lasted more than 30 years.[378]

27 February

NASA researchers announced that the ER-2, a modified U-2 aircraft, had collected tiny interplanetary dust particles (IDPs) in Earth's stratosphere, which likely contained bits of ancient stars. The particles, collected over a period of two decades, included the only samples of comets that researchers were able to study in a laboratory. Lindsay Keller, a researcher in the Office of Astromaterials Research and Exploration Science at NASA's JSC, remarked that the stardust grains were typical of the kind of dust available at the beginning of the solar system—the building blocks of the Sun and planets. Scott Messenger, an astrophysicist at Washington University in St. Louis, Missouri, described the IDPs as rich in stardust and molecular cloud material, suggesting that the particles had remained essentially unchanged since the solar system's formation. To detect the remnants of the early stars, scientists had used Washington University's new type of ion microprobe, which measured isotopic ratios on scales much smaller than previously possible.[379]

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[376] Brian Berger, "NASA Official: Agency Won't Seek Waiver to Iran Act," *Space News*, 20 February 2003.
[377] Frank Oliveri, "NASA Gets $50 Million for Shuttle Investigation," *Florida Today* (Brevard, FL), 22 February 2003.
[378] NASA, "Pioneer 10 Spacecraft Sends Last Signal," news release 03-082, 25 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_03082.html* (accessed 16 July 2008).
[379] NASA, "NASA Finds Remnants of Ancient Stars in Earth's Upper Atmosphere," news release 03-084, 27 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_03084.html* (accessed 16 July 2008).

28 February
NASA released a flight-deck videotape, which the crew of STS-107 had recorded on 1 February between 8:35 and 8:48 a.m. (EST). NASA had recovered the videotape from the Shuttle's crash site near Palestine, Texas. The video showed flight-deck activity as *Columbia* passed over the south central Pacific Ocean at an altitude of approximately 500,000 feet. Filmed with a small on-board camera, mounted to the right of Pilot William C. McCool and then passed to Mission Specialist Laurel B. Clark, the videotape showed Commander Rick D. Husband, Pilot McCool, Mission Specialist Kalpana Chawla, and Mission Specialist Clark on the flight deck during reentry. The astronauts were conversing among themselves as they worked through routine checklist activities with flight controllers at NASA's Mission Control.[380]

MARCH 2003

3 March
Missile Defense Agency (MDA) officials announced that the flight test in December 2002 of the Ground-based Midcourse Defense (GMD) system had been unsuccessful, because a faulty computer-chip connection in the Raytheon exoatmospheric kill vehicle (EKV) had prevented the EKV from separating from its booster during flight. Although the MDA had not recovered the EKV, engineers had determined the problem with the chip's connection using laboratory simulations, concluding that no significant underlying problem with the EKV technology had caused the failure. The December test, the third unsuccessful GMD intercept attempt, had been the second attempt in which the EKV had failed to separate from the booster. U.S. Air Force Lieutenant General Ronald T. Kadish, Director of the MDA, remarked that quality-control problems had likely caused the test failure and announced the formation of an office to improve the MDA's performance.[381]

5 March
ESA formally opened its first deep space ground station in New Norcia, Australia. Construction on the US$47 million (EUR 28 million) facility had begun in April 2000. The key component of the station was a massive antenna, 40 meters (125 feet) high and weighing 600 tonnes (661.4 tons or 600,000 kilograms), with a 35-meter (110-foot) dish. ESA had selected the New Norcia site because its distance from urban areas protected it from interference from other transmission devices, its latitude was perfect for deep space operations, and its weather was excellent. ESA had built and opened the station in time for it to play a key role in ESA's Mars Express mission, scheduled for launch in June. The Mars Express craft would carry a lander dubbed Beagle 2—named in honor of the ship that Charles Darwin sailed on during his search for the origins of life—which would map the surface, subsurface, atmosphere, and ionosphere of Mars.[382]

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[380] NASA, "NASA Releases Columbia Crew Cabin Video," news release N03-23, 28 February 2003, *http://www.nasa.gov/home/hqnews/2003/feb/HP_news_n03023.html* (accessed 16 July 2008).
[381] Marc Selinger, "Test Failure of GMD System Blamed on Problem with Computer Chip," *Aerospace Daily*, 5 March 2003.
[382] ESA, "ESA's First Deep Space Ground Station Opens in Western Australia," ESA news release 14-2003, 5 March 2003, *http://www.esa.int/esaCP/Pr_14_2003_p_EN.html* (accessed 28 August 2008); Agence France-Presse, "Australian Town Host to European Space Quest," 6 March 2003.

NASA announced that Administrator Sean O'Keefe had appointed three new members to the CAIB in compliance with a request from CAIB Chairperson Harold W. Gehman Jr. The new members were Douglas D. Osheroff, the J. G. Jackson and C. J. Wood Professor of Physics and Applied Physics at Stanford University and a 1996 Nobel Prize Laureate in Physics; Sally K. Ride, a physicist and professor of Space Science at the University of California, San Diego, as well as a former NASA astronaut and the first American woman in space; and John M. Logsdon, Director of the George Washington University Space Policy Institute. O'Keefe had also appointed NASA astronaut retired U.S. Air Force Colonel Michael J. Bloomfield, in response to Gehman's request that Bloomfield replace former astronaut Bryan D. O'Connor as Astronaut Advisor to the Board. O'Connor would return to NASA Headquarters in his role as NASA Associate Administrator for Safety and Mission Assurance.[383]

6 March

Four witnesses appeared before the CAIB at its first public hearing. Director of NASA's JSC Jefferson D. Howell Jr. and Space Shuttle Program Manager Ronald D. Dittemore spoke about workforce issues, particularly, about NASA's concern regarding the erosion of its skill base. Keith Chong, a senior scientist at the Boeing Company, discussed Boeing's work on the foam insulation applied to large propellant tanks such as the Shuttle's external tank and the Boeing Delta 4 booster. Henry McDonald, former Director of NASA's ARC, discussed the Space Shuttle Independent Assessment Team (SIAT), which he had led before leaving NASA. The SIAT report had identified problems within the Shuttle program. McDonald expressed disappointment that NASA had not implemented some of the SIAT's recommendations. He said that he believed some of the recommended improvements, such as modernized records, could have significantly influenced decisions that NASA had based on risk assessments.[384]

10 March

The newest Boeing Delta rocket, the Delta 4, launched the USA 167—also known as the Defense Satellite Communications Systems Phase 3 (DSCSIII-A3), or Discus satellite—into orbit, from the Cape Canaveral Air Force Station in Florida. The American geostationary military communications satellite was the first U.S. Air Force craft launched atop Boeing's newest Delta rocket, as well as the first mission for the U.S. Air Force's Evolved Expendable Launch Vehicle (EELV) Program. The craft, a triaxially stabilized spacecraft with solar power of 1.24 kilowatts, operating at six superhigh frequencies between 40 and 85 megahertz, joined the DSCS III constellation of eight similar craft to provide very secure global links to the U.S. military. The launch of the Discus satellite featured the smallest of the Delta 4's several possible configurations, with two stages and no booster rocket.[385]

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[383] NASA, "New Members Added to the Columbia Accident Investigation Board," news release 03-097, 5 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_03097.html* (accessed 25 August 2008).
[384] Leonard David, "Columbia Accident Hearing Probes NASA Workforce Erosion, Shuttle Safety Issues," *Space.com*, 6 March 2003, *http://www.space.com/missionlaunches/caib_hearing_030306.html* (accessed 29 August 2008); Matthew L. Wald, "NASA Records in Disarray, Study Leader Tells Board," *New York Times*, 7 March 2003.
[385] *Spacewarn Bulletin*, no. 593, 1 April 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx593.html* (accessed 28 August 2008); Reuters, "Delta 4 Sends Up Its First U.S. Air Force Satellite," 10 March 2003.

11 March

NASA scientist Robert Michael Hornstein died of a brain tumor at the age of 57. Hornstein had worked for NASA since 1968, directing its worldwide network of antennas used for communicating with orbiting spacecraft. Hornstein, who had joined NASA during the Apollo program to design programs for ground tracking systems, was "recognized for helping save the Apollo 9 mission from being aborted shortly after launch when he modified tracking software to compensate for a computer malfunction in the launch vehicle." As Ground Networks Director, Hornstein had helped administer network-tracking facilities during Space Shuttle orbits, the Voyager program, the Galileo recovery effort and mission to Jupiter, the Magellan program, and the international Halley's Comet tracking program. He had helped manage the upgrade of Deep Space Network facilities in Australia, California, and Spain and had acted as NASA's primary representative in arranging cooperative tracking efforts with other countries. NASA had awarded Hornstein its Outstanding Leadership Award and Exceptional Service Medal, and the Soviet Union had honored him with membership in its Federation of Cosmonautics.[386]

NASA awarded Wyle Laboratories Inc. a five-year contract to perform a range of activities in the Office of Bioastronautics of the Space and Life Sciences organization at NASA's JSC. Previously, NASA had relied on multiple contracts to perform these tasks. The contract was a cost-plus-award-fee contract with indefinite quantity/indefinite delivery and level-of-effort work. Although the base period of the contract was five years, two options could extend it to 10 years, bringing the total value to US$968.9 million.[387]

13 March

The U.S. Air Force Space Command announced its planned elimination of 1,125 positions over the next seven years, as part of a service-wide, post-September 11 initiative to reduce staffing levels. The move would free it to "pour more resources into the Air Force's 'highest priority missions'," such as special operations and intelligence. The plan called for the elimination of 314 civilian and 442 military positions by October 2004, at both senior and lower levels. U.S. Air Force Major Sean McKenna, a Space Command spokesperson, commented that the reductions did not indicate that the Air Force had assigned lower priority to space.[388]

NASA announced its selection of the Time History of Events and Macroscale Interactions during Substorms (THEMIS) project for the next mission of NASA's Medium-class Explorer (MIDEX) program. The mission would study the causes of auroras. THEMIS comprised five small satellites with identical suites of electrical, magnetic, and particle detectors. With a launch date set for 2007, NASA would place the craft in carefully coordinated orbits, where they would line up along Earth's magnetic tail every four days, to track disturbances. THEMIS satellite data would combine with data gathered from a network of observatories across the Arctic Circle. NASA also announced that it had the opportunity to select an instrument for ESA's Extreme

[386] *Washington Post*, "Robert Hornstein; NASA Scientist Ran Tracking System," 28 March 2003.
[387] NASA, "Wyle Wins NASA Contract To Support Bioastronautics," news release c03-f, 11 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_c03f.html* (accessed 25 August 2008).
[388] Jeremy Singer, "Air Force Space Command To Cut Staff," *Space News*, 13 March 2003.

Universe Space Observatory mission aboard the ISS, which would observe the blue light generated when high-energy cosmic rays collide with Earth's atmosphere.[389]

NASA awarded a contract valued at up to US$238.7 million to the Physical Science Laboratory at New Mexico State University, to operate and maintain scientific balloon facilities and to provide engineering support for the NASA Scientific Balloon Program. The four-year contract with two three-year options had a baseline value of US$39.8 million.[390]

18 March

In the CAIB's second public hearing, expert witnesses discussed what they knew about the reentry of Space Shuttle *Columbia* on 1 February. William H. Ailor III, Director of the Center for Orbital and Reentry Debris Studies at the Aerospace Corporation, explained to the CAIB that part of the difficulty of deciphering the precise cause of the orbiter's breakup was that space agencies had done little work over the past years in reconstructing spacecraft breakups. The lack of a systematic effort to retrieve debris from such incidents compounded the problem. R. Douglas White, Director for Operations Requirements, Orbiter Element Department for United Space Alliance, the prime contractor for NASA's Space Shuttle Program, provided a "dramatic portrayal of *Columbia*'s troubled trajectory from orbit." He drew attention to the behavior of *Columbia*'s aileron, the hinged control surface attached to the craft's trailing edge, remarking that its behavior was a first indication that "something odd was happening to the space plane." Paul Hill, Space Shuttle and ISS Flight Director at NASA's JSC and leader of the team piecing together the still and video images of the Shuttle's final minutes, told the CAIB about the work of the image analysts. Hill also expressed gratitude to the public for submitting amateur photographs and videos for analysis.[391]

19 March

NASA opened its inaugural annual Service Life Extension Program (SLEP) Summit at the NASA Michoud Assembly Facility near New Orleans. SLEP was part of the new Integrated Space Transportation Plan (ISTP) established to "ensure the viability of the Space Shuttle Program." NASA intended the annual summit to provide a forum to aid the U.S. spaceflight community in shaping long-range strategy, setting priorities, and determining the selection and recommendation process to sustain the Shuttle system. In the wake of the *Columbia* tragedy, the summit also addressed return-to-flight issues in its first meeting. The summit brought together approximately 200 government and aerospace industry professionals who heard from seven SLEP panels: Safety, Sustainability, Infrastructure, Aerospace Industry, Performance, Operations, and Resources. Panels consolidated and submitted their recommendations to NASA's Space Flight Leadership Council (SFLC), which then identified 60 candidate projects for further consideration and chartered a team to prepare an internal submission, which SLEP

[389] NASA, "NASA Selects Next Medium-Class Explorer Mission," news release c03h, 20 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_c03h.html* (accessed 25 August 2008).
[390] NASA, "NASA Selects PSL for Balloon Program Support Contract," news release c03-g, 14 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_c03g.html* (accessed 25 August 2008).
[391] Leonard David, "Columbia Board Hearing: 'Clues, Critical Events' Destroyed on Reentry," *Space.com*, 18 March 2003, *http://www.space.com/missionlaunches/sts107_caib_030318.html* (accessed 29 August 2008).

would vet over the summer, during NASA's upcoming FY 2005 budget process. SLEP intended to refine its long-term strategy further at the following year's summit.[392]

21 March

NASA announced the replacement of its Mishap Response Team with the newly formed NASA Accident Investigation Team (NAIT), which would continue to support the CAIB. NASA had formed the Mishap Response Team within hours of the *Columbia* disaster on 1 February but had drawn criticism for the team's composition, which included staff that had directly overseen the Shuttle's mission. Linda Ham had led the Mishap Response Team, even though, as a senior Shuttle program manager, she had assisted in making key decisions during the 16-day *Columbia* mission. NASA and the CAIB intended for the NAIT to support the CAIB, and they had organized the NAIT to mirror the CAIB's structure, with three subsections: materials, operations, and engineering. NASA had appointed Deputy Director of JSC Randy Stone to chair the NAIT.[393]

NASA officials and a CAIB spokesperson stated that NASA had recovered intact, from a field in Texas, the Orbital Experiment Support System, an electronic box containing vital information from Space Shuttle *Columbia*'s descent. NASA had designed the system to activate at about 400,000 feet, when Earth's atmosphere first affects the Shuttle. The box contained data that the Shuttle had not transmitted to NASA's Mission Control via telemetry.[394]

22 March

A NASA four-engine, P3-turboprop, "flying laboratory" airplane flew its last flight in a two-week-long series of flights scanning a section of Alaska's coast. The scanning was part of a collaborative project between NASA, NOAA, and representatives from the University of Colorado and the University of Alaska at Fairbanks. The project, called Arctic 2003, had collected data about sea-ice variability for comparison with data that NASA's Aqua satellite had collected. The Aqua had launched in May 2002 with a state-of-the-art radiometer for studying water systems. The P3 had carried equipment similar to Aqua's radiometer—a Japanese-developed microwave scanner—but because it had flown closer to the ground than the Aqua, the P3 had been able to collect sharper images. P3 flights had traveled over Norton Sound, St. Lawrence Island, St. Matthew Island, Point Hope, and Barrow. In addition to the P3 and Aqua data, ground crews had traveled to some areas to collect samples of ice and snow.[395]

25 March

NASA announced that it had awarded US$39.9 million in additional work under the consolidated space operations contract (CSOC) with Lockheed Martin Space Operations Company, to fund NASA's JPL's maintenance and operation of the Deep Space Network in the United States, as

[392] NASA, "Space Shuttle Program Holds First Summit," news release n03-030, 14 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_n03030.html* (accessed 25 August 2008); NASA, "NASA Develops Long-Term Planning Process for Space Shuttle," news release 03-119, 24 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_03119.html* (accessed 25 August 2008).
[393] NASA, "NASA Columbia Accident Support Activities Reorganized," news release 03-113, 21 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_03113.html* (accessed 25 August 2008); Robyn Suriano, "New Team Created To Help with Shuttle Probe," *Orlando Sentinel* (FL), 24 March 2003.
[394] CNN, "Crucial Columbia Part Found," 20 March 2003.
[395] Associated Press, "Flights Help Scientists Understand Sea Ice Changes," 24 March 2003.

well as to provide technical support to the Spanish and Australian Deep Space Network complexes. The additional work brought the total value of the CSOC to US$2.1 billion.[396]

In the CAIB's third public meeting, U.S. Air Force Lieutenant General Aloysius G. Casey, a retired three-star general and former Director of the Space Division of Air Force Systems Command, presented his opinions about the *Columbia* disaster, based on his decades of experience with missiles and rocket systems. Casey shared with the Board his knowledge of high-speed impacts, referring to the insulating foam that had fallen from the Shuttle's external tank 81 seconds after the 16 January launch. He also shared his knowledge of the level of testing necessary to determine whether a system is qualified to fly. Casey stated that NASA needed to "do a better job in quantifying the safety margins for all of the shuttle's various systems and be more sensitive to clues the hardware may be offering when things don't work as designed." Board Chairperson Harold W. Gehman Jr., remarking that the "subject of 'successful flights don't re-establish margins' has come back again and again," called Casey's insight very helpful. However, Roy D. Bridges Jr., Director of NASA's KSC, noted that he had never considered falling foam to be a safety issue and that it had never caused "any significant damage in the program to date." Rather than a safety issue, Bridges had considered the foam a maintenance concern. Bridges commented that if he had been aware of the safety implications, he would have recommended a stop to flying.[397]

26 March

NASA awarded its Commercial Invention of the Year to the Video Image Stabilization and Registration System (VISAR) and its Government Invention of the Year to the Computer Implemented Empirical Mode Decomposition Method, also known as the Hilbert-Huang Transformation (HHT) Method. David H. Hathaway, a solar physicist, and Paul Meyer, an atmospheric scientist, both of NASA's MSFC, had created the basis for the VISAR technology, which turns dark, jittery images into clearer stable images. NASA had developed VISAR in response to an FBI request for assistance. The FBI first used VISAR in 1996 to analyze video of the bombing at the Olympic Summer Games in Atlanta. At the time of the award, investigators were using VISAR to help isolate images collected during the launch of the ill-fated Space Shuttle *Columbia*, images that they were examining to locate possible damage to the orbiter. Norden E. Huang, Director of the Goddard Institute of Data Analysis at NASA's GSFC, had invented the HHT Method, which had applications in a variety of fields. Researchers could use the HHT Method in the study of topics as diverse as climate cycles, earthquake engineering, geophysical exploration, submarine design, turbulence flow, basic nonlinear mathematics, satellite data analysis, structural damage detection, nonlinear wave evolution, variations in solar neutrinos, blood pressure variations, and heart arrhythmias. NOAA had used the HHT Method to analyze sea-surface temperature data collected by Earth-orbiting spacecraft, successfully linking environmental changes with weather changes.[398]

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[396] NASA, "NASA Awards $39.9 Million Contract Addition to Lockheed Martin," news release c03-i, 25 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_c03i.html* (25 August 2008).
[397] Jim Banke, "NASA Missed Trouble Signs, Expert Tells Columbia Board," *Space.com*, 25 March 2003, *http://www.space.com/missionlaunches/sts107_caib_030325.html* (accessed 29 August 2008).
[398] NASA, "NASA Selects Commercial and Government Inventions of the Year," news release 03-120, 26 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_03120.html* (accessed 25 August 2008); Brian Lawson, " NASA Cites Two for Imaging Work: Invention Has Been Used To Help Law Enforcement Effort," *Huntsville Times* (AL), 27 March 2003.

27 March
On the 35th anniversary of the accident that killed Yuri Gagarin, the Russian daily *Komsomolskaya Pravda* published extracts of a secret investigation of Russia's KGB (the Soviet-era Office of State Security) into the cause of the Soviet cosmonaut's death. Gagarin and his instructor had died on 27 March 1968, during a routine training exercise at the Chkalovsky Air Base outside Moscow. The government had ordered three official investigations, one by the civilian government and two military, but all three had ruled out sabotage. An inspection of Gagarin's MiG-15 had identified no mechanical failures and investigators had concluded that the fighter "went into a spin after either hitting birds or suddenly swerving to avoid a weather balloon or another aircraft." The circumstances of his death had since "been cloaked in mystery and rumours that the Communist Party had Gagarin killed because of his love of drink and women." The KGB's counterintelligence unit had conducted its own secret investigation, finding that ground staff's actions had "amounted to a 'dangerous violation' of standing instructions," leading to the death of Gagarin and his instructor.[399]

Investigators of the Space Shuttle *Columbia* accident stated that the recently recovered Orbital Experiment Support System, which stored data about temperature, aerodynamic pressure, vibration, and other variables, appeared to contain information up to a fraction of a second before the orbiter broke apart over Texas. Technicians had located a time tag on the tape indicating that it had stored data until 9:00:18 a.m. (EST) on 1 February. [400]

28 March
NASA announced the publication in the *Journal of Geophysical Research* of the conclusions of a research team that had used data spanning the years 1991 through 2000, which the Microwave Limb Sounder on NASA's *Upper Atmosphere Research Satellite* had collected. The team had found that ozone depletion over Earth's Arctic region varies in amount, timing, and pattern of loss, confirming previous variations in Arctic ozone-loss estimates. The team's findings provided the first "consistent, three-dimensional picture of ozone loss during multiple Arctic winters." [401]

Administrator Sean O'Keefe announced an agreement between NASA and the National Imagery and Mapping Agency (NIMA), which provided for NIMA to capture detailed satellite images of Space Shuttles in orbit. NASA had sought this agreement with NIMA because of critics' "pointed questioning" of NASA's decision not to capture satellite images that it could have used to check for damage to *Columbia*'s heat shields while the Shuttle was in orbit. The agreement would enable NASA to "employ NIMA assets during targets of opportunity" without requiring NASA to make a specific request for imaging. Before the disaster, NASA had turned down a NIMA offer to capture images of *Columbia*, and NASA officials had withdrawn an unofficial request for U.S. Air Force telescopes to capture images. O'Keefe stated that the agreement did not represent any NASA decision "about whether those images might have helped determine damage" to *Columbia.*[402]

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[399] Ben Aris, "KGB Held Ground Staff To Blame for Gagarin's Death," *Daily Telegraph* (UK), 28 March 2003.
[400] Kathy Sawyer, "Columbia's Last Seconds Recorded," *Washington Post*, 28 March 2003
[401] NASA, "NASA Finds Wide Annual Fluctuations in Arctic Ozone Loss," news release 03-125, 28 March 2003, *http://www.nasa.gov/home/hqnews/2003/mar/HP_news_03125.html* (accessed 25 August 2008).
[402] Associated Press, "Military To Capture Future Shuttle Flight Images," 29 March 2003.

Japan launched two reconnaissance satellites—Information Gathering Satellites (IGSs), IGS 1A and IGS 1B—atop an H-2 rocket from Tanegashima Space Center. The pair, the first of at least four such spacecraft that Japan intended to place in orbit as part of a US$2.05 billion program, were capable of monitoring global natural disasters and hurricanes, as well as observing nuclear explosions and missile launches in nearby countries. Because the craft were able to monitor weather events, the launch did not violate the terms of the Japan-North Korea Declaration of September 2002. However, Japanese space officials acknowledged that Japan had developed the program in reaction to the "Taepodong shock," when a North Korean Taepodong ballistic missile flew over Japan's main island in 1998. North Korea protested the IGS program as a "'hostile act' that violates the spirit" of the countries' bilateral agreement. One of the IGS craft carried optical cameras with 1-meter (3.3-foot) resolution and the other carried synthetic-aperture radar to capture images with resolutions of several meters. Japanese space officials provided no information about which craft carried which instrument.[403]

31 March
An American GPS satellite, GPS 2R-9, launched atop a Delta 2 rocket from Cape Canaveral Air Force Station in Florida. The GPS 2R-9—also known as NAVSTAR 52 and USA 168—replaced the aging GPS 2-5, which had been in orbit since 1989. The fleet of GPS satellites consisted of 28 spacecraft.[404]

APRIL 2003

1 April
NASA named astronaut and veteran Shuttle Commander James D. Halsell Jr. to lead its Return to Flight Team, which would prepare for the first Shuttle launch since the loss of *Columbia*, to occur as early as September 2003. Halsell had logged more than 1,250 hours in space on five Shuttle missions and, most recently, had served as Manager of Shuttle Launch Integration at NASA's KSC. Before the *Columbia* disaster, NASA had assigned Halsell to STS-118, a mission to the ISS scheduled for later in 2003.[405]

2 April
The Russian military successfully launched from Plesetsk Cosmodrome a military communications satellite aboard a Molniya-M booster. The purpose of the satellite Molniya 1-92 was to orbit above the far northern regions of Russia relaying commands and communications among military forces. At the lower end of its orbit, the craft would sweep quickly over the Southern Hemisphere, returning to orbit above northern Russia. From this position, the craft would serve users who were out of range of most communications satellites, which, traditionally, orbit at geostationary positions above the equator.[406]

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[403] NASA, *Spacewarn Bulletin*, no. 593; Eric Talmadge for Associated Press, "Japan's First Spy Satellites Reach Earth Orbit," 27 March 2003.
[404] *Spacewarn Bulletin*, no. 593; Kelly Young, "Delta 2 To Carry GPS Satellite into Space," *Florida Today* (Brevard, FL), 31 March 2003.
[405] Larry Wheeler, "NASA Names Shuttle Leader," *Florida Today* (Brevard, FL), 2 April 2003.
[406] *Spacewarn Bulletin*, no. 594, 1 May 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx594.html* (accessed 14 October 2008); Stephen Clark, "Military Spacecraft Launched by Russian Forces," *Spaceflight Now*, 2 April 2003.

Alex Roland, a history professor at Duke University and former NASA historian, and Brian E. Chase, Executive Director of the National Space Society and a former congressional aide, testified before the U.S. Senate Commerce Subcommittee on Science, Technology, and Space concerning problems in NASA's Space Shuttle Program. Roland stated that the Shuttle was not sustainable as a safe, reliable, and economical launch vehicle and recommended its phaseout. Roland faulted NASA for ignoring the findings of the Presidential Commission on the Space Shuttle *Challenger* Accident (Rogers Commission), which had paved the way for the Shuttle to return to flight after the *Challenger* disaster in 1986. The Rogers Commission had recommended that NASA begin developing a next-generation launch vehicle immediately. However, 16 years later, NASA continued to rely on the Space Shuttle and had no replacement in sight. Chase recommended the short-term maintenance of the remaining Shuttles and endorsed the George W. Bush administration's plan to develop an Orbital Space Plane (OSP) ready to transport crews to the ISS by 2010. He also recommended that NASA use commercial heavy-lift launch vehicles for hauling cargo to the space station.[407]

4 April

Boeing announced that its Integrated Defense Systems unit had signed a contract with the Japan Defense Agency and the trading company ITOCHU Corporation to build the first aircraft of the Japan Air Self Defense Force 767 Tanker Transport Program, comprising four aircraft and support. For its 767 Tanker Transport, Japan had selected the military derivative of the 767-200ER commercial aircraft, reconfigured with an advanced Boeing air-refueling boom and an advanced remote aerial refueling operator system. With its selection of the convertible freighter configuration, Japan would have the flexibility to carry either cargo or passengers. The 767 Tanker Transport Program would enable Japan to meet its commitment to international cooperative efforts, such as delivering humanitarian aid and meeting the air-refueling needs of Japan and other countries around the world. [408]

NASA and industry researchers completed a series, begun on 1 April, of collision-avoidance tests between airplanes and remotely controlled UAVs. Although UAVs had achieved high-profile military roles overseas, the United States had not yet approved the use of robotic drones within U.S. airspace. The collision-avoidance tests were part of the efforts of the FAA, NASA, and the DOD to determine what safety and reliability standards UAVs would need to meet. For example, the FAA sought to ensure that robotic drones could respond to instructions from air traffic controllers as quickly as human pilots of conventional aircraft could respond. Researchers had created 20 collision scenarios in restricted airspace over four days, using an F/A-18 jet and a propeller-driven Beechcraft. During the tests, ground-based pilots operating the experimental Proteus drone had only been able to see evidence of the other two planes in the form of a stream of radar and other data and had never actually observed the physical aircraft. Yet, in each scenario, the pilots had been able to maneuver the drone to avoid colliding with the other aircraft.[409]

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[407] Jefferson Morris, "Former NASA Historian Urges Phaseout of Shuttle," *Aerospace Daily*, 4 April 2003; Larry Wheeler, "Experts Disagree on Future of Shuttle," *Florida Today* (Brevard, FL), 3 April 2003.
[408] The Boeing Company, "Boeing, Japan Sign 767 Tanker Transport Contract," news release, 4 April 2003, *http://www.boeing.com/news/releases/2003/q2/nr_030404m.html* (accessed 19 September 2008).
[409] Andrew Bridges for Associated Press, "NASA Envisions Robot Planes in U.S. Skies," 5 April 2003.

7 April
The CAIB questioned NASA flight managers and tank engineers about damage from launch debris—a key concern of the CAIB—during 4 hours of technical testimony at a public hearing. The CAIB sought to uncover why NASA officials had considered the recurrent problem of foam falling during launches a maintenance issue rather than a flight safety concern. NASA testimony included the description of the layers of checks, justifications, and paperwork required to certify a Shuttle for launch, as well as evidence of NASA engineers' collective conviction that the shedding foam did not present a threat to flight safety and, therefore, was not a sufficient reason to cancel a launch. In October 2002, foam falling from the bipod area of its external tank—the area where two metal struts connect the fuel reservoir to the orbiter—had struck Space Shuttle *Atlantis*. The foam that had fallen from Space Shuttle *Columbia* striking its wing had come from the same area of *Columbia*'s external tank as the foam that had struck *Atlantis*. However, engineers and managers had examined *Atlantis*'s debris incident and had determined that falling foam did not present a safety-of-flight concern for *Columbia*. Nevertheless, because of the *Atlantis* incident, managers had requested that engineers responsible for the Shuttle's external tank develop a plan to prevent debris from breaking away from the bipod area of the tank. Engineers had not completed the plan at the time of *Columbia*'s flight.[410]

8 April
The U.S. Air Force and Lockheed Martin launched the Milstar II military communications satellite into orbit aboard a Titan 4B launch vehicle with a Centaur upper stage. The satellite joined four other Milstar satellites already in orbit, completing the constellation. The Milstar constellation provided secure, global communication links for U.S. military joint forces, transmitting voice, data, and imagery, as well as providing video-teleconferencing capabilities. Milstar II was the third satellite to carry the Boeing Satellite Systems–built, medium-data-rate payload, which had 32 channels, each capable of processing data at speeds of 1.5 megabits per second. The craft carried a low-data-rate payload as well, built by Northrop Grumman Space Technology.[411]

American astronauts Kenneth D. Bowersox and Donald R. Pettit undertook a 6½-hour spacewalk at the ISS to finish preparing the station for the arrival of a new crew. In the second spacewalk of their four-month mission, Bowersox and Pettit worked on power connections, replaced lighting for a transport trolley, reconfigured cables on a navigational gyroscope, and secured covers on the station's thermal control system. Cosmonaut Nikolai M. Budarin monitored the astronauts' work from inside the ISS.[412]

9 April
A European Ariane 5 rocket launched two satellites into orbit from Kourou, French Guiana—PanAmSat's Galaxy 12 commercial telecommunications satellite and the Indian Space

[410] Todd Halvorson, "Engineers: Launch Debris Troublesome Since Start," *Florida Today* (Brevard, FL), 8 April 2003; Marcia Dunn for Associated Press, "Earlier Shuttle Flight Had Foam Problem," 8 April 2003.
[411] Lockheed Martin, "U.S. Air Force and Lockheed Martin Team up to Successfully Launch Final Milstar II Satellite on a Titan IV B Rocket," news release, 8 April 2003, *http://www.lockheedmartin.com/news/press_releases/2003/USAirForceLockheedMartinTeamUpSucce.html* (accessed 19 September 2008).
[412] Reuters, "Astronauts End Space Walk from Orbiting Station," 9 April 2003.

Research Organisation's (ISRO's) INSAT 3A satellite. The Ariane 5G standard version was the first launch of an Ariane rocket since the enhanced Ariane 5 ECA had failed in December 2002, a failure that had prompted a complete review of the Ariane 5 system, particularly its main-stage cryogenic engine. The 1.8-tonne (2-ton, 1,800-kilogram, or 3,968-pound) Galaxy satellite built by Orbital Sciences Corporation carried 24 C-band transponders to provide voice, video, and data transmissions to North America and South America from its position at longitude 72º west. The 3-tonne (3.3-ton, 3,000-kilogram, or 6,614-pound) INSAT 3A geostationary communications and weather-monitoring satellite carried 12 C-band, 6 extended C-band, and 6 Ku-band transponders, to provide voice, video and data transmission to western Asia, eastern Asia, and India from its position at longitude 93.5º east. The ISRO satellite carried the typical INSAT package of visual, infrared, and water-vapor band sensors to monitor clouds and storms, as well as a separate transponder for an international search-and-rescue program.[413]

10 April

British Airways and Air France announced that, because of poor economic conditions, supersonic jet travel aboard Concorde jets would end in October after 26 years of the premium service. British Airways announced it would retire its fleet of seven at the end of October, and Air France announced it would stop flying its Concorde aircraft on 31 May, with a definitive retirement date for the fleet set for 31 October.[414]

11 April

International Launch Services (ILS) successfully launched the Boeing-built AsiaSat 4 satellite aboard a Lockheed Martin–built Atlas 3 rocket from Cape Canaveral Air Force Station in Florida, marking 64 consecutive successful launches for the Atlas rocket over 10 years. The mission was ILS's third launch for AsiaSat, the dominant satellite operator in its region. Boeing Satellite Systems had designed the AsiaSat 4 craft, a high-power 601HP spacecraft, to provide 15 years of direct-to-home communications and broadband services to customers in Asia and Australia.[415]

14 April

Boeing announced that Boeing Electronic Dynamic Devices Inc. (EDD) had won three new contracts—the Carbon-Based Ion Optics project, the NASA Evolutionary Xenon Thruster (NEXT) system, and the High Power Electric Propulsion (HiPEP) project—under NASA's In-Space Propulsion Program to develop advanced xenon ion–propulsion technologies. Teamed with NASA's JPL and GRC, EDD would lead the two-phased effort to develop advanced carbon-based ion optics, ultimately testing designs for carbon-based ion optics for their potential use in the next-generation ion engine. According to terms of the second contract, EDD would support GRC in developing the NEXT system, a next-generation, high-power, ion-propulsion

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[413] *Spacewarn Bulletin*, no. 594; Peter B. de Selding, "Ariane 5 Successfully Returns to Flight," *Space News*, 11 April 2003.
[414] *Los Angeles Times*, "Economic Woes Bring End to Flights of Supersonic Jets," 10 April 2003.
[415] Lockheed Martin, "Atlas III Launch of Asiasat 4 Successful in 1st ILS Mission of 2003," news release, 11 April 2003, *http://www.lockheedmartin.com/news/press_releases/2003/AtlasIIILaunch OfAsiaSat4 SuccessfulI.html* (accessed 19 September 2008); The Boeing Company, "Boeing-Built AsiaSat 4 Communication Satellite Successfully Launched," news release, *http://www.boeing.com/news/releases/ 2003/q2/nr_030411t.html* (accessed 19 September 2008).

system intended for space science missions. Under the third contract, EDD would support GRC in developing and testing technologies for the HiPEP project.[416]

17 April
John E. Riley, a 33-year member of NASA's Public Affairs Department, broadcast voice of NASA's Mission Control for the Apollo program, and NASA spokesperson, died of cancer at the age of 78. He had begun working for NASA in 1959 and, as a member of the Apollo program team, had provided commentary during the first moonwalk. Riley had also initiated the practice of encouraging astronauts' interviews with media and had traveled with astronauts internationally.[417]

The CAIB released its first two official recommendations, suggesting that before resuming Shuttle missions, NASA should 1) improve its inspections of the leading edge of the orbiters' wings, and 2) ensure that U.S. spy satellites would capture detailed images of the orbiters during each mission. Although the Board had not yet begun developing its final report, the CAIB released preliminary recommendations so that NASA could begin to implement them expeditiously. The CAIB made the first recommendation because it had found that inspection techniques in place did not enable engineers to assess the structural integrity of the orbiter's heat shield, considered a "criticality one" item. The failure of the heat shield—comprising the reinforced carbon-carbon (RCC) panels that protect the front of the orbiter's wings during reentry, the RCC panels' supporting structure, and the attaching hardware—would lead to the loss of the vehicle and crew. The CAIB made the second recommendation because it had discovered that NASA officials had cancelled an informal request that the U.S. military capture images of *Columbia* to check for possible damage caused by launch debris. NASA already had a new memorandum of agreement with the National Imagery and Mapping Agency (NIMA) to provide NASA with images of orbiting Shuttles. Previously, NIMA had only made images available upon request, but the CAIB recommended that NASA and NIMA make imaging each Shuttle flight a standard requirement.[418]

18 April
At the Mojave Airport in California, aircraft designer Burt Rutan unveiled for the first time his White Knight launch system and *SpaceShipOne* spacecraft, which he had built in secret. Rutan had designed the White Knight, a type of aircraft, to carry the spacecraft to 50,000 feet, where the White Knight would release *SpaceShipOne* to launch like an aircraft into a steep climb. Rutan had begun testing the launch platform at lower altitudes in August 2002, also testing on the ground the release mechanism between the spacecraft and the launch platform. In the public unveiling, Rutan flew the White Knight only. The craft flew to an altitude of 9,000 feet (2,734 meters) before spiraling down to make a soft but extremely short landing. Rutan demonstrated *SpaceShipOne*'s systems, explaining that the craft should land in the same manner as the launch system. The flight profile of the system allowed *SpaceShipOne* to reach 54 nautical miles (62 miles or 99.8 kilometers) maximum altitude over a flight patch of 35 miles (56.3 kilometers).

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[416] The Boeing Company, "Boeing EDD Wins NASA Contracts for Advanced Electric Propulsion," news release, 14 April 2003, *http://www.boeing.com/news/releases/2003/q2/nr_030414s.html* (accessed 19 September 2008).
[417] Matt Schwartz, "Obituary: Riley, 78, Longtime Spokesman for NASA," *Houston Chronicle*, 21 April 2003.
[418] Jim Banke, "Columbia Board Releases Two Recommendations to NASA," *Space.com*, 17 April 2003, *http://www.space.com/missionlaunches/sts107_caib_030417.html* (accessed 17 November 2008).

NASA designated anyone flying at an altitude of over 50 miles (80.4 kilometers) as an astronaut. If Rutan's system succeeded in flights outside the atmosphere, it would become the first private human spaceflight program.[419]

23 April
NASA announced the resignation of Space Shuttle Program Manager Ronald D. Dittemore. A 26-year veteran of NASA, Dittemore had supervised the Space Shuttle Program for more than four years. Dittemore had joined NASA in 1977 as a propulsion-systems engineer, working on orbital maneuvering and reaction-control systems for the Space Shuttle before his selection as a Space Shuttle Flight Director in 1985. In 1993 NASA had appointed him Deputy Manager for the Space Shuttle Program Integration and Operations Office in the Space Shuttle Program Office. He had also served as Manager of Space Shuttle Program Integration and as Chairperson of the Space Shuttle Mission Management Team before his selection in 1996 to manage the Space Shuttle Vehicle Engineering Office. He had become Space Shuttle Program Manager in 1999, assuming responsibility for the overall management, integration, and operation of the program. In announcing his departure, Dittemore remarked that, before the *Columbia* tragedy, he had been struggling over whether to leave NASA and had decided to resign in the spring of 2003. However, after the *Columbia* accident, he had immediately postponed his departure. Deputy Associate Administrator for the Space Shuttle Program Michael C. Kostelnik and NASA Administrator Sean O'Keefe credited Dittemore with keeping communications open between NASA and the public in the wake of the tragedy. Dittemore planned to remain in his position until the CAIB had finished its work and established a return-to-flight program, to enable NASA to make a smooth management transition.[420]

A panel of five retired NASA and contractor managers, whose expertise dated to the Mercury, Gemini, and Apollo programs, testified in a public hearing before the CAIB that engineers had never designed orbiters' wings to sustain strikes from any form of debris. The panel members agreed that engineers had known in the 1970s that the RCC panels along the leading edge of the orbiters' wings presented a technical challenge, and that NASA should have taken appropriate precautions against debris striking the RCC panels. Milton A. Silveira, who had helped design the orbiter, remarked that wings of airplanes were also incapable of sustaining such strikes. Robert F. Thompson, another designer of the orbiter, who had headed the Space Shuttle Program in the 1970s, added that providing an impenetrable wing edge was impossible. According to Thompson, if NASA had insisted on that standard, it would have had to abandon the Shuttle project. Diane Vaughn, a sociologist affiliated with Boston College, who in 1996 had published the book *The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA*, spoke to the panel about NASA's approach to risk-management and decision-making systems. Vaughn observed that NASA had failed to address institutional problems present at the time of the *Challenger* disaster, and that as a result, NASA decision-makers had remained unable to access the type of data they needed to assess risk accurately and to act on that knowledge.[421]

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[419] Jon Bonne, "Private Manned Space Plane Unveiled," *MSNBC.com*, 19 April 2003.
[420] NASA, "Space Shuttle Program Manager Decides To Leave Post," news release 03-149, 23 April 2003, *http://www.nasa.gov/home/hqnews/2003/apr/HP_news_03149.html* (accessed 19 September 2008); Paul Recer for Associated Press, "Shuttle Director Dittemore To Leave NASA," 23 April 2003.
[421] Marcia Dunn for Associated Press, "NASA Pioneers Testify on Shuttle Columbia Tragedy," 24 April 2003; Kathy Sawyer, "NASA Mistakes Will Repeat Without Changes, Board Told," *Washington Post*, 24 April 2003.

24 April
The Russian military launched the geostationary Cosmos 2397 aboard a Proton-K rocket. According to rumor, Cosmos 2397, a classified spacecraft reportedly built by NPO Lavochkin, was an early warning satellite.[422]

The NASA Accident Investigation Team (NAIT) presented to the CAIB the results of its ongoing analysis of the *Columbia* disaster. Ten members of the CAIB were either present or listening via telephone, and 30 to 40 NASA and contractor personnel participated in the private briefing. The CAIB indicated that the Space Shuttle Program required more work in four areas—aerothermal analysis, foam-impact testing, testing of flown RCC panels, and metallurgical analysis from debris. According to the CAIB, NAIT had "provided an overview of the latest data-recorder information, and the CAIB issued its guidance based on that data and board investigators' continuing analysis of the latest orbiter debris."[423]

25 April
NASA Administrator Sean O'Keefe named the commander, the pilot, and a mission specialist of the next Space Shuttle mission, even though NASA had not selected any dates for future Shuttle missions since the suspension of Shuttle flights following the *Columbia* disaster. O'Keefe said that NASA's target to resume Shuttle flights was the end of the calendar year. O'Keefe said that the crew—Commander Eileen M. Collins, Pilot James M. Kelly, Mission Specialist Stephen K. Robinson, and Mission Specialist Soichi Noguchi of Japan's NASDA—would be "challenged with the opportunity to be the first crew to return to flight." O'Keefe said that the ISS partners would probably fill the other three slots with a three-member crew headed for the ISS.[424]

26 April
Soyuz TMA-2 launched aboard a Soyuz-U rocket from Baikonur Cosmodrome in Kazakhstan, carrying one Russian cosmonaut and one American astronaut for a six-month stay at the ISS. American Edward T. Lu and Russian Yuri I. Malenchenko would replace the three-person crew that had lived at the space station since November 2002. An expert on solar flares, Lu had flown to Russia's space station *Mir* in 1997 and to the fledgling ISS in 2000 on STS-106. Malenchenko and Lu had been fellow crew members aboard Space Shuttle *Atlantis* on STS-106. During that mission, Lu and Malenchenko had teamed up in a spacewalk to hook up exterior cables.[425]

28 April
In its first launch since the Space Shuttle *Columbia* disaster in February, NASA launched its Galaxy Evolution Explorer (GALEX) research satellite aboard a Pegasus XL rocket released from an L-1011 cargo plane that had flown out of Cape Canaveral Air Force Station in Florida. GALEX carried a telescope measuring 19.7 inches (50 centimeters) in diameter, designed to

[422] NASA, "Space Shuttle Program Manager Decides To Leave Post"; Stephen Clark, "Proton Lifts Military Satellite," *Spaceflight Now*, 24 April 2003.
[423] William Harwood, "NASA, CAIB Investigators Compare Notes on Disaster," *Spaceflight Now*, 24 April 2003.
[424] Deborah Zabarenko for Reuters, "Next Shuttle Crew Named as Columbia Probe Proceeds," 25 April 2003.
[425] *Spacewarn Bulletin*, no. 594; Chris Kindler, "Soyuz Capsule Includes NASA-Required Features," *Florida Today* (Brevard, FL), 23 April 2003; Marcia Dunn for Associated Press, "Astronaut, Cosmonaut Named for Space Station Mission," 2 April 2003, "NASA Mission Archives: STS-106," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-106.html* (accessed 17 November 2008).

provide a wide-angle view of the ultraviolet light that distant galaxies emit. NASA had planned the mission, which would survey the light emitted by a million galaxies over 28 months, to learn more about galaxies dominated by hot, short-lived stars that give off a great deal of energy as ultraviolet light. The mission cost US$103.7 million.[426]

29 April
The Dutch-Italian satellite known as BeppoSAX reentered Earth's atmosphere and splashed into the equatorial Pacific Ocean seven years after its launch into orbit on 30 April 1996. The Italian Space Agency and the Netherlands Agency for Aerospace jointly operated the 3,086-pound (1,400-kilogram) x-ray satellite, best known for its discovery of 50 gamma-ray bursts (GRBs). The Italian Space Agency had estimated that as much as 1,325 pounds (601 kilograms) of the craft could survive reentry, with individual pieces weighing 220 pounds (99.7 kilograms) and had, therefore, notified 39 countries that pieces of the spacecraft could potentially land in their territory. However, the debris falling closest to land splashed into the ocean 186 miles (299 kilometers) northwest of the Galapagos Islands.[427]

30 April
Investigators announced their discovery that thousands of worms known as *C. elegans*—part of a science experiment aboard *Columbia*—were still alive, having survived the violent, high-velocity reentry and impact, traveling at least 120 miles per hour (193 kilometers per hour). The containers holding the worms had remained sealed for several weeks following their recovery while accident investigators at NASA's KSC processed them. Terri L. Lomax, a NASA space biologist, remarked that, although it was unclear what scientists would learn from the worms, the fact that they had survived the accident was data in and of itself.[428]

MAY 2003

3 May
The National Inventors Hall of Fame in Akron, Ohio, inducted 17 aviation and aerospace inventors, among them Harold A. Rosen, recognized for his pioneering work in developing the world's first 24-hour commercial communications satellite and for his subsequent contributions to satellite communications. Rosen had led the Boeing Satellite Systems team that had begun developing the geostationary Syncom in 1959. The team had planned for Syncom to communicate directly and continuously with any ground station in its line of sight, in contrast to the communications satellites in use at the time, which required expensive tracking computers. The first Syncom had failed to launch successfully, but Syncom 2 had reached its synchronous orbit on 26 July 1963. Later that year, Syncom 2 had relayed by satellite the first live two-way call between heads of state—a phone call between President John F. Kennedy in Washington, DC, and Nigerian Prime Minister Abubaker Balewa in Africa. Syncom 3 had brought live coverage of the 1964 Tokyo Olympics to U.S. viewers. The satellites had remained active through 1966, surpassing their one-year design life. David L. Ryan, Vice President and General Manager of Boeing Satellite Systems, remarked that contemporary satellites that deliver video,

[426] *Spacewarn Bulletin*, no. 594; Associated Press, "NASA in 1st Launch Since Columbia Breakup," 28 April 2003.
[427] Andrew Bridges for Associated Press, "BeppoSAX Satellite Falls Harmlessly into Ocean," 30 April 2003.
[428] Kathy Sawyer, "Worms Used for Study Survive Columbia Crash," *Washington Post*, 1 May 2003.

voice, and data communications are all descendants of Syncom, and "when Harold Rosen and his colleagues launched Syncom, they launched a revolution and changed the world."[429]

4 May

Returning from the ISS aboard *Soyuz* TMA-1, American astronauts, Kenneth D. Bowersox and Donald R. Pettit, and Russian cosmonaut Nikolai M. Budarin, touched down in the steppes of Kazakhstan 276 miles (444 kilometers) off course. The landing was the first time American astronauts had returned to Earth in a foreign spacecraft. Budarin, Bowersox, and Pettit had arrived at the ISS in November 2002 aboard *Endeavour*, scheduled to return to Earth aboard another Shuttle flight on 11 March. However, the *Columbia* disaster in February had grounded the remaining three Shuttles in NASA's fleet, prolonging the crew's stay aboard the ISS. Russian search teams took 2 hours, using a helicopter and fixed-wing aircraft, to find the crew. The last radio contact between the capsule and Mission Control Center in Moscow had occurred after the craft's parachutes opened, about 15 minutes before landing. Failure to reestablish contact had caused concern for the trio's welfare. Russian Space Agency spokesperson Sergei Gorbunov announced that a special commission would investigate the causes of the malfunctions during landing.[430]

7 May

Boeing announced the successful completion of Phase III testing of the X-31A Vector aircraft—the world's only international experimental airplane in the X-plane series to receive international collaboration—demonstrating the use of thrust-vectoring technologies for performing extremely short takeoff and landing (ESTOL) operations. The U.S. Navy, Germany's defense procurement agency, the European Aeronautic Defence and Space Company, and Boeing Phantom Works had conducted the ESTOL demonstrations, carrying out the final flight on 29 April at Patuxent River Naval Air Station in Maryland. The demonstrations had consisted of a series of fully automated ESTOL landings on an actual runway using a high angle-of-attack landing, proving that an integrated flight-and-propulsion control system had potential use in ESTOL. Such capabilities would give fighter aircraft greater operational flexibility and lower life-cycle costs.[431]

NASA announced that it had selected several radioisotope-based, power-conversion technologies for research and development. The awards represented the first competitive technology procurement funded entirely by NASA's Project Prometheus. The projects covered distinct areas in power-conversion technology: thermoelectrics, thermophotovoltaics, Stirling engines, and Brayton engines. NASA intended the awards to lay the foundation for technology development enabling new classes of missions, such as networked science stations on Mars and small spacecraft capable of complex maneuvers in deep space. Each award would cover three one-year performance periods with continued support from one period to the next, contingent on the program's needs, availability of funds, and each team's ability to meet milestones. The total

[429] The Boeing Company, "Boeing Satellite Pioneer Harold Rosen Inducted to National Inventors Hall of Fame," news release, 1 May 2003, *http://www.boeing.com/news/releases/2003/q2/nr_030501n.html* (accessed 21 November 2008).
[430] Mark Carreau, "Anxiety as Astronauts Miss Target for Landing," *Houston Chronicle*, 5 May 2003; Sharon LaFraniere, "Space Station Crew Returns Home in Russian Soyuz," *Washington Post*, 5 May 2003.
[431] The Boeing Company, "Boeing X-31A Vector Completes International Flight Test Program," news release, 7 May 2003, *http://www.boeing.com/news/releases/2003/q2/nr_030507a.html* (accessed 21 November 2008).

funding was US$43 million divided into various increments covering fiscal years 2003 to 2006.[432]

8 May

The Indian Space Research Organisation (ISRO) successfully launched the Geostationary Satellite Launch Vehicle (GSLV)–D2 rocket from Satish Dhawan Space Center in Sriharikota, Andhra Pradesh, India. The main payload was the GSAT-2, a geostationary communications and space-monitoring satellite, which carried four C-band and two Ku-band transponders that would provide voice and video transmissions to India and neighboring countries. The GSLV-D2 also carried into orbit experimental payloads: a Coherent Radio Beacon Experiment, a Solar X-ray Spectrometer, an external Total Radiation Dose Monitor, a Radiation Sensitive Field Effect Transistor, and a Surface Change Monitor. However, its main mission was to test the GSLV-D2, an improved version of the GSLV first launched in April 2001.[433]

9 May

The Japanese probe Muses-C—renamed Hayabusa (Falcon) after its deployment—launched from Kogoshima Space Center on the southern Japanese island of Kyushu, aboard an M-5 solid-fuel rocket. The probe's mission was to rendezvous with the asteroid 1998 SF36, gather surface samples, and return to Earth. Japan's Institute of Space and Astronautical Science expected the 510-kilogram (1,124-pound) spacecraft to arrive at the asteroid in June 2005. The craft would then skim the surface several times over three months, collecting 1 gram (0.04 ounces) of surface material from various sites. The Institute had designed the mission to return the samples to Earth in a capsule in June 2007. If the probe succeeded, the samples would be the first space rocks collected since the end of the U.S. Apollo Lunar Exploration Program 30 years before.[434]

NASA announced the selection of William W. Parsons Jr., Director of NASA's SSC, to succeed Ronald D. Dittemore as Manager of the Space Shuttle Program. Dittemore had announced his resignation on 23 April. NASA appointed SSC Deputy Director Michael U. Rudolphi to serve as interim Director of SSC.[435]

12 May

Northrop Grumman Corporation, Raytheon Company, and the Boeing Company formed a team to develop the U.S. Air Force E-10A Multi-Sensor Command and Control Aircraft (MC2A), a next-generation aircraft that could replace the Airborne Warning and Control System and the Joint Surveillance Target Attack Radar System aircraft. The initial agreement called for the production of five MC2A craft for the U.S. Air Force, but the program could increase to allow

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[432] NASA, "Advanced Radioisotope-Power Technologies R&D Teams Selected," contract release c03-n, 7 May 2003, *http://www.nasa.gov/home/hqnews/2003/may/HQ_news_c03n.html* (accessed 20 November 2008).
[433] *Spacewarn Bulletin*, no. 595, 1 June 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx595.html* (accessed 20 November 2008); K. S. Jayaraman, "India Launches Second GSLV Rocket with GSAT," *Space.com*, 8 May 2003, *http://www.space.com/missionlaunches/gslv_launch_030508.html* (accessed 1 December 2008).
[434] *Spacewarn Bulletin*, no. 595; Eric Talmadge for Associated Press, "Japan Launches Rocket To Probe Asteroid," 9 May 2003.
[435] NASA, "NASA Selects New Space Shuttle Program Manager," news release 03-164, 9 May 2003, *http://www.nasa.gov/home/hqnews/2003/may/HP_news_03164.html* (accessed 2 December 2008); Michelle Krupa, "No 2 Man Takes Helm at Stennis Center: Ex-director Moves Up to Shuttle Position," *New Orleans Times-Picayune*, 13 May 2003.

for production of as many as 50 such aircraft. Boeing would provide its twin-jet 767-400 transport aircraft as a platform for powerful multifunction radar with the capability of detecting enemy forces on the ground, as well as low-flying cruise missiles. Northrop Grumman and Raytheon would develop a radar and electronic self-defense system to integrate with a Battle Management Command and Control System produced under a separate contract.[436]

13 May

The White House unveiled the U.S. Commercial Remote Sensing Policy, which President George W. Bush had approved on 25 April to replace former President William J. Clinton's 1994 Presidential Decision Directive-23. The new policy loosened government restrictions on the collection and sale of commercial satellite imagery, directing military and civilian agencies first to approach the commercial sector to fulfill satellite imagery needs. The NSC had created the new guidelines as part of a review of U.S. national space policy, which the White House had directed the NSC to conduct in June 2002 with the support of the Office of Science and Technology Policy. The new policy retained the government's ability to restrict operations of commercial satellite imaging companies for national security reasons, but emphasized that the U.S. military should plan actions in the knowledge that adversaries also had access to commercial satellite imagery. The policy encouraged companies to use the most capable systems possible. However, at the same time, the government retained the right to restrict the sale of the most advanced imagery to U.S. government customers. The policy named the U.S. National Imagery and Mapping Agency (NIMA) as the interface between government and industry for national security applications of commercial satellite imagery. The U.S. Department of Commerce, U.S. Department of Interior, and NASA would fulfill that role for civilian applications.[437]

Hellas-Sat, a geostationary communications satellite jointly owned by Greece and Cyprus, launched from Cape Canaveral Air Force Station in Florida aboard an Atlas 5 rocket with a Russian RD-180 motor. The 3.45-tonne (3.8-ton or 3,450-kilogram) Astrium Eurostar 2000+ model carried 30 Ku-band transponders to provide voice, video, data, and broadcast services to Europe, North Africa, the Middle East, and Southeast Asia. The launch, the second for the Atlas 5 series, was the 65th consecutive successful flight for the Lockheed Martin–built Atlas rocket and for mission provider International Launch Services (ILS).[438]

14 May

Columbia Accident Investigation Board (CAIB) Chairperson Harold W. Gehmen Jr. testified before the U.S. Senate Committee on Commerce, Science and Transportation, that the safety office created at NASA in the aftermath of the *Challenger* explosion in 1986 had been "all but useless." Gehman stated that serious conflicts of interest had "hamstrung the NASA engineering

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[436] Northrop Grumman, "Northrop Grumman, Boeing and Raytheon Announce Teaming Agreement for Next-Generation Air Force Surveillance System," news release, 12 May 2003, *http://www.irconnect.com/noc/press/pages/news_releases.html?d=40216* (accessed 8 December 2008); *Congress Daily*, "Aerospace Giants To Team Up On Air Force Project," 12 May 2003.

[437] Jason Bates, "White House Loosens Curbs on Commercial Satellite Imaging," *Space News*, 13 May 2003; Dan Caterinicchia, "Commercial Satellite Policy Released," *Federal Computer Week*, 15 May 2003.

[438] Lockheed Martin, "ILS Launches Hellas-Sat on Atlas V—65 Successes in a Row for Atlas," news release, 13 May 2003, *http://www.lockheedmartin.com/news/press_releases/2003/ILSLaunchesHellasSat OnAtlasV.html* (accessed 21 November 2008); *Spacewarn Bulletin*, no. 595.

department that advises senior managers about shuttle safety." He explained that the links of engineering specialists with NASA's Space Shuttle Program had apparently been too close to permit independent review of the condition of the orbiters. In addition, he said that NASA's Safety Organization lacked sufficient personnel. Gehman testified that, although NASA's Safety Organization appeared perfect on paper, the procedures lacked substance in reality. NASA Administrator Sean O'Keefe, who appeared at Gehman's side at the hearing, assured the Senate panel that NASA would hold its officials accountable, and that NASA would correct all faults in management that the CAIB identified. However, O'Keefe did not respond to Gehman's criticism of NASA's safety team.[439]

16 May

NASA's ARC in Mountain View, California, closed three wind tunnels until the end of FY 2003 because of budget cuts, fewer defense contracts, and the increased use of computer simulations. NASA reported that, unless it received major contracts from the DOD or from the private sector within a year from October 2003, ARC would close the wind tunnels permanently. Two of the wind tunnels, the largest and second-largest wind tunnels in the world, had operated for nearly six decades, testing dozens of aircraft and spacecraft, including Korean War–era fighter planes, helicopters, and the Space Shuttle. The largest wind tunnel, known as "80 by 120" in reference to its height and width, was the only wind tunnel in the world that could accommodate full-size aircraft. With the closure of the three tunnels, ARC dismissed 23 contractors and reassigned 23 employees, changes that would save ARC US$12 million per year in operational costs.[440]

NASA announced the selection of 15 organizations from industry, government, and academia to carry out 22 propulsion-technology research proposals in five areas of the In-Space Propulsion Program: aerocapture, advanced chemical propulsion, solar-electric propulsion, space-based tether propulsion, and solar-sail technologies. The goal of the program, under the management of the Office of Space Sciences at NASA Headquarters, was to make exploration of deep space more practical, affordable, and productive.[441]

21 May

Lockheed Martin announced it had teamed up with Argon Engineering to conduct a flight test and evaluation of Argon's Lighthouse Communications Intelligence (COMINT) processing capability in a high-density urban environment. The test team had flown the Lighthouse COMINT sensor in the area of Phoenix, Arizona, for more than 24 hours, during eight flights ranging in altitude from 5,000 to more than 20,000 feet (1,524 to more than 6,096 meters). The series of flights confirmed that the sensor was "capable of handling the high dynamic signal densities of urban and military environments." Wes Colburn of Lockheed Martin ISR Systems remarked that Argon's open architecture Lighthouse COMINT system provided a dynamic sensor suite capable of meeting fighters' needs in complex and modern electromagnetic threat environments. The flight tests had validated that the Lighthouse COMINT system was extremely

[439] Traci Watson, "Probe Slams NASA Safety," *USA Today*, 15 May 2003; Nick Anderson, "NASA Is Chided for Faults in Safety Teams," *Los Angeles Times*, 15 May 2003.
[440] Joshua L. Kwan, "NASA/Ames Center Shuts Wind Tunnels," *San Jose Mercury News* (CA), 19 May 2003.
[441] NASA, "NASA Selects In-Space Propulsion Innovations for Research," contract release C03-q, 16 May 2003, *http://www.nasa.gov/home/hqnews/2003/may/HQ_news_c03Q.html* (accessed 20 November 2008).

capable in an airborne environment, as well as on submarines, ships, and land sites where it was already in use.[442]

23 May
NASA announced the appointment of David A. King as the new Director of NASA's MSFC in Huntsville, Alabama, effective 15 June. NASA would reassign Director of MSFC Arthur G. Stephenson, in preparation for his planned January 2004 retirement from NASA. King had been MSFC's Deputy Director since November 2002, assisting Stephenson in managing a range of propulsion, space science, and materials research, as well as development work. NASA had also dispatched King to Lufkin, Texas, within hours of the *Columbia* disaster, to serve as the senior on-site NASA official in the search-and-recovery effort. In that capacity, he had created critical, initial work processes; established effective working relationships among federal and state government agencies; and set the foundation for the two subsequent NASA officials who would share responsibility for leading effective recovery efforts. Before serving as Deputy Director of MSFC, King had been Deputy Director of Shuttle Processing, Launch Director of six Shuttle missions, and Director of Shuttle Processing at NASA's KSC. As Director of Shuttle Processing at KSC, he had managed and coordinated all Space Shuttle processing, launch, and landing operations and had made the final determination to launch during the three-day countdown process.[443]

24 May
Beidou 1C, a People's Republic of China geostationary navigational satellite, launched from Xichang Satellite Launching Center in Sichuan province aboard a Long March 3A rocket, joining two other Beidou craft launched in 2000 to complete the satellite constellation. Xinhua, the Chinese national media outlet, reported that the transportation industry, telecommunications industry, weather forecasters, environmental planners, emergency personnel would be able to use the global positioning and navigational satellites. However, western analysts speculated that China was more likely to use the Beidou satellites' capabilities to make its own military and weapons systems more precise.[444]

26 May
Nikolai I. Zelenschikov, who had led the investigation into the off-target landing of *Soyuz* TMA-1, announced that a technical malfunction, rather than crew error, had caused the craft's unexpectedly steep and off-course landing on 4 May, when the craft returned two astronauts and a cosmonaut to Earth. Zelenschikov, Deputy Chief Designer of RSC Energia (S.P. Korolev Rocket and Space Corporation), stated that specialists had found no problems with the new software on *Soyuz* TMA-1 and had discovered no errors attributable to the crew. Instead, investigators had found that a 25-year-old instrument had failed to control the spacecraft's descent. Soviet engineers had a plan for modifying the instrument to ensure its reliability.

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[442] Lockheed Martin, "Lockheed Martin and Argon Engineering Team Up for the First Flight of the Lighthouse COMINT System," news release, 21 May 2003, *http://www.lockheedmartin.com/news/press_releases/2003/LockheedMartinArgonEngineeringTeamU.html* (accessed 21 November 2008).
[443] NASA, "David A. King Named Marshall Space Flight Center Director," news release 03-181, 23 May 2003, *http://www.nasa.gov/home/hqnews/2003/may/03181_king_msfc_director.html* (accessed 20 November 2008); Patty Reinert, "Marshall Space Flight Center Chief Will Leave Post in January," *Houston Chronicle*, 21 May 2003.
[444] *Spacewarn Bulletin*, no. 595; Stephen Clark, "China Lofts Navigation Craft on Long March Booster," *Spaceflight Now*, 25 May 2003.

Investigators had also recommended that the Russian Space Agency position more airplanes and helicopters along the trajectory of landing *Soyuz* craft, but cosmonaut Pavel V. Vinogradov, a member of the commission investigating the accident, noted that chronic underfunding had led to a shortage of aircraft available for this purpose. The commission further recommended equipping *Soyuz* craft with satellite communication technology. Because several of the craft's antennas had failed, the *Soyuz* TMA-1 crew had lost radio contact with Mission Control Center in Moscow during landing and had not regained it. Zelenschikov stated that the Russian space industry would make all necessary modifications to the *Soyuz* TMA-3 craft but could make no repairs to *Soyuz* TMA-2, which had already docked at the ISS. However, the Russian Space Agency planned to ferry a satellite phone to the ISS aboard a cargo mission, for use on the return flight of to TMA-2.[445]

27 May

NASA Chief of Staff and White House Liaison Courtney A. Stadd announced his resignation, effective 4 July 2003, to pursue opportunities in the private sector. NASA Administrator Sean O'Keefe announced the appointment of John D. Schumacher to succeed Stadd as Chief of Staff. Stadd had led President George W. Bush's NASA transition team and had worked with two NASA administrators to help cast NASA's strategic direction. Schumacher brought invaluable experience and perspective to his new position. Since June 1995, he had served as NASA's Assistant Administrator for External Relations, with responsibility for NASA's interaction with Executive Branch offices and agencies, for international relations, and for administration of export and international technology-transfer control. In addition, he had served as a liaison with NASA's History Office, advisory councils, and commissions.[446]

European space ministers met at ESA headquarters in Paris to sign an agreement to save the Ariane 5 launcher program. The officials voted to re-obligate EUR 228 million (US$269 million) from an existing program to put the rocket's new version back on track for commercial service by late 2004. Additionally, they agreed to reimburse Ariane 5 contractors for many fixed costs of maintaining their plants and equipment between 2005 and 2009, a measure expected to keep the industry afloat with the injection of EUR 960 million (US$1 billion) while waiting for the commercial launch market to improve.[447]

Science Applications International Corporation (SAIC) of San Diego, California, announced that it had won a US$48 million, four-year contract to support the development of NASA's next-generation space vehicle under NASA's Space Launch Initiative (SLI) program. Under the contract, SAIC would provide vehicle and systems engineering as well as other services, such as scheduling, configuration management, risk management, and financial planning.[448]

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[445] Mara D. Bellaby for Associated Press, "Rough Soyuz Landing Blamed on Malfunction," 26 May 2003; Agence France-Presse, "Officials Promise To Fix Fault in Russia's Soyuz Craft Before Next Space Mission," 26 May 2003.
[446] NASA, "Chief of Staff Courtney Stadd Announces Plans To Leave Agency," news release 03-177, *http://www.nasa.gov/home/hqnews/2003/may/HQ_03177_stadd.html* (accessed 20 November 2008); NASA, "NASA Names New Chief of Staff," news release 03-178, *http://www.nasa.gov/home/hqnews/2003/may/HQ_03178_schumacher_chiefofstaff.html* (accessed 20 November 2008).
[447] Peter B. de Selding, "European Nations Commit To New Ariane 5 Investment," *Space News*, 28 May 2003.
[448] Jacob Jackson, "SAIC Wins $48 Million NASA Space Work," *Washington Technology*, 28 May 2003.

29 May
The CAIB carried out preliminary tests at the Southwest Research Institute in San Antonio, Texas, firing foam at a fiberglass replica of the wing of an orbiter. The impact of a 1.67-pound (0.76-kilogram) piece of foam fired at 533 miles per hour (858 kilometers per hour) created a narrow 22-inch-long (56-centimeter-long) gash in the fiberglass wings. The CAIB conducted the test in preparation for an official test with panels composed of reinforced carbon-carbon (RCC), a material two and one-half times more resilient than fiberglass. In addition to determining whether foam could damage the fiberglass, the CAIB intended the test to calibrate the mechanism for testing the RCC without using up scarce RCC samples.[449]

30 May
Japan's Unmanned Space Experiment Recovery System (USERS) capsule splashed down 620 miles (1,000 kilometers) south of Tokyo, Japan, near the Ogasawara Islands, while the USERS Service Module continued to orbit Earth. Japan's NASDA had launched the system aboard an H-2A booster from the Tanegashima Space Center in September 2002, along with a Japanese Data Relay Test Satellite. The capsule contained a superconductive product, created within the capsule during its 10 months in space, using an electrically heated furnace. Japanese researchers were investigating contamination-free, high-quality crystals, created in a microgravity environment, for their potential use in the superconductive magnets needed in flywheel-type, electric-energy storage systems and magnetically levitated train transportation. Scientists planned to collect data from the USERS Service Module to use in the design and production of future satellite hardware. The Institute for Unmanned Space Experiment Free Flyer, a group established in 1986 to promote the industrialization of space, had initiated the USERS project.[450]

JUNE 2003

2 June
ESA launched its Mars Express mission from Baikonur Cosmodrome in Kazakhstan aboard a Russian Soyuz-Fregat rocket. Mars Express consisted of ESA's Mars Orbiter and a 65-kilogram (143.3-pound) lander, Beagle 2, named in honor of the ship that Charles Darwin sailed on during his search for the origins of life. The orbiter, scheduled to reach Mars in December, carried multiple cameras, spectrometers, and radar equipment. Following the launch, ESA Director of Science David J. Southwood remarked that its success signified Europe's official entry into the interplanetary travel club.[451]

3 June
The Canadian Space Agency awarded a four-year, US$116 million contract to MD Robotics to provide engineering services for robotic elements for the ISS. Under the contract, MD Robotics, a subsidiary of MacDonald, Dettweiler and Associates Ltd., would maintain and upgrade software for robotic components and would continue developing and testing a two-armed robot

[449] John Schwartz and Matthew L. Wald, "Mockup Wing Is Torn by Foam in Shuttle Test," *New York Times*, 30 May 2003; Mark Carreau, "Foam Test Leaves Gash in Shuttle Wing Replica," *Houston Chronicle*, 30 May 2003.
[450] Leonard David, "Japan Recovers Capsule That Carried Made-in-Space Product," *Space.com*, 29 May 2003, *http://www.space.com/missionlaunches/japan_capsule_030529.html* (accessed 4 December 2008).
[451] *Spacewarn Bulletin*, no. 596, 1 July 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx596.html*, (accessed 12 December 2008); Agence France-Presse, "Europe Launches First Ever Mars Space Mission," 3 June 2003.

called Dextre, scheduled for installation at the ISS in 2005. MD Robotics had designed Dextre for attachment to the ISS, either at the end of the robotic arm currently in place—Canadarm 2—or on the mobile base station. Dextre would perform external maintenance tasks at the ISS.[452]

Edward J. Weiler, NASA's Associate Administrator for Space Science, testified before the U.S. Senate Commerce Subcommittee on Science, Technology, and Space about Project Prometheus, a proposed nuclear technology program. The proposal called for NASA to spend US$3 billion between 2003 and 2008, developing more powerful radioisotope thermoelectric generators (RTGs) to convert energy from the decay of radioactive material into electricity and to explore the use of fission to power spacecraft and their instruments. A strong supporter of the program, NASA Administrator Sean O'Keefe, a former Secretary of the Navy, hoped to apply lessons learned from the nuclear submarine program to spacecraft. Weiler stated that nuclear fission was necessary for sending spacecraft to scrutinize the outer planets of the solar system, such as Jupiter, and could open the door to human spaceflight to Mars. NASA hoped to use the powerful RTGs developed in Project Prometheus for a robotic mission to Mars in 2009. NASA proposed to make a mission to Jupiter's moons as its first use of fission technology in space exploration.[453]

6 June

NASA announced that it had awarded the contract to manage the James Webb Space Telescope (JWST) Science and Operations Control Center to a nonprofit consortium, the Association of Universities for Research in Astronomy (AURA). The contract, valued at US$162.2 million, stipulated that AURA manage the Science and Operations Control Center at the Space Telescope Science Institute in Baltimore, Maryland. AURA would provide products and services required to prepare the science program, develop ground systems, provide science and engineering support, provide integration and test support, perform educational and public outreach, and perform flight and science operations during the launch and commissioning of JWST, scheduled for launch in 2011.[454]

The CAIB conducted an outdoor test re-creating the conditions at *Columbia*'s launch, to determine whether foam could break reinforced-carbon wing pieces. During the test, a pair of orbiter wing parts cracked and shifted out of alignment after investigators shot a 1.5-pound (0.68-kilogram) piece of foam at the panel at a speed of 525 miles per hour (845 kilometers per hour). The impact created a gap of less than 0.1 inch (0.25 centimeter) wide and at least 3 inches (7.6 centimeters) long. G. Scott Hubbard, the CAIB member in charge of the test, stated that the Board required further analysis to determine whether the damage would have allowed hot atmospheric gases to penetrate the wing during reentry.[455]

7 June

France's Alcatel Space signed a US$148 million contract with South Korea's state-operated KT Corporation to build South Korea's first satellite with military capabilities. South Korea planned

[452] Jason Bates, "MacDonald Dettweiler Nabs Space Station Contract," *Space News*, 3 June 2003.
[453] Gwyneth K. Shaw, "Advice to NASA Supports Nuclear-Fueled Spaceflight," *Orlando Sentinel* (FL), 4 June 2003.
[454] NASA, "Webb Spacecraft Science and Operations Center Contract Award," contract release c03-r, 6 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_c03r_Webb.html* (accessed 6 June 2003).
[455] Marcia Dunn, "Impact Test Supports Shuttle Foam Theory," *Washington Post*, 9 June 2003.

to place Koreasat 5 in orbit by early 2006. KT Corporation spokesperson Cho Chul-Je told the media that South Korea's military would use military transponders on the satellite for communication and operation, but he declined to confirm reports that the craft would assist the military in collecting security information in Northeast Asia. The craft would also be equipped with commercial transponders. Koreasat 5 would replace Koreasat 2, which had launched in 1996, allowing telecommunications companies to expand mobile networks to Japan, the People's Republic of China, Taiwan, and the Philippines.[456]

8 June

Progress M1-10 launched successfully from Baikonur Cosmodrome in Kazakhstan carrying 2,400 kilograms (5,300 pounds) of fuel, canned food, water, oxygen, and equipment for scientific experiments to the ISS. Yuri P. Semyonov of RSC Energia (S.P. Korolev Rocket and Space Corporation), the company leading Russia's participation in the ISS, remarked that Progress M1-10 carried a supply of extra water because NASA had canceled all Shuttle flights in the wake of the *Columbia* disaster. The ISS Expedition 7 would have a staff of two, rather than three crew members—Russian Flight Commander Yuri I. Malenchenko and U.S. Flight Engineer Edward T. Lu—to save fuel and water until Shuttle flights resumed.[457]

9 June

NASA announced the successful first test flight of Altair, its UAV. The purpose of the test flight was to evaluate Altair's airworthiness and flight controls. NASA's Earth Science Enterprise had established performance specifications for the craft, which was an extended-wing version of the MQ-9 Predator B military UAV—one of several UAVs designed for civil applications.[458]

10 June

From its floating platform Odyssey, Sea Launch launched a telecommunications satellite Thuraya-2 aboard a Zenit 3-SL rocket. The satellite belonged to Thuraya Satellite Telecommunications Company based in Abu Dhabi in the United Arab Emirates, a company providing mobile telephone services to more than 100 countries in the Middle East, Europe, Africa, and Asia. Sea Launch had launched Thuraya-1 in October 2000.[459]

NASA launched the first of two Mars Exploration Rovers from Cape Canaveral Air Force Station in Florida aboard a Delta 2 rocket. The destination of the 384-pound (174-kilogram) rover Spirit was the Gustev Crater, a site that scientists believed had been a crater lake. NASA intended the second of the identical rovers, called Opportunity, to launch later in June and to land on the opposite side of Mars from the Gustev Crater at a site called Meridiani Planum, which had a large deposit of a type of mineral (gray hematite) that usually forms in wet environments. NASA had designed the rolling rovers to capture sharper images, explore wider regions, and

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[456] Agence France-Presse, "French Company To Build South Korea's First Military Satellite," 8 June 2003.
[457] *Spacewarn Bulletin*, no. 596; Agence France-Presse, "Russian Supply Vessel Docks with International Space Station," 11 June 2003; Reuters, "Russian Rocket Sends Fuel, Food to Space Station," 9 June 2003.
[458] NASA, "NASA's Newest Unmanned Aircraft Makes Successful First Flight," news release 03-193, 9 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03193_altair.html* (accessed 12 December 2008).
[459] *Spacewarn Bulletin*, no. 596; Associated Press, "Communications Satellite Launched," 10 June 2003; Jim Banke, "Sea Launch Soars Again Carrying Thuraya-2 to Orbit," *Space.com*, *http://www.space.com/missionlaunches/zenit_launch_030610.html* (accessed 15 December 2008).

examine rocks better than any previous craft that had landed on Mars, searching for evidence of wet environments on the planet.[460]

11 June
ESA launched aboard an Ariane 5G rocket Optus-1, a Japanese-built, hybrid communications/military satellite jointly owned by Australia and Singapore, and B-Sat 2C, a Japanese geostationary communications satellite from Kourou, French Guiana. The Australian Defence Force and Optus, the Australian telecommunications firm and subsidiary of Singapore Telecommunications, had jointly funded the Optus-1 craft. To avoid mixing up data between defense and commercial applications, the two portions of the Optus-1 payload operated independently, one devoted to military use and the other to television broadcasts, high-speed Internet services, and voice and data communications across Australia and parts of Asia. B-Sat 2C would provide direct digital broadcasts to Japan and neighboring countries using Ku-band transponders.[461]

12 June
U.S. Representative Bart Gordon (D-TN), senior Democrat on the House Science Subcommittee on Space and Aeronautics, introduced H. R. 2450, the Human Space Flight Independent Investigation Commission Act, in an effort to ensure that future investigations of human spaceflight accidents would remain independent and "free from any perception that [NASA] is hiding something." Gordon had wanted President George W. Bush to appoint an independent commission, free of any NASA personnel, to investigate the *Columbia* disaster—similar to the commission that had investigated the *Challenger* accident in 1986. Instead, NASA Administrator Sean O'Keefe had to revise the charter of the CAIB three times before the Board had attained a measure of independence. Moreover, the Board still included one NASA official and relied on NASA staff, an arrangement that Gordon feared would undermine the credibility of the CAIB's final report. H.R. 2450 proposed that, in the event of another disaster, the investigative panel would follow the *Challenger* model, requiring a 15-member commission, with the chairperson of the National Transportation Safety Board (NTSB) serving as a member and the President of the United States appointing the other 14. Under the terms of the Act, commission members would have diverse backgrounds, although some would also have spaceflight and accident investigation experience. The resolution also stipulated that NASA personnel could not serve, either on the investigative panel or on its staff. The commission would have subpoena powers and would report its findings simultaneously to the President, Congress, and the public.[462]

The CAIB held its final public hearing, moving its focus beyond the cause of the disaster to a probe of the overall state of NASA's management. Witnesses identified several key weaknesses in NASA's management of its personnel, which could have affected safety issues in the Space Shuttle Program. Allen Li of GAO, which had issued a report in 2001 about NASA workforce issues, noted that NASA had faced substantial challenges in attracting and retaining a highly

[460] NASA, "NASA Prepares Two Robot Rovers for Mars Exploration," news release 03-189, 4 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03189_ROVERS.html* (accessed 12 December 2008); Andrew Bridges for Associated Press, "First of NASA Rovers En Route to Mars," 11 June 2003.
[461] *Spacewarn Bulletin*, no. 596; Agence France-Presse, "Europe Launches Japanese-Built Australian Military Satellite Half Owned by Singapore Government," 12 June 2003.
[462] Leonard David, "Lawmaker Calls for Independent Space Accident Investigations," *Space.com*, 16 June *2003*, *http://www.space.com/missionlaunches/sts107_gordon_030616.html* (accessed 19 December 2008).

skilled workforce. Therefore, key areas of NASA's programs had an insufficient number of qualified workers, and the remainder of the staff showed signs of overwork and fatigue. In response to the 2001 report, NASA had developed new systems for monitoring such issues, and Li said that NASA had made noteworthy progress. However, NASA was still requesting congressional approval of personnel reforms that would help ameliorate the situation, reforms that would give NASA the authority to streamline the hiring process and the ability to offer larger recruitment and retention bonuses. Marcia S. Smith of the Congressional Research Service provided the CAIB with a history of NASA's budget situation but remarked that the CAIB would have difficulty tying budgetary changes directly to safety issues and Shuttle operations. Russell D. Turner, the former CEO of the prime contractor for Shuttle operations, United Space Alliance, defended the work of the firms involved in the Space Shuttle Program.[463]

13 June

NASA named Roy D. Bridges Jr., Director of NASA's KSC, to head NASA's LaRC in Hampton, Virginia, effective 10 August. Bridges, a retired U.S. Air Force Major General and former astronaut who had piloted STS-51F in 1985, was a "natural selection to lead the Agency's premiere center for aviation and space research," according to William F. Readdy, Associate Administrator for Space Flight at NASA Headquarters. Bridges had been Director of KSC since 1997 and, before that, had held various key aerospace positions, serving as Commander of the Air Force Flight Test Center at Edwards Air Force Base in California, as well as Commander of the Eastern Space and Missile Center at Patrick Air Force Base in Florida and Commander of the 412th Test Wing at Edwards Air Force Base. With his appointment as Director of LaRC, Bridges replaced Delma C. Freeman Jr., who had planned to retire but had been serving as Acting Director until NASA found a permanent director. Freeman planned to retire. In transferring Bridges to LaRC from KSC, NASA hoped to strengthen its engineering department in preparation for resuming Shuttle flights.[464]

NASA appointed two veteran astronauts—*Apollo* Commander Thomas P. Stafford and Space Shuttle Commander Richard O. Covey—to lead the task force assisting NASA's return-to-flight team. The Stafford-Covey Return to Flight Task Group (SCTG), composed of distinguished experts and industry professionals representing a wide range of disciplines, would help the NASA team implement the CAIB's findings following the release of its final report. Stafford, a retired Lieutenant General in the U.S. Air Force who had flown four missions during the Gemini and Apollo programs, had also chaired the NASA Advisory Council Task Force on ISS Operational Readiness. Covey, a retired U.S. Air Force Colonel, had piloted the 1988 Shuttle Mission STS-26, the first flight following the *Challenger* accident. He had also piloted Mission STS-51I in 1985 and had commanded STS-38 in 1990 and STS-61 in 1993.[465]

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[463] Tom Shoop, "NASA Needs Management Overhaul, Shuttle Investigators Told," *Government Executive*, 13 June 2003.

[464] NASA, "Gen. Roy D. Bridges Named Langley Center Director," news release 03-197, 13 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03197_bridges.html* (accessed 12 December 2008); Marcia Dunn for the Associated Press, "Kennedy Space Center Director Transferred," 13 June 2003.

[465] NASA, "Former Apollo and Shuttle Commanders Lead Columbia Accident Report Task Force," news release 03-196, 13 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03196_covey_lead.html* (accessed 12 December 2008).

15 June
The CAIB and members of the U.S. Congress reached an agreement giving selected members and staff of the U.S. House Committee on Science and Technology access to confidential interviews that CAIB had conducted with 225 witnesses, including NASA managers and others involved with *Columbia*'s mission. Because the most sensitive testimony about management decision making and engineering practices was contained in privileged statements, CAIB Chairperson Harold W. Gehman Jr. had resisted unfettered congressional access, fearing the potential effect on witnesses in future investigations of accidents if the CAIB were to release privileged testimony. Gehman had argued that privacy was critical to the Board's ability to elicit full, frank, and timely information, citing U.S. Supreme Court decisions supporting privileged interviewing, which was a common practice in military aircraft accident investigations. The agreement had granted committee members and a select list of staff access to the statements at the CAIB's office and—in limited circumstances and under the supervision of a CAIB representative—to those at congressional offices. The CAIB retained the right to refuse to make information from statements to the Board available to the public. In addition, the CAIB would keep a record of those who viewed the information.[466]

19 June
Russia's Space Forces launched a Molniya 3-53 military communications satellite aboard a four-stage Molniya-M rocket from Plesetsk Cosmodrome in the Arkhangelsk region of Russia. Molniya 3-53 was the second Molniya communications satellite launched in 2003.[467]

NASA released topographic data collected during its Shuttle Radar Topography Mission (SRTM), which had lasted from 11 to 22 February 2000, producing three-dimensional measurements of more than 80 percent of Earth's landmass between 60° north and 56° south of the equator. Because of South America's proximity to the equator and its frequent tropical cloud cover, traditional satellites had encountered difficulty acquiring imagery of its topography, but the cloud-penetrating radar on board the SRTM had produced information with scientific and commercial value that would help improve life on the continent. SRTM Project Scientist Michael Kobrick of NASA's JPL remarked that the data would assist governments to prepare for natural hazards like earthquakes, volcanic eruptions, landslides, and floods. In addition, the information would help improve aviation safety in mountainous areas, and would help land-use planners make better-informed decisions about the development of critical infrastructure. The mission was a cooperative project of NASA, the National Imagery and Mapping Agency (NIMA) of the U.S. DOD, and the German and Italian space agencies.[468]

24 June
NASA announced that 12 new teams would join the NASA Astrobiology Institute (NAI), a research consortium studying the origin, evolution, distribution, and future of life on Earth and in

[466] Kathy Sawyer, "Congress To Review Shuttle Interviews," *Washington Post*, 16 June 2003.
[467] *Spacewarn Bulletin*, no. 596; Associated Press, "Russia Lofts Military Payload from Plesetsk, Makes Plans for Commercial South American Shots," 20 June 2003; Stephen Clark, "Molniya Satellite Deployed from Plesetsk Spaceport," *Spaceflight Now*, 20 June 2003.
[468] NASA, "South America Shines in NASA's Latest Space Radar Map Release," news release 03-204, 19 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03204_S_Amer_Space_Radar.html* (accessed 12 December 2008).

the universe. The new teams, with members from the Carnegie Institution of Washington, DC; Indiana University in Bloomington; Marine Biological Laboratory in Woods Hole, Massachusetts; SETI (Search for Extraterrestrial Intelligence) Institute in Mountain View, California; and NASA's ARC and GSFC would join the four lead teams that NASA had selected in 2001. The five-year awards, with annual funding levels of US$1 million, would commence in the autumn of 2003 when the agreements with the NAI's 11 founding teams had concluded. Six of the new teams were among the founding member teams.

NASA released to the public recovered photographs and video that *Columbia*'s crew had taken during its mission in January. The CAIB had determined that the material was not relevant to their investigation into the Shuttle's demise. The imagery included nearly 10 hours of recovered video and 92 photographs. The Shuttle had carried 337 videotapes, of which 28 had recoverable footage, and 137 rolls of film, of which only 21 contained recoverable photographs. Search-and-recovery crews had located more than 84,000 pieces of debris.[469]

26 June

NASA announced the appointment of James W. Kennedy as the new Director of NASA's KSC, effective 10 August, succeeding Roy D. Bridges Jr. On 13 June, NASA had appointed Bridges to lead NASA's LaRC. Kennedy had served as KSC's Deputy Director since November 2002 and, before that, he had served as Deputy Director of NASA's MSFC in Huntsville, Alabama. Kennedy had also served as Project Manager for the X-34 and DC-XA initiatives and had led KSC's OneNASA effort to coordinate teamwork across all field centers. He had managed MSFC's Space Shuttle Projects Resident Office at KSC in 1996, returning to MSFC later that year to manage the Solid Rocket Booster Project. In 1998 he had become Deputy Director of Science and Engineering and, one year later, Director of Engineering. In those positions, he had established and maintained a nationally recognized research and development capability in space research and technology.[470]

The remotely operated Helios Prototype aircraft crashed into the Pacific Ocean during a test flight within the confines of the U.S. Navy Pacific Missile Range Facility (PMRF) test range. Ground-based mission controllers had been flying the solar-electric, propeller-driven, proof-of-concept flying wing remotely. The craft had been aloft west of Kauai, Hawaii, for about 29 minutes at approximately 8,000 feet (2,438 meters), when the accident occurred, destroying it. High-efficiency solar cells, spread across the upper surface of its 247-foot-long (75-meter-long) wing, supplied power to its electric motors and other systems during daylight; at night, an experimental fuel cell–based electrical system generated power. The prototype, designed to fly at altitudes up to 100,000 feet (30,480 meters) had set a world record for altitude of winged aircraft—96,863 feet (29,524 meters)—during a flight in August 2001. NASA had intended the craft to fly single-day atmospheric-science and imaging missions at high altitudes, as well as to perform multiday telecommunications-relay missions at lower altitudes of 50,000 to 65,000 feet (15,240 to 19,812 meters). The prototype was one of several in development that NASA had

[469] NASA, "New Space Shuttle Columbia Images Released," news release 03-212, 24 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03212_columbia_images.html* (accessed 12 December 2008).
[470] NASA, "James W. Kennedy Named Director, NASA KSC," news release 03-217, 26 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03217_Kennedy_KSC.html* (accessed 12 December 2008); Kelly Young, "Kennedy Takes Over KSC," *Florida Today* (Brevard, FL), 27 June 2003.

sponsored and funded under the Environmental Research Aircraft and Sensor Technology program.[471]

27 June
NASA announced the creation of a five-member board, led by Thomas E. Noll of LaRC, to investigate the Helios Prototype accident. The board would work with the U.S. Navy and the National Oceanographic and Atmospheric Administration to determine the cause of the accident.[472]

30 June
The German-Russian Eurockot Launch Services' Rockot launch vehicle, a modified Russian ballistic missile, lifted off from Russia's Plesetsk Cosmodrome carrying nine satellites and nanosatellites. The Rockot booster fired its Breeze upper stage twice, the first time releasing the 145-pound (66-kilogram) Czech Micromeasurements of Satellite Acceleration (MIMOSA) satellite into orbit and, the second time, leaving the Canadian Microvariability and Oscillation of Stars (MOST) scientific satellite and six Japanese, Danish, and U.S. nanosatellites in a Sun-synchronous orbit. A mock-up of a Russian Earth observation satellite that remained attached to the upper stage would gather mission data before de-orbiting. The Czech Astronomical Institute had launched MIMOSA to gather data on the density of Earth's upper atmosphere, using a sensitive accelerometer designed to detect slight drag forces. President of the Canadian Space Agency Marc Garneau described the 113-pound (51.3-kilogram) MOST as "the world's smallest space telescope," with an aperture of just 15 centimeters (6 inches), about the size of Galileo's telescope. Using an ultra-high-precision attitude-control system, the craft would very finely point toward targets, such as neighboring stars, studying how stars eject gas into the interstellar medium and seeking data to answer fundamental questions about the universe. Students had designed the two Japanese nanosatellites—CubeSat XI-IV and CUTE-1—to test various space technologies in flight. Three more student-built nanosatellites deployed via a launch tube—the Canadian CANX-1and the Danish AAU CubeSat and DTUSAT—would image stars. Quakesat, an American photo-imaging nanosatellite, would conduct an earthquake detection experiment.[473]

JULY 2003

5 July
Armadillo Aerospace successfully carried out a milestone test of the company's candidate for the X Prize, dropping the reusable suborbital spacecraft from a helicopter to demonstrate that they could recover the complete vehicle after flight. To conduct the test, the team placed 660 pounds (273 kilograms) of sandbags in the craft's cabin area, to simulate passengers, and mounted a set of five Olympic barbell plates, to simulate the weight of the engines, plumbing, and backup

[471] NASA, "Helios Prototype Solar Aircraft Lost in Flight Mishap," news release 03-219, 27 June 2003, *http://www.nasa.gov/home/hqnews/2003/jun/HQ_03219_Helios.html* (accessed 12 December 2008); B. J. Reyes for Associated Press, "Record-Setting Solar Airplane Crashes," 26 June 2003.
[472] Warren E. Leary, "Board Named To Investigate Crash of a Plane Prototype," *New York Times*, 28 June 2003.
[473] *Spacewarn Bulletin*, no. 597, 1 August 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx597.html* (accessed 12 December 2008); Stephen Clark, "Rockot Booster Successfully Launches 9 Payloads," *Spaceflight Now*, 30 June 2003; Peter B. de Selding, "Rockot Delivers Multiple Satellites to Earth Orbit from Russia," *Space.com*, 30 June 2003, *http://www.space.com/missionlaunches/rockot_ launch_ 030630.html* (accessed 15 December 2008).

recovery system that the competitor's full-size vehicle would have. A helicopter towed and released the craft, the drogue immediately inflated, pulling out the main parachute. Nine seconds elapsed between release and full canopy inflation, causing a negligible shock of only two Gs. The team was expecting greater opening shock after high-altitude flights. Overall, the vehicle fared well—the craft sustained minor damage to the vehicle's crushable nose cone, and none of the sandbags in the cabin ruptured.[474]

7 July
NASA engineers and investigators, together with members of the CAIB, watched as engineers fired foam insulation at a mockup of the leading edge of an orbiter wing, creating a 16-inch-wide (40.6-centimeter-wide) hole in the reinforced-carbon-carbon panel. Engineers used a compressed nitrogen gas cannon to fire a 1.7-pound (0.77-kilogram) piece of foam at the wing mockup at a speed of 530 miles per hour (853 kilometers per hour), duplicating the force exerted on *Columbia*'s wing when a piece of foam of the same size hit the orbiter during launch. The test results showed that it was possible that a foam block falling from the external tank could have breached the orbiter's leading edge, allowing hot gases to penetrate the wing structure during reentry and resulting in the breakup of *Columbia*.[475]

8 July
After numerous delays, NASA launched Mars Explorer Rover-B (MER-B) aboard a Delta 2 rocket from Cape Canaveral, Florida, in time to meet the 15 July deadline. If NASA had not met that deadline, it would have had to wait an additional four years to launch the craft. MER-B, nicknamed Opportunity, was an exact duplicate of MER-A, known as Spirit, which had launched on 10 June. Bad weather, a failed battery cell, and a problem with the cork insulation, which had failed to adhere to the aluminum rocket, had caused the launch's delay.

NASA released documents showing that the *Columbia* accident was not the first time that superheated gas had invaded an orbiter's wing when it reentered Earth's atmosphere. The documents showed that in 2000 *Atlantis* had entered orbit with a 0.25-inch (0.64-centimeter) breach in its wing's leading edge, allowing plasma to enter the wing during the orbiter's reentry. The incident had caused only minor damage. Improper insulation installation during *Atlantis*'s overhaul in 1997 had caused the gap to form. Instead of filling up the gap, the insulation had been "folded up and pushed away," leaving an exposed cavity.[476]

15 July
The Boeing Company announced that, because commercial launches were costly and in relatively low demand, it would not seek commercial satellite launch contracts for five years, focusing instead on providing service for the U.S. military and NASA. However, Boeing was a member of the consortium International Launch Services (ILS), which would continue to offer commercial launch services. ILS used Russian-made Zenit 3-SL rockets to launch commercial

[474] Leonard David, "X Prize Entry Undergoes Drop Test," *Space.com*, 7 July 2003, *http://www.space.com/businesstechnology/technology/armadillo_test_030707.html* (accessed 12 January 2009).
[475] Alan Levin, "Shuttle Foam Test Leaves Hole," *USA Today*, 8 July 2003; John Kelly, "Foam Punches Large Hole in Wing: Test is 'Smoking Gun', Shuttle Panel Says," *Florida Today* (Brevard, FL), 8 July 2003.
[476] John Schwartz and Matthew L. Wald, "Earlier Shuttle Flight Had Gas Enter Wing on Return," *New York Times*, 9 July 2003.

payloads from a floating platform known as Sea Launch. Boeing indicated that it would accommodate customers that preferred to use Delta rockets instead of the Russian-made rockets. The company stated that the change in business strategy would not affect any employees who worked on the launch programs.[477]

Undersecretary of the U.S. Air Force Peter B. Teets testified before the House Science Subcommittee on Environment, Technology, and Standards that the National Polar Orbiting Environmental Satellite (POES) System spacecraft would not be available until late 2009 or 2010, at the earliest. The U.S. Air Force and NOAA had jointly funded the system, the first of its kind, originally planning to deliver it in early 2008. The Bush administration had decided to request less money for the project in the near term than it had previously planned, and that decision had reportedly caused the delay. Because of the postponement of the delivery date, the Air Force and NOAA would need to restructure the contract to account for anticipated cost growth. The new system would replace the polar-orbiting systems that the agencies had previously operated separately. Greg Withee, NOAA's Assistant Administrator for Satellite and Information Services, stated that the delay could result in a 21-month gap in coverage if NOAA encountered problems with its existing fleet.[478]

In response to the anticipated recommendations of the CAIB, NASA announced its plans to create an independent NASA Engineering and Safety Center (NESC) at NASA's LaRC, providing a central location to coordinate engineering and safety assessment for all of NASA. The NESC, expected to draw on the talents of 250 staff throughout NASA to conduct analysis and share technical information, would report to Director of LaRC Roy D. Bridges Jr. Bryan D. O'Connor, Associate Administrator for the Office of Safety and Mission Assurance at NASA Headquarters, would have responsibility for policy. NASA intended for the NESC to provide independent assessment and testing of engineering, in support of critical NASA projects and programs; to conduct reviews and evaluations of engineering and safety; to provide a central location for trend analysis; to provide a structure to support engineering collaboration for problem resolution; to provide central coordination of engineering and programmatic lessons learned, technical standardization, and development of technical discipline expertise; and to provide independent inspection and validation of activities to ensure the constant maintenance of NASA safety standards.[479]

17 July

An Atlas 5 rocket launched from Cape Canaveral, Florida, at 11:45 p.m. (UT), carrying the Rainbow 1 satellite into orbit. The 4.3-tonne (4.7-ton or 4,300-kilogram) Cablevision Systems Corporation satellite would provide direct-to-home television services in the contiguous United States. The Atlas 5, on its third flight since its inaugural flight in August 2002, carried for the first time two 64-foot (19.5-meter), Aerojet-built solid rocket boosters, which enabled the rocket to clear the launchpad in just 7 seconds—only half of the time required in the two previous

[477] Brian Monroe and Wayne T. Price, "Boeing To Bail Out of Commercial Launches," *Florida Today* (Brevard, FL), 17 July 2003.
[478] Jeremy Singer, "Delay Means Cost Growth for New Weather Satellites," *Space News*, 17 July 2003.
[479] NASA, "NASA Announces Independent Engineering and Safety Center," news release 03-239, 15 July 2003, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03239_safety_center.html* (accessed 23 December 2008); Warren E. Leary, "In Response to Panel, NASA Plans Safety Center," *New York Times*, 16 July 2003.

launches. The launch marked the completion of flight-testing of all major new systems in the Atlas line. The U.S. military had designed Atlas 5 under its Evolved Expendable Launch Vehicle (EELV) Program.[480]

NASA issued new safety standards for future space vehicles, such as the proposed Orbital Space Plane (OSP) and next-generation launch systems, requiring crew-escape systems and methods of aborting launches. Earlier, NASA had rejected recommendations for the proposed systems as too impractical or expensive for the existing Space Shuttle fleet. The new standards represented NASA's effort to provide "maximum reasonable assurance" that, in the future, mission failures would not automatically endanger the crew. The standards, known as the Human-Rating Requirements and Guidelines for Space Flight Systems, stipulated that NASA would design future spacecraft to allow the crew to escape quickly during prelaunch procedures and to abort the mission or to effect an emergency escape during ascent.[481]

18 July

NASA's JSC extended its contract with Hamilton Sundstrand Space Systems International Inc. (HSSSI) for work related to the Extravehicular Mobility Unit (EMU), the U.S. spacesuit used for extravehicular activity (EVA). The extended option, valued at US$26 million, was the last of the available annual-renewal options of a contract worth US$333 million over six years. Under the contract, HSSSI was responsible for the successful performance of the EMU, including the design, development, certification, production, and enhancement of the EMU and of other hardware used in spacewalking.[482]

21 July

NASA announced the release of the first scientific product of the Gravity Recovery and Climate Experiment (GRACE) mission, a joint effort of NASA and the German Aerospace Center. The GRACE mission had produced the most accurate map to date of Earth's gravity field, using preliminary data collected over 111 days. Project scientists had created the map from selected data, which they had used to calibrate and validate the instruments of the pair of American and German satellites comprising GRACE. The satellites had measured Earth's gravitational force from orbits 500 kilometers (310.7 miles) high, with 220 kilometers (136.7 miles) separating them, making a pass of the entire planet once each month, and producing measurements of unprecedented accuracy. The measurements provided precise views of ocean currents and tidal changes, enabling scientists to better understand how the oceans affect climate. Although the data was preliminary, NASA had released it to oceanographers immediately, months in advance of the scheduled start of routine GRACE scientific operations, underscoring the mission's importance and the data's value.[483]

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[480] *Spacewarn Bulletin*, no. 597; Associated Press, "Most Powerful Atlas Rocket Carries Cablevision Satellite into Space," 18 July 2003.
[481] Eric Pianin, "New Standards Are Issued for Space Vehicle Safety," *Washington Post*, 18 July 2003.
[482] NASA, "NASA Extends Spacesuit Contract," contract release C03-x, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_c03x_spacesuit.html* (accessed 23 December 2008).
[483] NASA, "Oceanographers Catch First Wave of Gravity Mission's Success," news release 03-244, 21 July 2003, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03244_gravity_success.html* (accessed 23 December 2008); Larry O'Hanlon, "Gravity Map Shows Earth Is Very Lumpy," *Discovery News*, 29 July 2003.

NASA announced the successful implementation of new software in three computers controlling the precision pointing of NASA's Far Ultraviolet Spectroscope Explorer (FUSE) satellite. In mid-April 2003, NASA had installed the software for the spacecraft's Attitude Control Instrument Data System and the processor for the Fine Error Sensor guide camera, and testing of the new configuration had been ongoing since that time. George Sonneborn, FUSE Project Scientist at NASA's GSFC, explained that the uploaded software would allow FUSE to operate with any number of gyroscopes, or none, in the event of gyroscope failure. Tests showed that FUSE could operate with no gyroscopes without experiencing any degradation in quality of scientific data and with only a slight loss of efficiency in scheduling observations. Before the new software installation, FUSE had required at least one operating gyroscope on each of its three axes to conduct normal scientific operations.[484]

22 July

Starchaser Industries Ltd., a British entry for the X Prize competition, successfully tested its Nova 2 rocket capsule, dropping it from a Fairfield C123K aircraft near Kingman, Arizona. Parachute expert Ted Strong piloted the capsule, which the aircraft had released at an altitude of 10,000 feet (3,048 meters). Traveling at 100 miles per hour (161 kilometers per hour), the craft deployed a 10-foot (3-meter) drogue parachute to stabilize its descent, and 5 seconds later, the pilot "oriented the capsule into a horizontal position" before deploying the main steerable canopy. The pilot flew the capsule like a glider to a precision landing.[485]

23 July

NASA announced the selection of the Lockheed Martin Commercial Launch Services' Atlas 5 expendable launch vehicle for the Pluto New Horizons mission scheduled to launch in January 2006. The agreement with Lockheed Martin stipulated a firm fixed-price, launch-service task order under the terms of NASA's launch services contract with Lockheed Martin. NASA planned for its Pluto New Horizons mission to conduct the first reconnaissance of the binary planet system of Pluto-Charon, gathering information about the surfaces, atmospheres, interiors, and space environments of Pluto and Charon.[486]

NASA announced the results of its own mishap investigation board's review of the loss of the X-43A Hyper-X research vehicle during its launch on 2 June 2001. The experimental plane was the first of three that NASA had developed and produced in a US$185 million program. The board concluded that the flight had failed because "the vehicle's control system design was deficient in several analytical modeling areas, which overestimated the system's margins." For the test flight, the X-43A had launched aboard the nose of a modified Pegasus launch vehicle carried by NASA's modified B-52 bomber. The bomber had released the Pegasus at an altitude of 24,000 feet (7,315.2 meters), igniting its solid rocket motor (SRM) and sending the research-vehicle payload on its test flight. After beginning its planned pitch-up maneuver, the X-43A had experienced a control anomaly leading to a structural overload of the starboard elevon. The

[484] NASA, "NASA Team Gives Fuse Spacecraft Triple Brain Transplant," news release 03-243, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03243_fuse_transplant.html* (accessed 23 December 2008).
[485] *Space.com*, "X Prize Entry Starchaser Successfully Test Drops Piloted Capsule," 24 July 2003, *http://www.space.com/businesstechnology/technology/starchaser_test_030424.html* (accessed 12 January 2009).
[486] NASA, "Atlas V Chosen To Launch New Horizons Mission," contract release C03-y, *Space.com* (accessed 23 December 2008).

vehicle had then deviated significantly from its planned trajectory, and NASA had destroyed it 48.6 seconds after its release. The mishap investigation board, which had found a number of modeling inaccuracies, had been able to reproduce the flight mishap only after incorporating all of the inaccuracies into its analysis, leading the board to conclude that no single factor or potential contributing factor had caused the mishap. The board also found that preflight analyses, including wind tunnel tests, had failed to predict how the rocket would perform in flight.[487]

25 July
NASA announced appointments to the Stafford-Covey Return to Flight Task Group (SCTG), formed to conduct an independent assessment of NASA's implementation of the CAIB's recommendations. On 13 June, NASA had initially announced the formation of the SCTG to oversee an independent assessment of NASA's efforts to implement the CAIB's recommendations. Cochaired by veteran astronauts Thomas P. Stafford and Richard O. Covey, NASA had selected the SCTG's members from experts in industry, academia, and government, active in fields relevant to spaceflight safety. NASA had organized the SCTG pursuant to the Federal Advisory Committee Act, selecting only non-NASA employees as members, as well as one nonvoting, ex officio NASA representative—the Deputy Associate Administrator for Safety and Mission Assurance.[488]

29 July
NASA confirmed that its satellites' observations had provided the first evidence that the rate of ozone depletion in Earth's upper atmosphere was decreasing, a possible indication of the first stage of ozone-layer recovery. Scientists had analyzed data that NASA's first and second Stratospheric Aerosol and Gas Experiment (SAGE) and Halogen Occultation Experiment (HALOE) satellite instruments had collected, discovering a decrease in ozone depletion after 1997. The scientists had found that the rate of depletion was consistent with the decline in abundance of the human-made chemicals that contribute to ozone destruction. However, according to Michael J. Newchurch of the University of Alabama, the lead scientist for the study, ozone depletion was still occurring, although its rate had decreased. Joseph M. Zawodny, a scientist on the SAGE II satellite-instrument science team at NASA's LaRC, remarked that the finding would not have been possible if the two satellites had not lasted so long past their normal mission lifetimes. SAGE II was approaching its 19th launch anniversary, and HALOE had returned data for 11 years. Scientists had also used international ground networks to corroborate the satellites' data. The findings indicated the effectiveness of international treaties in encouraging countries to curb pollution—specifically the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer and its amendments.[489]

The ISS marked its 1,000th consecutive day of human residency aboard the station. The first crew had arrived 2 November 2000, and since then, seven crews had lived and worked on the ISS.

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[487] NASA, "NASA Mishap Board Identifies Cause of X-43a Failure," news release 03-246, 23 July 2003, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03246_X43A_Mishap.html* (accessed 23 December 2008); Associated Press, "Rocket Failure Doomed Hypersonic NASA Jet, Investigation Finds," 23 July 2003.
[488] NASA, "NASA Names Return to Flight Task Group Members," news release 03-248, 25 July 2003, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03248_SCTG_Named.html* (accessed 23 December 2003).
[489] NASA, "NASA Observations Confirm Expected Ozone Layer Recovery," news release 03-253, 29 July 2003, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03253_Ozone_Recovery.html* (accessed 23 December 2008); Peter N. Spotts, "After 30 Years, Ozone Is Recovering," *Christian Science Monitor*, 1 August 2003.

During that time, the living and working area had increased by 6,000 cubic feet (170 cubic meters) to the current area of 15,000 cubic feet (424.8 cubic meters), and ISS partners expected the station would eventually more than double its size. The seven ISS crews, consisting of 10 American and 10 Russian crew members, had conducted 12 spacewalks and had welcomed 11 visiting Space Shuttles, 4 *Soyuz* taxi crews, and 10 Progress cargo vehicles. Crews had added to the ISS the largest solar arrays ever produced for use in space, the first track-mounted railcar in space, and a science facility described as the most sophisticated space laboratory to date.[490]

31 July

For the first time, NASA quantified the costs related to the loss of the Shuttle, stating that, in the six months since the Space Shuttle *Columbia* disaster, it had spent US$152.4 million to conduct the investigation and recover debris. The figure included US$111.9 million for NASA to support the CAIB's inquiry with research and analysis, including the expensive high-speed, foam-impact tests at the Southwest Research Institute in San Antonio, Texas, which had provided evidence that foam striking *Columbia* after lift off had caused the hole in the left wing. NASA had spent US$18.7 million to fund the 13-member investigative board, paying the salaries of the five civilian members, office rent, travel expenses, and the expense of holding public hearings and maintaining the CAIB's Web site. NASA had also spent US$21.8 million recovering debris from the *Columbia* accident, compared to the US$30 million it had spent salvaging pieces of *Challenger*. Shortly after the tragedy, the U.S. Congress had approved US$50 million to cover expenses, and it was considering a supplemental appropriation of US$50 million. John Scofield, spokesperson for the House Committee on Appropriations, remarked that nobody had criticized NASA's spending, because nobody wanted to do the necessary work "on the cheap." Scofield added that the committee was conducting its own analysis to confirm that NASA had correctly estimated its expenditures, but that Congress would likely reimburse NASA for much of the cost. NASA had spent a total of US$62 million (adjusted for inflation) to investigate the 1986 explosion of *Challenger*. [491]

AUGUST 2003

4 August

NASA selected the University of Arizona's Phoenix lander concept for a US$325 million mission to Mars in 2007, beating out finalists from Arizona State University, NASA's JPL, and NASA's LaRC. The Phoenix concept, aptly named for the mythical bird that rose from ashes, drew on the technology of past expeditions, such as the canceled 2001 Mars Surveyor Program. Phoenix's purpose was to search for evidence of water and carbon dioxide gas—a robotic arm would scoop soil samples, small on-board ovens would heat the samples, and on-board instruments would analyze them, checking the soil for organic compounds. NASA called the Phoenix mission the first of a type of mission it had designated as Scout missions. If funding remained available, NASA planned to hold competitions every four years to select relatively small missions like Phoenix as Scout missions.[492]

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[490] NASA, "Milestone Marked in Space—1,000 Days of Human Presence on Station," news release 03-251, 29 July 2003, *http://www.nasa.gov/home/hqnews/2003/jul/HQ_03251_iss1000_days.html* (accessed 23 December 2008).
[491] William Glanz, "NASA Outlines Cost of Columbia Probe," *Washington Times*, 1 August 2003.
[492] Chris Kridler, "Mission Will Look for Mars Ice," *Florida Today* (Brevard, FL), 5 August 2003

7 August
X Prize contestant *SpaceShipOne* successfully carried out its first glide flight after the White Knight carrier craft towed it to an altitude of 47,000 feet (14,326 meters) and released it. Pilot Michael W. Melvill guided the craft to a desert landing. Scaled Composites, which had built *SpaceShipOne*, issued a report of the test indicating that the two vehicles had separated cleanly, that handling qualities of the craft had correlated closely with ground-based simulations, and that on-board avionics and cockpit displays had performed flawlessly.[493]

8 August
From its Odyssey Platform in the Pacific Ocean, Sea Launch lifted off its 10th commercial mission, launching the shared commercial communications satellite Echostar 9—also known as Telstar 13—atop a Ukrainian Zenit 3-SL rocket. Space Systems/Loral had built the 10,443-pound (4,737-kilogram) satellite, which two companies shared. Echo Star Communications Corporation operated the Ku-band and Ka-band transponders to provide additional direct-broadcast television service, via the corporation's DISH network. Loral Skynet operated the 24 C-band transponders to provide cable television service to North America, Alaska, Hawaii, Puerto Rico, Mexico, and Central America.[494]

NASA announced the selection of Donald J. Campbell, Director of GRC at Lewis Field, as Special Assistant to the Deputy Administrator for Nuclear and Alternative Power Generation Systems, effective 1 October 2003. In his new position, Campbell would lead the development and integration of high-power generation systems for propulsion, considered fundamental building blocks for sustained robotic and human exploration in outer space and deep space. Campbell had directed GRC since January 1994. Local political and community leaders had criticized Campbell for his leadership style, which had not galvanized the GRC workforce or fully leveraged the Center's economic potential. NASA named Deputy Director of GRC Julian M. Earls to succeed Campbell as GRC's Director.[495]

13 August
The Canadian Space Agency successfully launched its scientific satellite SciSat 1 aboard a Pegasus XL rocket dropped from an L-1011 jet flying out of Vandenberg Air Force Base in California. The 330-pound (150-kilogram) atmospheric-research satellite carried two instruments—the Fourier Transform Spectrometer and the Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO)—intended to monitor atmospheric ozone and dust composition in an altitude range of 4 to 100 kilometers (2.5

[493] Leonard David, "X Prize Contestant Scaled Composites' SpaceShipOne Flies," *Space News*, 9 August 2003.
[494] *Spacewarn Bulletin*, no. 598, 1 September 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx598.html* (accessed 21 January 2009); Jim Banke, "Shared Communications Satellite Lofted into Orbit by Sea Launch," *Space News*, 8 August 2003.
[495] NASA, "Glenn Research Center's Donald J. Campbell Selected as NASA Deputy Administrator Special Assistant," news release 03-260, 8 August 2003, *http://www.nasa.gov/home/hqnews/2003/aug/HQ_03260_Campbell.html* (accessed 29 December 2008); NASA, "Dr. Julian M. Earls Selected To Lead NASA Glenn Research Center," news release 03-261, 8 August 2003, *http://www.nasa.gov/home/hqnews/2003/aug/HQ_03261_Earls.html* (accessed 29 December 2008); John Mangels and Michael O'Malley, "NASA Glenn Chief Leaves; Deputy Gets Job," *Cleveland Plain Dealer* (OH), 9 August 2003.

to 62.1 miles). Designed to last two years, the craft would orbit Earth 15 times each day, focusing on the chemical processes that control the distribution of ozone in the atmosphere.[496]

14 August

NASA released the final report of the Hubble Space Telescope–James Webb Space Telescope (HST-JWST) Transition Plan Review Panel, an advisory panel assembled to review NASA's plans for removing the HST from service as early as 2011, when NASA was preparing to launch the JWST. John N. Bahcall of the Institute for Advanced Study in Princeton, New Jersey, had chaired the independent panel of astronomers. The panel recommended three options to NASA: 1) to launch two additional Shuttle-servicing missions to the HST in 2005 and 2010, to maximize the scientific productivity of the telescope; 2) to launch one Shuttle-servicing mission before the end of 2006, to replace gyroscopes and, possibly, to install a propulsion device to de-orbit the craft once scientific operations had become impossible, or, alternatively, to de-orbit the craft using an autonomous robotic system; and 3) if no Shuttle missions were possible, to launch a robotic mission to install a propulsion module to bring down the HST in a controlled descent once scientific operations had become impossible. The panel also described various ways to extract maximum scientific return from the HST if NASA opted for any of the recommended three scenarios.[497]

21 August

NASA announced that the Demonstration for Autonomous Rendezvous Technology (DART) spacecraft had completed the lengthy design-certification review for the Orbital Space Plane (OSP) program, verifying the craft's safety, performance, and functional requirements. The DART team, based at NASA's MSFC, planned to demonstrate the vehicle without a human pilot in 2004, launching it on a Pegasus rocket dropped from an L-1011 jet. At 40,000 feet (12,192 meters) over the Pacific Ocean, the Pegasus rocket and the DART craft would separate, and DART would travel from a parking orbit to maneuver close to a target satellite or to rendezvous with it. The demonstration would require 24 hours. DART was the first of three flight-testing demonstrators: Boeing Expendable Launch Systems was developing the X-37 flight demonstrator, and Lockheed Martin Corporation was developing the launchpad-abort demonstrator. DART was NASA's first completely computer-controlled, rendezvous-capable spacecraft.[498]

22 August

A 66-foot-high (20-meter-high) VLS-1 O3 rocket exploded on its launchpad during tests at Alcântara Launch Center in Brazil, delivering "a serious blow to Brazil's nascent space program." Brazil had hoped to be the first Latin American nation to place a satellite in orbit.

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[496] *Spacewarn Bulletin*, no. 598; Associated Press, "Canadian Ozone Satellite Successfully Launched from Plane Off California Coast," 13 August 2003.

[497] NASA, "Panel Identifies Three Options for Space Telescope Transition," news release 03-264, 14 August 2003, *http://www.nasa.gov/home/hqnews/2003/aug/HQ_03264_telescope_transition.html* (accessed 23 January 2009); NASA Space Telescope Transition Plan Review Panel, "Report of the HST-JWST Transition Panel: Executive Summary" (report, Washington, DC, August 2003), *http://www.nasa.gov/ audience/formedia/features/ MP_Public_Reports.html* (accessed 23 January 2009); Sam Silverstein, "Hubble Review Panel Urges Second Extra Servicing Mission," *Space News*, 19 August 2003.

[498] NASA, "Space Flight Demonstrator Completes Design Certification," news release 03-274, 21 August 2003, *http://www.nasa.gov/home/hqnews/2003/aug/HQ_03274_dart_design.html* (accessed 29 December 2008).

According to the Brazilian Ministry of Defence, the accident, which occurred three days before a scheduled launch, killed 21 people, mostly civilian technicians, injured 20 others, and destroyed two research satellites. The rocket had successfully completed two days of tests before the explosion. Brazil's Minister of Defence José Veigas Filho stated that, for unknown reasons, one of the four main motors of the US$2.2 million rocket had ignited, leading to the explosion that destroyed the launchpad. The accident was Brazil's third failed attempt to launch a rocket with a research satellite.[499]

Scientists studying data produced by the thermal emission spectrometer (TES) on board NASA's Mars Global Surveyor published findings in the journal *Science* disputing the theory that Mars once had a warm climate. Using the TES, which measured infrared light from rocks, scientists had searched for patterns of color to identify different minerals, particularly carbonates. Carbonates form only in the presence of liquid water. TES data confirmed small concentrations of carbonates in Martian dust, but no large deposits, such as those that would have formed at the bottom of a lake or ocean. Lead author of the article, Philip R. Christensen of Arizona State University, remarked that, according to the data, it was "extremely unlikely" that large bodies of water exposed to the atmosphere for an extended period had ever existed on Mars. Matthew P. Golombek of NASA's JPL commented that the new findings directly contradicted the idea that, at one time, Mars may have been warmer and wetter with a denser carbon-dioxide atmosphere. Previously, scientists had proposed this theory to explain Mars's apparent geological formations resembling the intricate patterns of riverbeds, carved canyons, and delta fans.[500]

25 August

NASA successfully launched its Space Infrared Telescope Facility (SIRTF) aboard a Delta 2 rocket from Cape Canaveral, Florida. The Lockheed Martin–built SIRTF was the fourth and final of NASA's Great Observatories, following the HST, the Compton Gamma Ray Observatory, and the Chandra X-ray Observatory. NASA had designed the 110-pound (50-kilogram), 33.5-inch (85-centimeter) telescope to measure heat from celestial objects. SIRTF would study some of the same deep space objects as the other Great Observatories, as well as studying other parts of the cosmos. Michael Jura, SIRTF interdisciplinary scientist for planetary science at the University of California at Los Angeles, remarked that one of SIRTF's main scientific goals was to develop a better understanding of star and planet formation. The project, originally proposed in the mid-1970s, had faced repeated budgetary cutbacks and delays. NASA planned for SIRTF's mission to last a minimum of 30 months, at an anticipated cost of US$1.19 billion.[501]

26 August

NASA announced that it had awarded a follow-on contract to the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, to continue providing scientific and operational support for the Chandra X-ray Observatory. The Smithsonian Astrophysical Observatory had provided scientific and operational support since Chandra's launch in July 1999. The follow-on

[499] "Brazil's Rocket Test Kills 21," *Orlando Sentinel* (FL), 23 August 2003; Stan Lehman, "Brazil Mourns Dead, Vows to Reinforce Space Program," *Houston Chronicle*, 25 August 2003.
[500] Joshua L. Bandfield, Timothy D. Glotch, and Philip R. Christensen, "Spectroscopic Identification of Carbonate Minerals in the Martian Dust," *Science* 301, no. 5636 (22 August 2003): 1084; *New York Times*, "Study: No Past Standing Water on Mars," 22 August 2003; Kenneth Chang, "New Data Dispute Theory That Mars Had Warm Climate," *New York Times*, 22 August 2003.
[501] *Spacewarn Bulletin*, no. 598; Associated Press, "NASA Launches Rocket with Infrared Scope," 25 August 2003.

contract, valued at US$373 million, funded support through 31 July 2010. NASA had planned Chandra's mission to last five years from the time of its launch, but had extended the mission to 10 years because of Chandra's success.[502]

Harold W. Gehman Jr. delivered the CAIB's final report to NASA Administrator Sean O'Keefe, presenting its findings and recommendations. The CAIB found that a 1.7-pound (0.77-kilogram) piece of foam insulation, traveling at more than 500 miles (804.6 kilometers) per hour, had damaged *Columbia*'s wing during launch, ultimately leading to its disintegration during reentry. The report stated that management decisions during *Columbia*'s flight reflected missed opportunities, ineffective communication channels, flawed analysis, and ineffective leadership. When cameras tracking *Columbia* provided two grainy images showing the foam striking the wing, engineers had immediately begun to discuss obtaining further images of the Shuttle or initiating a spacewalk to check for damages. However, mission managers had "adjourned for a holiday weekend and did not discuss the foam strike." Upon returning to work on 21 January, the managers had assessed the strike as a postlanding maintenance problem, because smaller foam strikes had left harmless dents in Shuttles during all previous missions. The CAIB's Executive Director John L. Barry remarked that, among NASA's competing goals of maintaining costs and meeting schedules, safety had lost out. The Board directly criticized Administrator Sean O'Keefe for increasing pressure to meet a February 2004 launch deadline, thereby creating a pattern similar to that which had led to the *Challenger* disaster in 1986. The CAIB recommended that NASA implement 15 actions before the next Shuttle flight, including creating an independent safety-and-engineering organization to help establish satisfactory safety margins. Upon receiving the Board's final report, O'Keefe reiterated NASA's intention to comply fully with the recommendations.[503]

29 August

Progress M-48 12P launched on a Soyuz FG rocket, carrying 2.6 tonnes (2.87 tons or 2,600 kilograms) of food, fuel, water, and equipment to the ISS. Among the supplies Progress M-48 carried were an Iridium satellite phone and GPS equipment for the use of the Expedition 7 crew—Russian Commander Yuri Malenchenko and NASA Science Officer Edward T. Lu—when they returned to Earth in the *Soyuz* TMA-2 spacecraft in October. The Russian Space Agency had added the satellite phone and GPS equipment to the supplies because *Soyuz* TMA-1 had experienced an internal glitch while returning the Expedition 6 crew to Earth, resulting in a long, tense search for the craft and crew.[504]

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[502] NASA, "NASA Awards Chandra X-ray Observatory Follow-on Contract," contract release c03-z, 26 August 2003, *http://www.nasa.gov/home/hqnews/2003/aug/HQ_C03z_Chandra_Contrct.html* (accessed 29 December 2008).

[503] NASA, "NASA Administrator Accepts Columbia Accident Report," news release 03-276, 26 August 2003, *http://www.nasa.gov/home/hqnews/2003/aug/HQ_03276_AOK_Acpt_CAIB.html* (accessed 29 December 2008); Mark Carreau, "Columbia Accident Board Casts Wide Net of Blame," *Houston Chronicle*, 27 August 2003; Kathy Sawyer and Eric Pianin, "Report Blames Flawed NASA Culture for Tragedy," *Washington Post*, 27 August 2003.

[504] *Spacewarn Bulletin*, no. 598; Justin Ray, "Resupply Ship Bound for the International Space Station," *Spaceflight Now*, 28 August 2003.

SEPTEMBER 2003

3 September
NASA announced the appointment of John M. Grunsfeld to succeed Shannon W. Lucid as NASA's Chief Scientist, effective immediately. NASA tasked Grunsfeld with ensuring the scientific merit of NASA's programs. Grunsfeld, an astronomer, astrophysicist, and veteran astronaut, had been an integral member of two Space Shuttle–servicing missions to the HST. Lucid had served as Chief Scientist since February 2002. NASA's Administrator Sean O'Keefe had asked her to return to NASA's JSC in Houston, Texas, to help with return-to-flight efforts. During her tenure as Chief Scientist, Lucid had updated NASA science policy, a project that NASA had not undertaken since 1996. One of her most important tasks had been working with the Offices of Biological and Physical Research, Earth Science, Space Science, and Space Flight to develop a comprehensive plan for prioritizing research projects on board the ISS.[505]

CAIB Chairperson Harold W. Gehman Jr. and NASA Administrator Sean O'Keefe appeared before the U.S. Senate Committee on Commerce, Science and Transportation to discuss NASA's return-to-flight goals in light of the CAIB's findings. Committee members criticized the CAIB for its reluctance to assign individual blame within NASA for the *Columbia* disaster, but Gehman replied that the Board did not need to make judgments about individual accountability. O'Keefe added that NASA would have held individuals accountable only if someone had acted maliciously in the sequence of events that led to the loss of *Columbia*. O'Keefe also pointed out that all former members of the Shuttle team had either left their positions, or NASA had reassigned them. Gehman testified that the decisions and conditions that had led to the loss of the orbiter had begun years before, stating that Congress and the White House shared responsibility with NASA for creating the conditions responsible for the accident. Congress and the White House had reduced NASA's budget by 40 percent over the previous decade, affecting the operation of NASA's management system. When committee members asked whether NASA required additional funding for 2004, O'Keefe responded that the current budget did not cover some of the CAIB's recommended activities, such as establishing an independent authority to oversee Space Shuttle technical requirements, recertifying the orbiters, and accelerating the Orbital Space Plane (OSP) program. Committee members asked for O'Keefe's assurance that NASA would change its culture, implementing processes that would prevent future Shuttle accidents.[506]

4 September
NASA announced the completion of tests, which had taken place on 27 August at Edwards Air Force Base in California, demonstrating the possibility of reducing the impact of sonic booms. The research team showed that modifying an aircraft's shape alters the shape of its sonic boom, thus reducing the sound level. Northrop Grumman Corporation had modified the fuselage and nose of an F-5E fighter jet for the demonstration. The modified jet and a regular F-5E had each flown at Mach 1.36 from the same supersonic corridor. The two aircraft had demonstrated no

[505] NASA, "Astronaut John M. Grunsfeld Succeeds Shannon Lucid as NASA Chief Scientist," news release 03-280, 3 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03280_Grunsfeld.html* (accessed 28 January 2009).
[506] Paul Recer for Associated Press, "Senators Rip NASA over Columbia Probe," 4 September 2003; Brian Berger, "Lawmakers Press O'Keefe for Cost Figures," *Space News*, 4 September 2003.

difference in performance except that the modified jet's sonic boom was 33 percent less intense than that of the unmodified F-5E. Analysis and wind tunnel tests had predicted the outcome, but NASA had never before flight-tested the theory. Richard Weizman of NASA's Office of Aerospace Technology remarked that the demonstration was the culmination of 40 years of work by visionary engineers. The Defense Advanced Research Projects Agency had managed the Shaped Sonic Boom Demonstration (SSBD) program under its Quiet Supersonic Platform Initiative. NASA's LaRC and Dryden Flight Research Center (DFRC), as well as Northrop Grumman Corporation, had been partners in the SSBD program under a US$7 million cooperative agreement.[507]

CAIB Chair Harold W. Gehman Jr. and three other Board members appeared before the U.S. House Committee on Science and Technology to discuss the CAIB's findings. Gehman testified that budgetary pressures that the U.S. Congress and the White House ultimately controlled had been partly responsible for NASA's management failures. House Committee Chair Sherwood L. Boehlert (R-NY) concurred that Congress shared some of the blame in the 1 February loss of *Columbia* but reiterated that NASA needed to make changes. Many of the committee's questions focused on prospective remedies for NASA's poor risk management. While agreeing that NASA had a tendency to be overly optimistic in risk assessment, Gehman and other investigators explained to the committee that, because of the age of the Shuttle fleet, risk calculations were little more than estimates. Boehlert expressed concern that NASA was rushing to meet unrealistic return-to-flight dates—NASA had proposed a March 2004 launch date—rather than studying the CAIB report carefully and taking deliberate steps toward returning the Shuttles to flight.[508]

6 September

While moving NOAA's 14-foot (4.3-meter) NOAA-N Prime weather satellite from a vertical to a horizontal position, workers at a Lockheed Martin plant dropped the nearly completed US$239 million craft, causing serious damage. Lockheed Martin spokesperson Buddy Nelson stated that the cart holding the spacecraft "was not in the proper configuration for the planned activity." NASA's GSFC was responsible for overseeing the construction and launch of the satellite, and NOAA would assume control of the craft once it was in orbit. Lockheed Martin Space Systems Company had been building weather satellites since the NOAA satellites' initial launch in the early 1960s.[509]

8 September

NASA released its first preliminary return-to-flight plan, briefing reporters at JSC in Houston, Texas. The 158-page report, which Associate Administrator William F. Readdy called "an evolving document," indicated that 11 March 2004 was the earliest possible date for a Space Shuttle to return to flight. However, Readdy emphasized that NASA would be safety-driven, not

[507] NASA, "NASA Opens New Chapter in Supersonic Flight," news release 03-283, 4 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03283_supersonic_flight.html* (accessed 28 January 2009); Irene Mona Klotz for United Press International Science News, "Test Shows Shape Sheds Sonic Boom's Bang," 22 September 2003.

[508] Paul Recer for Associated Press, "Shuttle Probe Rips White House, Congress," *Washington Post*, 5 September 2003; Patty Reinert and Mark Carreau, "Don't Rush New Launch, Lawmakers Warn NASA," *Houston Chronicle*, 5 September 2003.

[509] Associated Press, "$239M Satellite Damaged at Lockheed Plant," *New York Times*, 10 September 2003.

schedule-driven, in its efforts to launch the first Shuttle to fly since the *Columbia* disaster. NASA had tentatively scheduled *Atlantis* for a launch between 11 March and 6 April 2004. In the preliminary plan, NASA indicated that it had changed *Atlantis*'s original mission of ferrying supplies and a new crew to the ISS. Instead, the mission would be a developmental flight during which the crew would test the new procedures and safety equipment that the CAIB had recommended. Although the ISS would still be *Atlantis*'s destination, the mission would not carry ISS replacement crew. NASA's Space Shuttle Program Manager William W. Parsons Jr. said that the greatest challenges for future Shuttle missions would be developing methods to minimize the shedding of foam from the orbiter's external tank and to repair tile and protective heat panels while in space. In addition, NASA would have to install cameras and sensors on the Shuttles and on the ISS robotic arms, to detect vehicle damage.[510]

9 September

NASA selected Team Encounter LLC as the first private company contracted to manage a commercial mission carrying one of NASA's space science technology experiments into space. Valued at approximately US$6.5 million, the contract required the commercial company to mount NASA's hardware on Team Encounter's spacecraft and to integrate and test the system before the launch, scheduled to take place in 2004 or 2005. As the demonstration experiment for the mission, NASA selected a solar-sail technology known as the Inertial Stellar Compass (ISC) Technology Experiment. After the launch, Team Encounter would provide to NASA about 30 days of data from the ISC experiment. Charles Gay, NASA Program Executive for the New Millennium Program, remarked that the award was an opportunity for NASA to work with commercial industry in a mutually beneficial venture providing NASA with an effective way of validating its technology experiments in space at a reasonable cost.[511]

The U.S. Air Force launched a Titan 4B rocket with a Centaur upper stage carrying USA 171, an Orion classified satellite serving the National Reconnaissance Office (NRO). The Air Force provided no comment on the payload's destination or its whereabouts following the separation of the second stage of the Centaur. The Air Force had delayed the launch of USA 171 since April 2002 because of a series of technical problems and issues with the payload. The launch was likely the last of the Titan-Centaur launches, with only three Lockheed Martin–built Titan 4 rockets and one Titan 2 remaining to launch. The Air Force had contracted with Boeing and Lockheed Martin to replace the Titan 4 family with the Boeing Delta 2 and the Lockheed Martin Atlas 5, to provide the Air Force with cheaper, more reliable access to space for military payloads.[512]

NASA announced that NOAA, Lockheed Martin, and NASA had formed teams to investigate the 6 September accident involving the NOAA-N Prime satellite. While moving the spacecraft

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[510] John Schwartz and Warren E. Leary, "NASA Says It Won't Rush Shuttle Back to Space," *New York Times*, 9 September 2003.

[511] NASA, "NASA Selects Commercial Space Ride for Technology Experiment," contract release c-03-cc, 4 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_c03cc_space_ride.html* (accessed 28 January 2009).

[512] *Spacewarn Bulletin*, no. 599, 1 October 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx599.html* (accessed 3 February 2009); Associated Press, "Air Force Launches Titan 4B Rocket Carrying Secret Military Payload," 9 September 2003; Chris Kridler, "Titan Carries Spy Satellite into Orbit," *Florida Today* (Brevard, FL), 9 September 2003.

from a vertical to a horizontal position, Lockheed Martin workers had dropped it, significantly damaging the craft. NASA and Lockheed Martin had placed the satellite under guard, securing all records. NASA and NOAA were waiting for an assessment of the damage to determine how the accident would affect satellite programs.[513]

11 September

The Boeing Company named John Elbon to replace Joe Mills as Vice President and Program Manager of Boeing's ISS NASA Systems. In his new position, Elbon would lead Boeing's efforts as prime contractor of the ISS, holding the central role in the space station's design, testing, and building, as well as working with the 16 participating countries. Boeing had appointed Mills to lead its newest space initiative, the Jupiter Icy Moon Orbiter Program, part of NASA's development of nuclear-power and electronic-propulsion technologies intended to revolutionize space exploration.[514]

12 September

NASA announced the appointments of three additional voting members to the Stafford-Covey Task Group mandated to perform an independent assessment of NASA's implementation of the CAIB's recommendations. The new members were Kathryn C. Thornton, a physicist, former astronaut, and veteran of three Space Shuttle missions; Susan J. Helms, Chief of the Space Control Division's Requirements Directorate at U.S. Air Force Space Command, who had been a member of five Space Shuttle crews and had lived aboard the ISS as a member of Expedition 2; and career systems analyst Christine H. Fox, Vice President and Director of the Operations Evaluation Group at the Center for Naval Analyses. The new appointments brought the total number of task group members to 30, including one member selected from NASA staff who would not vote. Members representing industry, academia, and government, divided among three panels, would examine the management, technical, and operational aspects of NASA's return-to-flight effort.[515]

16 September

NASA and the U.S. Army transferred an XV-15 tilt-rotor aircraft to the National Air and Space Museum's Steven F. Udvar-Hazy Center near Washington Dulles International Airport in Virginia. J. Victor Lebacqz, Acting Associate Administrator for NASA's Office of Aerospace Technology, described the XV-15—a unique type of aircraft possessing the takeoff, hover, and landing capabilities of a helicopter, with the range and speed of a turboprop aircraft—as one of NASA's most successful research aircraft and a prime example of cutting-edge aerospace research. Tilt-rotor flight research had begun in the 1950s with the Bell XV-3 convertiplane. In 1977 the first of two XV-15s built by Bell Helicopter–Textron had made its maiden flight. The XV-15 had achieved speed and altitude records for its class, receiving multiple awards from national organizations. Its success had led to the development of the V-22 Osprey and to the

[513] NASA, "NASA, NOAA and Lockheed Martin Investigate Satellite Accident," news release 03-287, 9 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03287_satellite_accident.html* (accessed 28 January 2009).
[514] *Florida Today* (Brevard, FL), "Boeing Names New ISS Leader," 12 September 2003.
[515] NASA, "Three Members Added To Stafford-Covey Task Group," news release 03-293, 12 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03293_three_members.html* (accessed 28 January 2009).

world's first civil tilt-rotor, the nine-passenger Bell-Agusta 609, which was under development and scheduled for delivery in 2007.[516]

17 September
NASA awarded its Kennedy Space Center Integrated Communications Services (KICS) contract, valued at approximately US$190.7 million, to InDyne Inc. of McLean, Virginia. Under the cost-plus-award fee/firm-fixed price, indefinite-delivery/indefinite-quantity contract, InDyne would provide communications services at NASA's KSC in support of the Space Shuttle Program, ISS Program, Payload Carriers Program, and Launch Services Program Office payloads. The KICS contract was the first of five work packages in NASA's space mission communications and data services solicitation, which succeeded the NASA consolidated space operations contract (CSOC) and incorporated the requirements of the visual information technical contract as well as the telephone service requirements of the outsourcing desktop initiative.[517]

NASA announced the successful completion at KSC of the Multi-Element Integrated Test (MEIT) between *Kibo*, the Japanese Experiment Module-Pressurized Module (JEM-PM), and NASA's *Node 2*. Only the third such integrated test carried out at KSC, its successful completion was a major milestone in demonstrating on-orbit performance of key ISS elements—on-orbit activation sequence, command-and-track systems that support audio and video systems, and caution-and-warning systems that monitor life systems in ISS modules. A team of international participants representing many organizations had carried out the MEIT. Members included ESA, Japan's NASDA, the Canadian Space Agency, and the Italian Space Agency; NASA and Boeing employees at NASA's KSC, JSC, DFRC, and GRC; as well as flight-crew members from the United States, Japan, and Brazil.[518]

20 September
A team of engineers from academia and industry conducted the first known flight test of a powered, liquid-propellant, aerospike engine, which they had developed under the California Launch Vehicle Education Initiative (CALVEIN). The X-33/Venturestar single stage–to–orbit rocket plane, which NASA and Lockheed Martin had shelved, had been a prototype for aerospike-motor technology. Students at California State University at Long Beach had designed and developed the research vehicle Prospector 2 to use a mixture of liquid oxygen and ethanol. The rocket pitched after several seconds of stable flight, crashing to the floor of the Mojave Desert in California and destroying student payloads on impact. However, the aft section of the vehicle, which contained the aerospike, remained mostly intact. The mission achieved its single objective: to lift the vehicle into the air using the liquid-propellant aerospike engine. The test revealed several areas of the aerospike-engine design that needed improvement.[519]

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[516] NASA, "Tilt Rotor Aircraft Joins National Air and Space Museum Collection," news release 03-295, 16 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03295_tilt_rotor.html* (accessed 28 January 2009).
[517] NASA, "First Contract in SMCDS Solicitation Awarded To InDyne, Inc.," contract release c03-ff, 17 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_c03ff_indyne_contract.html* (accessed 28 January 2009).
[518] NASA, "Space Station Elements Successfully Complete Testing," news release 03-298, 17 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03298_station_elements.html* (accessed 28 January 2009).
[519] *Space News*, "Rocketeers Fly Aerospike Engine," 24 September 2003.

21 September
NASA's Galileo mission ended when the Galileo spacecraft disintegrated in Jupiter's atmosphere. NASA had managed the course of the craft's demise to prevent its becoming uncontrollable once it had depleted its propellant. Galileo had launched from Space Shuttle *Atlantis* in 1989, following multiyear delays—originally, NASA had planned for the craft to launch in 1982 aboard a Centaur rocket. The probe had made significant contributions to scientists' knowledge of Jupiter and its moons, including collecting evidence of the possibility of life on Europa. Galileo had outlasted its prime mission by six years, despite enduring numerous technical problems and more than four times the amount of radiation that engineers had designed the spacecraft to withstand.[520]

23 September
The National Academies' National Research Council and Transportation Research Board released a report addressing the need to overhaul the air transportation system to meet an ever-increasing demand for air travel. NASA and the FAA had sponsored the report, *Securing the Future of U.S. Air Transportation: a System in Peril*, which representatives of industry, academia, and government had written. The Board had found that aircraft and air traffic–management systems were not improving to meet growing demand; noise and air pollution were increasing as air traffic increased; passengers were dissatisfied with travel costs and with uncomfortable conditions in airplanes; and security continued to be a major concern to travelers and to the industry. In comparing the U.S. air transportation system to that of Europe, the report stated that Europe considered the satisfaction of consumer needs a priority, whereas the United States did not address the issue. Among its goals, Europe hoped to achieve the primacy of the European aeronautics industry, to develop a supersonic aircraft carrying 1,200 passengers, and to build an air traffic system that would set the global standard for efficiency, whereas the United States had no similar strategy. Therefore, the report recommended that the federal government make air transportation a national priority with strong, focused leadership.[521]

NASA Administrator Sean O'Keefe accepted the resignation of all members and staff of the Aerospace Safety Advisory Panel (ASAP), which the U.S. Congress had first chartered in 1967 following the *Apollo 1* fire. ASAP's function was to provide an independent body to advise NASA's Administrator about the safety of NASA's operations, facilities, and personnel. In her resignation letter, ASAP Chairperson Shirley C. McCarty stated that the panel had decided to resign so that the NASA's Administrator and Congress would have an opportunity to revitalize ASAP and to reshape its charter and mission. The panel also noted its frustration that, over the years, legislation had weakened its authority and that the CAIB final report had described the ASAP as "often not very influential." Experts had noted that NASA had often ignored warnings that the safety panel issued and that ASAP had possessed no authority to enforce its recommendations. In accepting the ASAP members' resignations, O'Keefe pledged to strengthen

[520] NASA JPL, "Galileo End of Mission Status," news release, 21 September 2003, *http://www.jpl.nasa.gov/news/news.cfm?release=129* (accessed 2 February 2009); Usha Lee McFarling, "Stalwart Galileo Is Vaporized near Jupiter," *Los Angeles Times*, 22 September 2003.
[521] The National Academies, "Overhaul of Air Transportation System Needed To Meet Ever-Increasing Demand," publication announcement, 23 September 2003, *http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=10815* (accessed 4 February 2009); National Research Council, *Securing the Future of U.S. Air Transportation: A System in Peril* (Washington, DC: National Academies Press, 2003); Associated Press, "Report: US Aviation Needs Major Changes," *New York Times*, 24 September 2003.

the panel by studying its original concept and determining how to help its successor panel best meet the needs of NASA.[522]

NASA announced the successful completion of the systems-requirement review for the OSP program, evaluating the contractor teams' concept designs for providing crew rescue and transfer for the ISS according to Level 1 requirements. The Boeing Company, Lockheed Martin, and a team composed of members from Orbital Sciences Corporation and Northrop Grumman had conducted systems analysis, trade studies, and concept feasibility in preparation for the review. The review had also set Level 2 requirements, addressing guidelines for safety, launch, emergency-return and crew-transfer missions, mission frequency, on-orbit mission duration, contingency cargo requirements, and docking and interfacing with the ISS.[523]

26 September
NASA notified Resource21 LLC, a remote-sensing firm based in Englewood, Colorado, that NASA had rejected the company's US$500 million bid to provide Landsat-type data for five years. NASA had managed the bidding process for the Landsat Data Continuity Mission on behalf of the USGS, which was responsible for archiving and distributing Landsat data. Resource21 was the only company to submit a final bid in the competition to commercialize the U.S. government's satellite-based Landsat information program.[524]

27 September
A Russian Cosmos-3M rocket launched from Plesetsk Cosmodrome in Russia carrying three 100-kilogram (0.1-tonne or 0.11-ton) satellites into orbit for Nigeria (NigeriaSat-1), Turkey (BILSAT-1), and the United Kingdom (UK-DMC). The satellites joined a similar satellite from Algeria, launched in November 2002, to form the Disaster Monitoring Constellation (DMC). The DMC's purpose was to provide environmental information regarding floods, earthquakes, and fires. Surrey Satellite Technology Ltd. of Guildford, United Kingdom, which specialized in small satellites, had initiated the DMC project. The four craft had ground resolution of 32 meters (105 feet), and each image produced by the satellites showed 600 square kilometers (231.7 square miles). The Cosmos-3M also carried two military satellites for Russia. One of the satellites, Rubin-4 DSI, was a Russian communications experiment in transmitting telemetry data via standard e-mail, using Orbcomm communications satellites. Another, Mozheyets-4, built by students at the Mozhaisk Military Space Academy, tested hardware for future use on Russia's GLONASS (Global Satellite Navigation System). The third was South Korea's KAITSAT-4 scientific-research microsatellite, a demonstration platform to test new satellite systems, hosting five science experiments from an international team of researchers.[525]

In its first mission to the Moon, ESA launched its Small Mission for Advanced Research in Technology (SMART-1) spacecraft aboard an Ariane 5 rocket from Kourou, French Guiana.

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[522] NASA, "NASA Administrator Accepts Aerospace Safety Panel Resignation," news release 03-301, 23 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03301_asap_resign.html* (accessed 28 January 2009); Paul Recer for Associated Press, "Nine NASA Safety Panel Members Resign," 24 September 2003.
[523] NASA, "NASA Completes Orbital Space Plane Design Review," news release 03-299, 23 September 2003, *http://www.nasa.gov/home/hqnews/2003/sep/HQ_03299_orbital_plane.html* (accessed 28 January 2009)
[524] Brian Berger, "NASA Rejects Only Bid for Landsat Data Buy Contract," *Space News*, 30 September 2003.
[525] Peter B. de Selding, "Disaster Monitoring Satellites Launched," *Space News*, 30 September 2003; Jim Banke, "Kosmos 3M Booster Carries Six Satellites to Earth Orbit," *Space News*, 29 September 2003.

SMART-1 was the first spacecraft since NASA's 1998 Lunar Prospector to attempt the journey to the Moon. ESA planned for the 770-pound (349.2-kilogram) craft, powered by an ion-propulsion engine, to reach the Moon in early 2005. SMART-1 carried 33 pounds (15 kilograms) of miniature instruments, which researchers from Finland, Germany, Italy, Sweden, Switzerland, and the United Kingdom had provided, including a color camera the size of a human eye, a 4.4-pound (2-kilogram) infrared spectrometer, and an 11-pound (5-kilogram) x-ray spectrometer. The purpose of the SMART-1 mission was to solve certain mysteries about the Moon's formation, its mineralogical composition, and the amount of water it has, if any. The Ariane 5 also carried into orbit two telecommunications satellites—the INSAT 3-E for India and the European e-BIRD. ESA had delayed the launch of e-BIRD since 28 August to allow the Indian Space Research Organisation (ISRO) to make further checks on its satellite.[526]

OCTOBER 2003

1 October
A telecommunications satellite jointly owned by the United States and Japan—known as Horizons 1 or Galaxy 13—launched aboard a Sea Launch Zenit 3-SL rocket from a platform in the equatorial Pacific Ocean. Connecticut-based PanAmSat and Tokyo-based JSAT corporations launched the craft to provide digital video, Internet, and data transmission services to Hawaii and to Central America and North America. PanAmSat owned the satellite's C-band payload Galaxy 13 and planned to use it as part of the company's Galaxy cable constellation. President and CEO of PanAmSat Joseph R. Wright Jr. remarked that the addition of Galaxy 13 to the company's fleet would create the first high-definition neighborhood and would help to meet the growing demand for high-resolution television. The two companies would jointly operate the satellite's Ku-band payload Horizons 1, which would offer a variety of digital video, Internet, and data services, as well as creating new IP-based content-distribution networks.[527]

Japan merged its three space agencies with the goal of saving US$89.8 million a year. According to the new configuration, the Japan Aerospace Exploration Agency (JAXA) would manage the unified entities of the Institute of Space and Astronautical Science, NASDA, and the National Aerospace Laboratory. Modeled on NASA but about one 10th of the size of its American counterpart, JAXA had 1,800 employees and an initial annual budget of US$1.66 billion.[528]

8 October
NASA announced its selection of Allied Aerospace Industries of Tullahoma, Tennessee, to manufacture three flight-ready experimental demonstrator vehicles for the X-43C project, a NASA-led initiative. NASA's LaRC had led the team, comprising members from the U.S. Air Force and from the aerospace industry, to design and develop the X-43C demonstrator vehicle and propulsion system. Following the example of the Hyper-X (X43-A), a vehicle designed to demonstrate short-duration, scramjet-powered flight at Mach 7 and Mach 10, the creators of the

[526] Frank D. Roylance, "Europe Finally Ready for Mission to Moon," *Baltimore Sun*, 29 September 2003; Agence France-Presse, "European Rocket Places Lunar Explorer, Two Satellites into Orbit," 29 September 2003.
[527] *Spacewarn Bulletin*, no. 600, 1 November 2003, *http://nssdc.gsfc.nasa.gov/spacewarn/spx600.html* (accessed 27 January 2009); Justin Ray, "Communications Satellite Launched from Pacific Ocean," *Spaceflight Now*, 2 October 2003.
[528] Reuters, "Japan Streamlines Its Space Effort: Three Agencies Merged into JAXA; Tokyo Keeps Its Eye on Beijing," 2 October 2003.

X-43C intended it to demonstrate free flight of a scramjet-powered vehicle, with acceleration capability between Mach 5 and Mach 7. Allied Aerospace Industries had also developed the X43-A vehicle. The Air Force had provided a dual-mode scramjet capable of operating as a ramjet or scramjet for the X-43C vehicles. The cost-plus-fixed-fee completion-type contract that NASA awarded to Allied Aerospace Industries was valued at US$150 million over 66 months, covering all work through completion of the Preliminary Design Review; options covered the final design, hardware fabrication, and all support activities. X-43C Project Manager Paul L. Moses remarked that the demonstrator vehicle would validate advanced technologies, design tools, and test techniques for designing reusable space-access vehicles in the future.[529]

10 October

NASA announced the appointment of Steven J. Dick as NASA's Chief Historian, to succeed Roger D. Launius, who had departed in July 2002 to become Historian of the National Air and Space Museum. An astronomer and historian of science, Dick had served as the first Historian of the U.S. Naval Observatory and, just before his NASA appointment, had been Acting Chief of the Naval Observatory's Nautical Almanac Office. As an expert in the field of astrobiology and its cultural implications, Dick had served on a panel examining the potential societal implications of the discovery of life in the Mars rock. He had received the NASA Group Achievement Award in recognition of his contributions to the establishment of the NASA Astrobiology Institute (NAI), including the definition of the field of astrobiology. Dick had authored more than 100 works, including a history of the Naval Observatory, *Sky and Ocean Joined: The U.S. Naval Observatory, 1830–2000*, which had won the John Lyman Award of the North American Society for Oceanic History for best book in 2002 in Science and Technology and the U.S. Naval Observatory's Captain James Melville Gilliss Award for extraordinary dedication and exemplary service. At the time of his appointment, Dick served on the editorial boards of several journals and was an associate editor of the *International Journal of Astrobiology*. From 1993 to 1994, Dick had served as Chairperson of the Historical Astronomy Division of the American Astronomical Society, and between 1997 and 2000, he had been President of the History of Astronomy Commission of the International Astronomical Union.[530]

14 October

NASA and the U.S. Department of Energy (DOE) commissioned the US$34 million NASA Space Radiation Laboratory (NSRL) at the DOE's Brookhaven National Laboratory in Upton, New York, where NASA biologists and physicists would perform thousands of experiments to measure the hazards of space radiation and to develop countermeasures to protect astronauts. Construction of the facility had begun in 1998. NASA and the DOE had cooperated in building the NSRL, which housed an accelerator producing beams of protons or heavy ions, like those that the Sun and other cosmic sources typically produce. The beams moved through a 328-foot (100-meter) transport tunnel to a 400-square-foot (37-square-meter) target hall, to hit a target composed either of a biological sample or of shielding material. Scientists planned to measure

[529] NASA, "NASA Selects Allied Team To Provide Hypersonic Vehicles," contract release C03-ll, 8 October 2003, *http://www.nasa.gov/home/hqnews/2003/oct/HQ_c03ll_x43c.html* (accessed 27 January 2009); Brian Berger, "Hypersonic Efforts Get an Extra Boost: NASA, Air Force Providing $150 Million for Test Program," *Space News*, 21 October 2003.

[530] NASA, "NASA Names New Historian," news release 03-327, 10 October 2003, *http://www.nasa.gov/home/hqnews/2003/oct/HQ_03327_new_historian.html* (accessed 27 January 2009).

the interaction of specific particles with targets to determine the effectiveness of various materials in shielding against radiation and to develop and to test new materials. An NSRL health team would perform tests with biological samples to learn how radiation damages cells, how to predict risks, and to develop countermeasures to mitigate radiation effects.[531]

15 October

The People's Republic of China launched *Shenzhou 5* on a Long March 2F rocket, becoming the third nation after Russia and the United States to send a human into orbit. Veteran fighter pilot Yang Liwei expected to orbit Earth 14 times before landing. The launch was the culmination of the decade-long effort of China's secretive, military-linked space program, undertaken with the hope of improving the communist nation's image abroad, as well as among its own citizens. Chinese officials described the *Shenzhou* program as homegrown, but western analysts stated that Russia had provided China with important technology and training for its taikonaut (astronaut) corps. Western analysts described the *Shenzhou* craft as an improvement over the Russian *Soyuz* design, with new solar arrays enabling the front-end orbital module to remain in space after the taikonaut compartment had returned to Earth. In addition, the craft's improved collision-avoidance systems provided *Shenzhou* with enhanced capacity to avoid dangerous space debris.[532]

NASA released its Comet Nucleus Tour (CONTOUR) Mishap Investigation Board (MIB) report, which identified four possible causes for the failure of the comet-rendezvous mission. The CONTOUR Mission—intended to encounter at least two comets and to perform investigations and analyses of comet material—had launched on 3 July 2002. NASA had lost contact with the craft on 15 August 2002, following a propulsive maneuver involving the solid rocket motor (SRM), and had been unable to reestablish contact as of 20 December 2002. On that date, NASA and Johns Hopkins University's Applied Physics Laboratory had concluded that the spacecraft was lost. NASA had established the MIB on 22 August 2002. The CONTOUR MIB's task was to examine the processes, data, and actions surrounding the events of 15 August; to search for proximate and root causes of the loss of the craft; and to develop recommendations for future missions. In its report, the CONTOUR MIB concluded that the probable cause of the mission's failure was the structural failure of the spacecraft resulting from plume heating during the embedded SRM burn on 15 August. However, the lack of telemetry and observational data, immediately before and during the burn, as well as the lack of recoverable debris, left open the possibility that one of several other problems might have contributed to the loss of the spacecraft. The MIB report identified as other possible causes the catastrophic failure of the SRM; collision with space debris or meteoroids; and the loss of dynamic control of the spacecraft.[533]

NASA announced that astronaut Franklin R. Chang-Dìaz had won *Discover Magazine*'s Innovation Award for Space Science and Technology in the Space Explorer category. The annual

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[531] NASA, "New NASA Facility Will Help Protect Space Crews from Radiation," news release 03-326, 14 October 2003, *http://www.nasa.gov/home/hqnews/2003/oct/HQ_03326_new_facility.html* (accessed 27 January 2009).
[532] *Spacewarn Bulletin*, no. 600; David Lynch, "China Blasts Off into Space," *USA Today*, 15 October 2003; Christopher Bodeen for Associated Press, "China Launches First Manned Space Mission," 15 October 2003.
[533] NASA, "Contour Mishap Board Completes Investigation," news release 03-324, 15 October 2003, *http://www.nasa.gov/home/hqnews/2003/oct/HQ_03324_contour.html* (accessed 27 January 2009); NASA, "Comet Nucleus Tour (CONTOUR) Mishap Investigation Board Report," 31 May 2003; Associated Press, "Heat from Rocket Likely Broke Up Unmanned Spacecraft—NASA," 16 October 2003.

awards, presented in the categories of Space Explorer, Communications, Space Scientists, Technology for Humanity, and Aerospace, honored scientists whose work had benefited the U.S. space program and all of humanity. A veteran of seven spaceflights, a record he shared with only one other astronaut, Chang-Dìaz was Director of the Advanced Space Propulsion Laboratory at NASA's JSC in Houston, Texas, where he was leading a team to develop the Variable Specific Impulse Magnetoplasma Rocket (VASIMR) Engine. The team was working on a conceptual engine that would eventually enable humans to explore distant regions of Earth's solar system and, perhaps, regions beyond the solar system. A native of Costa Rica, Chang-Dìaz had earned undergraduate and advanced degrees in mechanical engineering and applied plasma physics from the University of Connecticut and the Massachusetts Institute of Technology before becoming an astronaut in 1981. He had first traveled to space in 1986 and, most recently, had participated in the ISS assembly and crew-exchange mission in June 2002, during which he undertook three spacewalks.[534]

16 October
Chinese taikonaut Yang Liwei successfully completed his 21-hour mission of 14 orbits around Earth aboard the *Shenzhou 5*, landing safely in the Gobi Desert in Mongolia. From aboard the ISS, American astronaut Edward T. Lu, speaking in Chinese, had welcomed Yang to space and wished him a safe journey and success. Russian cosmonaut Yuri I. Malenchenko had told Mission Control in Houston that he was glad to have someone else in space besides himself and Lu, congratulating the great accomplishment of thousands of people in the People's Republic of China who had worked together to send Yang into space. After emerging from his capsule, Yang stated that *Shenzhou 5* had operated very well, that he felt well, and that he was "proud of the motherland."[535]

18 October
Soyuz TMA-3/ISS-9S launched from the Baikonur Cosmodrome in Kazakhstan transporting to the ISS the Expedition 8 crew—American Mission Commander C. Michael Foale, Russian Flight Engineer Alexander Y. Kaleri, and Spanish astronaut Pedro Duque. Foale and Kaleri were traveling to the ISS for a 200-day mission, replacing American Edward T. Lu and Russian Yuri I. Malenchenko who were completing a six-month stay aboard the orbiting station. Duque would conduct 10 days of scientific experiments on the ISS and would return to Earth with Lu and Malenchenko.[536]

The U.S. Air Force launched its Defense Meteorological Satellite Program (DMSP) F16 craft aboard a Titan 2 rocket from Vandenberg Air Force Base in California, marking the final launch of the Lockheed Martin launch vehicles. In keeping with its 1986 agreement with the U.S. Air Force, Martin Marietta had converted 14 Titan 2 intercontinental ballistic missiles (ICBMs) into space launch vehicles. The Air Force had used the converted missiles to launch weather and spy satellites into low Earth orbit; the first such converted missile launched in September 1988. The

[534] NASA, "Astronaut Chang-Diaz Wins Discover Magazine Award," news release 03-335, 15 October 2003, *http://www.nasa.gov/home/hqnews/2003/oct/HQ_03335_ChangDiaz_Award.html* (accessed 27 January 2009).
[535] John Pomfret, "China's First Space Traveler Returns a Hero: Craft Made 14 Orbits in 21-Hour Mission," *Washington Post*, 16 October 2003; Ching-Ching Ni, "China Completes Spaceflight: Nation's First Astronaut, Lt. Col. Yang Liwei, Returns from Earth Orbit," *Los Angeles Times*, 16 October 2003.
[536] *Spacewarn Bulletin*, no. 600; Dmitry Solovyov for Reuters, "ISS Crew Blasts Off at Baikonur," 20 October 2003; Justin Ray, "New Station Residents Arrive at Their Orbiting Home," *Spaceflight Now*, 21 October 2003.

Titan 2 that launched the DMSP F16 satellite was the 13th of the 14 converted ICBMs to launch; the Air Force had no plans for the 14th converted ICBM except to hold it as a spare. The successful launch of the satellite marked the end of the 33 months of postponements of the US$450 million mission that had resulted from technical problems. The Air Force intended for the craft to track clouds, storm systems, and hurricanes, planning to use the data that the satellite collected to forecast weather and to monitor ice and snow coverage, pollution, and fires. The constellation of two primary DSMP satellites and older backups provided meteorologists with information for generating forecasts, which commanders and troops relied upon for strategic and tactical planning. DSMP F16 replaced DSMP F15, which had launched in December 1999, as the lead craft in the constellation's mid-morning orbit.[537]

21 October

CBERS 2, a China-Brazil Earth Resources Satellite (CBERS) launched aboard a Long March 4B rocket from the Taiyuan Satellite Launch Center in the People's Republic of China's Shanxi province. The 1.6-tonne (1.76-ton or 1,600-kilogram) CBERS 2 remote-sensing satellite, designed to collect data related to the environment, agriculture, urban planning, and water pollution, would be under Chinese control for 18 months before transferring to Brazilian control for a minimum of six months.[538]

NASA awarded a US$9.7 million grant to Colorado State University to study radiation and cancer. The grant was one of three that NASA awarded to institutions as part of a new initiative to establish national centers studying risks associated with deep space travel. The grant established the NASA Specialized Center of Research (NSCOR) at Colorado State University, which would investigate the risk of the development of cancer associated with radiation exposure—particularly with the development of acute myelogenous leukemia (AML), which has a direct correlation with radiation exposure. The research, which would study threats to astronauts from radiation in space, would directly benefit cancer patients who develop AML as a secondary cancer after radiation therapy treatments of the initial cancer.[539]

25 October

JAXA officials announced that mission controllers had lost contact with the Advanced Earth Observing Satellite 2 (ADEOS 2), nicknamed Midori 2. The environmental research satellite was conducting a joint mission of the United States and Japan designed to study ocean winds, sea surface temperatures, sea ice, and water vapor distribution in the atmosphere; to monitor plant life and vegetation in marine areas; and to monitor Earth's ozone layer. The craft had launched 14 December 2002 to replace Midori 1, which had been lost in 1997 when a solar-array malfunction had left it with no power supply.[540]

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[537] *Spacewarn Bulletin*, no. 600; Justin Ray, "US Weather Satellite Finally Escapes Grasp of Hard Luck," *Spaceflight Now*, 14 October 2003; Roger Fillion, "Titan II Rocket Soars into Retirement," *Rocky Mountain News* (Denver, CO), 21 October 2003.

[538] *Spacewarn Bulletin*, no. 600; Reuters, "China Launches Satellite Developed with Brazil," 21 October 2003; Stephen Clark, "Earth Monitoring Satellite Launched by China and Brazil, *Spaceflight Now*, 21 October 2003.

[539] Christiana Nelson, "NASA Grants CSU Almost $10 Million," *Rocky Mountain Collegian* (Colorado State University, Fort Collins, CO), 22 October 2003.

[540] Justin Ray, "Earth Monitoring Satellite Goes Silent," *Spaceflight Now*, 25 October 2003; Jason Bates, "Japan Loses Contact with ADEOS-2 Satellite," *Space News*, 27 October 2003.

27 October
At 8:47 p.m. (EST), *Soyuz* TMA-2 landed safely in the steppes of Kazakhstan, returning to Earth the ISS Expedition 7 crew, American astronaut Edward T. Lu and Russian cosmonaut Yuri I. Malenchenko. Spanish astronaut Pedro Duque of ESA was also aboard the flight, returning from a 10-day mission performing scientific experiments in the ISS lab. The *Soyuz* TMA-2 flight was equipped with a GPS and satellite phones, which NASA had donated to prevent a disruption in communications between the crew and Mission Control Center in Moscow. Such a disruption had occurred in May 2003, when a *Soyuz* craft returning from the ISS had landed 250 miles (402.3 kilometers) off course because of a computer malfunction.[541]

28 October
NASA released to the public five additional volumes of the CAIB's report. The new volumes—including reports that NASA and other organizations had written; working documents the CAIB had produced; and findings or suggestions that the CAIB had, ultimately, not adopted—provided the full context of the technical reports and background information that the Board had used as the basis for its official 29 findings. The CAIB stated that conclusions and recommendations found in the new volumes did not necessarily reflect the Board's official views; therefore, the Board emphasized that the first volume, containing its official findings and recommendations, should always take precedence over the other volumes in the event of a conflict in findings.[542]

29 October
The GAO presented testimony to the Senate Commerce, Science and Transportation Subcommittee on Science, Technology and Space regarding the impact of the Shuttle fleet's grounding on ISS construction and maintenance. Based on a GAO report published in September, a report that the full Senate committee had requested, GAO testified that the grounding of the Shuttle fleet would increase the cost of completing the ISS and could expose the station's two-person crew to additional risk. NASA had originally estimated the cost of the ISS at US$10 billion, but since 1985, the U.S. Congress had appropriated US$32 billion to the project. The Bush administration had cancelled several planned ISS modules in 2001, to offset US$4 billion in cost overruns. Since the grounding of the Shuttle fleet following the *Columbia* disaster in February 2003, several components of the station—completed and ready to launch—had reached their storage limit, necessitating their replacement or refurbishment. The inability to ferry heavy items to the ISS had hampered NASA's ability to correct known safety concerns, such as the delivery of additional shielding to protect the ISS crew dormitory from orbital debris. Furthermore, NASA had estimated that the probability of space debris penetrating ISS living quarters increased by 1.6 percent for each year that the ISS partners postponed installing new shielding. The U.S. Senate Committee on Commerce, Science, and Transportation had requested the report from GAO. Members of Congress had repeatedly asked NASA to provide financial details about the effect of the *Columbia* accident on the ISS program. However, GAO's September report stated that neither NASA nor GAO could accurately estimate the costs associated with the grounded Shuttle fleet. GAO testified that it would be able to make such an

[541] Mara D. Bellaby of Associated Press, "Soyuz Crew Safely Returns to Earth from Space Station," 27 October 2003.
[542] Jim Banke, "Columbia Accident Board Report Complete with New Volumes," *Space.com*, 29 October 2003, *http://www.space.com/missionlaunches/caib_report_031028a.html* (accessed 23 February 2003).

estimate once NASA had identified precisely when Shuttle flights would resume. NASA officials agreed with GAO's findings.[543]

30 October
The FAA certified the ASDE-X (Airport Surface Detection Equipment) technology, a new airport surface–detection system for preventing runway and taxiway collisions, which would replace the expensive ASDE-3 system. General Mitchell International Airport in Milwaukee, Wisconsin, deployed the first ASDE-X system, and 25 other airports planned to install ASDE-X systems during the following four years. The ASDE-X system, which integrated several air traffic–control systems, used strategically placed sensors to report the location of aircraft and vehicles to controllers, giving them a real-time view of all aircraft and vehicles on airport grounds or flying in the area. A collaborative effort between a team of FAA employees, Sensis Corporation of Syracuse, New York, and Raytheon Corporation, the FAA had initially intended ASDE-X as a lower-cost alternative to the ASDE-3.[544]

31 October
JAXA officials announced that the chances of restoring the operations of ADEOS 2, known as Midori 2 in Japan, were extremely slight. JAXA had lost contact with ADEOS 2 on 25 October and had been unable to restore communications with the US$654 million craft. Analyses of the malfunction had provided little hope for recovery. ADEOS 2 had replaced the ADEOS 1 mission of 1996, which Japan had abandoned after 10 months when its solar panel had broken down as a result of a design fault. Japanese officials stated that they believed ADEOS 2 had not suffered exactly the same fate as its predecessor but, rather, had experienced a problem with its power circuitry. A JAXA spokesperson suggested that recent solar flares might have affected the craft—one of the solar flares had been the largest in three decades.[545]

NOVEMBER 2003

3 November
NASA filed a request for proposal with Federal Business Opportunities, inviting companies to define their schedules for Orbital Space Plane (OSP) design completion, development, testing, and delivery. NASA requested the completion of a crew-rescue vehicle by 2008 and a crew-transfer vehicle by 2012, despite congressional requests that NASA slow down its work on the OSP project. The Boeing Company and a Lockheed Martin–Northrop Grumman team had both been developing concepts for the OSP, a vehicle anticipated as the next space vehicle to ferry astronaut crews to and from the ISS. NASA had hoped to award the prime contract in August 2004 at the earliest. On 29 October, the U.S. House of Representatives Committee on Science and Technology, responsible for authorizing NASA programs, had restated its position that

[543] U.S. General Accounting Office, "Shuttle Fleet's Safe Return to Flight is Key to Space Station Progress" (report no. GAO-04-201T, Washington, DC, 29 October 2003), 1–11, *http://www.gao.gov/new.items/d04201t.pdf* (accessed 8 May 2009); Marc Carreau, "Costs Up for Space Station, Report Says," *Houston Chronicle*, 15 October 2003; Larry Wheeler, "Report: Shuttle's Absence Hurts ISS, GAO Claims Station Is in 'Survival Mode'," *Florida Today* (Brevard, FL), 15 October 2003.
[544] Don Phillips, "FAA Deploys System To Prevent Airport Runway Collisions," *Washington Post*, 31 October 2003.
[545] Agence France-Press, "Japan Bids Adios to ADEOS Earth Observation Satellite," 31 October 2003; Justin Ray, "Hope of Salvaging Japanese Environmental Satellite Fades," *Spaceflight Now*, 31 October 2003.

NASA should halt work on the OSP Program until the White House, Congress, and NASA had agreed on the direction the U.S. human spaceflight program would take after completion of the ISS. Congressional leaders had also questioned NASA's funding profile for the program.[546]

6 November
ESA's Science Programme Committee (SPC) dropped the Eddington mission and scaled back the BepiColombo mission because of budgetary concerns—the SPC had determined that ESA would only have sufficient resources to fund one new mission in the next decade. For that mission, the Committee had selected the Laser Interferometer Space Antenna (LISA) Pathfinder mission, which would launch in 2006 or 2007 and would test technologies and strategies for the planned 2012 LISA mission to detect gravitational waves. ESA had planned for the Eddington mission, scheduled for launch in 2008, to monitor the brightness of stars, study their interiors, and search for planets—of the size of Earth or smaller—passing in front of the stars. Japan and Europe had scheduled BepiColombo, their joint mission to Mercury, for launch in 2011 and had originally planned to send a lander to Mercury as part of that mission. Although the SPC had cancelled the lander portion of the mission, it still planned for ESA to launch two satellites to orbit the planet.[547]

NASA released an 84-page report, "Implementation Plan for the International Space Station Continuing Flight," detailing NASA's plans to improve exterior inspections of the ISS and to shield the station from debris strikes, while continuing to maintain a crew aboard the ISS during the disruption of Space Shuttle flights. Before the *Columbia* accident, Space Shuttle crews visiting the ISS had routinely photographed the exterior of the station; NASA expressed concern that in the absence of Shuttle flights, external damage would go undetected. The report outlined plans to conduct thorough inspections of external surfaces of the ISS using external cameras and classified satellite images, as well as to inspect more closely the wiring and equipment inside the station.[548]

The U.S. Air Force 45th Space Wing transferred operation of Launch Complex 47 at Cape Canaveral Air Station to the Florida Space Authority (FSA) by means of a licensing agreement under the Commercial Space Transportation Act. J. Gregory Pavlovich, Commander of the 45th Space Wing, stated that the transfer of operations was a positive development, remarking that, although the Air Force had previously scheduled the launchpad for deactivation, licensing it to the FSA would enable Launch Complex 47 to remain available for educational use for years into the future. Under the agreement, Brevard Community College could offer as many as 200 educational launch opportunities over the following five years, allowing for hands-on technical education that would help motivate students to join the aerospace workforce.[549]

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[546] Jason Bates, "NASA Releases Request for Orbital Space Plane Plans Despite Congressional Concern About the Program," *Space News*, 4 November 2003.
[547] Vanessa Thomas, "ESA Axes Planet-Finding Mission and Mercury Lander," *Astronomy.com*, 12 November 2003; Peter B. de Selding, "European Planet-Finding Mission Cancelled," *Space News*, 10 November 2003.
[548] Patty Reinert, "Armed with Lessons, NASA Outlines Safer Space Station," *Houston Chronicle*, 7 November 2003; Marcia Dunn for the Associated Press, "NASA: Space Station Safety Can Be Better," 7 November 2003.
[549] Jim Banke, "Florida Space Authority Will Run Cape Launch Pad for Education," *Space.com*, 7 November 2003, *http://www.space.com/missionlaunches/fsa_cx47_031107.html* (accessed 17 March 2009).

NASA announced the successful test of a launchpad-abort test vehicle designed to support its OSP Program. Wind tunnel tests had demonstrated the Lockheed Martin–designed Pad Abort Demonstration (PAD) vehicle's stability and maneuverability under simulated conditions approximating escape from a catastrophic failure of a launch vehicle. The tests, which followed the completion of September's PAD Preliminary Design Review, marked a significant success in the development of a safe and effective crew-escape system, clearing the way for the initial testing of the vehicle's engine in November 2003 and the first set of parachute drop tests in December 2003. NASA had not pursued the PAD Project to integrate crew-escape capability into spacecraft design since the Apollo program ended.[550]

7 November

Russian Deputy Prime Minister Boris Alyoshin and French Prime Minister Jean-Pierre Raffarin signed an agreement allowing Russian access to the ESA launch complex in French Guiana, beginning in 2006. The agreement provided for the construction of a new launchpad at Kourou for the launching of Russian *Soyuz* rockets. France agreed to contribute half of the cost of EUR 314 million (US$361 million), with other ESA member states providing the remainder. The agreement also allowed Arianespace to collaborate with the Russian company Starsem to use Soviet-era *Soyuz* rockets for launching medium-sized payloads, thereby closing a gap in Arianespace's marketing range.[551]

The U.S. Senate confirmed the appointment of Gwendolyn S. Brown as NASA's Chief Financial Officer. Before her nomination in July 2003, Brown had served as NASA's Deputy Chief Financial Officer for Financial Management, and before joining NASA, she had served on the U.S. Senate staff and had held various positions within the DOD. Brown had come to NASA from the Office of the Under Secretary of Defense (Comptroller), Directorate for Program and Financial Control, where she had been a senior program analyst.[552]

NASA announced the names of three additional members of the crew of the Space Shuttle Program's Return to Flight Mission STS-114. In 2001 NASA had named four astronauts to STS-114—Mission Commander Eileen M. Collins, Pilot James M. Kelly, Mission Specialist Stephen K. Robinson, and Mission Specialist Soichi Noguchi of JAXA. The four were already training for the flight, scheduled to launch no earlier than September 2004. Astronauts Andrew S. W. Thomas, Wendy B. Lawrence, and Charles J. Camarda rounded out the mission's crew of seven. NASA had originally planned for STS-114 to have a seven-member crew, but in the wake of the *Columbia* accident, NASA had changed the mission objective to focus on testing and evaluating new procedures for flight safety, rather than on ISS logistics and crew rotation. Thomas and Lawrence were veteran astronauts—Thomas was the second-highest-ranking member of NASA's Astronaut Office, and Lawrence had flown on the Shuttle three times. Camarda was a

[550] NASA, "NASA Conducts Successful Pad Abort Demonstration," news release 03-359, 6 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03359_pad_abort_demo.html* (accessed 5 February 2009).
[551] Agence France-Presse, "France, Russia Sign Deal for European Space Pad," 7 November 2003.
[552] NASA, "Senate Confirms Gwendolyn Brown as NASA Chief Financial Officer," news release 03-346, 7 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03346_brown_confirmed.html* (accessed 5 February 2009).

rookie making his first orbital flight. NASA had assigned Robinson and Noguchi to conduct spacewalks on the flight.[553]

12 November
NASA announced the appointment of U.S. Navy Rear Admiral Thomas Q. Donaldson V as Director of its SSC in Mississippi, effective 5 January 2004. Since February 2000, Donaldson had served as Commander of the Naval Meteorology and Oceanography Command, one of 30 agencies at SSC. NASA appointed Deputy Director of SSC Michael Rudolphi, who had been acting as interim Director since May 2003, to manage the Space Shuttle Propulsion Office at NASA's MSFC in Huntsville, Alabama, effective 1 December 2003.[554]

The Partnership for Public Service announced the results of the first survey measuring employee satisfaction in the federal government, conducted several months before the Space Shuttle *Columbia* accident. The survey results ranked NASA first, overall, among 28 major government agencies; NASA's MSFC in Huntsville, Alabama, ranked first, and its JSC in Houston, Texas, ranked second, among 200 smaller divisions. NASA Administrator Sean O'Keefe attended a news conference to publicize the results of the survey, describing the findings as a "proud day" for NASA. O'Keefe remarked that, although NASA was in the midst of working through the tragedy of the *Columbia* accident, the survey results established that NASA had a "very good foundation upon which to work."[555]

14 November
NASA Administrator Sean O'Keefe announced the appointment of the team that would lead the new NASA Engineering and Safety Center (NESC), chartered in the wake of the Space Shuttle *Columbia* accident. NASA's Office of Safety and Mission Assurance would assume oversight of the NESC. Based at NASA's LaRC, the NESC would coordinate and conduct testing and safety assessments in support of critical NASA projects and programs. O'Keefe had charged Director of LaRC Roy D. Bridges Jr. with assembling a team to get the Center up and running. O'Keefe remarked that Bridges had "assembled a dynamic group of recognized experts in the fields of engineering analysis and risk mitigation." The group comprised new Director of the NESC Ralph R. Roe Jr., formerly Manager of the Space Shuttle Vehicle Engineering Office at NASA's JSC; new Deputy Director Paul M. Munafo, formerly Manager of Materials, Processes and Manufacturing at NASA's MSFC; and new Deputy Director of Safety J. Larry Crawford, formerly Director of Research Engineering at NASA's DFRC. Roe's appointment as Director of

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[553] NASA, "NASA Names Crew Members for Shuttle Return to Flight Mission," 7 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03360_STS_114_crew.html* (accessed 5 February 2003); Todd Halvorson, "Astronaut Veterans, Rookie Fill Return-to-Flight Shuttle Crew," *Florida Today* (Brevard, FL), 10 November 2003; Jim Banke, "NASA Names Additional Crew for Return to Flight Mission," *Space.com*, 7 November 2003, *http://www.space.com/missionlaunches/sts114_ crew_ 031107.html* (accessed 13 March 2009).
[554] NASA, "NASA Names New Stennis Space Center Director," news release 03-362, 12 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03362_stennis_director.html* (accessed 5 February 2009); NASA, "Rudolphi Named NASA Space Shuttle Propulsion Manager," news release 03-363, 12 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03363_rudolphi.html* (accessed 5 February 2009).
[555] Mark Carreau and Megh Duwati, "Federal Employees Rate NASA Tops," *Houston Chronicle*, 13 November 2003; Jeffrey McMurray for the Associated Press, "Huntsville Space Center Named Best Federal Place To Work," 12 November 2003; David Lerman, "Study: It's Good To Be at NASA Langley," *Hampton Roads Daily Press* (VA), 13 November 2003.

the NESC drew criticism from the U.S. Congress because of his involvement in decisions regarding *Columbia*'s fatal mission. As Director of Shuttle Vehicle Engineering at the time of the *Columbia* accident, Roe had been one of several managers who dismissed concerns about possible damage to the Shuttle's external tank when foam insulation struck the orbiter's left wing after launch. Moreover, he and other mission managers had decided that it was unnecessary to obtain satellite images of the orbiting *Columbia* to check for damage.[556]

18 November

NASA announced the new charter and new members of its Aerospace Safety Advisory Panel (ASAP). All members of the previous ASAP, which the U.S. Congress had initially chartered in 1967 following the *Apollo 1* fire, had resigned in late September 2003 in the wake of the *Columbia* accident investigation. The original charter had intended the panel to act as an independent body to advise NASA's Administrator on safety issues, but over the years, additional administrative procedures had governed the panel's work. In the new charter, NASA revoked those procedures to enable the panel to develop its agenda in accordance with CAIB findings. The ASAP's original 1967 charter formed the foundation of the new charter, with the following revisions: 1) the ASAP would make quarterly reports, instead of annual; 2) new members would have two-year terms, extendable to a maximum of six years; 3) members would have staggered terms to ensure fresh perspectives at regular intervals; and 4) the ASAP would focus on industrial and systems safety, risk management, trend analysis, and management of NASA's safety and quality systems. NASA Administrator Sean O'Keefe named, as new members of the ASAP, Rear Admiral Walter H. Cantrell, Vice Admiral Joseph W. Dyer, Augustine O. Esogbue, Major General Francis C. Gideon Jr., Deborah L. Grubbe, Rosemary O'Leary, John C. Marshall, Steven B. Wallace, Rick E. Williams, and ex officio member, Brigadier General Joseph A. Smith. The new members represented academic, military, and industrial sectors; no member was a current or former NASA employee or contractor.[557]

Federal investigators concluded that a series of avoidable mistakes had caused the fatal crash of the chartered King Air A100 carrying Senator Paul D. Wellstone (D-MN) on 25 October 2002. The National Transportation Safety Board (NTSB) found that the two charter pilots had possessed inferior flying skills, they had twice failed to align the twin-engine turboprop on the proper course for an instrument landing, and they had subsequently permitted the airspeed to drop to dangerously low levels. The craft had stalled and plummeted into the woods, killing all eight on board. The NTSB recommended that the FAA improve inspections of on-demand charter companies in an effort to improve pilot training and in-flight procedures. The NTSB report also recommended that the FAA and NASA create a special technical panel to study the feasibility of "low airspeed alert systems," which would automatically warn pilots, especially those of small aircraft, of conditions that could lead to a disastrous stall.[558]

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[556] NASA, "NASA Names Leaders for Engineering and Safety Center," news release 03-352, 14 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03352_NESC_leaders.html* (accessed 5 February 2009); Todd Halvorson, "NASA Promotes Criticized Manager," *Florida Today* (Brevard, FL), 15 November 2003.
[557] NASA, "NASA Names New Safety Advisory Panel," news release 03-370, 18 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03370_asap.html* (accessed 5 February 2009); Patty Reinert, "NASA Safety Panel Takes Flight Again with New Members," *Houston Chronicle*, 19 November 2003.
[558] Ricardo Alonso-Zalvidar, "Pilots Are Blamed in Wellstone Crash," *Los Angeles Times*, 19 November 2003.

20 November
NASA announced the successful test of a High Power Electric Propulsion (HiPEP) ion engine using commercial-utility electrical power, marking the first successful test of an engine that could "lead to revolutionary propulsion capabilities for space exploration missions throughout the solar system and beyond." The test used the largest microwave ion thruster ever built. The test was also the first in a series, demonstrating the high-velocity and high-power thrust necessary for the new nuclear electric propulsion (NEP) applications. NASA's Project Prometheus had been studying the HiPEP—one of several candidate propulsion technologies—for possible use on the Jupiter Icy Moons Orbiter (JIMO). The JIMO Mission's design included a small nuclear reactor as its power source and electric thrusters to provide propulsion. NASA planned for JIMO to study Jupiter's three icy moons—Ganymede, Callisto, and Europa. Director of Project Prometheus Alan R. Newhouse remarked that the test represented a "huge leap in demonstrating the potential for advanced ion technologies."[559]

The ISS marked its five-year anniversary in space. Since the Russian *Zarya* control module had launched from Baikonur Cosmodrome in Kazakhstan on 20 November 1998, the ISS had grown from an uninhabited module to a permanently staffed research facility the size of a three-bedroom house. After five years, the ISS was not completely constructed—NASA was preparing more than 80 tons (72,575 kilograms or 72.58 tonnes) of equipment and hardware, including solar arrays and support structures, for launch at the Space Station Processing Facility at its KSC. Also in launch preparation at KSC was the *Node 2* module, which would connect the U.S., European, and Japanese research laboratories; and the *Kibo* Japanese Experiment Module. The eventual launch of the European *Columbus* laboratory under construction in Bremen, Germany, would expand the station's volume to that of a five-bedroom house. The first crew to live aboard the orbiting facility had arrived on 2 November 2000, and since that date, eight successive crews—22 people—had staffed the ISS, conducting research in bioastronautics, physical sciences, fundamental space biology, space product development, and spaceflight disciplines.[560]

29 November
JAXA launched an H2-A rocket carrying two classified satellites intended to monitor North Korea, but aborted the launch when one of the vehicle's two boosters failed to separate. Because the malfunction meant that the rocket would be unable to attain sufficient height and speed to achieve orbit, JAXA destroyed the rocket 10 minutes after launch. In March 2003, Japan had launched its first two spy satellites to monitor North Korea's missile and nuclear programs.[561]

DECEMBER 2003

2 December
NASA's Office of Safety and Mission Assurance signed an agreement with the Naval Sea Systems Command (NAVSEA) to participate in each other's engineering investigations and

[559] NASA, "NASA Successfully Tests Ion Engine," news release 03-377, 20 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03377_ion_engine.html* (accessed 5 February 2009).
[560] NASA, "International Space Station Marks Five Years in Orbit," news release 03-374, 19 November 2003, *http://www.nasa.gov/home/hqnews/2003/nov/HQ_03374_iss_five_yrs.html* (accessed 5 February 2009).
[561] Audrey McAvoy for the Associated Press, "Failed Launch Blamed on Rocket Booster Malfunction," 30 November 2003.

technical analyses. The memorandum of agreement was the second that the two organizations had signed—the latest agreement between NASA and another organization managing high-risk operations. The previous agreement between NASA and NAVSEA had enabled the two to share information regarding critical supplier quality and performance.[562]

The U.S. Air Force launched an Atlas 2-AS rocket carrying a classified satellite for the National Reconnaissance Office (NRO), marking the final launch of the II-AS model from Vandenberg Air Force Base in California. The launch cleared the way for officials from the military and from Lockheed Martin to begin renovating Launch Complex 3 to accommodate the Atlas 5 rocket. Renovation plans included raising the mobile service tower 30 feet (9.14 meters) to accommodate the taller launch vehicles, building a fixed launch platform, modifying the umbilical tower, and enlarging the flame trench. The Lockheed Martin Atlas team planned to launch the first Atlas 5 from Vandenberg Air Force Base in 2005.[563]

4 December

Scientists studying data from NASA's Imager for Magnetopause to Aurora Global Exploration (IMAGE) satellite and ESA's four-satellite Cluster constellation published a study in the journal *Nature* reporting that solar wind creates large cracks in Earth's magnetic field, allowing the wind to penetrate the magnetic field and causing geomagnetic storms. The leader of the study, Harald U. Frey of the University of California at Berkeley, stated that the data showed that the cracks do not open and close sporadically, as scientists had previously thought, but rather, that the cracks can remain open for several hours. Using this information, scientists would be able to create a better model of the affect of space weather on Earth, helping them to predict geomagnetic storms, which disrupt power, interfere with satellites, and endanger astronauts. IMAGE had monitored a spot in Earth's upper atmosphere, revealing an area of heavy particles (ions) striking the ionosphere above the Arctic region, thereby creating an aurora with enough energy to power 75,000 homes. Unlike the auroras known as the northern and southern lights, this aurora was not visible to the human eye. Far above the IMAGE satellite, the Cluster constellation had flown through the opening created by the solar wind's interaction with Earth's protective magnetic field. The scientists estimated that the size of the crack was twice that of Earth. The crack occurred at the edge of the magnetic field, 38,000 miles (61,155 kilometers) above the planet.[564]

5 December

Russia successfully conducted its first test of a modified Soviet RS-18 Stiletto missile, launching the missile from an underground silo at Baikonur Cosmodrome in Kazakhstan. The Stiletto, renamed Strela, or Arrow, carried a dummy satellite into low Earth orbit. Originally designed to carry six individually guided nuclear warheads, Russia planned for the modified Stiletto to become the world's cheapest booster rocket for commercial satellite launches. Spokesperson for

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[562] NASA, "NASA Engineering Investigations Get Navy Input," news release 03-393, 4 December 2003, *http://www.nasa.gov/home/hqnews/2003/dec/HQ_03393_enginr_investgtns.html* (accessed 23 March 2009).
[563] Associated Press, "Air Force Sends Spy Satellite into Space," 2 December 2003; Justin Ray, "Atlas Soars on Secret Mission Under Cover of Darkness," *Spaceflight Now*, 2 December 2003.
[564] H. U. Frey et al., "Continuous Magnetic Reconnection at Earth's Magnetopause," *Nature* 426, no. 6966 (4 December 2003): 533–537; Maggie Fox for Reuters, "Cracks Let Solar Wind Disrupt Earth's Atmosphere," 4 December 2003; Chris Kridler, "Protective Layer's Cracks Make Earth Vulnerable," *Florida Today* (Brevard, FL), 4 December 2003.

the Russian military Lieutenant-Colonel Igor Zatula stated that Russia would need to conduct several more test launches before the rocket would become available for commercial use.[565]

NASA announced the creation of the first detailed map of the water contained in Earth's atmosphere, a map that would help scientists better understand the nature of atmospheric water vapor and its implications for climate change and ozone depletion. In July 2002, NASA had taken detailed measurements of water isotopes in the atmosphere using Alias, an aircraft laser infrared absorption spectrometer flying aboard NASA's WB-57F high-altitude jet aircraft. The new laser technique had enabled scientists to map the water isotopes with sufficient resolution for researchers to use the map to study water transport, as well as to examine the detailed microphysics of clouds—key parameters necessary for understanding atmospheric composition, storm development, and weather prediction. The resulting map showed heavy hydrogen and heavy oxygen atoms, from Earth's surface to 25 miles (40.2 kilometers) above the planet. NASA's Earth Science Enterprise had funded the mission, which had used six aircraft provided by NASA and other federal agencies, to record observations above, in, and below the clouds.[566]

8 December

NASA astronaut C. Michael Foale, living aboard the ISS, set a new U.S. space record—Foale had spent more time in orbit than any other American had achieved. During four Shuttle missions, an expedition aboard Russia's former space station *Mir*, and his current residence at the ISS, Foale had spent more than 231 days in space, surpassing Carl E. Walz's previous record for an American in space—230 days, 13 hours, 3 minutes, and 37 seconds. Walz had participated in four Shuttle missions and one ISS expedition in 2002. Along with astronaut Daniel W. Bursch, Walz continued to hold the U.S. record for the longest, single spaceflight—196 days.[567]

9 December

JAXA spokesperson, Junichi Moriuma, announced that JAXA had failed in its final effort to return the Nozomi craft to the correct trajectory for orbiting Mars. Insufficient fuel supplies had prevented the craft's engines from firing. Nozomi—Hope—had been traveling toward Mars for five years and was schedule to arrive in one week. JAXA had planned for Nozomi to examine the Martian atmosphere's interaction with the solar wind, to determine whether the planet has a magnetic field. During its journey from Earth to Mars, Nozomi had experienced several malfunctions that had altered its trajectory, placing it on a course that was too low and causing concern that the spacecraft would crash into Mars, possibly contaminating the surface. JAXA officials stated that, although they had failed to place the craft on the correct trajectory, they had greatly reduced the probability of the craft's colliding with Mars. Instead, the craft would escape Mars's gravitational field and enter a long-term orbit of the solar system. Moriuma remarked that

[565] Reuters, "Russia Tests New Role for Cold War Nukes," 8 December 2003.
[566] NASA, "The Measure of Water: NASA Creates New Map for the Atmosphere," news release 03-394, 5 December 2003, *http://www.nasa.gov/home/hqnews/2003/dec/HQ_03394_water_map.html* (accessed 23 March 2009).
[567] NASA, "NASA Astronaut Breaks U.S. Space Endurance Record," news release 03-400, 9 December 2003, *http://www.nasa.gov/home/hqnews/2003/dec/HQ_03400_Foale_record.html* (accessed 23 March 2009); Todd Halvorson, "Astronaut Michael Foale's 231 Days in Orbit Sets Record," *Florida Today* (Brevard, FL), 9 December 2003; Associated Press, "Astronaut Sets Record for Time in Space," 9 December 2003.

Japanese scientists would continue to modify Nozomi, allowing it to carry out alternative missions, such as monitoring solar activity.[568]

10 December

NASA's GRC and the U.S. Department of Energy's (DOE's) Pacific Northwest National Laboratory (PNNL) signed a Space Act Agreement to collaborate in developing sealing technologies for the stacks of solid oxide fuel cells (SOFC), groups of thin ceramic cells separated by gas seals. A combustion-free electrochemical process generates electricity between these thin cells. NASA had been investigating SOFC technology to meet the need for high-efficiency, low-emission power capabilities for aviation and space applications. Prabhakar Singh, Director of PNNL Fuel Cell Development, commented that the agreement combined the two agencies' complementary research—PNNL's work in glass seals and NASA's expertise in glass and glass-ceramic composites.[569]

17 December

SpaceShipOne broke the sound barrier during its first powered flight, but a partial landing gear collapse caused the privately built supersonic aircraft to veer off its desert runway. Test pilot Brian Binnie was not injured during the landing. Scaled Composites LLC, which built the craft, stated that engineers could easily repair the damage the craft had sustained. The test flight represented a milestone—the first piloted supersonic flight of an aircraft developed by a small private company. *SpaceShipOne*'s specially designed jet aircraft, the White Knight, carried *SpaceShipOne* to an altitude of 48,000 feet (14.63 kilometers) before releasing it. Traveling near Mach 1.2, the rocket shut down after firing for 15 seconds. Binnie then placed the craft into a vertical climb to reach 68,000 feet (20.72 kilometers). Nine seconds into the climb, the craft broke the sound barrier. Binnie then reconfigured the craft to its conventional shape, and glided to touchdown, at which time the landing gear collapsed.[570]

18 December

NASA released the first pictures from its Space Infrared Telescope Facility and officially renamed the craft Spitzer Space Telescope. NASA had named the telescope for one of the 20th century's most influential scientists, Princeton University astronomer Lyman Spitzer Jr., who in 1946 had first proposed placing telescopes in space. Spitzer had been a major force behind the 1990 launch of the HST, the first of NASA's Great Observatories. With the release of the Spitzer Space Telescope's first observations—a glowing stellar nursery; a swirling, dusty galaxy; a disc of planet-forming debris; and organic material in the distant universe—Project Scientist Michael Werner of NASA's JPL remarked that the telescope was working extremely well. The fourth of its Great Observatories, NASA had designed the craft with powerful infrared detectors to capture never-before-seen cosmic features. Unlike its predecessor Great Observatories, which circle

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[568] Kenji Hall for the Associated Press, "Japan Quits Mars Mission as Probe Strays," 10 December 2003; Jason Testar for Canadian Press, "Japanese Fail To Salvage Mars Mission Carrying Canadian Research Instrument," 10 December 2003.

[569] Pacific Northwest National Laboratory, "NASA and DOE Lab Team on Fuel Cell Research," news release 03-46, 10 December 2003, *http://www.pnl.gov/news/2003/03-46.htm* (accessed 26 March 2009); *Utility Automation and Engineering T&D*, "NASA and DOE Lab Team on Fuel Cell Research," 12 December 2003.

[570] Associated Press, "Private Rocket Plane Breaks Sound Barrier," 18 December 2003; Leonard David, "Privately Funded SpaceShipOne Breaks Sound Barrier," *Space.com*, 18 December 2003, *http://www.space.com/businesstechnology/technology/rutan_update_031217.html* (accessed 30 March 2009).

Earth, NASA had deployed the Spitzer Space Telescope in a novel trajectory that placed it in an orbit closely trailing that of Earth.[571]

NASA announced the successful completion of a series of engine and parachute tests, clearing the way for NASA to carry out integrated Pad Abort Demonstration (PAD) test flights to support its Orbital Space Plane (OSP) program. In November and December 2003, engineers had conducted a series of 14 hot-fire tests of a 50,000-pound-thrust (22,680-kilogram-thrust) RS-88 rocket engine, resulting in a total of 55 seconds of successful engine operation. The Rocketdyne Propulsion Power unit of the Boeing Company had designed and built the engine. On 9 December 2003, engineers had tested the parachutes at the U.S. Army's Yuma Proving Grounds in Yuma, Arizona, verifying the function, performance, and stability of an 80-foot (24.38-meter) drogue parachute and of four 156-foot (47.55-meter) main parachutes. Testers had dropped a 12.5-ton (11.34-tonne or 11,340-kilogram) pallet from 10,000 feet (3,048 meters) to simulate the size and weight of a vehicle and crew. The pallet had descended to a soft landing under nearly two acres of parachutes.[572]

19 December
ESA announced that the Beagle 2, ESA's Mars Lander, had separated from the Mars Express orbiting spacecraft. ESA had scheduled the Beagle 2 to land on Mars early on 24 December (EST), while, at approximately the same time, Mars Express would enter Martian orbit.[573]

23 December
NASA announced that a team of JPL engineers had successfully tested a new ion-propulsion engine design, marking the first performance test of the Nuclear Electric Xenon Ion System (NEXIS) engine at the high-efficiency, high-power, and high-thrust operating conditions needed for use in large-scale, nuclear-electric-propulsion applications. The NEXIS engine was one of several candidate propulsion technologies under review by NASA's Project Prometheus, an initiative to make strategic investments in nuclear-fission power and electric-propulsion technologies for use in space travel. NASA intended for Project Prometheus to enable development and implementation of a new class of missions to the outer solar system. Lead Investigator for the JPL test, James E. Polk, remarked that the NEXIS thruster had demonstrated one of the highest efficiencies of any xenon-ion thruster ever tested, and that the research team expected the NEXIS design to meet the requirements for the proposed Jupiter Icy Moons Orbiter Mission.[574]

29 December
The People's Republic of China and ESA launched Double Star 1 from Xichang Satellite Launch Center in southwest China. Double Star 1 was the first of two spacecraft in the Double Star

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[571] NASA, "NASA Releases Dazzling Images from New Space Telescope," news release 03-411, 18 December 2003, *http://www.nasa.gov/home/hqnews/2003/dec/HQ_03411_newly_named_prt.htm* (accessed 23 March 2009); Patty Reinert, "Stargazer's Delight: NASA's New Space Infrared Telescope Puts On a Dazzling Show," *Houston Chronicle*, 19 December 2003.
[572] NASA, "Engine, Parachute Tests Pave Way for Launch Escape System," news release 03-417, 18 December 2003, *http://www.nasa.gov/home/hqnews/2003/dec/HQ_03417_escape_system.html* (accessed 23 March 2003).
[573] Chris Kridler, "Beagle 2 On Its Own," *Florida Today* (Brevard, FL), 20 December 2003.
[574] NASA, "Ion Engine Design Passes Key NASA Test," news release 03-421, 23 December 2003, *http://www.nasa.gov/home/hqnews/2003/dec/HQ_03421_passes_test.html* (accessed 23 March 2003).

mission to study Earth's magnetic fields—the first joint project between China and ESA. Known in China as Tan Ce 1, Double Star 1 carried eight instruments for investigating Earth's magnetosphere—five from ESA and three from the Chinese National Space Administration. ESA and China had designed the mission to study how magnetized and charged particles streaming off the Sun affect Earth. The space agencies had scheduled the second of the two craft to launch six months after the first.[575]

JANUARY 2004

2 January
NASA's Stardust spacecraft performed a flyby of comet Wild 2, obtaining particle samples, as well as the most detailed, high-resolution images ever taken of a comet. Stardust was the first robotic mission created to collect material from outside the Moon's orbit. Scientists planned to analyze the particle samples of the comet in January 2006, once the spacecraft had returned to Earth. During the flyby, Stardust flew within 240 kilometers (149 miles) of Wild 2, capturing images of the comet's nucleus at resolutions ranging from 6.5 to 32 kilometers (4 to 20 miles) per pixel. NASA scientists hoped that the images would help them better understand conditions on comets and that the particle samples—composed of materials identical to those that had formed planets—would reveal information about how comets and Earth's solar system formed.[576]

3 January
NASA succeeded in landing the first of two robotic laboratories on the planet Mars. The robotic rover Spirit was one of two mobile laboratories—Mars Exploration Rovers—that NASA had designed to collect and analyze geological samples on Mars. Analysis of the samples would help scientists determine whether the planet had previously possessed water and the ability to support life. The twin rovers, part of NASA's Mars Exploration Program, would land at sites on opposite sides of the planet, where scientists believed that liquid water might have existed in the past. To conduct geological research on the planet, NASA scientists had equipped each rover with a microscopic imager, a panoramic camera, and a variety of spectrometers. NASA had scheduled Opportunity, the second rover, to land on Mars later in January.[577]

5 January
Thomas Q. Donaldson replaced Michael U. Rudolphi as Director of NASA's SSC. Donaldson had previously served as Commander of the Naval Meteorology and Oceanography Command headquartered at SSC. Rudolphi had served as interim Director of SSC since May 2003 but had left the Center in December 2003 to become Manager of the Space Shuttle Propulsion Office at NASA's MSFC.[578]

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[575] *Spacewarn Bulletin*, no. 602, 1 January 2004, *http://nssdc.gsfc.nasa.gov/spacewarn/spx602.html* (accessed 26 March 2009); United Press International, "China-EU Launch Space Project," 30 December 2003.
[576] NASA JPL, "NASA Spacecraft Makes Great Catch . . . Heads for Touchdown," news release 2004-001, 2 January 2004; NASA JPL, "Stardust: NASA's Comet Sample Return Mission—Encounter with Comet Wild 2," *http://stardust.jpl.nasa.gov/mission/details2.html* (accessed 9 January 2009).
[577] NASA, "Spirit Lands on Mars and Sends Postcards," news release 2004-003, 4 January 2004; NASA, "Mars Exploration Rover Mission: Summary," *http://marsrover.nasa.gov/overview/* (accessed 11 January 2009).
[578] NASA, "Stennis Space Center—Michael U. Rudolphi," *http://www.nasa.gov/centers/stennis/about/history/personalities/rudolphi.html* (accessed 11 January 2009); NASA, "Stennis Space Center—Rear Admiral

8 January
Astronomers published their analysis of the first observations ever made of a supernova occurring in a binary star, thereby providing crucial support for a theory concerning the most violent type of event in the universe. Supernovas occur when stars exhaust their nuclear fuel reserves and collapse, ejecting their outer layers in a massive explosion. Previously, scientists had regarded the study of supernovas as important for understanding the evolution of galaxies and of the universe, but they had remained uncertain about the origins of supernovas, including whether they occur in solitary or binary star systems. However, the team of astronomers from ESA and the University of Hawaii had used the HST and the W. M. Keck Telescope in Hawaii to observe the remnants of supernova SN 1993J. They had discovered a massive star in close proximity to the star that had caused SN 1993J, demonstrating that supernovas emerge from binary star systems. According to the astronomers, supernovas occur in binary systems when one star collapses, shedding its mass, and a nearby star of comparable size accretes the lost mass.[579]

12 January
NASA announced that astronaut Leroy Chiao would replace William S. McArthur Jr. as Commander of Expedition 9, the next mission to the ISS. NASA had disqualified McArthur from Expedition 9 because of an unspecified medical issue. Chiao, who had trained as McArthur's substitute, would join Russian cosmonaut Valery I. Tokarev for the mission, scheduled to launch in April 2004.[580]

ISS crew members repaired an air leak in the space station. Astronaut C. Michael Foale and cosmonaut Alexander Y. Kaleri fixed a leak in a flex hose located in the ISS's *Destiny* laboratory module. The orbiting space station had begun to lose air on 22 December 2003. After examining the station's air pressure readings, NASA's Mission Control had informed ISS crew members of the leak on 5 January 2004. The air leak had not endangered either the ISS crew or operations. By systematically isolating the ISS's compartments and using an ultrasound device to determine the location of a hissing sound emitted by the faulty hose, Foale and Kaleri had discovered the source of the air loss.[581]

14 January
In a speech at NASA Headquarters, President George W. Bush announced the new space policy for the United States, which he called the Vision for Space Exploration. President Bush's new policy called for the completion of the ISS by 2010, the subsequent retirement of the Space Shuttle fleet, and the development of a replacement Crew Exploration Vehicle (CEV) capable of conducting human spaceflight missions by 2014. President Bush stated that he would seek US$1 billion in funding over the next five years to begin research on the new vehicle program. In addition, he called for robotic exploration of the Moon by 2008, followed by crewed missions to the Moon in 2020 and, eventually, astronaut missions to Mars, directing NASA to divert US$11

Thomas Q. Donaldson, V, USN (Ret.)," *http://www.nasa.gov/centers/stennis/about/history/personalities/donaldson.html* (accessed 11 January 2009).
[579] ESA, "First Supernova Companion Star Found," *http://www.esa.int/esaSC/SEMT0J374OD_ index_0. .html* (accessed 14 January 2009); Justyn R. Maund et al., "The Massive Binary Companion Star to the Progenitor of Supernova 1993J," *Nature* 427, no. 6970 (8 January 2004): 129–131.
[580] NASA, "Chiao Replaces McArthur as Next Space Station Commander," news release 04-019, 12 January 2004.
[581] Mark Carreau, "Leak on Space Station Stopped," *Houston Chronicle*, 13 January 2004.

billion from existing space programs over the next years to fund the development of the technology to travel to the Moon and Mars. President Bush also extended an invitation to other countries to cooperate in attaining the objectives of the Vision. Major newspapers described the Vision for Space Exploration as a response to the *Columbia* disaster and a means of regaining public support for continued space exploration.[582]

15 January

NASA announced it would undergo an internal reorganization to meet its new objectives under the Vision for Space Exploration, the blueprint for American space policy that President George W. Bush had released one day before. The reorganization included the creation of a new office to develop a new CEV and other technologies for future missions to the Moon and Mars. NASA named Craig E. Steidle to oversee the new Office of Exploration Systems. Furthermore, NASA renamed its Office of Aerospace Technology, which had previously been responsible for spacecraft development. Under its new name—Office of Aeronautics—it would have responsibility for developing aviation technologies. J. Victor Lebacqz, former Acting Associate Administrator of the Office of Aerospace Technology, became Associate Administrator of the new Office of Aeronautics.[583]

The GAO released its assessment of NASA's efforts to upgrade the Space Shuttle fleet in the wake of the *Columbia* tragedy. NASA planned to implement the recommendations of the *Columbia* Accident Investigation Board, as well as those of its own Space Shuttle Service Life Extension Program (SLEP). The GAO report stated that before NASA determined the upgrade requirements and priorities for the Shuttles, it should first determine the Shuttles' operational life and the requirements for meeting the objectives of the Integrated Space Transportation Plan (ISTP). Before the announcement of the new Vision for Space Exploration, the ISTP had encompassed the space policy of the United States. However, GAO noted that the establishment of President Bush's new Vision for Space Exploration, which formally changed the duration of operations for both the Space Shuttles and the ISS, had largely invalidated the recommendations offered in GAO's assessment.[584]

18 January

ESA reported that Mars Express had discovered the first direct evidence of water on Mars. Whereas some previous research had suggested that water might be present on Mars, Mars Express had detected the presence of actual water ice covered by a layer of frozen carbon dioxide at the planet's south pole. The spacecraft had also found that the amount of carbon dioxide in Mars's atmosphere was inadequate to have warmed the planet sufficiently for the formation of

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[582] Patty Reinert, "Bush Aims for 'Worlds Beyond Our Own'," *Houston Chronicle*, 15 January 2004; David E. Sanger and Richard W. Stevenson, "Bush Backs Goal of Flight to Moon To Establish Base," *New York Times*, 15 January 2004; NASA, "The Vision for Space Exploration," *http://www.nasa.gov/pdf/55584main_vision_space_exploration-hi-res.pdf* (accessed 30 January 2009).

[583] Patty Reinert, "New NASA Office To Focus on Advancing Bush Space Agenda," *Houston Chronicle*, 16 January 2004; Kenneth Chang, "NASA Creating Office for Missions to the Moon and Beyond," *New York Times*, 16 January 2004.

[584] U.S. General Accounting Office, "Space Shuttle: Further Improvements Needed in NASA's Modernization Efforts" (report no. GAO-04-203, Washington DC, 15 January 2004), *http://www.gao.gov/new.items/d04203.pdf* (accessed 30 January 2009).

liquid water and the support of life on the planet's surface. Scientists regarded the findings as crucial in determining whether Mars could have supported life in the past.[585]

19 January
NASA Administrator Sean O'Keefe officially informed HST Program staff that he had decided to eliminate all future servicing missions to the space telescope. NASA had conducted previous HST servicing missions to replace aging or inoperable components and to install new technologically improved equipment. According to NASA, O'Keefe had made the decision to halt the missions in the wake of the Space Shuttle *Columbia* disaster, based on assessments of the risk to astronauts performing HST servicing missions.[586]

23 January
NASA announced that the Mars Exploration Rover Spirit was malfunctioning because of problems related to its flash memory that could take several weeks to repair. Flash memory, a type of memory commonly installed in electronic devices, such as digital cameras, retains data when the device's power is off. The mobile robotic geological laboratory Spirit had landed on Mars on 3 January 2004 and had performed satisfactorily until it had abruptly terminated communications with NASA on 21 January 2004. On 23 January 2004, Spirit had reestablished contact with NASA, but, according to major newspapers, NASA scientists doubted that the robotic spacecraft would regain full functionality.[587]

The U.S. Air Force awarded the Boeing Company a US$472 million contract to develop a military satellite system capable of secure, high-capacity global communications for NASA, the U.S. intelligence community, and the DOD. Under the terms of the contract, Boeing would lead a team of companies that would conduct risk-reduction and system-definition studies for the Transformational Communications MILSATCOM (Military Satellite Communications) Space Segment, which uses laser communications, advanced processors, and other advanced technologies to provide communications for airborne intelligence, surveillance, and reconnaissance. The companies selected to conduct research on the project included Ball Aerospace, Cisco Systems, and Raytheon.[588]

24 January
NASA's Mars Exploration Rover Opportunity landed on Mars nearly three weeks after its twin rover Spirit had landed on the planet. NASA had created the two mobile robotic rovers to explore rocks and soils on Mars to determine whether the planet had previously possessed water

[585] ESA, "Mars Express Sees Its First Water—Scientific Results," ESA news release 6-2004, 23 January 2004; Jean-Pierre Bibring, "Perennial Water Ice Identified in the South Polar Cap of Mars," *Nature* 428, no. 6983 (8 April 2004): 627–630.
[586] NASA, "Hubble Space Telescope: Program News Archive," *http://hubble.nasa.gov/news/archive.php* (accessed 31 January 2004).
[587] Mark Carreau, "NASA Declares Spirit Rover Broken," *Houston Chronicle*, 24 January 2004; NASA, "Spirit Condition Upgraded as Twin Rover Nears Mars," news release 04-036, 24 January 2004.
[588] The Boeing Company, "Boeing Awarded $472 Million for Next-Generation Military Satellite System," news release, 23 January 2004, *http//www.boeing.com/news/releases/2004/q1/nr_040123s.html* (accessed 28 January 2010).

and the ability to sustain life. NASA had designed the mission so that the rovers would explore Mars simultaneously, on nearly opposite sides of the planet.[589]

27 January
President George W. Bush formally established the President's Commission on Implementation of United States Space Exploration Policy, to provide recommendations on implementing elements of his recently announced Vision for Space Exploration. The Commission would make recommendations regarding the type of scientific research U.S. scientists would conduct on the Moon, the development of technologies to enable human and robotic exploration of the Moon and the planets, and the criteria for selecting future destinations for human space explorers. The appointed members of the Commission were Edward C. Aldridge Jr., Carleton S. Fiorina, Michael P. Jackson, Laurie A. Leshin, Lester L. Lyles, Paul D. Spudis, Neil deGrasse Tyson, Robert S. Walker, and Maria T. Zuber.[590]

29 January
The Russian Space Agency successfully launched the Progress M1-11 resupply vehicle to the ISS from Baikonur Cosmodrome in Kazakhstan at 6:58 a.m. (EST). The Progress vehicle, the 13th resupply flight to the ISS, carried 2.5 tons (2,300 kilograms or 2.3 tonnes) of food, fuel, and equipment. The vehicle's mission designation was ISS 13P.[591]

FEBRUARY 2004

2 February
NASA Administrator Sean O'Keefe and families of the Space Shuttle *Columbia* crew unveiled a commemorative monument for the *Columbia* crew at Arlington National Cemetery. The crew had died when *Columbia* broke apart during reentry into Earth's atmosphere on 1 February 2003. The marble monument was 66 inches (1.7 meters) tall, 48 inches (1.2 meters) wide, and bore two bronze plaques portraying the crew and the shoulder patch they had worn on the mission.[592]

5 February
NASA's MSFC and KSC provided law enforcement agencies with analysis of video and imagery relevant to their investigation of the abduction of an 11-year-old girl in Sarasota, Florida. When law enforcement officials asked the two centers to examine security camera footage showing the girl's abduction by an unknown individual, MSFC provided assistance using its Video Image Stabilization and Registration System (VISAR), an image-stabilization software program developed for space program research. KSC examined the security camera footage using its Image Analysis Facility, which NASA had developed for visual analysis of Space Shuttle

[589] NASA, "NASA Hears from Opportunity Rover on Mars," news release 04-037, 25 January 2004.
[590] The White House, Office of the Press Secretary, "Executive Order Creating the Presidential Commission on Implementation of United States Space Exploration Policy," news release, 30 January 2004, *http://www.nasa.gov/missions/solarsystem/aldridge_executive_order.html* (accessed 30 January 2009); The White House, Office of the Press Secretary, "Members of the Presidential Space Exploration Commission," news release, 30 January, 2004, *http://www.nasa.gov/missions/solarsystem/ aldridge_members.html* (accessed 30 January 2009).
[591] *Spacewarn Bulletin*, no. 603, 1 February 2004, *http://nssdc.gsfc.nasa.gov/spacewarn/spx603.html* (accessed 31 January 2009).
[592] NASA, "NASA Dedicates Space Shuttle Columbia Memorial," news release 04-049, 2 February 2004.

launches. Although this was not the first time that the two centers had assisted law enforcement in this manner, the case garnered major press coverage throughout the United States.[593]

6 February

ESA's Mars Express orbiter relayed information between ground-based NASA engineers and NASA's Mars Exploration Rover Spirit, the first in-orbit communication between ESA and NASA spacecraft and the first successful international communications network outside of Earth. As part of their general efforts to cooperate in space exploration, the two space agencies had planned the information relay to enable future cooperative use of their communications technologies during Mars missions. In this particular communication sequence, Spirit's operation personnel at NASA's JPL transferred commands for the rover to ESA's Space Operations Centre in Germany, which then transmitted the instructions to the Mars Express. The Express successfully commanded Spirit and, subsequently, relayed telemetry information from the rover to JPL via the Space Operations Centre.[594]

NASA and the ISS partners announced crew assignments for the next two expeditions to the space station. NASA astronaut E. Michael Fincke and Russian cosmonaut Gennady I. Padalka would serve on Expedition 9, and NASA astronaut Leroy Chiao and Russian cosmonaut Salizhan S. Sharipov would provide the crew for Expedition 10. In addition, Chiao and Sharipov would serve as the backup crew for Expedition 9, while NASA astronaut William S. McArthur Jr. and Russian cosmonaut Valery I. Tokarev would serve as the backup crew for Expedition 10. Although NASA and its partners had previously scheduled Tokarev to pair with Chaio on Expedition 10, the ISS partners had decided to replace Tokarev with Sharipov, because Sharipov had previously trained with Chiao.[595]

Jerome F. Lederer, NASA's first Director of Manned Space Flight Safety, died at the age of 101. Lederer, an aviation-safety expert, had introduced notable aviation-safety technologies, such as blinking anticollision lights and flight-data recorders. Lederer had started his career in aviation safety in 1926 as an aeronautical engineer for the U.S. Air Mail Service, where he had redesigned the service's airplanes to prevent them from igniting after crashes, a frequent cause of death of the pilots. In the 1950s, he had helped establish the agency that later became the FAA. In 1967, after a fire on *Apollo 1* had killed three astronauts during a launchpad test, NASA had asked Lederer to establish an Office of Manned Space Flight Safety. In 1970 NASA had appointed Lederer as the safety director for all NASA activities. Lederer had retired two years later. Later, Lederer had taught at the University of Southern California and had served two three-year terms on the Advisory Council for the Institute of Nuclear Power Operations.[596]

11 February

ESA and UK Science Minister Lord David Sainsbury announced that ESA and the United Kingdom would conduct a joint inquiry into the failure of the Beagle 2 Mars lander. ESA

[593] NASA, "NASA Technology Helps Investigators in Florida Abduction Case," news release 04-055, 5 February 2004; Fred Barbash, "Fla. Police Find Body of Abducted Girl," *Washington Post*, 7 February 2004.
[594] NASA, "International Interplanetary Networking Succeeds," news release 04-060, 12 February 2004.
[595] NASA, "New Crews Named for 2004 Space Station Missions," news release 04-056, 6 February 2004.
[596] Stuart Lavietes, "J. F. Lederer, 101, Dies; Took Risk Management to the Sky," *New York Times*, 9 February 2004.

Inspector-General René Bonnefoy would oversee the inquiry, which would investigate the reasons for the mission's failure and establish lessons that ESA could apply in future missions. Beagle 2, a component of ESA's Mars Express mission, had failed to communicate with ESA after the time of its scheduled landing on Mars on 25 December 2003. The Beagle 2 Management Board had declared the spacecraft lost on 6 February 2004.[597]

12 February

ESA's Science Programme Committee approved a proposal to extend the operation of the Ulysses spacecraft—a joint project of ESA and NASA—until March 2008. NASA had already approved continuing the spacecraft's operations. The two space agencies had designed the spacecraft to study the heliosphere, a region of space influenced by the Sun and its magnetic field. Scientists of the agencies hoped that the continued operations of Ulysses would help them better understand the Sun. Since the 1990 launch of Ulysses, ESA and NASA both had launched additional fleet of solar and heliospheric spacecraft: NASA's Cassini, ESA's four Cluster satellites, and another collaborative project between ESA and NASA, the Solar and Heliospheric Observatory (SOHO).[598]

16 February

An international team of astronomers discovered a galaxy cluster that could be the most distant known galaxy in the universe. The team, led by Jean-Paul Kneib of California Institute of Technology, had used the W. M. Keck Telescopes in Hawaii and the HST to observe a galaxy known as Abell 2218. The astronomers believed that the Abell 2218 galaxy, which they estimated at 13 billion light-years from Earth, could be the most distant known galaxy, but precise measurements of its distance were particularly difficult, because the galaxy is so far from Earth that its visible light stretches into infrared wavelengths. Moreover, the scientists suggested that the galaxy might be a young stellar system formed at the initial stages of the universe's inception. Further observation of Abell 2218 and other distant galaxies could yield important clues about the universe's formation.[599]

18 February

NASA and ESA jointly announced that scientists had obtained evidence of a black hole consuming a star, an event known as stellar tidal disruption. Previously, scientists had only theorized the existence of such an event. Using observations from NASA's Chandra X-ray Observatory and ESA's XMM-Newton orbiting observatory, an international team of scientists had discovered a star that had been thrown from its orbit after a close encounter with another star and, subsequently, had moved into the gravitational field of a black hole. The black hole, with a mass estimated at 100 million times greater than the Sun, had exerted a gravitational pull on the

[597] ESA, "UK and ESA Announce Beagle 2 Inquiry—Investigation To Learn Lessons from Mars Lander," ESA news release 9-2004, 11 February 2004.
[598] ESA, "Ulysses Mission Home: Ulysses Mission Extended," *http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=34647* (accessed 4 February 2009).
[599] ESA, "Hubble and Keck Team Up To Find Farthest Known Galaxy in the Universe," ESA news release SNR 4-2004, 16 February 2004; Jean-Paul Kneib et al., "A Probable *z*~7 Galaxy Strongly Lensed by the Rich Cluster A2218: Exploring the Dark Ages," *Astrophysical Journal* 607, no. 2 (1 June 2004): 697–703.

star that led to its eventual disintegration. Stefanie Komossa of the Max Planck Institute for Extraterrestrial Physics in Germany led the group of scientists that had made the discovery.[600]

19 February

NASA's Space Flight Leadership Council (SFLC), which was overseeing NASA's efforts to resume Shuttle flights, announced that NASA would not launch another Space Shuttle before March 2005. NASA had delayed a Shuttle launch because of a new requirement that launches occur during daylight hours, to enable photographing the liftoff from multiple angles. Because of the limited number of days available in which a launch could take place in daylight, the next Shuttle launch could occur no earlier than March 2005. In addition, NASA announced that, when Shuttle launches recommenced, one Shuttle would function as a standby rescue vehicle in case the Shuttle carrying the crew sustained damage during flight. NASA announced that, although rescue vehicles would not necessarily be positioned on the launchpad, they would be ready for launch within 45 to 90 days, the maximum length of time that seven astronauts could survive on the ISS before their supplies ran out.[601]

20 February

NASA announced its findings concerning how and why a piece of insulation had separated from a fuel tank on Space Shuttle *Columbia*, an event that had later contributed to *Columbia*'s destruction upon reentry into Earth's atmosphere. According to NASA official William F. Readdy, NASA had determined that extremely cold fuel had liquefied air or nitrogen, which subsequently had seeped into a portion of the foam or had collected on nuts and bolts below the foam, eventually expanding and explosively jettisoning a piece of the foam. The foam had shot from the fuel tank, hitting the orbiter and creating a large—and ultimately fatal—gash in its left wing. Before the *Columbia* tragedy, engineers had believed that when the fuel tanks shed foam, it fell away from the body of the orbiter. Readdy stated that NASA had redesigned the fuel tanks and improved techniques for applying the foam to remedy the problem that had caused the accident to *Columbia*.[602]

26 February

ISS crew members Alexander Y. Kaleri and C. Michael Foale conducted a spacewalk, leaving the station vacant. The spacewalk marked the first time that the ISS crew had left the station without another crew member remaining on board to assist in case of emergency. The purpose of the spacewalk was to service experiments located on the station's exterior and to prepare the orbiting structure for future assembly work. The astronauts were unable to complete all of the planned tasks, however, because a problem with Kaleri's spacesuit prompted Russian flight controllers to end the spacewalk early.[603]

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[600] John Noble Wilford, "Black Holes' Vast Power Is Documented," *New York Times*, 19 February 2004; Stefanie Komossa, Jules P. Halpern, and Suvi Gezari, "Follow-up *Chandra* Observations of Three Candidate Tidal Disruption Events," *Astrophysical Journal* 604, no. 2 (1 April 2004): 572–578.

[601] NASA, "NASA Updates Space Shuttle Return to Flight Plans," news release n04-065, 19 February 2004; Warren E. Leary, "Shuttle Won't Fly Before March Next Year," *New York Times*, 20 February 2004.

[602] Warren E. Leary, "Repairs and Need for Rescue Craft Pushed Back Shuttle Timetable, NASA Says," *New York Times*, 21 February 2004.

[603] William Harwood, "Spacewalk Is Cut Short; Malfunction in Cosmonaut's Suit Cited," *Washington Post*, 27 February 2004.

27 February
In an internal review, NASA concluded that the ISS program suffered from many of the same problems as the Space Shuttle program and that the ISS partners needed to make improvements in the station's management. NASA had drafted the 172-page report to apply lessons learned from the *Columbia* disaster to NASA's other programs. The report identified seven areas of concern, such as inconsistencies in monitoring the ISS's hardware, lack of training for personnel administering equipment problems, and an incomplete set of blueprints for hardware. In their response to the report, NASA managers stated that the ISS program had no major problems and that NASA was already pursuing measures to improve the station's operations. For example, NASA had worked to minimize the sources of debris that could hit the ISS. In addition, NASA had expanded an existing agreement with U.S. intelligence agencies to use intelligence satellites to examine the ISS for damages. Managers also noted that they planned to install additional cameras to the station's exterior and that, during future spacewalks, astronauts would photograph the ISS more extensively.[604]

29 February
A team of researchers led by scientist Marc L. Imhoff of NASA's GSFC published research indicating that increasing urbanization in the United States had reduced the amount of fertile land available for agriculture. Using data from the Defense Meteorological Satellite Program (DMSP) and NOAA's polar-orbiting satellites, the scientists had discovered that cities covered 3 percent of the land area in the continental United States. Moreover, the team found that the urbanized areas were capable of producing an amount of food and fiber rivaling that produced on agricultural lands, which covered 29 percent of the land area in the continental United States. Furthermore, they found that the urbanized land areas had the potential to produce enough food to meet the caloric requirements of 16.5 million people, nearly 6 percent of the U.S. population. The authors explained that, throughout history, human settlement has tended to occur on lands best suited for growing food. The research results, which were consistent with this trend, strongly suggested that urbanization should occur in conjunction with agricultural and environmental considerations.[605]

MARCH 2004

1 March
Researchers announced that they had found a new type of celestial object, which they suspected was a new class of black holes. A group of scientists led by Rosanne Di Stefano of the Harvard-Smithsonian Center for Astrophysics had examined data collected by NASA's Chandra X-ray Observatory. The team had studied x-rays emitted by enigmatic objects located in nearby galaxies, finding that the volume of x-rays emanating from these objects was comparable to or greater than the volume emitted by relatively warmer, larger hard x-ray sources, such as neutron

[604] Warren E. Leary, "NASA Report Says Problems Plague Space Station Program," *New York Times*, 28 February 2004; Mark Carreau, "Space Station Safety Problems Noted," *Houston Chronicle*, 28 February 2004.
[605] NASA, "Cities Built on Fertile Lands Affect Climate," news release 04-059, 11 February 2004; Marc L. Imhoff et al., "The Consequences of Urban Land Transformation on Net Primary Productivity in the United States," *Remote Sensing of Environment* 89, no. 4 (29 February 2004): 434–443.

stars and supermassive black holes. The findings indicated that the newly discovered objects could be a type of black hole that the researchers termed "quasi-soft" x-ray sources.[606]

2 March
ESA launched the Rosetta comet probe on an Ariane 5 rocket at 7:17 a.m. (UT) from the Guiana Space Centre in French Guiana. ESA had created Rosetta—the first spacecraft designed to enter a comet's nucleus and to place a probe on a comet's surface—to study the comet 67P/Churyumov-Gerasimenko. Rosetta, equipped with solar arrays spanning 105 feet (32 meters) and relying on solar cells for its power supply, was also the first probe designed to travel past Mars. Scientists hoped that, in studying comet 67P/Churyumov-Gerasimenko—a remnant of a primitive nebula from which Earth's solar system emerged—Rosetta would help them understand more about the role of comets in forming the solar system and contributing to the development of life on Earth.[607]

3 March
Former astronaut Robert D. Cabana became Deputy Director of NASA's JSC, replacing Brock R. Stone, who had retired after a 36-year career with NASA. Cabana had previously served on four Space Shuttle missions and in many management positions supporting the Astronaut Office and the ISS Program. Before becoming Deputy Director of JSC, Cabana had served as Director of Flight Crew Operations. NASA had appointed former astronaut Kenneth D. Bowersox to fill that position.[608]

5 March
NASA reported that its Mars Exploration Rovers had discovered geological evidence indicating that Mars had once had water. The rover Spirit had found a volcanic rock containing fissures filled with material that could have crystallized from water. A few days earlier, on 2 March 2004, the rover Opportunity, operating nearly 6,600 miles (10,622 kilometers) from Spirit, had found minerals and geological features that appeared to have been leached by groundwater or to have been formed by sediment in what was previously a body of water. However, scientists were unable to conclude from the two rovers' findings when Mars had actually had water in the past or whether the water had been located above or below the planet's surface.[609]

The airline company Virgin Atlantic conducted the first successful test flight of its Globalflyer airplane. The company had designed the Globalflyer to conduct a flight around the world in 3.3 days without refueling, which, if achieved, would create a world's record for the length of an unrefueled flight. During a test flight lasting 1½ hours, the Globalflyer aircraft—also known as the Model 311 Capricorn—exhibited no significant mechanical problems. However, the experimental aircraft had required several modifications, such as the development of a cabin-

[606] NASA, "Enigmatic X-ray Sources May Point To New Class of Black Holes," news release 04-067, 1 March 2004; Frank Morring Jr., "In Orbit," *Aviation Week and Space Technology* 160, no. 10 (8 March 2004): 19.
[607] ESA, "Rosetta Begins Its 10-Year Journey to the Origins of the Solar System," ESA news release 14-2004, 2 March 2004; Warren E. Leary, "Intricate European Mission Goes Hunting for a Comet," *New York Times*, 24 February 2004.
[608] NASA JSC, "NASA Fills Key Space Flight Positions," news release I-I04-080, 3 March 2004.
[609] Guy Gugliotta, "Mars Rover Finds Signs of Water," *Washington Post*, 7 March 2004; NASA, "Opportunity Rover Finds Strong Evidence Meridiani Planam Was Wet," news release 04-077, 2 March 2004.

pressurization system, to reach its final design parameters. Previously, the longest duration for an unrefueled flight around the world had been nine days, a record set by Dick Rutan and Jeana Yeager in 1986.[610]

9 March

A group of astronomers announced the most detailed telescopic view ever taken of the visible universe. NASA's HST had captured a 1 million-second-long exposure of a small portion of dark sky, with a resulting image containing an estimated 10,000 galaxies, some so far away that astronomers had never before seen them. Astronomers called the image the Hubble Ultra Deep Field. They believed that the Hubble Ultra Deep Field might have revealed light from galaxies created near the time of the Big Bang and hoped that the image would provide information about the creation of the universe.[611]

13 March

Japan's Mobile Broadcast Corporation and South Korea's Sun Kyung Telecom launched the Loral Mobile Broadcasting Satellite (MBSAT), which the two companies had designed to provide the world's first digital multimedia broadband broadcasting system. The MBSAT, launched on a Lockheed Martin Atlas 3 rocket, carried a 40-foot-diameter (12.2-meter-diameter) antenna designed to provide audio, video, and data services to users of portable audio and visual devices in Japan and South Korea. International Launch Services (ILS), a U.S.-Russian private company, provided the launch services for the Japanese-South Korean joint venture.[612]

15 March

William H. Pickering, a former Director of NASA's JPL, died at the age of 93. Pickering had begun his career at JPL in 1944 and had served as Director from 1954 to 1976. Soon after becoming Director of JPL, Pickering had led a project that had successfully launched the first U.S. satellite Explorer 1 into Earth orbit on 31 January 1958. During the remainder of Pickering's tenure, JPL had launched the Ranger and Surveyor missions to the Moon and the Mariner missions to Mars and Venus. Pickering had received numerous awards during his lifetime: NASA had presented him with its Distinguished Service Medal, President Gerald R. Ford had awarded him the National Medal of Science, and the Queen of England had given him an honorary knighthood.[613]

NASA-funded researchers announced that they had found the most distant object orbiting the Sun yet discovered. Michael E. Brown of the California Institute of Technology had led a team of scientists to discover a small body of rock and ice located 8 billion miles (13 billion kilometers) from Earth. They had named the object Sedna after the Inuit goddess of the ocean. Sedna was the largest object found in the solar system since Pluto's discovery in 1930. However, astronomers reported that they could not designate Sedna as a planet because, like Pluto, Sedna

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[610] Michael A. Dornheim, "Globalflyer Airborne," *Aviation Week and Space Technology* 160, no. 11 (15 March 2004): 38.
[611] NASA, "Hubble's Deep View of the Universe Unveils Earliest Galaxies," news release 04-086, 9 March 2004; Dennis Overbye, "Images Reveal Deepest Glance into Universe," *New York Times*, 10 March 2004.
[612] Craig Covault, "Mobile Milestone," *Aviation Week and Space Technology* 160, no. 12 (22 March 2004): 35; International Launch Services, "About Us," *http://www.ilslaunch.com/about-us/* (accessed 18 March 2009).
[613] NASA, "NASA Remembers William H. Pickering, Former Director of JPL," news release 04-094, 16 March 2004.

is too small—with an estimated diameter of 1,100 miles (1,770 kilometers)—and possesses an irregular orbit. The scientists stated that the discovery might also have been the first observation of a region called the Oort Cloud, which is located outside of Pluto's orbit. Astronomers had long hypothesized the existence of this region of small frozen objects, the source of comets that enter Earth's solar system. The team had discovered Sedna using the Samuel Oschin Telescope at the California Institute of Technology's Palomar Observatory.[614]

A NASA-funded study found that some climate-forecasting models might have incorrectly estimated future increases in Earth's temperatures. Scientists Kenneth R. Minschwaner of the New Mexico Institute of Mining and Technology and Andrew E. Dessler of the University of Maryland had determined that some climate models might have incorrectly estimated the amount of water vapor that enters Earth's atmosphere as the planet warms. For years, scientists had debated the extent to which water vapor—the most important heat-trapping greenhouse gas in Earth's atmosphere—influences Earth's surface temperatures. Using data from NASA's Upper Atmosphere Research Satellite, the scientists had found that, although the amount of water vapor in the atmosphere had increased with surface warming, the increase had not been as high as previous researchers had assumed. The findings also cast doubt on research suggesting that Earth's temperatures would decrease because of a lack of water vapor in the atmosphere.[615]

18 March

At a hearing held by the U.S. House Science and Technology Subcommittee on Space and Aeronautics, officials from NASA and the Pentagon stated that they expect to work together on President Bush's exploration strategy for Mars and the Moon, without altering the traditional divisions between the two organizations. According to officials, NASA and the Pentagon would cooperate on technical issues of concern to both agencies, including the development of lightweight fabrication systems and systems for unpiloted docking of spacecraft. The two agencies would also explore sharing launch systems, including NASA's possible use of the Atlas 5 and Delta 4 rockets, which the Pentagon had developed to launch its own satellites. According to major media, House subcommittee members were interested in the possibility of saving money through the collaboration between NASA and the Pentagon, but they were also concerned about the possibility of the two agencies repeating their previous collaborative failures. As an example of such a failed collaboration, they cited the Advanced Launch System project, a collaborative project between the two agencies during the 1980s and 1990s.[616]

A team of European scientists released research that solved a long-standing puzzle concerning the sources of gamma rays in the center of the Milky Way. Scientists already knew that the Milky Way produces a substantial quantity of gamma rays, which illuminate the galaxy. However, they were uncertain about whether the galaxy's gamma rays originate predominantly from so-called point sources, such as black holes and neutron stars, or from diffuse sources, such as gas atoms, which are abundant in the Milky Way. Using data from ESA's INTEGRAL—International Gamma Ray Astrophysics Laboratory—researchers led by François

[614] NASA, "Most Distant Object in Solar System Discovered," news release 04-091, 15 March 2009; Thomas H. Maugh II, "Scientists Discover Icy Planetoid Beyond Pluto," *Los Angeles Times*, 16 March 2009.
[615] NASA, "Satellite Finds Warming 'Relative' to Humidity," news release N04-090, 15 March 1990; *New York Times*, "Study Disputes Idea of Global Warming," 18 March 2004.
[616] Mark Carreau, "NASA, Military To Work Closely on Space Effort," *Houston Chronicle*, 19 March 2004.

Lebrun found that point sources account for nearly all of the gamma rays in the Milky Way, and diffuse sources play a distinctly minor role in gamma-ray production.[617]

22 March
Russian President Vladimir V. Putin appointed Anatoly N. Perminov as Director of the Russian Space Agency. Perminov, a professor at the Moscow Aviation Institute, had previously served as Commander-in-Chief of the Russian Space Force. He replaced previous Russian Space Agency Director Yuri N. Koptev, who Russian President Boris N. Yeltsin had appointed in 1992.[618]

27 March
NASA's X-43A Hyper X plane set a new record for flight speed, traveling at Mach 7, which is nearly 5,000 miles (8,050 kilometers) per hour and seven times the speed of sound. The flight was also the first free flight of an aircraft powered by a supersonic combustion ramjet engine—a scramjet—a type of engine that provides thrust by funneling air and fuel into a hollow chamber at extremely high speed. The 12-foot-long (3.7-meter-long) unpiloted, experimental aircraft flew for approximately 11 seconds over the Pacific Ocean, at an altitude of 95,000 feet (approximately 29,000 meters), before NASA deliberately landed the aircraft in the ocean. NASA used a modified B-52 aircraft to carry the X-43A into the sky, launching the X-43A into flight using a Pegasus rocket mounted to the B-52. The test flight, which took place near San Nicolas Island off the California coast, originated from NASA's DFRC at Edwards Air Force Base in California.[619]

30 March
The FAA released an analysis of the economic impact of the commercial space-transportation industry on the United States' economy. The report examined how industries—such as launch-vehicle manufacturing, satellite services, and remote sensing—affect economic activity, employee earnings, and the amount of employment in all major industry sectors. Based on data from 2002, the FAA had found that the commercial space-transportation industry had contributed US$95 billion to economic activity in the United States, including US$23.5 billion in employee earnings. The report also stated that demands for commercial space transportation and its products and services had resulted in the employment of nearly 600,000 people. In addition, the FAA had found that much of this economic impact was the result of increased demands for satellite services and ground-equipment manufacturing, which includes satellite-related hardware and consumer electronics used with satellite services.[620]

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[617] Henry Fountain, "Observatory," *New York Times*, 23 March 2004; F. Lebrun et al., "Compact Sources as the Origin of the Soft Gamma-Ray Emission of the Milky Way," *Nature* 428, no. 6980 (18 March 2004): 293–296.
[618] Russian Federal Space Agency, "Head of the Russian Federal Space Agency—Anatoly N. Perminov," *http://www.roscosmos.ru/about_rukovod.asp?Lang=ENG* (accessed 18 March 2009); "World News Roundup," *Aviation Week and Space Technology* 160, no. 12 (22 March 2004): 18–19.
[619] Peter Pae, "Fast Times at 12 O'Clock High: 5,000 MPH," *Los Angeles Times*, 28 March 2004; NASA, "X-43A Soars on Scramjet Power," 27 March 2004.
[620] FAA Office of Commercial Space Transportation, "The Economic Impact of Commercial Space Transportation on the U.S. Economy: 2002 Results and Outlook for 2010" (study, Washington, DC, March 2004), 1–6.

APRIL 2004

1 April
NASA Administrator Sean O'Keefe testified before the U.S. Senate Commerce Subcommittee on Science, Technology and Space concerning NASA's budget request for FY 2005. NASA had requested US$16.2 billion for FY 2005, an increase of 5.6 percent over its budget for FY 2004. Much of O'Keefe's testimony and the Senate subcommittee members' questions were concerned with the likelihood of NASA's achieving the objectives that President George W. Bush had established for NASA in his Vision for Space Exploration, announced in January 2004. Those objectives included human flights to the Moon and replacing the Space Shuttles with a new space-exploration vehicle.[621]

2 April
The GAO released an analysis of NASA's budgetary outlays for fiscal years 2002 through 2004. Under Pub. L. No. 106-391, the National Aeronautics and Space Administration Authorization Act of 2000, GAO was required to verify NASA's accounting of its funds obligated against established budgetary limits for the ISS and for Space Shuttle support for the ISS. Under the Act, NASA's obligations were limited to US$25 billion for the ISS and US$17.7 billion for Shuttle support. GAO's report noted that NASA had not provided sufficient documentation for the amounts it had reported as obligated against budgetary limits. Thus, GAO could not verify the amounts that NASA had reported to Congress in its budget requests for fiscal years 2002 through 2004. Similarly, NASA had not reported any documentation of its FY 2004 budget obligations in its FY 2005 budget request to Congress. NASA officials acknowledged that NASA's accounting system presented some difficulties for GAO's auditors, but explained that those difficulties were the result of NASA's having reported budgetary figures based on the amount it was authorized to spend rather than on the amount it was obligated to spend.[622]

5 April
A commission composed of officials from ESA and the British National Space Centre released the results of their investigation into the loss of the Beagle 2 spacecraft, the first European spacecraft designed to explore the surface of Mars. On 19 December 2003, the Beagle 2 had successfully separated from ESA's Mars Express, the spacecraft that had carried the Beagle 2 to its orbit of Mars. However, subsequently, Beagle 2 had failed to send any signals to mission engineers, and its eventual fate remained unknown. Although its report did not identify any single technical issue that had caused the mission loss, the investigating panel did provide 19 recommendations for future missions. These recommendations, implicitly critical of the Beagle 2 mission, suggested that future missions should have adequate funding and adequate testing, and that an agency with appropriate capabilities and resources should manage the missions.[623]

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[621] NASA, "Administrator O'Keefe's Senate Testimony," news release, 1 April 2004; Gwyneth K. Shaw, "NASA Chief Faces Lawmakers' Queries," *Orlando Sentinel* (FL), 2 April 2004.
[622] Patty Reinert, "GAO Says Lax Bookkeeping Thwarts Space Agency Audit," *Houston Chronicle*, 7 April 2004; U.S. General Accounting Office, "International Space Station and Shuttle Support Cost Limits" (report no. GAO-04-648R, Washington, DC, 2 April 2004), *http://www.gao.gov/new.items/d04648r.pdf* (accessed 19 March 2009).
[623] British National Space Centre, "Beagle 2" (report, ESA/UK Commission of Inquiry Swindon, UK, 5 April 2004), *http://www.bnsc.gov.uk/assets/channels/resources/press/report.pdf* (accessed 31 March 2009), 3–7; ESA, "Beagle 2: Lessons Learned and the Way Forward," ESA news release 27-2004, 20 May 2004.

8 April
NASA approved a five-month extension of the Mars Exploration Rovers' mission nearly two weeks before its originally scheduled end on 26 April 2004. NASA had originally planned for the mission to last three months but had decided to extend it because the robotic rovers—Opportunity and Spirit—had satisfied all of their primary mission criteria, achieving several successes, such as discovering evidence that Mars had once had water. According to officials, NASA planned to provide US$15 million to continue the rovers' operations, doubling the mission's duration at less than 2 percent of the overall mission's cost.[624]

15 April
In a newly released survey, U.S. federal government employees ranked NASA as the best place to work in the federal government. The Office of Personnel Management had collected the data during a 2002 survey of federal employees, and the nonpartisan Partnership for Public Service and American University's Institute for the Study of Public Policy Implementation had produced the rankings. According to the survey, in eight out of 10 categories related to employment satisfaction, federal employees had ranked NASA first—federal employees had ranked NASA as the best place to work for women, for racial minorities, and for individuals under 40 years of age.[625]

Astronomers announced the first successful use of a new technique to discover a planet outside of the solar system. Astronomer Ian Bond of the University of Edinburgh in Scotland and his team of researchers had used a technique called *gravitational lensing* to identify a star located 17,000 light-years from Earth in the constellation Sagittarius. The gravitational lensing technique entailed the observation of increases in the brightness of the light of distant stars, caused by the gravitational fields of stars closer to Earth. The astronomers made these observations when a star nearer Earth passed before the lens of a telescope on Earth, between the telescope and a more distant star. When this occurred, the nearer star's gravity caused the light of the more distant star's light to become brighter, so that the distant star became more visible to astronomers on Earth.[626]

Sirpa Häkkinen of NASA's GSFC announced that a research team had discovered changes in the North Atlantic Ocean indicating significant changes in the ocean's climate. Using data from several NASA and European satellites, the researchers had found a dramatic weakening in a particular current in the ocean, which circulates water between Ireland and Canada. The change in the current indicated substantial climate variability in high-latitude areas, but the research remained uncertain of whether or not the change related to global warming. However, the scientists emphasized that the North Atlantic Ocean region is key for analyzing climate and that changes in the ocean's current could influence the circulation of the entire Atlantic Ocean system.[627]

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[624] NASA, "NASA Extends Mars Rovers' Mission," news release 04-122, 8 March 2004.
[625] Stephen Barr, "NASA Soars to Top of Satisfaction Ratings Among Various Workers," *Washington Post*, 16 April 2004.
[626] "Thomas H. Maugh II, "Distant Planet Spotted Around the Bend," *Los Angeles Times*, 16 April 2004.
[627] NASA, "Satellites Record Weakening North Atlantic Current," news release 04-130, 15 April 2004; Sirpa Häkkinen and Peter B. Rhines, "Decline of Subpolar North Atlantic Circulation During the 1990s," *Science* 304, no. 5670 (23 April 2004): 555–559.

18 April
The Expedition 9 crew of the ISS launched at 11:19 p.m. (EDT) from Baikonur Cosmodrome in Kazakhstan on the Russian *Soyuz* TMA-4/ISS-8S. The crew members consisted of Russian cosmonaut, Expedition 9 Commander Gennady I. Padalka; NASA astronaut E. Michael Fincke; and ESA astronaut André Kuipers of the Netherlands. Padalka and Fincke would remain at the ISS for nearly six months, while Kuipers would spend nine days on the ISS, returning to Earth with the crew members of Expedition 8—NASA astronaut C. Michael Foale and Russian cosmonaut Alexander Y. Kaleri.[628]

20 April
NASA launched its Gravity Probe B (GP-B) on a Boeing Delta 2 rocket from Vandenberg Air Force Base in California at 12:57 p.m. (EDT). NASA had designed the satellite to test two fundamental aspects of Albert Einstein's theory of relativity. According to Einstein's theory, time and space create a veritable fabric in space. When massive objects, such as Earth and other planets, distort the fabric of space, causing relatively smaller objects to move towards them, they create gravity. Einstein's theory of relativity also states that large objects twist the fabric of space around them as those objects spin on their axes. Gravity Probe A, which NASA had launched in 1975, had tested the former part of the theory, and GP-B would test both aspects. GP-B contained some of the most accurate scientific instruments ever constructed, including the most precise gyroscopes ever built.[629]

Scientist Menglin Jin of NASA's GSFC published research based on the first use of satellites to create a multiyear record of Earth's land-surface temperatures. Jin had used remote-sensing data, which satellites had collected from 1981 to 1998, to develop an 18-year record of global land-surface temperatures more comprehensive and detailed than data derived from ground-station measurements. According to the satellite data, average global land-surface temperatures had increased by 0.43˚C (0.77˚F) per decade, whereas ground-station data had indicated an increase of 0.34˚C (0.61˚F). The different findings produced different measurements because satellites measure actual land-surface temperatures—also known as skin temperatures—and ground stations measure air temperatures 6.6 feet (2 meters) above land surfaces. However, Jin also noted regional variations in temperature changes, with the central regions of North America and Asia experiencing some declines in temperatures.[630]

21 April
NASA Administrator Sean O'Keefe provided testimony concerning NASA's FY 2005 budget request to the U.S. House Appropriations Subcommittee on VA, HUD, and Independent Agencies. In his testimony, O'Keefe highlighted NASA's planned efforts to achieve the goals that President George W. Bush had established for NASA in his Vision for Space Exploration. According to major media, although several House subcommittee members were supportive of

[628] NASA, "Expedition 9 on the Way to Space Station," news release 04-133, 18 April 2004; National Space Science Data Center, *Spacewarn Bulletin*, no. 605, 1 May 2004, *http://nssdc.gsfc.nasa.gov/ spacewarn/spx605.html*.
[629] Thomas H. Maugh II, "Einstein's Theory Rockets into Orbit," *Los Angeles Times*, 21 April 2004; NASA, "The Gravity Probe B: The Relativity Mission," *http://www.nasa.gov/mission_pages/ gpb/index.html* (accessed 23 March 2009).
[630] NASA, "Satellites Act as Thermometers in Space," news release 04-121, 20 April 2004; Menglin Jin, "Analysis of Land Skin Temperature Using AVHRR Observations," *Bulletin of the American Meteorological Society* 85, no. 4 (April 2004): 587–600.

NASA's goals, they also expressed doubts about whether Congress would give NASA its requested FY 2005 budget, which included an increase of 5.6 percent over its FY 2004 budget.[631]

22 April

NASA researchers discovered a previously unknown property of Arctic sea ice, challenging conventional models of climate change that had incorporated data on Arctic sea ice. A group of scientists led by Ronald Kwok of NASA's JPL had used satellite data from Canada's RADARSAT and NASA's ICESat to examine changes in Arctic sea ice. In the past, scientists had tended to examine data from ocean buoys to determine changes in Arctic sea ice, rather than using satellite data. The NASA researchers had discovered that, during 12-hour intervals, Arctic sea ice makes subtle, back-and-forth motions, which result in approximately 20 percent of ice growth during the Arctic winter. Although conventional models of the dynamics of Arctic sea ice had incorporated data regarding the ice's motion, those models had not incorporated ice motion occurring during such brief periods and, thus, may have inaccurately simulated large-scale changes in the ice and underestimated the production of Arctic sea ice.[632]

23 April

The State Council of the People's Republic of China appointed Sun Laiyan as Administrator of the China National Space Administration (CNSA). Laiyan had become the CNSA's Vice Administrator in 1999 and had served as Deputy Director of the Beijing Institute of Satellite Environment Engineering. Laiyan replaced Luan Enjie, who was retiring as head of the CNSA.[633]

29 April

After more than six months in space, the crew members of ISS Expedition 8 returned to Earth, safely landing in Kazakhstan at 8:12 p.m. (EDT). The crew of Expedition 8 consisted of NASA astronaut C. Michael Foale and Russian cosmonaut Alexander Y. Kaleri. During their tenure at the ISS, Foale and Kaleri had conducted scientific research. Expedition 8 had been the second-longest expedition to the ISS, with the two men spending a total of 194 days, 18 hours, and 35 minutes in space. Returning with them to Earth was ESA astronaut André Kuipers, who had spent nine days on the space station conducting research as part of ISS Expedition 9. The other two members of Expedition 9, Gennady I. Padalka and E. Michael Fincke, remained at the ISS for a mission scheduled to last nearly six months.[634]

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[631] NASA, "Administrator O'Keefe's House Testimony," 21 April 2004, *http://www.nasa.gov/audience/formedia/speeches/okeefe_house_testimony_042104.html* (accessed 23 march 2009); Patty Reinert, "Lawmakers Warn NASA Fund Boost May Be Modest," *Houston Chronicle*, 22 April 2004.

[632] NASA, "NASA Arctic Sea Ice Study May Stir Up Climate Models," news release 04-132, 22 April 2004; Ronald Kwok, H. Jay Zwally, and Donghui Yi, "ICESat Observations of Arctic Sea Ice: A First Look," *Geophysical Research Letters* 31, no. 16 (18 August 2004): L16401–L16405.

[633] China National Space Administration, "Mr. Sun Laiyan Appointed as Administrator of CNSA," news release, 12 May 2004, *http://www.cnsa.gov.cn/n615709/n620682/n639462/54319.html* (accessed 19 March 2009); China National Space Administration, "Resumes of Leaders: Prof./Dr. Sun Laiyan," *http://www.cnsa.gov.cn/n615709/n620681/n639436/53299.html* (accessed 19 March 2009).

[634] NASA, "International Space Station Status Report," news release SS04-007, 29 April 2004.

MAY 2004

4 May
Commercial airlines Air France and KLM Royal Dutch Airlines announced that they would merge, creating the world's largest airline, in terms of revenue. Under the terms of the merger, the two companies would trade stock shares, with KLM shareholders tendering almost 42 million shares—nearly 90 percent of the company's capital. Air France would issue approximately 46 million new shares to KLM shareholders, reducing the French government's interest in the airline from 54 percent to less than 45 percent of total shares. The combined annual revenue of the two companies would be nearly US$23 billion, eclipsing the US$17.4 billion annual revenue of American Airlines, which had previously received the highest revenue of any airline.[635]

6 May
NASA announced the selection of 11 individuals for the astronaut class of 2004—the first astronaut trainees since 2000. In June 2004, the new class would begin training at NASA's JSC as educator astronauts, engineers, pilots, and scientists, eventually working on NASA's next-generation space vehicle and other projects. The trainees for the class of 2004 included Joseph M. Acaba, Richard R. Arnold II, Randolph J. Bresnik, Christopher J. Cassidy, James P. Dutton Jr., José M. Hernández, Robert S. Kimbrough, Thomas H. Marshburn, Dorothy M. Metcalf-Lindenburger, Robert L. Satcher Jr., and Shannon Walker.[636]

8 May
A prototype of the Phoenix reusable launch vehicle (RLV), a joint project of European public and private funders, successfully completed its first atmospheric test flight. According to major media sources, European space agencies hoped eventually to use the Phoenix to launch payloads. The vehicle prototype was approximately 23 feet (7 meters) long and weighed 2,640 pounds (1,200 kilograms). During the test flight, a helicopter released the vehicle prototype from an altitude of 8,000 feet (2,400 meters). The Phoenix landed 90 seconds later at an airport in Vidsel, Sweden. EADS Space Transportation, along with German aerospace company OHB-System AG, the German Aerospace Center, and the government of Bremen, Germany, had funded the Phoenix.[637]

13 May
A piloted rocket called *SpaceShipOne* reached the highest altitude ever attained by a privately funded vehicle. After its release from a plane flying over the Mojave Desert in California, the winged rocket flew to an altitude of 211,400 feet (40 miles or 64 kilometers). The vehicle's pilot Michael W. Melvill landed *SpaceShipOne* at Mojave Airport. The event was a test flight in preparation for the planned official launch of *SpaceShipOne* on 2 June 2004. Scaled Composites, the company that had built the rocket, intended *SpaceShipOne* to become the first privately funded, piloted vehicle to achieve suborbital flight. Scaled Composites had built *SpaceShipOne*

[635] *Los Angeles Times*, "Air Frances Completes Deal with KLM Royal Dutch," 5 May 2004.
[636] NASA, "NASA Introduces the Next Generation of Explorers," news release 04-152, 6 May 2004; Patty Reinert, "11 Space Hopefuls Get NASA's Good News," *Houston Chronicle*, 7 May 2004.
[637] Frank Morring Jr., "In Orbit," *Aviation Week and Space Technology* 160, no. 20 (17 May 2004): 17; Frank Morring Jr., "In Orbit," *Aviation Week and Space Technology* 160, no. 11 (15 March 2004): 17; Mattias Karen for Associated Press, "Europeans Test Space-Shuttle Prototype," 9 May 2004.

for use in commercial spaceflights—spaceflights in which customers pay a fee for a brief trip to outer space.[638]

Researchers announced that they had found the remains of a large object that crashed into Earth 250 million years ago, possibly causing the largest mass extinction in history. Previously, many scientists had agreed that a large-scale event—the Permian-Triassic extinction—had occurred approximately 250 million years ago. However, they had debated about whether volcanic activity or the impact of an extraterrestrial object such as a meteor had caused the event. A team of scientists led by Luann Becker of University of California at Santa Barbara reported the discovery of strong evidence for the impact theory—part of a meteorite or comet, nearly 6 miles (10 kilometers) in diameter, buried in sediment off the coast of Australia. Based on analysis of the object's age and mineral composition, the team believed that the object might have caused the Permian-Triassic extinction—the extinction of 90 percent of marine species and 70 percent of land species. NASA and the National Science Foundation had funded the scientists, who cautioned that their findings did not prove definitively that extraterrestrial impact had caused the extinction event.[639]

17 May

Lufthansa became the world's first airline to provide its passengers with wireless broadband Internet access on a long-haul flight of an aircraft. The German airline company provided Boeing Connexion Internet service on a Boeing 747-400 airplane. The Internet service used a parabolic antenna extending 12 inches (30 centimeters) from the aircraft's exterior and capable of providing Internet services for airplanes flying in latitudes between 75° north and south.[640]

18 May

A group of astronomers reported new findings concerning two prominent enigmas of physics—dark energy and the expansion of the universe. Steve Allen of Cambridge University led a group of scientists who had used NASA's Chandra X-ray Observatory to examine 26 clusters of galaxies, located 1 to 8 billion light-years from Earth—a span of time covering the universe's initial explosion and subsequent expansion. Previously, many scientists had theorized that a force called dark energy might have counteracted gravity, causing the expansion. Chandra's observations of the distances between the galaxy clusters indicated that the universe's expansion had accelerated, and Chandra's data on the ratio of hot gas to dark matter within the galaxy clusters indicated that the density of dark energy had not changed. Both findings were contrary to many previous hypotheses. The astronomers stated that, although their findings were inconclusive, the data suggested that the constant density of dark energy causes the universe to

[638] Peter Pae, "In Capital Venture, Rocket Reaches the Edge of Space," *Los Angeles Times*, 14 May 2004; Scaled Composites, "Historic Space Launch Attempt Scheduled for June 21," news release, 2 June 2004, *http://www.scaled.com/projects/tierone/062104.htm* (accessed 27 March 2009).
[639] Guy Gugliotta, "Impact Crater Labeled Clue to Mass Extinction," *Washington Post*, 14 May 2004; Richard A. Kerr, "Evidence of Huge, Deadly Impact Found off Australian Coast?" *Science* 304, no. 5673 (14 May 2004): 941.
[640] Michael Mecham, "Ready to Download," *Aviation Week and Space Technology* 160, no. 2 (22 March 2004): 48; Lufthansa, "High Tech above the Clouds," *Newslink Special*, October 2004, 13, *http://konzern.lufthansa.com/en/downloads/presse/newslink/newslink_2004_12/newslink_sp10.pdf* (accessed 27 March 2009).

expand eternally. This finding is consistent with Albert Einstein's concept of cosmological constant, which states that the universe expands constantly and gradually.[641]

19 May

NASA's Chief Financial Officer Gwendolyn Sykes Brown and officials from the GAO provided testimony on NASA's accounting system to the U.S. House Government Reform Subcommittee on Government Efficiency and Financial Management. According to GAO, NASA had not acknowledged the nature and extent of its financial management problems, such as its inadequate documentation of financial statements. Brown responded, detailing NASA's efforts to improve its financial management system. For example, NASA had acquired new accounting software and had adopted a single financial system for all of its centers. Subcommittee members stated that they planned to monitor NASA and that they expected NASA to provide periodic reports on its progress in correcting its accounting system.[642]

20 May

NASA released pieces of the debris from Space Shuttle *Columbia* to a nongovernmental agency for study and testing. The release of the materials was the first implementation of NASA's new policy for the use of materials from a destroyed Space Shuttle. Henceforth, instead of burying Space Shuttle materials, as it had done after the *Challenger* accident, NASA would use materials from destroyed Space Shuttles for research. The company that received the parts—the Aerospace Corporation of El Segundo, California—was one of several organizations that had requested NASA's permission to study *Columbia*'s debris. Under the terms of the release, the company would keep the Shuttle parts for one year, using them to analyze the effect of atmospheric reentry on materials.[643]

27 May

NASA announced that the Spitzer Space Telescope (SST), launched on 25 August 2003, had made several new discoveries. The SST—formerly called the Space Infrared Telescope Facility, or SIRTF—was the largest infrared telescope ever launched. Among the SST's specific findings was the discovery of nearly 300 new stars in RCW 49, a region in the constellation Centaurus, 13,700 light-years from Earth. In addition, the SST had revealed high quantities of icy organic materials in planets forming around young stars in the constellation Taurus, located 420 light-years from Earth. The presence of organic materials in the newly forming planets could explain the origins of similarly icy bodies, such as comets. Scientists theorized that comets might have provided the water and other organic materials that enabled life to form on Earth.[644]

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[641] NASA, "Chandra Opens New Line of Investigation on Dark Energy," news release 04-163, 18 May 2004; Guy Gugliotta, "Astronomers Find More Evidence of 'Dark Energy'," *Washington Post*, 19 May 2004.
[642] NASA, "Chief Financial Officer's House Testimony," 19 May 2004, *http://www.nasa.gov/audience/formedia/speeches/brown_house_testimony_051904.html* (accessed 31 march 2009); *Houston Chronicle*, "GAO Criticizes NASA's Budget 'Mismanagement'," 23 May 2004.
[643] NASA, "First Columbia Debris Loaned for Research," news release 04-165, 20 May 2004; James R. Asker, "In Orbit," *Aviation Week and Space Technology* 160, no. 22 (31 May 2004): 19.
[644] NASA, "Raw Ingredients for Life Detected in Planetary Construction Zones," news release 04-167, 27 May 2004; Warren E. Leary, "NASA Spots New Youngest Planet, Just a Million Years Old," *New York Times*, 28 May 2004; NASA JPL, "About Spitzer," *http://www.spitzer.caltech.edu/about/index.shtml* (accessed 31 March 2009).

28 May
A group of scientists led by Enric Pallé of the New Jersey Institute of Technology published research indicating that, since 1999, the amount of sunlight reaching Earth's surface had declined. Analyzing NASA's data on cloud cover, along with data from Earth-based telescopes, the team had calculated how much sunlight Earth reflected to the Moon, using the results to determine the amount of sunlight that reached Earth. They reported that the amount of sunlight reaching Earth's surface had begun to increase in the mid-1980s, but had started to decline in the early 1990s, a trend that the team attributed to the increasing pollution of Earth's air. The air pollution had reduced the amount of sunlight reaching Earth's surface and had increased the amount of water droplets condensing in the atmosphere, thereby increasing the amount of cloud cover blocking sunlight.[645]

JUNE 2004

9 June
The Director of NASA's LaRC Roy D. Bridges Jr. appointed Lesa B. Roe as LaRC's Deputy Director. At the time of the appointment, Roe was LaRC's Associate Director for Business Management, a position she had held since August 2003. Roe had begun her career with NASA in 1987 as a radio-frequency communications engineer at KSC, later working in KSC's Payload Processing Directorate and in the ISS Hardware Integration Office.[646]

10 June
Kevin L. Petersen, Director of NASA's DFRC, appointed Steven G. Schmidt as DFRC's Deputy Director. Schmidt had served as Special Assistant to NASA's Administrator since January 2002. In addition, Schmidt had previously worked in numerous programs at DFRC, such as the X-33, X-43A, and the F-15 programs. Schmidt, who had begun working for NASA in 1994, had also served as Executive Director of the President's Space Commission and as Executive Secretary for Management on the *Columbia* Accident Investigation Board.[647]

11 June
Passing by Saturn's furthest moon Phoebe, the Cassini spacecraft returned analyses of the moon indicating that Phoebe's chemical composition is similar to the composition of comets, a finding that supported previous scientific theories about the enigmatic Phoebe. Because Phoebe has an unusually dark appearance and orbits Saturn in a direction opposite that of the planet's other moons, scientists had theorized that the moon is a captive object of Saturn. Cassini's analyses of Phoebe indicated that the diminutive moon's surface is composed of carbon dioxide, water ice, water-bearing minerals, and various organic chemicals. The results indicated possible chemical similarities between Phoebe's composite materials and materials observed in comets. The Cassini spacecraft was one of two in the Cassini-Huygens mission, a joint project of ESA, the Italian Space Agency, and NASA. Besides Cassini—an orbiter designed to orbit Saturn, studying

[645] Enric Pallé et al., "Changes in Earth's Reflectance over the Past Two Decades," *Science* 304, no. 5676 (28 May 2004): 1299–1301; Kenneth Chang, "After a Period of Brightness, Earth Dims, Researchers Say," *New York Times*, 28 May 2004.
[646] NASA, "NASA Names Langley Research Center Deputy Director," news release 04-185, 9 June 2004; NASA, "Langley Center Director Lesa B. Roe," 3 October 2005, *http://www.nasa.gov/centers/langley/ about/roe_bio.html* (accessed 1 April 2009).
[647] NASA, "NASA Names Dryden Flight Research Center Deputy Director," news release 04-188, 10 June 2004.

the planet and its system of moons—the project included the probe Huygens, created to examine Saturn's largest moon Titan. [648]

16 June

A commission created by President George W. Bush released its report outlining how NASA and other organizations might implement President Bush's new policy: the U.S. Vision for Space Exploration. The President's Commission, led by Edward C. Aldridge Jr., endorsed the Vision for Space Exploration's goals—to explore Mars and the Moon. In addition, the commission recommended that, to meet those goals, NASA needed to make numerous changes; the federal government needed to establish a permanent council to develop and coordinate space exploration policies; and the private sector needed to become more involved in space operations. Specific changes that the commission recommended were that NASA should focus on the research and development of space technology, and that private industry should conduct operational activities, such as launching payloads to low Earth orbit. The report also recommended that NASA pursue partnerships with the scientific community and with foreign space agencies.[649]

17 June

The U.S. Senate Commerce, Science, and Transportation Subcommittee on Science, Technology, and Space concluded a hearing on the final report of the President's Commission on Implementation of the U.S. Space Exploration Policy. The report, which the commission had released the previous day, addressed ways in which the federal government and private companies could implement the Vision for Space Exploration. Individuals testifying before the committee included Edward C. Aldridge Jr., who had led the President's Commission; Paul D. Spudis of the Johns Hopkins University Applied Physics Laboratory; Maria T. Zuber of the Massachusetts Institute of Technology Department of Earth Atmospherics and Planetary Sciences; Laurie A. Leshin of Arizona State University; and retired U.S. Air Force General Lester L. Lyles, formerly Commander of the Air Force Materiel Command at Wright-Patterson Air Force Base in Ohio.[650]

18 June

Scientists published research on comet Wild 2, revealing unexpected discoveries about comets. The researchers had based their findings on data that NASA's Stardust spacecraft had acquired during a flyby of Wild 2 on 2 January 2004—data that included the highest-resolution images ever taken of a comet. The scientists had discovered that the comet's surface is not simply icy and dirty; rather the comet has a diverse landscape, including peaks, cliffs, and craters, and isolated, volatile jets, violently spewing particles. Although scientists did not yet know whether

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[648] Richard A. Kerr, "Dirty Old Ice Ball Found at Saturn," *Science* 304, no. 5678 (18 June 2004): 1727; Warren E. Leary, "Craft Confirms a Comet Link for Peculiar Moon of Saturn," *New York Times*, 24 June 2004.

[649] President's Commission on Implementation of United States Space Exploration Policy, *A Journey To Inspire, Innovate, and Discover: Report of the President's Commission on Implementation of United States Space Exploration Policy* (Washington, DC, June 2004), *http://www.nasa.gov/news/reports/index.html* (accessed 6 April 2009); Warren E. Leary and John Schwartz, "NASA Is Urged To Widen Role for Business," *New York Times*, 15 June 2004.

[650] U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, *Final Report on the President's Commission on Implementation of U.S. Space Exploration Policy,* 108th Cong., 2nd sess., 17 June 2004.

other comets possessed features similar to those of Wild 2, the findings challenged previous understanding of comets.[651]

21 June

The company Scaled Composites launched the first privately developed piloted vehicle to travel beyond Earth's atmosphere. The vehicle, called *SpaceShipOne*, departed from Mojave Airport in California at 6:45 a.m. Pacific Standard Time (PST), attached to another aircraft. Upon reaching an altitude of 46,000 feet (8.7 miles or 14 kilometers), the aircraft released *SpaceShipOne*. Propelled by a fuel containing rubber and nitrous oxide—laughing gas—*SpaceShipOne* eventually attained an altitude of 328,491 feet (62 miles or 100 kilometers), achieving suborbital spaceflight. After *SpaceShipOne* had remained in suborbital flight for nearly 3½ minutes, the vehicle's pilot Michael W. Melvill—who became the first civilian astronaut with this flight—safely landed the craft at Mojave Airport. Burt Rutan, the founder of Scaled Composites, had designed *SpaceShipOne*, and Microsoft cofounder Paul G. Allen had financed the project.[652]

24 June

NASA Administrator Sean O'Keefe announced that, effective 1 August 2004, NASA would restructure its organization to render it better able to implement President George W. Bush's Vision for Space Exploration. Among many other announced changes, NASA planned to restructure its Earth Science, Space Science, and other Strategic Enterprises into four Mission Directorates—Aeronautics Research, Exploration Systems, Science, and Space Operations—with clearer organizational roles and responsibilities. In addition, to improve communication and clarify responsibilities, functional offices of NASA Headquarters and its field offices—including the office of the Chief Financial Officer—would become mission support offices.[653]

26 June

The European Union (EU) and the United States signed a cooperative agreement on their satellite navigation services—the EU's planned Galileo system and the United States' GPS. According to the agreement, the Galileo and GPS satellites would broadcast a common civil signal. They also agreed not to discriminate in commercial trade of satellite-navigation goods and services. In addition, the agreement stipulated that Galileo signals would not interfere with the efforts of the United States to prevent its adversaries' accessing satellite-based positioning signals. European Commission Vice President Loyola de Palacio, Irish Foreign Minister Brian Cowen, and U.S. Secretary of State Colin L. Powell signed the agreement in Dublin, Ireland.[654]

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[651] Zdenek Sekanina et al., "Modeling the Nucleus and Jets of Comet 81P/Wild 2 Based on the Stardust Encounter Data," *Science* 304, no. 5678 (18 June 2004): 1769–1774; NASA, "NASA Spacecraft Reveals Surprising Anatomy of a Comet," news release 04-197, 17 June 2004.

[652] Peter Pae, "Private Spaceflight Is a Public Success," *Los Angeles Times*, 22 June 2004; Scaled Composites, "SpaceShipOne Makes History: First Private Manned Mission to Space," news release, 21 June 2004.

[653] Warren E. Leary, "New Look for NASA for the Next Space Age," *New York Times*, 25 June 2004; NASA, "Administrator Unveils Next Steps of NASA Transformation," news release 04-205, 24 June 2004.

[654] NASA, *Aeronautics and Space Report of the President: Fiscal Year 2004 Activities* (Washington, DC, 2004), p. 95, *http://history.nasa.gov/presrep2004.pdf* (accessed 7 April 2009); United States Mission to the European Union, "U.S., EU Reach Agreement on Satellite Navigation Services," news release, 27 June 2004, *http://useu.usmission.gov/Article.asp?ID=E195E969-EFF9-4EE3-8E7B-58D02983E7C3* (accessed 7 April 2009).

30 June
Cassini-Huygens became the first spacecraft to successfully navigate Saturn's rings and to orbit the planet. A joint project of ESA, the Italian Space Agency, and NASA, the mission comprised two spacecraft: the orbiter Cassini and the probe Huygens. The space agencies had planned for Cassini to conduct 76 orbits of Saturn during a four-year survey of the planet and its moons. They had designed the Huygens probe to analyze the atmosphere of Titan, Saturn's largest moon. If the probe survived its descent to Titan, it would analyze the moon's surface, as well.[655]

American astronaut E. Michael Fincke and Russian cosmonaut Gennady I. Padalka successfully completed repairs to the ISS during a much-delayed spacewalk lasting 6 hours. Among the numerous repairs that Fincke and Padalka completed were the replacement of a faulty circuit breaker and the restoration of power to a gyroscope that helped stabilize the ISS. The ISS partners had rescheduled the spacewalk from 24 June 2004 because of problems with the crew members' spacesuits.[656]

JULY 2004

2 July
Scientists reported that they had produced the first three-dimensional views of the large solar eruptions known as coronal mass ejections, or CMEs. CMEs, the most powerful eruptions in the solar system, can disrupt power systems, radio communications, and satellite links with Earth. Although uncertain of the origin of these eruptions, scientists know that CMEs occur when billions of tons of electrified gas explode from the Sun's atmosphere into space at speeds of millions of miles per hour. The team had used data from ESA and from NASA's Solar and Heliospheric Observatory (SOHO) to construct the images, which they hoped would help scientists learn more about the structure of CMEs and the manner in which they affect Earth.[657]

9 July
Major media reported details of a NASA internal document, which stated that a proposed plan to use the ISS as a safe haven for Space Shuttle astronauts would likely have a high risk of failure. The NASA document was a response to a proposal that the ISS should temporarily house the Shuttle crew if a problem arose that prevented an orbiting Shuttle from returning its crew to Earth safely. In the internal document, NASA objected that the ISS had neither sufficient supplies nor support systems to keep both ISS and Shuttle crew members alive longer than a few months. NASA officials responded to the publication of the document, stating that the provisional contingency plan had been one of many ideas considered for improving Space Shuttle safety.[658]

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[655] ESA, "Cassini-Huygens Enters Orbit Around the Ringed Planet," ESA news release 36-2004, 1 July 2004; Guy Gugliotta, "Cassini First To Orbit Saturn," *Washington Post*, 1 July 2004.
[656] Mark Carreau, "Finally, Spacewalk a Success," *Houston Chronicle*, 1 July 2004; NASA, "International Space Station Status Report," news release SS04-018, 1 July 2004.
[657] ESA, "First 3D View of Solar Eruptions," ESA news release SNR 13-2004, 2 July 2004; Thomas G. Moran and Joseph M. Davila, "Three-Dimensional Polarimetric Imaging of Coronal Mass Ejections," *Science* 305, no. 5680 (2 July 2004): 66–70.
[658] John Schwartz, "NASA Rescue Plan Is Reported To Have High Risk of Failure," *New York Times*, 9 July 2004.

12 July
The FAA announced that, on 17 June 2004, it had issued a license for the United States' first inland launch site. The five-year license authorized California's East Kern Airport District, which included the Mojave Airport, to operate as a launch site for suborbital reusable launch vehicle (RLV) missions. On 21 June 2004, *SpaceShipOne* had staged the first commercial launch to outer space from Mojave Airport. The license made the Mojave Airport the fifth commercial spaceport licensed by the FAA. The other four licensed spaceports were the California Spaceport at Vandenberg Air Force Base, Spaceport Florida at Cape Canaveral Air Force Station, the Kodiak Launch Complex in Alaska, and the Virginia Spaceport at Wallops Flight Facility (WFF).[659]

13 July
The National Research Council (NRC) issued a report calling for NASA to send a Space Shuttle mission to service the HST. The report challenged Administrator Sean O'Keefe's earlier decision that NASA would not conduct a Shuttle servicing mission for the HST because of potential safety risks. According to the NRC report, if NASA did not service the orbiting telescope, it would eventually become dysfunctional and fall out of orbit. Although the report acknowledged that a Shuttle mission would pose some risks for astronauts, the NRC stated that the scientific value of continuing HST operations merited a mission, both to maintain the orbiting telescope and to upgrade its components. The report recommended that NASA should consider sending a robotic servicing mission for the HST instead of a Shuttle mission, but should not rule out sending a Shuttle servicing mission, if NASA determined that the robotic option was too costly or complex.[660]

15 July
NASA launched an Earth-observation satellite called Aura from Vandenberg Air Force Base in California at 3:01 a.m. (PDT). The spacecraft was one of three satellites in NASA's Earth Observing System (EOS)—the two others were Terra, which monitored land, and Aqua, which monitored the planet's water cycle. NASA had created Aura to collect scientific data on global air quality, ozone recovery, and climate change, equipping the satellite with four instruments: the High Resolution Dynamics Limb Sounder, the Microwave Limb Sounder, the Ozone Monitoring Instrument, and the Tropospheric Emission Spectrometer. Project engineers hoped that the instruments would enable the spacecraft to collect the most detailed measurements to date of atmospheric pollution, climate change, and the ozone layer.[661]

16 July
Engineers at NASA's SSC successfully completed the first test of the redesigned Space Shuttle Main Engine (SSME). NASA planned to use the redesigned SSME in the first Shuttle mission

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[659] FAA, "FAA Issues License for First Inland Launch Site," news release APA 29-04, 12 July 2004, *http://www.faa.gov/news/press_releases/news_story.cfm?newsid=5705* (accessed 28 January 2010).
[660] Guy Gugliotta, "Scientists Say Shuttle Can Service Telescope; Report Counters NASA Stance on Repairing Hubble," *Washington Post*, 14 July 2004; Aeronautics and Space Engineering Board and Space Studies Board, "Assessment of Options for Extending the Life of the Hubble Space Telescope" (letter report, National Academies Press, Washington, DC, 13 July 2004), *http://www.nap.edu/catalog.php?record_id=11051#toc* (accessed 28 April 2009).
[661] NASA, "Aura Launched, To Better Understand the Air We Breathe," news release 04-217, 15 July 2004; Eric D. Tytell, "Satellite To Study Atmospheric Pollutants," *Los Angeles Times*, 16 July 2004.

after the *Columbia* tragedy—the mission that NASA often called the Return to Flight Mission. The test of the SSME lasted for 520 seconds, the amount of time a Space Shuttle requires to reach orbit. Each Space Shuttle has three SSMEs—reusable rocket engines capable of generating 400,000 pounds (181,000 kilograms) of thrust.[662]

22 July

An independent panel of experts released an interim assessment of NASA's progress implementing recommendations of the *Columbia* Accident Investigation Board (CAIB). The U.S. Congress had chartered the group—formally called the Stafford-Covey Return to Flight Task Group (SCTG)—to provide independent evaluations of NASA's progress in meeting the CAIB's recommendations. The CAIB had enumerated safety and operational practices that NASA must implement before resuming Space Shuttle flights. In its interim assessment, the Task Group stated that NASA had successfully implemented two of the CAIB's recommendations: to define foreign-object debris and to create computer-accessible digital images of Shuttle hardware, taken at various stages of development and launch preparation. The Task Group would assess NASA's progress toward satisfying the other CAIB recommendations in future reports.[663]

23 July

Representatives of the space agencies of Canada, Europe, Japan, Russia, and the United States—the nations participating in the ISS project—met to discuss their cooperative activities for the station. At the meeting at ESA's Technical Centre in the Netherlands, ESA officials reviewed ISS operations and plans, unanimously endorsing a new technical configuration for the space station that would incorporate components from each of the ISS partner space agencies. Upon completion, the ISS would have improved research capabilities and would accommodate more crew members than the current maximum of three.[664]

NASA Administrator Sean O'Keefe presented the Congressional Space Medal of Honor to the families of the crew members of Space Shuttle *Challenger*. O'Keefe presented the honor in the name of the U.S. Congress and on behalf of President George W. Bush. The seven astronauts on board *Challenger* had died when the Shuttle exploded soon after launching on 28 January 1986.[665]

26 July

NASA announced its approval of a new design of the particular part of the Space Shuttle that may have critically contributed to Space Shuttle *Columbia*'s accident. The part—called a bipod

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[662] NASA, "Engineers Test the First Engine for NASA's Return to Flight Mission," news release 04-231, 19 July 2004.
[663] NASA, "Stafford-Covey Task Group Announces July 22 Public Meeting," news release N04-108, 19 July 2004; NASA, "Statement of Sean O'Keefe, Administrator, National Aeronautics and Space Administration, Before the Committee on Commerce, Science and Transportation, United States Senate" (statement of testimony, Washington, DC, 8 September 2004), *http://www.nasa.gov/pdf64686main_aok_/ 64686main_aok_ testimony_090804.pdf* (accessed 28 April 2009).
[664] NASA, "Joint Statement: International Space Station Heads of Agency Meeting," news release 04-237, 23 July 2004; Warren E. Leary, "More Astronauts Approved for Space Station," *New York Times*, 24 July 2004.
[665] NASA, "Challenger Crew Honored with Congressional Space Medal of Honor," news release S04-238, 23 July 2004.

fitting—connects a Shuttle's external fuel tanks to the orbiter during launch. The newly designed bipod fitting eliminated the use of foam covering in favor of four rod-shaped heaters, reducing the risk of falling debris during launch. Investigators believed that the *Columbia* disaster might have resulted from the impact of insulating foam, which had fallen from the bipod fitting, damaging the orbiter's left wing. According to NASA, the approval of the redesigned bipod fitting was a significant step in its efforts to resume safe Shuttle flights. Engineers would begin using the new fitting on the external tanks for the next Space Shuttle mission.[666]

29 July
A NASA-funded study found that artificial surfaces in urban areas often cause temperatures to increase, enabling longer growing seasons in cities than in surrounding rural areas. Using data from NASA's Terra satellite, a team of Boston University scientists led by Xiaoyang Zhang compared the growing seasons of 70 North American cities with those of adjacent rural areas. The scientists discovered that the growing season in urban areas lasted nearly 15 days longer than the growing season in rural areas. In addition, the data revealed that urban climates affect vegetation located up to 10 kilometers (6 miles) from urban land cover. According to the scientists, high concentrations of artificial surfaces in urban areas cause surface temperatures to be relatively higher in urban areas than in surrounding rural areas. In addition, the scientists suggested that their findings demonstrated how land use and other human activities affect Earth's environment.[667]

AUGUST 2004

2 August
Edward J. Weiler became Director of NASA's GSFC, taking over from Alphonso V. Diaz. Weiler, who had joined NASA in 1978, had served as Chief Scientist for the HST from 1979 to 1998 and as Associate Administrator for NASA's Space Science Enterprise from 1998 to July 2004. Diaz, who had served as Director of GSFC since 12 January 1998, became NASA's Associate Administrator of Science.[668]

3 August
NASA launched its MESSENGER spacecraft on a seven-year mission to study Mercury, the closest planet to the Sun. MESSENGER—Mercury Surface, Space Environment, Geochemistry, and Ranging—launched from Cape Canaveral Air Force Station in Florida at 1:16 a.m. (EDT). Six countries had provided equipment for the spacecraft, which would photograph Mercury's surface and analyze the planet's magnetic field and mineral composition. Project scientists planned to use the resulting data to determine whether Mercury's composition is similar to that of Earth, Mars, and Venus. Although the spacecraft was not the first to photograph

[666] NASA, "NASA Approves New Design for Shuttle External Tank Fitting," news release 04-240, 26 July 2004.
[667] NASA, "NASA Plays Key Role in Largest Environmental Experiment in History," news release 04-242, 27 July 2004; X. Zhang et al., "The Footprint of Urban Climates on Vegetation Phenology," *Geophysical Research Letters* 31, no. 12 (25 June 2004): L12209.
[668] NASA History Division, "NASA Center Directors," *http://www.hq.nasa.gov/office/pao/History/ director.html* (accessed 1 May 2009); NASA, "Associate Administrator for the Science Mission Directorate: Edward J. Weiler," 7 April 2008, *http://www.nasa.gov/about/highlights/weiler_biography.html* (accessed 1 May 2009); NASA, "Alphonso Diaz: Associate Administrator, Science," 4 November 2004, *http://www.nasa.gov/about/highlights/diaz_bio.html* (accessed 1 May 2009).

Mercury—NASA's Mariner 10 had photographed the planet during flybys in 1974 and 1975—MESSENGER was the first spacecraft designed to examine Mercury while orbiting the planet.[669]

ISS crew members E. Michael Fincke and Gennady I. Padalka performed a spacewalk to prepare the ISS for the arrival of new unpiloted cargo ships, scheduled to launch in late 2005. ESA had created the new cargo vessels, formally called Automated Transfer Vehicles (ATVs). Fincke and Padalka installed new communications antennas and laser reflectors to facilitate the docking of the ATVs at the ISS. During the 4½-hour excursion, the two men also replaced a circuit breaker and rotated scientific experiments.[670]

5 August

Data from NASA's Cassini spacecraft revealed a new radiation belt around Saturn. Researchers already knew that Saturn had radiation belts—ring-shaped concentrations of ionized particles—outside the orbit of the planet's rings. However, the newly discovered rings were inside Saturn's rings. Previously, scientists had thought that a radiation belt could not exist inside the planet's rings, because they believed that the rings would absorb any ionized particles that approached Saturn. The presence of radiation within the orbit of the rings indicated that the radiation belt's particles are able to move through Saturn's rings.[671]

7 August

NASA and NOAA announced that the two agencies would extend the Tropical Rainfall Measuring Mission (TRMM) by five months, effectively reversing an earlier decision to terminate the weather satellite's mission. NASA and NOAA also announced that they had requested the National Academy of Sciences to evaluate the utility of extending the satellite's mission for an additional 18 months. Launched in 1997, the TRMM—designed to measure rainfall—was a joint project of NASA and JAXA. NASA and JAXA had originally planned for the satellite's mission to last three years, but meteorologists and climate researchers, who continued to find the satellite's data highly valuable, particularly for analyzing tropical storms, had advocated to prolong the mission.[672]

10 August

NASA announced that it would commence work on a robotic mission to service the HST, reversing its earlier decision to remove the orbiting telescope from service. According to NASA, the robotic servicing mission, planned for launch in 2007, would perform maintenance and upgrades of the HST, including changing batteries and gyroscopes, repairing malfunctioning equipment, and adding new instruments. If successful, the mission would extend the operational life of the 15-year-old HST by at least five years.[673]

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[669] Mark Carreau, "Messenger Leaves on 7-Year Voyage," *Houston Chronicle*, 4 August 2004; NASA, "NASA Sending a Messenger to Mercury," news release 04-215, 15 July 2004.
[670] NASA, "International Space Station Status Report: SS04-024," news release SS04-024, 3 August 2004.
[671] John Noble Wilford, "Spacecraft Finds Belt Around Saturn Unlike Any Ever Seen Before," *New York Times*, 6 August 2004.
[672] Guy Gugliotta, "Weather Satellite Gets Reprieve for Hurricane Season," *Washington Post*, 8 August 2004.
[673] Guy Gugliotta, "NASA Plans Robotic Fix for Hubble," *Washington Post*, 11 August 2004.

11 August
The GAO published an assessment of the efforts of the DOD and the military services to develop personnel for space-related national security matters and to integrate those personnel into their forces. In the National Defense Authorization Act for FY 2004 (Pub.L.No. 108-136), the U.S. Congress had required the DOD to create a strategy to develop and integrate personnel who were capable of operating space-based systems and of developing space-related concepts, doctrine, and technology. In addition, Congress had required GAO to assess those efforts. In its report, GAO stated that the DOD did not have a plan to implement its strategy for developing and integrating space personnel. GAO also found that the military services varied in the extent to which they had implemented plans to develop and manage their space personnel. The report included recommendations to address these issues.[674]

16 August
NASA's Cassini spacecraft provided data revealing two previously unknown moons orbiting Saturn—a new total of 33 identified moons orbiting the planet. The two moons—designated S/2004-S1 and S/2004-S2, until receiving their formal names—measured 2 miles (3.2 kilometers) and 2½ miles (4 kilometers) in diameter. Because of the moons' diminutive size, scientists suspected that they might be fragments from a larger moon.[675]

26 August
A consulting firm, which NASA had hired, reported that NASA had made significant organizational reforms in its safety procedures and management culture. NASA had hired the consulting firm Behavioral Science Technology to assist in its three-year effort to implement the CAIB's recommendations. Reporting on the first anniversary of the CAIB's report, the consulting firm's chairperson Thomas R. Krause stated that NASA administrators and managers had made significant efforts to seek input from lower-ranking employees regarding safety enhancements. NASA had made the improvements in response to the CAIB's specific recommendation.[676]

30 August
Astronomers announced the discovery of three planets, comparable in size to Earth, orbiting stars outside the solar system, a finding they considered an important step in the search for life elsewhere in the universe. Although the planets have orbits too close to their stars to enable the planets to support life, all have relatively small mass, indicating that planets vary significantly in size. This discovery led the astronomers to hope that researchers might eventually discover planets as small as Earth. The three planets' masses ranged from 14 to 20 times greater than that of Earth, far smaller than planets that scientists had previously observed orbiting living stars, which have been around 50 times the mass of Earth. Three groups of astronomers had made the discoveries separately: the teams of R. Paul Butler of the Carnegie Institution, Michael Endl of

[674] U.S. Government Accountability Office, "Defense Space Activities: Additional Actions Needed to Implement Human Capital Strategy and Develop Space Personnel" (report no. GAO-04-097, Washington, DC, 11 August 2004).
[675] Mark Carreau, "Cassini Finds Two More Saturn Moons," *Houston Chronicle*, 19 August 2004; *New York Times*, "2 Little Saturn Moons," 17 August 2004.
[676] Mark Carreau, "NASA Making Recovery Following Shuttle Disaster," *Houston Chronicle*, 27 August 2004.

the University of Texas at Austin, and Michel Mayor of the Geneva Observatory in Switzerland.[677]

Astronomer Fred Lawrence Whipple, a pioneering comet researcher, died at the age of 97. Whipple, born on 5 November 1906 in Red Oak, Iowa, had begun his research at Harvard University in 1931, studying meteors and Earth's atmosphere. During his career, Whipple had contributed to many significant scientific achievements, including a meteor bumper known as the Whipple shield—a device that protects spacecraft from meteor collisions. However, Whipple was best known for research defying conventional scientific theories about comets: whereas many scientists had suspected that comets were composed of sand and rock bound by gravity, Whipple had theorized that comets are discrete bodies with a frozen nucleus that heats up and emits propulsive jets of gas and dust. Later spacecraft missions to comets had proven his theory correct.[678]

SEPTEMBER 2004

1 September
As part of its first efforts to meet the objectives of President George W. Bush's Vision for Space Exploration, NASA awarded contracts to 11 companies to provide research on human lunar exploration and the development of a vehicle to replace the Space Shuttle. The Vision for Space Exploration called for NASA to engage in human and robotic exploration of the solar system and regions beyond. NASA awarded three contracts of approximately US$1 million each to Raytheon, Science Applications International Corporation, and the SPACEHAB Corporation for preliminary studies of human lunar exploration. An additional eight companies—Andrews Space, The Boeing Company, Draper Labs, Lockheed Martin, Northrup Grumman, Orbital Sciences Corporation, Schafer, and Transformational Space Corporation—received contracts of approximately US$3 million to conduct preliminary research on human lunar exploration and on the development of a new crewed exploration vehicle.[679]

3 September
ISS crew members E. Michael Fincke and Gennady I. Padalka performed a spacewalk to conduct maintenance tasks and to prepare the ISS for the future arrival of a new cargo spacecraft. During the nearly 5½-hour spacewalk, Fincke and Padalka replaced a component of the ISS's cooling system, installed safety equipment for future spacewalks, and set up three antennas to aid the docking of ESA's Automated Transfer Vehicle (ATV), a new ISS cargo ship scheduled for launch in 2005.[680]

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[677] Dennis Overbye, "3 Planets Are Found Close in Size to Earth, Making Scientists Think 'Life'," *New York Times*, 1 September 2004; R. Paul Butler et al., "A Neptune Mass Planet Orbiting the Nearby M Dwarf GJ 436," *Astrophysical Journal* 617, no. 1 (10 December 2004): 580–588; Michael Endl et al., "HD 137510: An Oasis in the Brown Dwarf Desert," *Astrophysical Journal* 611, no. 2 (20 August 2004): 1121–1124.
[678] Adam Bernstein, "Fred L. Whipple, 97, Dies; Comet Research Pioneer," *Washington Post*, 1 September 2004.
[679] NASA, "NASA Selects Contractors for Vision for Space Exploration Studies," news release C04-s, 1 September 2004.
[680] NASA, "International Space Station Status Report: SS04-029," news release SS04-029, 3 September 2004.

8 September
NASA's Genesis space capsule returned to Earth but experienced a problematic landing, which NASA officials feared might have damaged the capsule's scientific cargo. NASA had launched Genesis in August 2001 to collect particle samples from solar winds, samples that scientists hoped would provide information about the solar system's chemical composition during its formation stages. To return Genesis to Earth, NASA had designed the capsule to release a rectangular parachute, which helicopters would grab, gently lowering the spacecraft to Earth. However, the parachute failed to deploy, and Genesis crashed into a desert area of Utah at nearly 200 miles per hour (322 kilometers per hour). Although NASA officials were uncertain about the extent of damage to the spacecraft's cargo, their initial prognosis was that researchers could still use some of the samples in scientific analyses.[681]

9 September
The ISS's main oxygen generator stopped working, but the equipment failure posed no immediate danger to the station's crew members. ISS Commander Gennady I. Padalka stated that the crew could repair the generator, which had failed on previous occasions. The malfunction did not pose an immediate threat to Padalka or his fellow crew member E. Michael Fincke, because they could access several alternative sources of oxygen stored in the orbiting space station.[682]

Scientists published research demonstrating that changes in Earth's gravitational field can affect the planet's climate and weather. Experts described the findings as an important advance in climate research. Bryon D. Tapley of the University of Texas at Austin led the team of scientists, who had discovered that changes in Earth's gravitational field are associated with changes in the distribution of water and ice masses. Their findings demonstrated that scientists could use satellite measurements of Earth's gravitational field to measure changes in the distribution of Earth's mass and to determine the causes of those changes—changes that included variations in climate and weather. In their analyses, the scientists had examined data from the Gravity Recovery and Climate Experiment (GRACE), consisting of two spacecraft that measure variations in Earth's gravitational field—a project of NASA and the German Aerospace Center.[683]

A NASA-funded study revised a fundamental idea in biological research: a concept known as the tree of life. Previously, biologists had theorized that all life had originated from three types of cells—archaea, bacteria, and eukaryotes—and had evolved in the pattern of a tree, with bacteria at the base and multicellular life forms branching out from those roots. However, the tree-of-life model did not explain the evolution of different cell types from a single cell or the merger of separate genomes, which form the branches of the tree of life. According to the new research of biologists Maria C. Rivera and James A. Lake, of the University of California at Los Angeles, two of the tree types of cells—bacteria and archaea—had merged to form the third type of cell,

[681] Guy Gugliotta, "Spacecraft Crashes with Solar Data," *Washington Post*, 9 September 2004; NASA JPL, "Genesis: Mission History—Launch," 23 June 2008, *http://genesismission.jpl.nasa.gov/gm2/mission/launch.htm* (accessed 7 May 2009).
[682] *New York Times*, "Oxygen Generator on Space Station Fails," 10 September 2004.
[683] NASA, "NASA's GRACE Gravity Mission Weighs In on Earth's Changing Climate," news release 04-286, 9 September 2004; Bryon D. Tapley et al., "GRACE Measurements of Mass Variability in the Earth System," *Science* 305, no. 5683 (23 July 2004): 503–505.

eukaryotes, encompassing all multicellular life forms, including animals, humans, and plants. The findings indicated that life had evolved in the pattern of a ring, rather than a tree. Experts described the research as a major contribution to the understanding of early evolution.[684]

15 September
NASA announced that it had made its Morning Report flight-safety software available for licensing. Scientists at NASA's ARC had created the Morning Report as part of NASA's Aviation System Monitoring and Modeling Project. The Morning Report, a flight-data-analysis software tool, could help flight-operations analysts automatically identify potentially problematic aircraft flights—flights with a high statistical probability of experiencing problems that could lead to an accident or another major problem.[685]

NASA awarded a US$814 million contract to Hamilton Sundstrand Space Systems International (HSSSI) to provide equipment and services supporting spacewalks performed by Space Shuttle and ISS crew members. Under the contract—formally called the Extravehicular Activity (EVA) Systems Contract—Hamilton Sundstrand would provide EVA hardware, training support, real-time mission support, and other products and services related to spacewalks. The contract had a five-year base period and five additional one-year options.[686]

21 September
NASA re-extended the missions of its Mars rovers by an additional six months. The two mobile robotic geological laboratories, Spirit and Opportunity, had landed on Mars in January 2004. The robotic rovers had successfully completed their primary three-month mission in April 2004, and NASA had extended their mission by five months. Because the rovers remained operable and continued to provide important scientific data on Mars, NASA officials had decided to provide funding to cover an additional six months of rover operations.[687]

23 September
Scientists revealed the first observations of the merger of two galaxy clusters, providing crucial support for a theory of the universe's formation. The scientists, led by J. Patrick Henry of the University of Hawaii, used ESA's XMM-Newton orbiting observatory to obtain data showing that the galaxy cluster Abell 754 formed from the collision of two distinct clusters. Galaxy clusters such as Abell 754 contain hundreds of galaxies and are the universe's largest gravitationally bound structures. Measurements of Abell 754's density, pressure, and temperature indicated that it is still in formation. Moreover, the evidence showed that Abell 754 had emerged from the collision of galaxy clusters, supporting the theory that the universe's hierarchical structure had resulted from small galaxies and galaxy clusters merging into relatively larger ones.[688]

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[684] NASA, "Molecular Biologists Uproot Perspective of Ancient History," news release N04-142, 9 September 2004; Maria C. Rivera and James A. Lake, "The Ring of Life Provides Evidence for a Genome Fusion Origin of Eukaryotes," *Nature* 431, no. 7005 (9 September 2004): 152–155.
[685] NASA, "NASA Develops New Tool for Airline Accident Prevention," news release 04-297, 15 September 2004.
[686] NASA, "NASA Awards Extravehicular Activity Systems Contract," news release C04-v, 15 September 2004.
[687] NASA, "Rovers Missions Renewed as Mars Emerges from Behind Sun," news release 04-307, 21 September 2004.
[688] NASA, "Massive Merger of Galaxies is the Most Powerful on Record," news release, 23 September 2004.

29 September
A privately funded rocket called *SpaceShipOne* became the first vehicle to complete a flight for the commercial spaceflight competition known as the Ansari X Prize. The X Prize competition would award US$10 million to the first private organization to create a spacecraft transporting a pilot and payload, with the equivalent weight of two passengers, to an altitude of 100 kilometers (62.1 miles) above Earth's surface, twice in two weeks. California-based Scaled Composites had built *SpaceShipOne*, and the company's founder Burt Rutan had designed the vehicle. The spacecraft left California's Mojave Airport at 7:11 a.m. (PST), affixed to another aircraft. The aircraft released *SpaceShipOne* after attaining an altitude of 48,000 feet (9.1 miles or 14.6 kilometers). Although *SpaceShipOne* had some difficulty during its ascent, the vehicle's pilot Michael W. Melvill was able to guide the vehicle to a peak altitude of 337,500 feet (63.9 miles or 102.9 kilometers). However, Scaled Composites would have to repeat the feat within the subsequent two weeks to win the Ansari X Prize.[689]

OCTOBER 2004

4 October
SpaceShipOne became the first privately developed, piloted spacecraft to exceed an altitude of 100 kilometers (62.1 miles) twice within 14 days, thus winning the Ansari X Prize competition. The spacecraft launched at 7:00 a.m. (PST) from Mojave Airport in California. During the flight, the spacecraft's pilot Brian Binnie set an unofficial world record for altitude for a private spacecraft, reaching 367,442 feet (69.6 miles or 112 kilometers) above Earth's surface. The founder of the X Prize competition, California entrepreneur Peter H. Diamandis, had modeled the Ansari X Prize on the Orteig Prize, which Charles A. Lindbergh had won in 1927 for completing the first nonstop flight from New York to Paris. To win the competition and its US$10 million award, a private team had to launch a spacecraft with a pilot and an equivalent weight of two passengers to an altitude of 100 kilometers (62.1 miles) twice within two weeks. California-based Scaled Composites had built *SpaceShipOne*, company founder Burt Rutan had designed the spacecraft, and Microsoft cofounder Paul G. Allen had financed the project.[690]

NASA scientists reported that many of the samples from the Genesis space capsule had survived the spacecraft's crash on 8 September 2004. NASA had launched Genesis in 2001 to obtain particle samples from solar winds, planning to use the particles in a study of the chemical composition of the solar system during its creation billions of years ago. However, Genesis's sample-return capsule had failed to land on Earth as planned. Instead, it had crashed into the Utah desert, risking the destruction of the particle samples. However, although the crash had complicated the extraction and processing of the capsule's fragile, wafer-like, sample-collection plates, NASA scientists had found many of the samples intact and usable for subsequent analyses.[691]

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[689] Scaled Composites, "SpaceShipOne Surpasses 100 Km Altitude on First X-Prize Flight," news release, 29 September 2004; Peter Pae, "Craft Rolls On into Space in Bid for Prize," *Los Angeles Times*, 30 September 2004.
[690] X PRIZE Foundation, "Ansari X PRIZE," *http://space.xprize.org/ansari-x-prize* (accessed 12 May 2009); Scaled Composites, "SpaceShipOne Captures X-Prize," 4 October 2004, *http://www.scaled.com/projects/tierone/041004_spaceshipone_x-prize_flight_2.html* (accessed 12 May 2009); John Schwartz, "Private Rocket Ship Earns $10 Million in New Space Race," *New York Times*, 5 October 2004.
[691] Warren E. Leary, "Space Specimens Saved from Wrecked Capsule," *New York Times*, 5 October 2004.

Former astronaut Leroy Gordon Cooper died at age 77 in Ventura, California. One of the original seven astronauts for the Mercury program, the United States' first human spaceflight program, Cooper was born in Shawnee, Oklahoma, on 6 March 1927. He had joined the U.S. Air Force in 1949, and NASA had selected him as a Mercury astronaut in April 1959. In May 1963, Cooper had piloted the program's last mission, which lasted 34 hours and 20 minutes—longer than all the combined duration of all previous Mercury missions. Cooper had made his second and final trip to space on *Gemini 5* in August 1965, in a two-person mission that had set a record for space endurance of 191 hours. The mission had demonstrated that humans could survive in a weightless environment and, therefore, that a trip to the Moon was feasible. In addition, Cooper had been the first American astronaut to make two spaceflights, to sleep in space, and to appear in a televised broadcast from space. After retiring from the Air Force in 1970, he had run several companies, including a consulting firm specializing in projects ranging from aerospace to hotel development.[692]

10 October

Maxime A. Faget, who had contributed to the designs of every U.S. spacecraft built to transport humans from *Mercury* to the Space Shuttle, passed away at age 83 in Houston, Texas. Born on 26 August 1921 in British Honduras, Faget had graduated with a degree in mechanical engineering from Louisiana State University in 1943. He had begun his career with NASA in 1946 as a research scientist at the NASA's LaRC in Hampton, Virginia. In 1958 he had joined the Space Task Group—later, NASA's JSC—where he had helped to design the spacecraft for the Mercury project and had led a team studying the feasibility of a lunar mission. Faget had also worked on the original feasibility study for the Space Shuttle, later contributing to the development of the Shuttles. After retiring from NASA in 1981, Faget had helped found Space Industries Incorporated, a private space company that had developed a Shuttle project for processing material in a near-perfect vacuum.[693]

13 October

The crew of Expedition 10 left for the ISS aboard the Russian *Soyuz* TMA-5/ISS-9S, which launched from Baikonur Cosmodrome in Kazakhstan at 11:06 p.m. (EDT). The crew members were American astronaut Leroy Chiao and Russian cosmonauts Yuri G. Shargin and Salizhan S. Sharipov. Chiao and Sharipov would stay at the ISS until April 2005, and Shargin would spend eight days on the ISS, returning to Earth with the crew of Expedition 9.[694]

18 October

Scientists announced research demonstrating that planets form according to a different process than scientists had previously thought. Comparing recent observations from NASA's Spitzer Space Telescope (SST) with data obtained earlier from other satellites, George H. Rieke of the University of Arizona at Tucson had led a team of scientists examining images of the dust clouds surrounding 266 stars of similar size. The prevailing theory of planetary formation held that small rocky planets collide to form larger planets, and the collisions produce a substantial

[692] John Johnson, "Leroy Gordon Cooper Jr., 77," *Los Angeles Times*, 5 October 2004; Matthew L. Wald, "Gordon Cooper, Astronaut, Is Dead at 77," *New York Times*, 5 October 2004.
[693] NASA, "Legendary Spacecraft Designer Dr. Maxime A. Faget Dies at 83," news release 04-350, 10 October 2004.
[694] NASA, "International Space Station Status Report: SS04-035," news release SS04-035, 13 October 2004.

quantity of dust, which steadily fades away over time. However, the team's SST observations had significantly challenged that theory, revealing that some relatively younger stars have no surrounding dust clouds and that older stars tend to have large, bright discs of orbiting dust. The presence of dust clouds around the older stars indicated that planetary collisions continue far after initial planetary formation. The team concluded that planetary formation is a longer and more chaotic process than scientists had previously assumed.[695]

21 October
NASA Administrator Sean O'Keefe announced the immediate appointment of James B. Garvin as NASA's new Chief Scientist. Garvin had previously served as Chief Scientist for NASA's lunar and Mars exploration programs. As Chief Scientist for all of NASA, Garvin would be responsible for ensuring the scientific merits of NASA's programs, including formulating the programs' scientific requirements. Garvin replaced former astronaut John M. Grunsfeld, who had served in the post since September 2003. NASA had selected Grunsfeld to train as an astronaut for a future long-duration mission.[696]

Scientists published the first direct evidence of one of the fundamental elements of Einstein's theory of general relativity: an effect known as *frame dragging*. Frame dragging—the distortion of space and time around rotating celestial bodies, such as Earth—occurs because the gravity of those objects pulls space and time along with them. Ignazio Ciufolini of the University of Lecce in Italy and NASA scientist Erricos C. Pavlis of GSFC had measured distortions in the orbits of the Laser Geodynamics Satellites, LAGEOS and LAGEOS2, to obtain the evidence of frame dragging. They had discovered that, although irregularities in Earth's surface account for some of the variation in the satellites' orbits, the remainder of the variation is the effect of space-time distortions.[697]

23 October
Brazil successfully launched its first rocket from the Alcântara launch site in the state of Maranhão. The two-stage rocket called the Veículo de Sondagem Booster-30 (VSB-30)—Spanish for Sounding Booster Vehicle—was 12.6 meters (41.3 feet) long, had a total mass of 2,570 kilograms (5,666 pounds), and was capable of carrying a payload of up to 400 kilograms (882 pounds). According to Brazilian officials, the government expected to sell up to 15 of the rockets to ESA.[698]

24 October
The crew of Expedition 9 returned to Earth aboard a Russian *Soyuz* capsule, landing in Kazakhstan at 6:36 a.m., local time. American astronaut E. Michael Fincke and Russian cosmonaut Gennady I. Padalka had spent 188 days at the ISS, where they had performed four

[695] NASA, "Astronomers Discover Planet Building Is Big Mess," news release 04-347, 18 October 2004; John Noble Wilford, "A New Look at How Planets Are Formed," *New York Times*, 19 October 2004.
[696] NASA, "NASA Administrator Names New Chief Scientist," news release 04-349, 21 October 2004.
[697] NASA, "As the World Turns, It Drags Space and Time," news release 04-351, 21 October 2004; Guy Gugliotta, "Theory of Relativity Evidence Found," *Washington Post*, 22 October 2004.
[698] *Los Angeles Times*, "Brazil Succeeds in Sending First Rocket to Space," 24 October 2004; Agénica Espacial Brasileira [Brazilian Space Agency], "Foguetes de Sondagem [Survey of Rockets]," *http://www.aeb.gov.br/indexx.php?secao=lancadores* (accessed 14 November 2009).

spacewalks. Returning with them was Russian cosmonaut Yuri G. Shargin, who had traveled to the ISS on 13 October 2004 with the crew members of Expedition 10.[699]

26 October
The Cassini-Huygens spacecraft completed the closest approach ever made to Titan, Saturn's largest moon, as well as the only moon in the solar system known to have an atmosphere. Soon after Cassini pierced Titan's viscous atmosphere, the spacecraft beamed images of the moon's surface to mission scientists at NASA's JPL. ESA, the Italian Space Agency, and NASA had launched the mission in 1997 to study Saturn and its moons. Even though it is too cold to support life, scientists remain greatly interested in Titan, because they suspect that conditions on the planet are similar to those on Earth before the development of life.[700]

NOVEMBER 2004

1 November
Rex D. Geveden became Chief Engineer and Director of NASA's Independent Technical Authority. Administrator Sean O'Keefe had appointed Geveden as Chief Engineer on 14 October 2004. The Office of Chief Engineer was responsible for ensuring that NASA planned and conducted its development efforts and missions operations on a sound engineering basis. The Chief Engineer reported the overall review and technical readiness of all NASA programs directly to the Administrator. Geveden, who had been Deputy Director of NASA's MSFC since July 2003, succeeded the retiring Theron Bradley Jr., who had served in the post since June 2002.[701]

8 November
NASA scientists published research showing that the El Niño Southern Oscillation (ENSO) is the single most important factor in interannual rainfall variability throughout the world. The scientists had used data from the Tropical Rainfall Measuring Mission (TRMM) satellite to identify geographic areas with the greatest variations in rainfall between 1998 and 2002. After comparing the TRMM data with rainfall patterns over the previous 50 years, they had found that changes in the ENSO directly correlated with local changes in rainfall patterns around the world. The TRMM satellite, a joint project of NASA and JAXA, used microwaves to measure precipitation over the tropics.[702]

15 November
Scientists from NASA's ARC and Yale University announced that they had designed a complete map of gene activities in human tissue. The researchers had affixed pieces of deoxyribonucleic acid (DNA) sequences from the human genetic blueprint—known as the genome—to specially patterned glass slides. Using these slides, they had measured levels of ribonucleic acid—biochemical copies of DNA, which activating genes produce to make proteins. Among

[699] Mark Carreau, "Station Crew Returns to Earth," *Houston Chronicle*, 24 October 2004; Stefano S. Coleman, "Two Safely Back After 6 Months on Space Station," *New York Times*, 24 October 2004.
[700] ESA, "Cassini-Huygens Makes First Close Approach to Titan," ESAnews release, 26 October 2004.
[701] NASA, "NASA Names Rex Geveden New Chief Engineer," news release 04-344, 14 October 2004.
[702] NASA, "TRMM Satellite El Niño Holds the Reins on Global Rains," news release 04-369, 8 November 2004; Z. S. Haddad et al., "Global Variability of Precipitation According to the Tropical Rainfall Measuring Mission," *Journal of Geophysical Research—Atmospheres* 109, no. D17 (16 September 2004): D17103.

their findings, the scientists had discovered that certain DNA sequences, which they had previously believed are nonfunctioning, are actually functioning—they are encoding active genes. The NASA scientists hoped their results would enable other researchers to analyze genes for human diseases and to develop new treatments for them. In addition, their research had a specific benefit for NASA: the NASA scientists hoped it would help them understand how human genes respond to spaceflight, so that they would be better able to protect the health of astronauts.[703]

16 November

NASA's X-43A research vehicle established an unofficial world speed record for aircraft of nearly 7,000 miles per hour (11,265 kilometers per hour) or Mach 10—10 times the speed of sound. The X-43A contained an experimental engine—called a supersonic combustion ramjet or scramjet. The scramjet engine had no moving parts and did not use fuel from an on-board tank, as is the case with rockets. Instead, the engine used oxygen from the atmosphere, passing through the vehicle, to ignite fuel. NASA had explored the use of scramjets as an alternative to rocket power for space-access vehicles, with the hope that scramjet vehicles would operate more like an airplane than a rocket. The mission lifted off from NASA's DFRC at Edwards Air Force Base in California at 2:30 p.m. (PST). A NASA B-52 carried the unpiloted X-43A to an altitude of 40,000 feet (7.6 miles or 12.2 kilometers). Before the X-43A had attained at an altitude of 111,000 feet (21 miles or 33.8 kilometers), a Pegasus rocket booster launched from the B-52, providing an initial acceleration that enabled the X-43A to attain an altitude of 111,000 feet (21 miles or 33.8 kilometers). The experimental aircraft flew for nearly 10 seconds at that altitude before descending into the Pacific Ocean as planned, nearly 800 miles (1,287 kilometers) off the coast of California.[704]

The SMART-1 spacecraft, the first of ESA's Small Missions for Advanced Research in Technology (SMART), successfully completed its first orbit of the Moon. ESA had launched SMART-1 in September 2003 to study the Moon's surface. SMART-1 was noteworthy for its use of a host of techniques and technologies to reach lunar orbit—including a solar-electric propulsion system or ion engine, which made the journey of 52.2 million miles (84 million kilometers) from Earth to the Moon using only 130 pounds (59 kilograms) of the 181 pounds (82 kilograms) of xenon fuel that it had carried. That fuel consumption rate was equivalent to more than 5 million miles per gallon. The 809-pound (367-kilogram) spacecraft was able to achieve this rate of fuel efficiency using solar panels. During 13 months of expanding orbits around Earth, the solar panels had charged the xenon gas atoms, providing the spacecraft with occasional thrusts. ESA hoped to replace conventional propulsion systems—which were either too expensive or incapable of fulfilling the same objective—with the new solar-panel technology, to propel future spacecraft further into space.[705]

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[703] NASA, "NASA Scientists Help Create Complete Human Genome Activity," news release 04-376, 15 November 2004; Viktor Stolc et al., "A Gene Expression Map for the Euchromatic Genome of Drosophila Melanogaster," *Science* 360, no. 5696 (22 October 2004): 655–660.

[704] John Johnson, "X-43A Aircraft Sets Speed Record at 6,500 MPH," *Los Angeles Times*, 17 November 2004; NASA, "NASA's X-43A Scramjet Breaks Speed Record," news release 04-373, 16 November 2004.

[705] ESA, "Europe Reaches the Moon," ESA news release 60-2004, 16 November 2004, *http://www.esa.int esaCP/SEM2S8WJD1E_index_0.html* (accessed 2 February 2010); David Rising for Associated Press, "Europe's First Moon Mission Successful," 17 November 2004.

19 November
NASA hosted representatives from 30 countries—including China—in talks about how to accomplish President George W. Bush's Vision for Space Exploration. Experts and participants described Chinese participation in the talks as a small but significant advance toward the goals of global security and space exploration—China's presence at the talks indicated its interest in collaborating with other countries, particularly the United States. According to analysts, Chinese contributions to space exploration could include expendable rockets, piloted spacecraft, and space robotics.[706]

20 November
NASA launched the Swift satellite from the Cape Canaveral Air Force Station in Florida. NASA and an international team of participants had designed the spacecraft to detect and analyze gamma-ray bursts (GRBs)—ephemeral explosions that occur throughout the universe, usually far from Earth. GRBs may indicate a number of significant cosmological events, such as the collision of extremely dense celestial bodies or the formation of black holes. Swift was equipped with three telescopes to study GRBs, including the Burst Alert Telescope, which could detect and locate GRBs, and the X-ray Telescope (XRT) and Ultraviolet/Optical Telescope (UVOT), two telescopes that could study the bursts' afterglows. Among the many participants in the Swift mission were the Italian Space Agency and the Particle Physics and Astronomy Research Council of the United Kingdom.[707]

Donald R. Puddy, longtime NASA Flight Director who had supervised numerous human spaceflight missions, died at the age of 67 in Houston, Texas. Born in Oklahoma, Puddy had joined NASA's JSC in 1964 and had spent 22 years at JSC's Mission Control Center. Puddy was only the 10th person to become a NASA flight director. He had later served in many other positions at NASA's JSC, ARC, and Headquarters. As JSC Flight Director, Puddy had led flight-control teams during the Apollo Program, the Apollo-Soyuz Test Project, and the Skylab missions, as well as serving as Flight Director for the first Space Shuttle mission. He had also created and managed projects related to aircraft-safety procedures and had played a significant role in early cooperative efforts between the space programs of the United States and the U.S.S.R. Among the numerous awards Puddy had received for his achievements were the Presidential Medal of Freedom and the NASA Outstanding Leadership Medal.[708]

23 November
NASA announced the crew for ISS Expedition 11, a six-month mission set to launch in April 2005. Russian cosmonaut Sergei K. Krikalev would serve as Station Commander, and American astronaut John L. Phillips would serve as Flight Engineer and ISS Science Officer. In 2000 Krikalev, who had experienced the most spaceflights of any Russian cosmonaut, had served as a member of the first ISS crew for Expedition 1. Phillips also had ISS experience as a member of

[706] Mark Carreau and Patty Reinert, "NASA Makes First Overture to China," *Houston Chronicle*, 19 November 2004.
[707] NASA, "NASA Successfully Launches Swift Satellite," news release 04-382, 22 November 2004; *New York Times*, "NASA Starts Hunt for Celestial Bodies," 21 November 2004.
[708] Mark Carreau, "Donald Puddy, Veteran NASA Flight Director," *Houston Chronicle*, 24 November 2004; NASA JSC, "NASA Honors Memory of Mission Control Veteran Don Puddy," news release J04-054, 23 November 2004.

Mission STS-100 in 2001. The backup crew members for Expedition 11 were American astronaut Daniel M. Tani and Russian cosmonaut Mikhail V. Tyurin.[709]

DECEMBER 2004

1 December
A NASA-funded study revealed evidence of newly discovered relationships between climate change, ice sheets, and sea-level rise. Researchers led by Ian R. Joughin of NASA's JPL found that, between 1992 and 2003, the speed of the ice movements of Greenland's Jakobshavn Isbræ glacier—which has the fastest flow of ice from land to ocean of any glacier—had doubled. The increased ice flow from this single glacier had led to nearly a 4 percent increase in the rate of global sea-level rise during the 20th century. Furthermore, remote-sensing data from Canadian, European, and NASA satellites indicated that the glacier's accelerated ice flow was largely the result of the warming of Earth's climate.[710]

8 December
The National Research Council (NRC) issued a report outlining recommendations for servicing the HST. The issue of servicing the HST had initiated a public discussion in January 2004, when NASA had decided to cancel a Shuttle mission to service the HST because of concern for astronaut safety. The debate had erupted again after April 2004, when NASA had announced that it would conduct an unpiloted servicing mission for the HST. In response to criticism for those decisions, NASA had requested that the NRC evaluate servicing options for the HST. The NRC recommended that NASA service the HST using a piloted Shuttle mission, because a robotic mission would be too complex for NASA to complete before 2007, when NASA anticipated that the HST's machinery would wear out. According to the guidelines recommended by the CAIB, astronauts would be able to service the HST by 2007. The NRC also reported that, if NASA carefully planned and conducted the piloted Shuttle mission, the mission would be far more likely to extend the telescope's operational life at a relatively lower cost.[711]

9 December
NASA officials announced that the crew members of the ISS were experiencing a food shortage and would have to eat less until a Russian supply capsule could bring additional food supplies. Russia had scheduled the resupply capsule to arrive at the ISS on 25 December 2004, but if it missed the delivery, crew members Leroy Chiao and Salizhan S. Sharipov would have to return to Earth aboard the Russian *Soyuz* capsule docked at the ISS. NASA also noted that, if the crew members had to evacuate the space station, Russia and the United States could continue to operate the ISS from Earth. Officials cited a number of reasons for the supply shortage on the ISS, including the postponement of regular supply missions after the *Columbia* accident and the

[709] NASA JSC, "Next International Space Station Crew Named," news release H04-383, 23 November 2004.
[710] NASA, "NASA Study Finds Glacier Doing Double Time," news release M04-192, 1 December 2004; Ian Joughin, Waleed Abdalati, and Mark Fahnestock, "Large Fluctuations in Speed on Greenland's Jakobshavn Isbræ Glacier," *Nature* 432, no. 7017 (2 December 2004): 608–610.
[711] Guy Gugliotta, "Astronauts Acceptable, Panel Says," *Washington Post*, 9 December 2004; National Research Council, *Assessment of Options for Extending the Life of the Hubble Space Telescope: Final Report* (Washington, DC: National Academy Press, 2005).

necessary removal of some food supplies from an August 2004 resupply flight, to make room for equipment to monitor air quality in the ISS.[712]

13 December
NASA Administrator Sean O'Keefe submitted his resignation in a handwritten letter to President George W. Bush. In his resignation, O'Keefe stated that he would continue serving as Administrator until Bush had named a successor, but that he would prefer to leave by February 2005. O'Keefe cited family commitments and his interest in pursuing better economic opportunities as the reasons for his resignation. Major media speculated about candidates to replace O'Keefe, but the White House provided no details about its choice for a successor. Before becoming NASA's Administrator in December 2001, O'Keefe had worked for the OMB.[713]

15 December
U.S. federal government agencies released details of a long-term business strategy for the development of the Next Generation Air Transportation System—NextGen. The air traffic system NextGen encompassed a collection of infrastructural, policy, and technological efforts to address air traffic control, security, and other air-transportation concerns, which the U.S. government expected would increase with the continued growth in U.S. air traffic. In 2003 the U.S. Congress had created the Joint Planning and Development Office to coordinate public and private efforts to create and implement NextGen. The federal agencies participating in the effort included NASA and the Departments of Commerce, Defense, Homeland Security, and Transportation. The newly released NextGen strategy did not provide specific recommendations on NextGen; rather, it outlined objectives and requirements according to eight subject areas, including airport infrastructure development, security, and weather forecasting.[714]

16 December
An independent panel of experts provided its interim assessment of NASA's efforts to meet the CAIB's requirements for resuming Space Shuttle flights. NASA had chartered the Stafford-Covey Return to Flight Task Group (SCTG) to assess independently its implementation of the CAIB's preflight recommendations—mandatory for NASA's resuming Space Shuttle flights. The 26-member Task Group, headed by former astronauts Thomas P. Stafford and Richard O. Covey, stated that it had approved NASA's compliance plans for eight of the CAIB's 15 requirements. The task force did not see any major obstacles to NASA's resuming Shuttle flights by May or June of 2005. The Task Group also noted, however, that NASA continued to have difficulty developing methods to repair the exterior heat tiles and thermal-resistant carbon-fiber material damaged during Shuttle flights.[715]

NASA awarded Jacobs Sverdrup a five-year, US$1.2 billion contract to provide engineering and scientific products and support services at NASA's JSC. Under the contract, Jacobs Sverdrup

[712] Mark Carreau, "Space Station Crew Endures Food Shortage," *Houston Chronicle*, 10 December 2004.
[713] Guy Gugliotta, "NASA Chief Formally Steps Down," *Washington Post*, 14 December 2004; Warren E. Leary, "NASA Leader Cites Finances and Submits His Resignation," *New York Times*, 14 December 2004.
[714] NASA, "Roadmap for Future of Air Transportation Announced," news release 04-399, 15 December 2004; Joint Planning and Development Office, "NextGen," *http://www.jpdo.gov/nextgen.asp* (accessed 4 June 2009).
[715] Warren E. Leary, "Panel Sees Shuttle Flights Resuming Soon," *New York Times*, 17 December 2004.

would provide engineering products and services to support the ISS, Space Shuttles, planetary missions, and numerous other NASA programs. In addition, the company would provide those services to JSC's Engineering Directorate and Astromaterials Research and Exploration Science Office.[716]

A NASA-funded study provided the first direct evidence that aerosols affect the absorption and release of carbon by ecosystems. Because carbon, in the form of carbon dioxide in the atmosphere, acts as a heat-trapping greenhouse gas, the research team sought to identify the factors that influence carbon transfer between the atmosphere and soils. Led by Dev S. Niyogi of North Carolina State University, the scientists had used NASA satellite data to examine atmospheric aerosol content and carbon absorption in different ecosystems. They had discovered that high aerosol levels increase carbon absorption in croplands and forests but decrease carbon absorption in grasslands. The researchers suggested that this variation occurs because of the way that aerosols interact with different types of vegetation canopies to affect the dispersion of radiation from sunlight. In the dense vegetation canopies of croplands and forests, aerosols scatter sunlight in a manner that enables more radiation to reach a greater quantity of plant leaves and increases carbon absorption through plant photosynthesis. However, in the less dense vegetation canopy of grasslands, aerosols scatter sunlight in a manner that raises ground temperatures, causing the soil to release more carbon dioxide.[717]

21 December

Researchers using images from NASA's Galaxy Evolution Explorer (GALEX) found evidence of dozens of newly forming galaxies, a discovery that challenged prevailing scientific understanding of the creation of galaxies. Many astronomers believe that the universe began 13.7 billion years ago after a massive explosion of dense matter—an event often referred to as the Big Bang—and that galaxy and star formation peaked around 8 to 10 billion years ago. However, the researchers using the GALEX data had found evidence of 36 massive galaxies, ranging in age from 100 million to 1 billion years old and producing stars at a prodigious rate. The findings suggested that the new formation of galaxies had not ended as early as scientists had believed, and that the peak of galaxy formation had occurred later than previously thought.[718]

22 December

NASA announced the selection of six proposals to provide research and payload instruments for the Lunar Reconnaissance Orbiter (LRO), the first spacecraft that NASA would build under the new Vision for Space Exploration. NASA planned the LRO as a robotic mission, which would orbit near the Moon, obtaining measurements to use in planning future human and robotic landing sites. The selected proposals included remote-sensing instruments, such as the Lunar Orbiter Laser Altimeter, which would conduct high-resolution measurements of landing-site

[716] NASA, "NASA Awards Engineering and Science Contract," news release c04-dd, 16 December 2004.
[717] NASA, "NASA Study Finds Tiny Particles in Air May Influence Carbon Sinks," news release 04-394, 16 December 2004; D. Niyogi et al., "Direct Observations of the Effects of Aerosol Loading on Net Ecosystem CO_2 Exchanges over Different Landscapes," *Geophysical Research Letters* 31, no. 20 (29 October 2004): L20506.
[718] Dennis Overbye, "Three Dozen New Galaxies Are Found in Nearby Space," *New York Times*, 22 December 2004; NASA, "Aging Universe May Still Be Spawning Massive Galaxies," news release 04-405, 21 December 2004.

slopes, and the Lunar Exploration Neutron Detector, which would measure the Moon's radiation.[719]

23 December
The Russian Space Agency launched Progress-M 51/ISS-16P, an automatic cargo vehicle, on a Soyuz-U rocket from Baikonur Cosmodrome in Kazakhstan at 10:19 p.m. (GMT). Progress-M 51, bound for the ISS, carried 2.75 tons (2,500 kilograms or 2.5 tonnes) of equipment, fuel, food, and water.[720]

A NASA study revealed that clouds that form from small haze particles do not reduce Earth's temperatures as much as previous research had suggested. Scientists had thought that low-lying clouds cool Earth by reflecting sunlight away from the planet's surface, and that the reflectivity of clouds increases as their volume of water increases. However, NASA scientist Andrew S. Ackerman led a group of researchers who found that polluted, low-lying clouds neither hold more water nor reflect more solar energy than do cleaner clouds. Using measurements from polar-orbiting satellites and from NASA aircraft flying through clouds, the scientists discovered that water tends to decrease in polluted clouds, rather than to increase. Because most predictions of climate change had incorrectly assumed that polluted clouds counteract greenhouse warming, this finding could significantly influence how scientists predict changes in climate.[721]

25 December
NASA's Cassini orbiter successfully released ESA's Huygens probe on a controlled course to Saturn's largest moon Titan. ESA, NASA, and the Italian Space Agency had created the Cassini-Huygens mission to study Saturn and its moons, scheduling the Huygens probe—specifically designed to analyze Titan's atmosphere and surface—to enter the moon's atmosphere in January 2005.[722]

JANUARY 2005

1 January
NASA's Cassini spacecraft made a close pass of Saturn's moon Iapetus, flying within 123,400 kilometers (76,677 miles) on its closest approach, and coming about 10 times closer to the moon than Voyager 2 had come in 1981. Cassini's closest approach had occurred over the moon's mysterious dark terrain, which scientists had never before seen at close range. Scientists described the dark coating, the origin of which was unknown, as rich in carbon-based molecules. The dark terrain blankets the side of Iapetus that leads in the direction of the orbital motion

[719] NASA, "NASA Selects Investigations for Lunar Reconnaissance Orbiter," news release 04-407, 22 December 2004.
[720] *Spacewarn Bulletin*, no. 614, 1 January 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx614.html* (accessed 5 June 2009).
[721] Andrew S. Ackerman et al., "The Impact of Humidity Above Stratiform Clouds on Indirect Aerosol Climate Forcing," *Nature* 432, no. 7020 (23–30 December 2004): 1014–1017; NASA, "NASA Finds Polluted Clouds Hold Less Moisture and Cool Earth Less," news release 04-404, 23 December 2004.
[722] ESA, "Huygens Begins Its Final Journey into the Unknown," ESA news release 67-2004, 25 December 2004, *http://www.esa.int/esaCP/SEMVR53AR2E_index.html* (accessed 2 February 2010).

around Saturn. Voyager's best images of Iapetus had a resolution of 8 kilometers (4.97 miles) per pixel, but Cassini had produced a resolution of about 1 kilometer (0.6 mile) per pixel.[723]

5 January
NASA announced that the Chandra X-ray Observatory had detected the most powerful eruption measured in the universe to date, generating a supermassive black hole that is growing at a remarkable rate. The eruption in the galaxy cluster MS 0735.6+7421 had been in process for more than 100 million years, generating energy equal to that of hundreds of millions of gamma-ray bursts (GRBs). In the past, scientists had usually detected the rapid growth of supermassive black holes by observing very bright radiation from galaxies. However, MS 0735.6+7421 had no detectable bright, central radiation, and the galaxy cluster's radio jets were faint. Chandra's x-ray observations of the hot cluster gas had revealed the true nature of the black hole. Michael R. Wise of the Massachusetts Institute of Technology remarked that, until Chandra had captured this information, scientists had no idea that the black hole was "gorging itself." Chandra's discovery demonstrated that, to observe and understand some of the most violent events in the universe, astronomers need x-ray telescopes.[724]

6 January
The ISS Expedition 10 crew, comprising Leroy Chiao and Salizhan S. Sharipov, successfully reactivated the station's Elektron oxygen generator, which had shut down on 1 January because of air bubbles in the system's lines. Flight Engineer Sharipov made three unsuccessful attempts to repair the Russian-built unit. While the ISS crew continued to work on the problem, flight controllers in Russia used oxygen stores aboard the Progress 16 supply ship to repressurize the station. Russian engineers then instructed the crew to hook up a backup liquid unit to infuse fresh electrolytes into the oxygen generator's system. The crew reactivated the Elektron generator without incident. Engineers planned to monitor the system's performance to ensure that it continued to function properly.[725]

The White House Office of Science and Technology released the Vision for Space Exploration, the new policy for transportation in space and the first wholesale revision of space policy since 1994. The new policy detailed broad principles and national security goals for providing access to space for military satellites, spy spacecraft, and other government missions, emphasizing the creation of a robust program for space exploration. The policy called for astronauts to return to the Moon by 2020, planned for future human missions to Mars, and supported the commercialization of large parts of the space industry. Under the new policy, the government would fund Boeing Company and Lockheed Martin Corporation rockets to launch government satellites through the end of the decade. At that time, the White House expected that the private sector would have developed launchers that were less costly and more flexible. The policy also reiterated President George W. Bush's plan for the retirement of the Space Shuttle at the completion of ISS construction—estimated to occur at the end of the decade. The projected

[723] *BBC News*, "Cassini Passes 'Two-Faced' Moon," 3 January 2005.
[724] NASA, "Most Powerful Eruption in the Universe Discovered," news release 05-004, 5 January 2005, *http://www.nasa.gov/home/hqnews/2005/jan/HQ_05004_chandra.html* (accessed 11 May 2009).
[725] Tariq Malik, "Repaired Oxygen Generator Fails Again Aboard ISS," *Space.com*, 5 January 2005, *http://www.space.com/missionlaunches/exp10_elektron_050104.html* (accessed 18 August 2009); William Harwood, "Space Station's Oxygen Generator Back in Action," *Spaceflight Now*, 6 January 2005.

retirement of the fleet required that the DOD and NASA recommend the best option for replacing the Space Shuttle. According to the new policy, the two agencies would work closely to determine long-term funding plans. In addition, the agencies would use heavy-lift rockets, which the military was developing, for satellites and other robotic missions.[726]

NASA announced the completion of the most extensive global topographic map ever created, using data collected during *Endeavour*'s Shuttle Radar Topography Mission (SRTM) in February 2000. NASA and the National Geospatial-Intelligence Agency (NGA) had processed the collected data for more than four years, creating digital elevation maps that encompassed 80 percent of Earth's landmass and revealed, for the first time, large, detailed swaths of topography previously obscured by persistent cloud cover. The data covered Australia and New Zealand in unprecedented, uniform detail, as well as the more than 1,000 islands comprising much of Polynesia and Melanesia in the South Pacific and the islands in the South Indian and Atlantic oceans, including many that geographers had never topographically mapped. The low topography typical of the islands makes them vulnerable to tidal effects, storm surges, and long-term rise in sea level. Mission Project Scientist at NASA's JPL, Michael Kobrick, remarked that the maps would help mitigate the effects of future disasters of the magnitude of the Indian Ocean tsunami, because scientists would now be able to see where rising waters would go. Kobrick also commented that the SRTM was among the most significant missions the Shuttle had performed and, probably, the most significant mapping mission of any single type.[727]

11 January

James D. Wetherbee, the only U.S. astronaut to command five Space Shuttle flights, announced his plans to retire from NASA. Wetherbee had participated in six Space Shuttle missions since becoming an astronaut in 1984, serving as pilot aboard Mission STS-32 in 1990 and commanding STS-52 in 1992, STS-63 in 1995, STS-86 in 1997, STS-102 in 2001, and STS-113 in 2002. His missions had included flights both to the Russian *Mir* space station, including the first Shuttle–*Mir* rendezvous, and to the ISS. Just before retiring, Wetherbee had worked as Space Shuttle Lead in the Independent Technical Authority at NASA's JSC, a group responsible for identifying and analyzing possible hazards and determining launch readiness. Wetherbee had also served for two years as Director of Flight Crew Operations at JSC and for five years as Deputy Director of JSC.[728]

12 January

The NASA probe known as Deep Impact launched aboard a Delta 2 rocket from Cape Canaveral in Florida, on its mission to Comet Tempel One. The craft carried an impactor, intended to collide with the comet to create a crater about 100 meters (328 feet) wide and 28 meters (92 feet) deep, as well as two instruments designed to observe the impact and its aftermath in visible and

[726] U.S. Office of Science and Technology Policy, "U.S. Space Transportation Policy Fact Sheet," 6 January 2005, *http://www.spaceref.com/news/viewsr.html?pid=15010* (accessed 18 August 2009); Gwyneth K. Shaw, "Space Policy Goes Private," *Orlando Sentinel* (FL), 7 January 2005; Amy Pasztor, "White House Releases New Space Strategy," *Wall Street Journal*, 7 January 2005.

[727] NASA, "NASA Goes 'Down Under' for Shuttle Mapping Mission Finale," news release 05-007, 6 January 2005, *http://www.nasa.gov/home/hqnews/2005/jan/HQ_05007_srtm_update.html* (accessed 11 May 2009).

[728] NASA, "Veteran NASA Space Shuttle Commander Retires," news release 05-017, 11 January 2005, *http://www.nasa.gov/audience/formedia/archives/2005-all-archives.html* (accessed 13 August 2009); Associated Press, "Veteran Space Shuttle Commander Retires," 12 January 2005.

infrared wavelengths. NASA planned for the craft to launch the impactor into the comet on 4 July 2005. Mission scientists hoped the data collected from the impact would reveal information about the birth of the solar system.[729]

14 January
ESA announced that its Huygens probe, which had undertaken a seven-year journey through the solar system, aboard NASA's Cassini spacecraft, had successfully landed on the surface of Saturn's moon Titan. ESA intended Huygens to provide the first direct and detailed sampling of Titan's atmospheric chemistry, the first photographs of its surface, and a detailed weather report of the moon. ESA had selected Titan as the probe's destination because Titan's nitrogen atmosphere is rich in methane, and scientists believe its surface may contain chemicals similar to those that existed on the young Earth, before life evolved. Before the landing of Huygens, scientists had been unable to see Titan's surface, because the methane in the atmosphere reacts with sunlight, creating a permanent blanket of smog. ESA had designed the Huygens probe specifically to breach that shroud.[730]

18 January
Russian Space Agency Chief Anatoly N. Perminov and ESA Director General Jean-Jacques Dordain signed an agreement allowing Russia to use ESA sites for space launches and enabling Russia and Europe freely to exchange research and development information. Specifically, ESA would permit Russia to conduct *Soyuz* launches from Kourou, French Guiana. In addition, the two would share information on the design of new launchers and fuels—information once closely guarded by both sides—with the intention of developing new launchers jointly. For example, Russia and Europe had studied the option of developing new reusable launchers and new propulsion systems.[731]

In the journal *Geophysical Research Letters*, researchers studying data from the Mediterranean Israeli Dust Experiment (MEIDEX) reported their determination that a strange flash over the Indian Ocean, which had occurred on 20 January 2003, was not related to lightning. The researchers named the mysterious reddish glow Transient Ionospheric Glow Emission in Red, or TIGER. Israeli astronaut Ilan Ramon, a crew member of the ill-fated STS-107, had recorded the glow while aboard Space Shuttle *Columbia*, using an infrared video camera. During the Shuttle flight, Ramon had collected data about dust particles in the atmosphere for the MEIDEX Sprite campaign at the Open University in Ra'anana, Israel. Researchers for MEIDEX had analyzed Ramon's video, including a single frame that showed a mysterious reddish glow 150 kilometers (93.2 miles) above the ocean near Madagascar. Like blue jets and elves, sprites are emissions—transient luminous events (TLEs)—that occur above thunderstorms. Airline pilots

[729] *Spacewarn Bulletin*, no. 615, 1 February 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx615.html* (accessed 13 August 2009).
[730] ESA, "Europe Reaches New Frontier—Huygens Lands on Titan," ESA news release PR 03-2005, 14 January 2005, *http://www.esa.int/esaCP/Pr_3_2005_p_EN.html* (accessed 14 August 2009); NASA JPL, "NASA Salutes Successful Huygens Probe," news release 2005-017, 14 January 2005, *http://saturn.jpl.nasa.gov/news/newsreleases/newsrelease20050114-3/* (accessed 14 August 2009); Guy Gugliotta, "Probe Lands on Moon of Saturn: A First Glimpse of Smog-Covered Titan," *Washington Post*, 15 January 2005.
[731] Agence-France Presse, "Russia and Europe Sign Space Agreement," 20 January 2005.

had first reported TLEs several decades ago. The TIGER phenomenon contrasted with typical TLEs because of its shape and its lack of any direct relationship to thunderstorm activity.[732]

21 January

NASA announced that the NASA-led Swift mission had detected and captured its first image of a GRB. On 17 January, the craft had turned, autonomously, to focus on the burst—quickly enough to capture an image with its X-ray Telescope (XRT), while its Burst Alert Telescope (BAT) continued to detect gamma rays. The event marked the first time that an x-ray telescope had imaged an in-process GRB. Previous images had captured the burst's afterglow, but never the burst itself. The event had also marked the first time that BAT had detected a burst, and an XRT detection had autonomously followed it. Swift had carried a third instrument, the Ultraviolet/Optical Telescope (UVOT), which was still in its testing phase. UVOT had not been collecting data when the other two telescopes detected the burst. John A. Nousek, Swift's Mission Operations Director at Pennsylvania State University in State College, Pennsylvania, remarked that Swift had successfully achieved, early in its mission, its primary purpose—to detect the fleeting bursts and to focus telescopes on them autonomously within a minute.[733]

24 January

Northrop Grumman Corporation announced that it had finalized an agreement with the Boeing Company to compete as a team to develop NASA's new Crew Exploration Vehicle (CEV) and related human lunar-exploration systems, in anticipation of NASA's formal request for proposals (RFPs). NASA intended the CEV to serve as the central human space-transportation system within the Project Constellation, which would incorporate human and robotic space systems, ferrying astronauts to the Moon and beyond. According to the agreement, Northrop Grumman's Integrated Systems sector would serve as team leader and prime contractor during the initial development phase, Spiral 1. During the Spiral 1 phase, the team hoped to demonstrate the CEV's ability to operate safely in low Earth orbit with astronauts aboard. Boeing NASA Systems, an operating unit of Boeing Integrated Defense Systems, would serve as principal subcontractor. The two companies' roles would reverse to implement the second phase, Spiral 2. During the Spiral 2 phase, NASA intended to begin to expand human space exploration to the Moon and beyond.[734]

26 January

NASA announced its selection of the Interstellar Boundary Explorer (IBEX) as part of NASA's Small Explorer Program (SMEX). Scheduled for launch in 2008, IBEX was the first mission designed to detect the edge of the solar system. IBEX planned to use two neutral atom imagers to detect the particles created from the termination shock that occurs at the boundary between the solar system and interstellar space. IBEX would also study galactic cosmic rays, which pose a

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[732] Maggie McKee, "Columbia Crew Saw New Atmospheric Phenomenon," *New Scientist*, 20 January 2005; Michael Schirber, "High-Altitude Mystery Flash Recorded by Space Shuttle," *LiveScience.com*, 19 January 2005, *http://www.livescience.com/environment/050118_tiger_flash.html* (accessed 18 August 2009).

[733] NASA, "Swift Mission Images the Birth of a Black Hole," news release 05-019, 21 January 2005, *http://www.nasa.gov/home/hqnews/2005/jan/HQ_05019_swift_blackhole.html* (accessed 11 May 2009).

[734] Northrop Grumman, "Northrop Grumman, Boeing Finalize Space Exploration Teaming Agreement," news release, 24 January 2005, *http://www.irconnect.com/noc/press/pages/news_releases.html?d=71298* (accessed 17 August 2009); *Los Angeles Business Journal*, "Northrop, Boeing Finalize Deal To Team for NASA Contract," 25 January 2005.

health and safety hazard for humans exploring beyond Earth's orbit. Since 1992, NASA had successfully launched six SMEX missions.[735]

ISS Expedition 10 Commander Leroy Chiao and Flight Engineer Salizhan S. Sharipov successfully carried out a spacewalk to install a universal work platform at the station's *Zvezda* module. The excursion was Chiao's fifth spacewalk and Sharipov's first. Over a period of 5 hours and 28 minutes, the crew attached a German-built test robot, ROKVISS (Robotic Components Verification on the ISS), to the newly installed work platform. The two-jointed robot, with an on-board camera and manipulator arm, would test the application of the lightweight robotic systems that may help support the ISS and other spacecraft in the future. Chiao and Sharipov encountered some difficulty fastening the power cables of the robot's antenna, but they succeeded in their second attempt. ISS crews would be able to operate the robot using a computer, but flight controllers in Germany would operate the robot remotely, relying on the antenna. Sharipov also inspected and photographed three vents, which the station's Elektron oxygen generator and other systems used to expel waste matter. He reported white residue resembling honeycomb, on the Elektron generator's vent, and brownish residue on the other two vents. Engineers on the ground planned to analyze the photographs to determine whether the residue had caused the repeated shutdowns of the main oxygen generator of the ISS.[736]

28 January
NASA announced that one of its scientific balloons had broken the balloon flight record for duration and distance, soaring for nearly 42 days and making three orbits around the South Pole, thereby exceeding the previous record of nearly 32 days and two orbits. The flight of the balloon, which carried the Cosmic Ray Energetics and Mass (CREAM) experiment, demonstrated the capabilities of NASA's Ultra-Long Duration Balloon (ULDB) support system. NASA had designed the CREAM experiment to study the supernova acceleration limit of cosmic rays—the relativistic gas of protons, electrons, and heavy nuclei arriving at Earth from outside the solar system. The ULDB system, which NASA was developing, would extend flights up to 100 days.[737]

FEBRUARY 2005

2 February
NASA announced it had accepted an invitation to join the National Invasive Species Council (NISC), a cabinet-level council established in 1999 to coordinate federal responses to harmful invasive species. As a member of the council, NASA would provide data acquired using Earth-observation spacecraft and predictive models to assist 12 other federal agencies' efforts to combat invasive species nationwide. The council had extended the invitation because of NASA's

[735] NASA, "NASA Selects Small Explorer Mission," news release, 26 January 2005, *http://www.nasa.gov/home/hqnews/2005/jan/HQ_05026_exp_mission.html* (accessed 11 May 2009).
[736] Tariq Malik, "First Spacewalk a Success for Space Station Crew," *Space.com*, 27 January 2005, *http://www.space.com/missionlaunches/exp10_eva1_050126.html* (accessed 18 August 2009); Reuters, "Station Crew Leaves Outpost for Spacewalk," 26 January 2005; Todd Halvorson, "Spacewalkers Spy Clue in Oxygen Generator Breakdowns," *Florida Today* (Brevard, FL), 27 January 2005.
[737] NASA, "NASA Research Balloon Makes Record-Breaking Flight," news release 05-031, 28 January 2005, *http://www.nasa.gov/home/hqnews/2005/jan/HQ_05031_balloon_record.html* (accessed 13 August 2009).

previous work monitoring invasive species: NASA had provided data, predictive models, and systems engineering to the USGS, information that had helped the USGS build predictive maps of invasive species in Utah's Grand Staircase-Escalante National Monument. With NASA's assistance, USGS had converted data from the Moderate Resolution Imaging Spectrometer aboard NASA's Terra satellite, as well as other data, to create predictive maps of plant species distribution. USGS had used the National Invasive Species Forecasting System to help improve the nation's response to invasive species.[738]

The U.S. House Committee on Science held a hearing to examine options for the HST. Astronauts had serviced the HST four times since its entry into orbit in 1990. NASA had scheduled a fifth servicing mission for 2004, planning to make repairs and upgrades. However, because it had grounded the Shuttle fleet following the *Columbia* disaster in February 2003, NASA had not performed the scheduled servicing mission. The decision about whether to service or to decommission the telescope hinged upon the expense of the mission and on NASA's budgetary allocation of funds for the mission. Joseph H. Taylor of Princeton University, head of the National Academy of Sciences committee that set priorities for planning astronomy missions for the first decade of the 21st century, testified that his committee had identified the servicing mission to the HST as a priority for NASA's space program, but only if the cost of the mission did not exceed US$400 million. Taylor stated that he would not support the mission if it would delay other programs or if NASA would have to rearrange its priorities to fund the mission. Newly revised NASA estimates placed the total cost of a fifth servicing mission at US$1 to US$2 billion, a cost that NASA's Space Science Division could not sustain on its own. Experts testifying before the committee agreed that, if the Office for Human Space Flight and the Space Sciences Division could share the expense, the mission would be well worth it.[739]

3 February

ESA and the government of the United Kingdom (UK) officially published the report of the investigation into the circumstances and possible reasons for the failure of the Beagle 2 mission. Beagle 2, the Mars lander that had "piggybacked" aboard ESA's Mars Express Orbiter, had failed to communicate after its landing date of 25 December 2005. The UK government and ESA had commissioned the report in February 2004, and the commission had completed the report in April 2004. Initially, ESA and the UK government had refused to publish the report, citing details of confidential intergovernmental agreements, as well as commercially sensitive information. Instead, they had issued a set of recommendations for future missions. However, the *New Scientist* had requested the report's publication under the UK's new Freedom of Information Act, in force since the beginning of 2005. Colin Pillinger, the planetary scientist who had first proposed the Beagle 2 project, and Mark Sims, the mission's project manager—both at the Open University in the UK—agreed that the report contained little, if any, commercially sensitive information. However, the report concluded that ESA and the UK government should never have approved the project. ESA committee investigating the loss of the

[738] NASA, "NASA Research to Aid Federal Invasive Species Council Efforts," news release 05-035, 2 February 2005, *http://www.nasa.gov/home/hqnews/2005/feb/HQ_05036_Invasive_Species.html* (accessed 19 August 2009).
[739] Warren E. Leary, "Repair Costs for Hubble Are Vexing to Scientists," *New York Times*, 3 February 2005; Deborah Zabarenko for Reuters, "Hubble Repair Could Hinge on Who Pays at NASA," 3 February 2005; U.S. Congress, House of Representatives, Committee on Science, *Options for Hubble Science*, 109th Cong., 1st sess., 2 February 2005.

probe had found several fundamental errors, such as classifying the lander as an instrument aboard Mars Express, instead of as a separate spacecraft, and making inaccurate estimates about the characteristics of the Martian atmosphere. The committee also determined that ESA and the UK had underfunded the mission from the start. Moreover, the committee found that the mission's logistics were too complex for Pillinger's team.[740]

The U.S. Air Force successfully launched two military satellites aboard an Atlas 3B, the last of Lockheed Martin's Atlas 3 rockets. The launch marked the 145th and final launch from Complex 36 at Cape Canaveral, Florida, after 43 years of operation. NASA had built the complex in the early 1960s, specifically for its Atlas-Centaur program, which included the launches of NASA's historic Surveyor, Mariner, and Pioneer missions. Launches from the site had proved highly successful; the launch of the last Atlas 3B marked the 75th consecutive successful Atlas rocket launch, including all six Atlas 3 flights. Launch Complex 36 was one of the United States' oldest continuously operating launch sites and the last of the U.S. launch sites to use a traditional blockhouse to control the launch. The final Atlas 3B carried a pair of formation-flying, classified satellites, which analysts believed were part of the Naval Ocean Surveillance System (NOSS) of the National Reconnaissance Office (NRO). Satellites in the NOSS, a network for monitoring ships around the globe, were reportedly capable of detecting radio transmissions from ships to pinpoint their locations precisely.[741]

4 February
NASA announced the inauguration of SERVIR, an innovative regional monitoring system designed to provide early warnings to Central American decision makers about various ecological and climatic changes. SERVIR, Spanish for "to serve," is the acronym for the Spanish phrase, Sistema Regional de Visualización y Monitoreo (Regional Visualization and Monitoring System). The purpose of the system was to aid the governments and industries of the seven countries of Central America and the southern Mexican states. NASA scientists had developed the system to track weather, climatological, and ecological events—for example, to monitor wildfires, red tides, and toxic algae blooms—using NASA's research in Earth sciences and space-based observations. Daniel E. Irwin, SERVIR Project Manager at NASA's MSFC, remarked that the system was an excellent tool for gauging slow or periodic shifts in climate that could lead to drought or other long-term problems, in addition to identifying quick-forming weather phenomena that threaten human lives.[742]

8 February
Officials of the Personal Spaceflight Federation announced the newly formed organization's establishment. The Federation's stated purpose was to design and uphold the standards and processes necessary to ensure public safety, while promoting the growth of the private spaceflight industry. Pursuant to landmark legislation signed by President George W. Bush in

[740] British National Space Centre, "Beagle 2"; Justin Mullins, "Beagle 2 'Should Never Have Been Built'," *New Scientist*, 4 February 2005; *BBC News*, "Report Scorns Beagle 2 Decision," 4 February 2005.
[741] Justin Ray, "Last Atlas 3 Rocket Launches a Pair of Spy Satellites" and "Atlas Rocket Workers Say Goodbye to Complex 36," *Spaceflight Now*, 4 February 2005; Todd Halvorson, "Atlas 3 Climbs Through Fog to Final Successful Mission," *Florida Today* (Brevard, FL), 4 February 2005.
[742] NASA, "NASA Develops Central American Monitoring System," news release 05-038, 4 February 2005, *http://www.nasa.gov/home/hqnews/2005/feb/HQ_05038_panama.html* (accessed 19 August 2009).

December 2004—Pub. L. No. 108-492, the Commercial Space Launch Amendments Act of 2004—the industry group planned to work with federal regulators to draft rules and standards for suborbital space tourism. The new federation brought together visionary space entrepreneurs, including *SpaceShipOne* designer Burt Rutan, whose team had won the US$10 million X Prize in October 2004 for conducting the first private suborbital spaceflight, and video-game developer John D. Carmack II, whose Armadillo Aerospace team had been among the leading contenders for the X Prize. Executive Director of the X Prize Foundation Gregg E. Maryniak, serving as the Federation's spokesperson, remarked on the law's new mandate that government and industry work together to develop safety standards. Maryniak stated that the Federation believed strongly that private industry must devise a suborbital product considerably safer than that of the current civil space program.[743]

9 February

The U.S. House Transportation and Infrastructure Subcommittee on Aviation held a hearing to explore the regulation of the nascent commercial spaceflight industry. Members of the newly formed Personal Spaceflight Federation and its Industry Consensus Standards Organization voiced their concern that the government would attempt to implement additional regulations, thereby overregulating the new industry and stifling innovation. The Commercial Space Launch Amendments Act of 2004 required the FAA to issue licenses for the launches of privately built spacecraft and had given the FAA three years to issue rules for licensing. However, the Act also prohibited the FAA from issuing safety regulations for passengers and crew for eight years, unless specific design features or operating practices had resulted in serious or fatal injuries. U.S. Representative James L. Oberstar (D-MN), ranking member of the Transportation Committee, objected to that approach and had introduced his own bill (H.R. 656), requiring the FAA to include in its licensing rules minimum safety and health standards for spacecraft passengers and crew. FAA Administrator Marion C. Blakey agreed with regulation of private spaceflight in principle but suggested that such oversight needed to develop alongside the industry, emphasizing the difficulty in stipulating regulations for vehicles that did not yet exist.[744]

12 February

ESA successfully launched from its base in Kourou, French Guiana, an Ariane 5 ECA rocket, the world's most powerful commercial launcher, more than two years after its inaugural flight in December 2002 had ended in disaster. Capable of carrying up to 10 tons (9,071 kilograms or 9.07 tonnes) into space, the rocket lifted a 7.3-ton (6,623-kilogram or 6.62-tonne) payload consisting of two satellites—the U.S.-Spanish XTAR-EUR satellite and the Dutch experimental SLOSHSAT-FLEVO microsatellite. Fitted with 12 wideband, X-band transponders, the XTAR-

[743] Personal Spaceflight Federation, "Space Entrepreneurs Resolve To Create Industry Group To Promote Safety Standards and Growth of the Personal Spaceflight Industry," news release, 8 February 2005, *http://www.commercialspaceflight.org/pressreleases/PSF%20Press%20Release%20-%20Original%20Announcement.pdf* (accessed 27 August 2009); Alan Boyle, "Space Racers Unite in Federation: Industry Group Will Follow Up on New Law," *MSNBC.com*, 9 February 2005, *http://www.msnbc.msn.com/id/6936543/* (accessed 28 August 2009).

[744] Leslie Miller for the Associated Press, "Space Entrepreneurs Fret Over Federal Regulation," 10 February 2005; Kelly Young, "Fledgling 'Space Federation' Fears Over-Regulation," *New Scientist*, 11 February 2005; Beth Dickey, "FAA Proposes Rules for Future Spaceliners," *Government Executive*, 15 February 2005; U.S. Congress, House of Representatives, Committee on Transportation and Infrastructure, Subcommittee on Aviation, *Commercial Space Transportation: Beyond the X Prize*, 109th Cong., 1st sess., 9 February 2005.

EUR geostationary satellite would provide military communications for the United States and Spain. For 10 days, the Netherlands' microsatellite SLOSHSAT-FLEVO, weighing just 127 kilograms (0.127 tonnes or 0.139 tons), would test the dynamics of de-ionized water in orbit. FLEVO was the acronym for Facility for Liquid Experimentation and Verification in Orbit, as well as the name of the latest Dutch province that the Netherlands had reclaimed from the sea. ESA also sent aloft a monitor, MAQSAT, which remained attached to the rocket to gather data about the rocket's dynamic behavior, from launch through the release of the two satellites. In its inaugural launch, the rocket had veered off course, prompting Mission Control to destroy it. An inquiry board had determined that the cooling system of the rocket's Vulcain engine had malfunctioned.[745]

15 February

NASA awarded a US$9.8 million, five-year research grant to the University of Texas's Southwestern Medical Center in Dallas to study the cancer risks of radiation exposure during space travel, adding another NASA Specialized Center of Research (NSCOR) to NASA's space radiation program. The name of the newest NSCOR was NASA Specialized Center of Research for the Estimation of Solid Tumor Cancer Risks from Space Radiation. The grant enabled researchers to study the relationship of lung cancer pathogenesis and exposure to HZE-particles (high-energy charged particles) at the cellular and molecular level, using data collected from animal models and tissues.[746]

17 February

The U.S. House Committee on Science held a hearing to discuss NASA's FY 2006 budgetary request and priorities. Committee Chair Sherwood L. Boehlert (R-NY) expressed doubt that NASA would receive the full US$16.45 billion it had requested. Committee members questioned Deputy Administrator Frederick D. Gregory on several topics: NASA's long-term plan to return to the Moon and to send a human mission to Mars; its projected cuts to science and astronautics programs; its decision not to fund a servicing mission to the HST; and its plans for its workforce. The committee also questioned the US$858 million NASA had designated for Mars and lunar exploration, while reducing spending in other space science programs, including that of the HST. The committee questioned budgetary proposals based on plans for 28 Shuttle flights to the ISS and no flights to repair the HST. Representative Vernon J. Ehlers (R-MI) remarked that that the HST was capable of conducting more and better scientific research in one week than the ISS could produce in its entire lifetime. Boehlert reminded NASA officials that the U.S. Congress had never endorsed or even discussed the President's January 2004 declaration urging NASA to return humans to the Moon within 15 years and, ultimately, to launch human missions to Mars and beyond. Representative Bart Gordon (D-TN) remarked that Congress had no consensus regarding the proposed changes in NASA's priorities, changes that he described as "almost staggering in terms of magnitude."[747]

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[745] *Spacewarn Bulletin*, no. 616, 1 March 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx616.html* (accessed 26 August 2009); Associated Press, "European Rocket Delivers Payload," 14 February 2005; Laurent Marot for Reuters, "Upgraded Ariane-5 Rocket Orbits Satellites," 13 February 2005.

[746] NASA, "NASA Satellite Observes Mysterious Earth Energy," news release 05-054, 22 February 2005, *http://www.nasa.gov/home/hqnews/2005/feb/HQ_05045_cancer_grant.html* (accessed 19 August 2009); Associated Press, "NASA Awards UT Southwestern $9.8 Million Grant to Study Radiation," 25 February 2005.

[747] James Janega, "House Science Panel Questions NASA Officials about Budget," *Chicago Tribune*, 18 February 2005; Jim Abrams, "Lawmakers Question White House on NASA," *Kansas City Star* (MO), 18 February 2005; U.S.

18 February
NASA officially refuted news reports that had circulated on 16 February claiming that NASA scientists affiliated with ARC had found strong evidence that life might exist on Mars. According to the news reports, during a private meeting in Washington, DC, two astrobiologists from Ames had told a group of space officials that they had found strong evidence, in the form of methane signatures, that life currently exists on Mars, hidden in caves and sustained by pockets of water. NASA stated that it did not have any observational data from any current Mars missions to support the claim. NASA further stated that the work the scientists had conducted did not directly support any conclusion regarding the existence of life on Mars but, rather, that the scientists' research could help formulate a strategy for searching for such life. The scientists had not submitted any research papers asserting the existence of Martian life to any scientific journal.[748]

22 February
The Boeing Company announced that it had reached an agreement to sell its Rocketdyne Propulsion and Power business to Pratt & Whitney, a United Technologies Corporation unit, for about US$700 million in cash. Rocketdyne, primarily a rocket engine developer and builder that provided booster engines for the Space Shuttle and the Delta series of expendable launch vehicles, had helped pioneer space exploration in the 1950s and1960s. The sale reflected Boeing's struggle to make a profit in the space-launch business and marked the company's latest move toward focusing on large-scale weapons and aerospace systems. United Technologies intended the acquisition to broaden the product line at Pratt & Whitney, which, in recent years, had lost market share in its core business of providing jet engines.[749]

24 February
NASA announced the completion of its pioneering Advanced Air Transportation Technologies (AATT) project, which, since 1996, had focused on developing technologies to improve the capacity of transportation aircraft operations at and between the major airports of the National Airspace System. The AATT project had collaborated with the FAA and the airline industry to develop decision-support tools for air-traffic controllers, airline pilots, and air-operations managers. Tools developed and implemented through the AATT project included: the Traffic Management Advisor, operational at eight Air Route Traffic Control Centers, which helped controllers manage air traffic by sequencing aircraft as the craft approached their destinations; the Surface Management System, scheduled for transfer to the FAA, which helped airport controllers and company traffic managers coordinate aircraft departures from the gate, preventing delays at the runway; other technologies, which helped aircraft fly the most direct

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Congress, House of Representatives, Committee on Science, *NASA's Fiscal Year 2006 Budget Proposal*, 109th Cong., 1st sess., 17 February 2005.
[748] NASA, "NASA Statement on False Claim of Evidence of Life on Mars," news release 05-052, 18 February 2005, *http://www.nasa.gov/home/hqnews/2005/feb/HQ_05052_mars_claim.html* (accessed 19 August 2009); *Bloomberg News*, "NASA Says Claims of Evidence of Current Life on Mars Are False," 19 February 2005; Brian Berger, "Exclusive: NASA Researchers Claim Evidence of Present Life on Mars," *Space.com*, 16 February 2005, *http://www.space.com/scienceastronomy/mars_life_050216.html* (accessed 28 August 2009).
[749] The Boeing Company, "Boeing To Sell Rocketdyne Propulsion Unit to Pratt & Whitney; news release, 22 February 2005, *http://www.boeing.com/news/releases/2005/q1/nr_050222o.html* (accessed 19 August 2009); *Los Angeles Times*, "Maker of Rocket Engines Is Sold," 23 February 2005.

route to their destination and assisted traffic managers in managing in-flight aircraft collaboratively; and new communication and visualization technologies, which helped airline industry personnel better understand air-traffic patterns and future trends. Michael R. Landis, Manager of the AATT project, remarked that NASA would incorporate many of the technologies and concepts developed by the AATT project into the Next Generation Air Transportation System, the initiative of the government and industry to modernize the National Airspace System.[750]

26 February

Japan successfully launched a geostationary weather satellite MTSAT-1R aboard an H-2A rocket from Tanegashima Space Center in Kagoshima prefecture, after a glitch in communications between the rocket and ground systems had caused a 76-minute delay. The launch was Japan's first launch of a heavy-lift vehicle since November 2003, when one of the H-2A's solid boosters had failed to jettison as expected after completing its burn, causing the launch to fail. In the failed launch, Japan had lost the second pair of the four spy satellites that it had built after North Korea had fired a missile into Japanese territory in 1998. The other pair of the four satellites—one optical and one radar-sounding satellite—were all Japan had left to monitor its threatening neighbor. Furthermore, the launch failure had dashed Japan's plans to enter the commercial satellite-launch business and had caused Japan to lose its international credibility. The successful launch of the MTSAT-1R restored morale to Japan's rocketry program. A second mission of the MTSAT-1R was to replace a satellite lost in November 1999 when the final H-2 rocket, the predecessor of H-2A, had failed to reach orbit. Japan had designed the MTSAT-1R to service the Japan Civil Aviation Bureau and the Japan Meteorological Agency, fulfilling the two missions of facilitating air-traffic management and obtaining satellite imagery for meteorologists.[751]

MARCH 2005

1 March

NASA's Exploration Systems Mission Directorate issued a request for proposals (RFP) for the Crew Exploration Vehicle (CEV) that NASA intended to use to transport astronauts beyond low Earth orbit and to the Moon by 2020. NASA had set the deadline for submissions for 2 May 2005 and planned to select two contractors in September 2005. The two contractors would develop competing prototypes with a December 2008 completion date, at which time NASA would select the prime contractor. NASA stipulated that the minimum specifications for the CEV were that the craft weigh 20 tonnes (18.14 tons) or less; house as many as four astronauts, for as long as 16 days; have the ability to rendezvous and dock with future lunar landers and interplanetary modules; and allow a safe abort throughout all phases of its flight. NASA stipulated that it would permit contractors to design spacecraft that exceeded these specifications. For instance, the RFP permitted the design of craft that could maintain a crew in space for longer

[750] NASA, "NASA Developed Tools for Successful Air Travel Program," news release 05-058, 24 February 2005, *http://www.nasa.gov/home/hqnews/2005/feb/HQ_05058_Improving_Air_Travel.html* (accessed 19 August 2009).
[751] *Spacewarn Bulletin*, no. 616; James Brooke, "After Failures, Space Effort in Japan Gets a Lift," *New York Times*, 28 February 2005; Justin Ray, "Beleaguered H-2A Rocket Roars Into Orbit," *Spaceflight Now*, 26 February 2005.

than 16 days or accommodate a crew of six. The RFP also gave contractors the flexibility to decide whether the CEV would be able to dock with the ISS.[752]

NASA signed a memorandum of agreement (MOA) with the United Nations Education, Scientific and Cultural Organization (UNESCO), in an effort to improve global conservation through increased use of NASA's Earth science research and remote-sensing data. Under the agreement, UNESCO would use NASA-generated data to share scientific information about how Earth functions. In addition, the MOA would further an existing partnership between the NASA-supported Global Learning and Observations to Benefit the Environment (GLOBE) education program and UNESCO's World Heritage Centre. NASA and UNESCO would train teachers in UNESCO-member states to work with UNESCO's Natural World Heritage Site managers on collaborative conservation program activities.[753]

3 March

J. Stephen Fossett landed the Virgin Atlantic GlobalFlyer experimental aircraft in Salinas, Kansas, after flying the first solo, nonstop, non-refueled, around-the-world airplane trip. The flight had lasted three days, during which Fossett had not slept and had only consumed 12 milkshakes. The craft, designed by X Prize–winning *SpaceShipOne* creator Burt Rutan, carried NASA's advanced experimental Tracking and Data Relay Satellite System (TDRSS) transceiver, the Low Power Transceiver (LPT) that NASA researchers believed would provide a flexible and inexpensive option for relaying information between spacecraft. NASA had placed the new transceiver on board GlobalFlyer to test the device's function during a real flight, especially its performance in delivering a constant video feed. NASA had loaned GlobalFlyer a modified version of its Personal Cabin Pressure Monitor to alert the pilot of potentially dangerous or deteriorating cabin pressure. Because the background noise in GlobalFlyer's cockpit was too loud for the pilot to hear an alarm, the modified monitor vibrated to signal a problem. The mission had successfully overcome periodic failures of GlobalFlyer's navigation system. Furthermore, while passing through Japanese airspace, the aircraft had appeared to be running out of fuel too quickly, but a solid tailwind had helped Fossett avoid making a landing in Hawaii.[754]

7 March

Aera Corporation, which had competed as American Astronautics in the X Prize private spaceflight competition, signed a five-year launch support agreement with the U.S. Air Force, securing access to Cape Canaveral Air Station in Florida. Although Aera had yet to launch a single test vehicle, the company planned to launch paying customers by the end of 2006. Aera's President and Chief Operating Officer Lewis Reynolds explained that the company had used computer-based modeling for most of its testing and had done very little testing of actual physical components for the spacecraft. The company intended to apply for a FAA launch

[752] NASA, "NASA Issues Solicitation for Crew Exploration Vehicle," news release 05-063, 1 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05063_crew_exploration.html* (accessed 2 September 2009); Robert Zimmerman for United Press International, "Space Watch: Spacefaring by Bureaucrats," 18 March 2005.
[753] NASA, "NASA Research Aids UNESCO Global Conservation Efforts," news release 05-061, 1 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05061_unesco-global.html* (accessed 2 September 2009).
[754] NASA, "NASA Technology Supports Virgin Atlantic GlobalFlyer," news release 05-068, 3 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05068_globalflyer_congrats.html* (accessed 29 June 2009); John Kelly, "NASA Helps Record Flight," *Florida Today* (Brevard, FL), 9 March 2005.

license within 30 days and to secure a manufacturing facility for its seven-seat spaceship, the Altairis, by the end of April.[755]

8 March

NASA-funded researchers reported that they had discovered that lightning in clouds a few miles above the ground clears a safe zone in the Van Allen Belt—the radiation belt located thousands of miles above Earth. Without this zone, satellites would have no safe area in which to orbit. The discovery, which NASA described as unexpected, resolved a 40-year debate about how the safe zone forms and how the region clears after magnetic storms fill it with radiation. Previously, the prominent theory held that turbulence in the zone generates radio waves in space, which clear the radiation. However, lightning also generates radio waves. The research team had confirmed the lightning theory using a global map of lightning activity created from data that the Micro Lab 1 spacecraft had collected. The team had also collected radio-wave data from the Radio Plasma Imager aboard the Imager for Magnetopause to Aurora Global Exploration (IMAGE) spacecraft, combining that data with archival data from the Dynamics Explorer spacecraft. These two data sets showed that radio-wave activity in the safe zone closely follows terrestrial lightning patterns; if the radio waves had originated in space rather than Earth, no such correlation would exist. Therefore, the team had concluded that lightning clears radiation within a few days following magnetic storms. According to NASA, engineers could eventually design spacecraft that generate radio waves at the correct frequency and location to clear radiation belts around other planets, enabling humans to explore planets and moons such as Jupiter's Europa.[756]

9 March

The GAO published a report warning that the lack of a detailed, long-term strategy regarding NASA's workforce could threaten the safety of Space Shuttle operations and delay implementation of the Bush administration's 2004 directive to return astronauts to the Moon. The U.S. Senate Committee on Commerce, Science and Transportation had tasked GAO with tracking NASA's efforts to develop a strategy for sustaining the Space Shuttle workforce until the Shuttle's retirement and identifying factors that impeded those efforts. GAO reported that NASA had made limited progress toward this goal. GAO found that NASA had taken preliminary steps: identifying lessons learned from the retirement of programs comparable to the Space Shuttle, such as the Air Force Titan 4 Rocket Program; enlisting the assistance of human capital experts; and revising its acquisition strategy for updating specific prime contracts. However, GAO concluded that NASA's failure to make decisions regarding contractor requirements during the remainder of the Shuttle program would hinder its progress. Moreover, GAO stated that NASA must develop a detailed strategy for retiring the Shuttle program, to enable it to protect agency-wide goals from the potential impact of workforce problems. GAO cited several factors hampering NASA's ability to accomplish this, such as NASA's near-term focus on returning the Shuttle to flight, a focus that had caused a delay in assessing hardware and

[755] Alan Boyle, "Dark Horse Makes Bold Claims in Space Race," *MSNBC.com*, 8 March 2005, *http://www.msnbc.msn.com/id/7121988//* (accessed 2 September 2009).
[756] NASA, "NASA Finds Lightning Clears Safe Zone in Earth's Radiation Belt," news release 05-070, 8 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05070_radiation_belt.html* (accessed 29 June 2009); Agence-France Presse, "Lightning Cuts Safe Zone Between Earth Radiation Belts: NASA," 9 March 2005.

facility needs. Furthermore, program officials remained uncertain about how to implement future aspects of the President's Vision for Space Exploration.[757]

11 March

International Launch Services (ILS) successfully launched the European satellite Inmarsat 4-F1 from Cape Canaveral, Florida, aboard a stretched version of the Atlas 5 rocket. Weighing 13,138 pounds (5,959 kilograms or 5.96 tonnes), the EADS Astrium-built Inmarsat 4 was the largest commercial satellite ever to launch. As part of a three-satellite constellation comprising the new Broadband Global Area Network, the spacecraft would provide wireless, broadband connections to ships, planes, and remote areas that had not previously had reliable access to ground-based, high-speed networks.[758]

15 March

NASA and the FAA brought a demonstration of the Small Aircraft Transportation System (SATS) to Foley Square in downtown New York City. SATS represented one aspect of a public-private partnership focused on developing technology that would enable more people to fly directly to their destinations at their own convenience. The ultimate goal of the SATS project was for people to be able to access air travel in much the same way that they hail a cab. NASA's SATS Project Manager Jerry N. Hefner described a scenario in which a person would board a plane in his or her neighborhood to fly to a destination 500 miles away, without changing planes and without going through a hub. Instead, SATS would fly into and out of underused rural and suburban airports, reducing congestion at larger airports and easing traffic on interstate highways across the country. SATS Project Manager for the FAA Peter C. McHugh commented that those involved in the project believed that, as the travel population using SATS aircraft grew, minimal interference or intersection with the larger airline system would occur.[759]

NASA selected Ball Aerospace and Technologies Corporation of Broomfield, Colorado, to develop, manufacture, and provide prelaunch and postlaunch support for the Global Precipitation Measurement (GPM) Microwave Imager (GMI) instrument. The total contract value was approximately US$100.2 million over a period of seven years and nine months. The GMI, a conical-scan microwave radiometer, would fly on the GPM Core spacecraft as part of a multinational collaborative effort to measure global precipitation. The spacecraft, which NASA had not yet built, would be the first in a constellation of spacecraft deployed under NASA's GPM mission. The GMI instrument would make calibrated, radiometric measurements from space at multiple microwave frequencies and polarizations. NASA's Deputy Associate Administrator for the Science Mission Directorate Ghassem R. Asrar remarked that scientists need to know the amount and distribution of precipitation worldwide so that they can assess the quantity and quality of fresh water resources for food and fiber production, human consumption, and other societal needs. Experts in water resource management, agriculture, transportation,

[757] U.S. Government Accountability Office, "Space Shuttle: Actions Needed To Better Position NASA To Sustain Its Workforce Through Retirement" (report no. GAO-05-230, Washington, DC, March 2005), 1–19, *http://www.gao.gov/new.items/d05230.pdf* (accessed 3 September 2009).
[758] *Spacewarn Bulletin*, no. 617, 1 April 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx617.html* (accessed 31 August 2009); Associated Press, "Atlas 5 Rocket Hauls Satellite into Space," 12 March 2005.
[759] Roger Clark for NY1 Cable TV, "NASA Tries To Change the Way Americans Fly," 16 March 2005.

forestry, weather forecasting, and other fields, would be able to use future research findings based on GMI data.[760]

16 March

The U.S. House Science Subcommittee on Space and Aeronautics held a hearing to examine NASA's proposal to reduce spending on aviation research by 20 percent over five years, which would necessitate the closure of some wind tunnels and other centers. Overall, the Bush administration had proposed a 2.4 percent increase in NASA's budget, with most of that increase directed toward funding travel to the Moon and Mars, initiatives requiring NASA to eliminate or reduce its other programs, such as aviation research. NASA's Associate Administrator for Aeronautics Research J. Victor Lebacqz defended the program, remarking that the United States remained a global power in aviation and had developed technologies to improve safety, reduce environmental impact, and increase efficiency of aviation operations. However, Lebacqz stated that NASA needed a clearer vision for the goals of the program. John M. Klineberg, a retired NASA official and industry executive, who had headed a National Research Council (NRC) study group in 2004, testified before the committee. The NRC study group had published a review of NASA's aeronautics programs. Klineberg warned against using the group's recommendations out of context to justify major cuts in programs. He testified that NASA's proposed aviation-research budget was a disaster, putting the program at risk of becoming irrelevant to the future of aeronautics in the United States and throughout the world. In an interview following the hearing, Klineberg emphasized that the study group had suggested consolidating and focusing programs but did not support budgetary cuts eliminating entire areas of research.[761]

The U.S. Air Force announced the findings of its investigation into the December 2004 inaugural launch of Boeing's Delta 4 Heavy Rocket, which had failed when engines shut down prematurely. The Air Force and Boeing had intended the launch of the rocket, which was transporting a dummy payload, as a full dress rehearsal. The plan had been to test the newest and largest member of Boeing's next-generation rocket series before critical national security satellites began using it. Boeing had designed the rocket with three Common Booster Cores, each with a cryogenic main engine. The three cores, secured together, formed a craft capable of launching large cargo into space. The investigation had determined that each booster's engines had undergone premature shutdown during the launch, after internal sensors incorrectly determined that the engines had exhausted their liquid-oxygen fuel supply. Investigators had concluded that cavitation—bubbles in the liquid oxygen plumbing—had caused the glitch. Major Rodney Houser, the lead investigator for the Air Force, stated that the investigating team would focus on determining the cause of the cavitation within the liquid-oxygen feed system and on implementing corrective measures to prevent the problem's repetition.[762]

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[760] NASA, "NASA Selects Firm To Provide GPM Microwave Imager Instrument," news release c05-g, 15 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_c05g_gpm_imager.html* (accessed 29 June 2009); Matt Branaugh, "Ball Gets In On NASA Mission," *Boulder Daily Camera* (CO), 16 March 2005.

[761] Warren E. Leary, "NASA Proposal To Reduce Spending for Aviation Research by 20% Dismays Experts," *New York Times*, 17 March 2005; Malia Rulon for Associated Press, "Lawmakers Question Proposed NASA Cuts," 17 March 2005; U.S. Congress, House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, *The Future of Aeronautics at NASA*, 109th Cong., 1st sess., 16 March 2005.

[762] Justin Ray, "Delta 4-Heavy Investigation Identifies Rocket's Problem," *Spaceflight Now*, 17 March 2005.

17 March

NASA announced the successful completion of flight tests above a virtual forest fire to evaluate new flight-control software on board two small UAVs. The software experiment had sought to guide the UAVs simultaneously around obstacles, using principles derived from studies of the movements of fish and birds. Engineers and technicians from NASA's ARC and DFRC had conducted the flight tests over a remote area of Edwards Air Force Base in California, to investigate cooperative flight strategies for atmospheric sampling and for airborne monitoring and surveillance of natural disasters. John E. Melton of ARC, Principal Investigator for the Networked UAV Teaming Experiment, explained that his team had used two autopilot-equipped APV-3 UAVs, each with a 12-foot wingspan, to flight-test several novel approaches for assisting wildfire-suppression crews. The two craft had flown along computer-generated paths to demonstrate their ability to avoid obstacles in a cooperative and synchronized manner, without the assistance of flight personnel. Melton commented that the technology could eventually enable swarms of aircraft to move safely from one area to another as a group, collecting air samples on scientific missions or helping ground personnel monitor natural disasters.[763]

22 March

NASA announced that the Spitzer Space Telescope had captured the light from two known planets that are orbiting stars other than the Sun, enabling scientists to measure and compare extrasolar planets directly. This event marked the beginning of a new era in planetary science. Previously, scientists had confirmed the existence of extrasolar planets using one of two techniques of indirect discovery—the "wobble" technique or the "transit" technique. The wobble technique detected the gravitational tug that a planet exerts on its parent star, and the transit technique inferred the presence of a planet when the planet passed in front of its star, causing the star to dim. Both techniques depended on visible-light telescopes. By contrast, Spitzer observed infrared light, enabling astronomers to contrast a planet against the glow of its parent star. If detected using the transit technique, the glow of the parent star would have overwhelmed the glimmer of light reflected by the planet.[764]

23 March

NASA announced findings from research exploring the impact of black carbon or soot on Earth's climate, findings that provided new and additional evidence that pollution generated through the process of incomplete combustion contributes to the accelerated melting of sea ice and snow, as well as to the changing atmospheric temperatures in the Arctic region. Dorothy M. Koch, of Columbia University and NASA's Goddard Institute for Space Studies (GISS), and James E. Hansen, also of GISS, coauthored the study, using satellite data and computer models to recreate the climate and to track pollution. In addition to confirming past findings regarding the relationship between pollution and climate change in the Arctic region, the study had found that most of the pollution in the environment and the atmosphere of the Arctic did not originate in the developed world, but rather in southern Asia, which had the highest level of industrial soot emissions in the world. Using the GISS General Circulation Model (GCM) to locate the origins of Arctic soot, Koch and Hansen had found that one-third of the pollution originated in southern

[763] NASA, "New Software Allows UAVs to Team Up for Virtual Experiments," news release 05-078, 17 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05078_UAV_Software.html* (accessed 6 June 2009).
[764] NASA, "NASA's Spitzer Marks Beginning of New Age of Planetary Science," news release 05-082, 22 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05082_Spitzer_First_Light.html* (accessed 29 June 2009).

Asia, one-third was the result of burning vegetation and natural materials around the world, and the remainder originated in Russia, Europe, and North America.[765]

NASA and its partner the Spaceward Foundation, a publicly funded, nonprofit organization dedicated to advancing the cause of space access, announced prizes totaling US$$400,000 for four competitions. The competitions would be the first under NASA's Centennial Challenges program, designed to promote technical innovation in support of the Vision for Space Exploration and NASA's goals. The first two competitions, the Tether Challenge and the Beam Power Challenge, would challenge innovators to focus on developing lightweight, yet strong, tether materials and wireless power transmission technologies. Winners of each of the initial 2005 challenges would receive a prize of US$50,000. The Tether Challenge would require teams to make the strongest tether of a specified diameter. Competing in a tournament-style bracket system, the tethers would be stretched until they broke, with the overall winner competing against NASA's "house tether" to win the cash. The Beam Power Challenge would require teams to use wireless technology to lift a weight off the ground. NASA planned a second set of Tether and Beam Power challenges, with a greater degree of difficulty, for 2006.[766]

28 March

ISS Expedition 10 Commander Leroy Chiao and Flight Engineer Salizhan S. Sharipov completed the second and final spacewalk of their mission 1 hour ahead of schedule, returning into the ISS after 4.5 hours. To help in navigation, Chiao and Sharipov installed a set of space-to-space antennas around a section of *Zvezda*, the Russian service module that would aid in the docking operations of Europe's Automated Transfer Vehicle (ATV) during a future cargo mission. The crew also attached a GPS unit to the *Zvezda* module to help the ATV. The ATV, scheduled to arrive during the next year, had the capability to deliver up to 8.5 tons (7,711 kilograms or 7.71 tonnes) of cargo, including 10,000 pounds (4,536 kilograms or 4.54 tonnes) of propellant. After the crew finished connecting the antennas, Sharipov returned to the *Pirs* docking compartment to retrieve a small satellite called NanoSputnik. The satellite, which weighed just 11 pounds (5 kilograms) and measured only 1 foot (0.31 meter) long, carried a transmitter designed to test control and orientation systems for small spacecraft during its 100-day mission. Sharipov released the satellite into a retrograde orbit by hand, while Chiao photographed the launch.[767]

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[765] NASA, "NASA Study Finds Soot May Be Changing the Arctic Environment," news release 05-084, 23 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_05084_arctic_soot.html* (accessed 29 June 2009); Miguel Bustillo, "Airborne Soot Adds To Arctic Melting, Study Finds," *Los Angeles Times*, 24 March 2005.

[766] NASA, "NASA Announces First Centennial Challenges' Prizes," news release M05-083, 23 March 2005, *http://www.nasa.gov/home/hqnews/2005/mar/HQ_m05083_Centennial_prizes.html* (accessed 2 September 2005); Robert Roy Britt, "NASA Details Cash Prizes for Space Privatization," *Space.com*, 24 March 2005, *http://www.space.com/news/050323_centennial_challenge.html* (accessed 2 September 2009).

[767] Tariq Malik, "Spacewalking Astronauts Outfit ISS for New Cargo Ship," *Space.com*, 29 March 2005, *http://www.space.com/missionlaunches/exp10_eva2_050328.html* (accessed 3 September 2009); Marcia Dunn for Associated Press, "Two Astronauts Complete Spacewalk Work," 29 March 2005.

APRIL 2005

5 April
NASA announced that scientists analyzing images from the its Polar Orbiting Environmental Satellite (POES) and from the Imager for Magnetopause to Aurora Global Exploration (IMAGE) spacecraft had discovered that Earth's northern and southern auroras are not mirror images of each other, as previously thought. Images from the two spacecraft showed that auroras move and change, depending on the tilt of Earth's magnetic field toward the Sun and on solar wind conditions. Knowing more about how auroras react to the solar wind could help scientists predict space weather. Timothy J. Stubbs of the Laboratory for Extraterrestrial Physics at NASA's GSFC remarked that the analysis was the first to track the locations of the auroras using simultaneous observations, in both the Northern and Southern Hemispheres, of the auroras in their entirety.[768]

6 April
NASA announced that it had approved the extension of operations for the twin Mars Rovers, Spirit and Opportunity, for up to 18 months. The robotic craft had already surprised engineers and scientists, having completed 11 months of extended activity beyond their successful three-month primary missions. Opportunity had driven more than three miles since arriving at Mars, eight times the distance originally planned, and, in March 2005, had set a new record of 722 feet (220 meters) in a single day's drive. Spirit had driven a shorter distance but was working in a much rougher terrain than Opportunity. Both rovers were exhibiting signs of wear and exposure, and scientists recognized that either mission could end suddenly because of a random part failure. James K. Erickson, Project Manager for the rovers at NASA's JPL, remarked that, despite the wear and the effects of exposure, both rovers remained in exceptional shape. Erickson said that NASA would work to get as much benefit as possible for as long as the craft were capable of producing worthwhile scientific results. Director of NASA's Mars Exploration Program J. Douglas McCuistion added that the rovers' successes had strengthened NASA's commitment to achieving the ambitious goals of returning samples from Mars and eventually sending a human expedition to the planet.[769]

7 April
NASA announced that Space Shuttle *Discovery* had reached a major milestone, arriving at Launch Pad 39B at NASA's KSC in preparation for its Return to Flight Mission, scheduled for 15 May. Over more than two years, *Discovery* had undergone 41 major modifications in response to the *Columbia* accident, including the addition of the new sensor system at the far end of the orbiter boom; cameras and laser systems to inspect its thermal protection system while in space; sensors in the leading edge of its wings to monitor for debris impacts; and a new digital camera for viewing the external tank during launch.[770]

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[768] NASA, "NASA Study Finds Earth's Auroras Are Not Mirror Images," news release 05-089, 5 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05089_aurora_images.html* (accessed 29 June 2009).
[769] NASA, "Durable Mars Rovers Sent into Third Overtime Period," news release 05-091, 6 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05091_mer_extension.html* (accessed 29 June 2009).
[770] NASA, "Space Shuttle Discovery at Launch Pad for Return to Flight," news release 05-095, 7 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05095_Discovery_Roll_Out.html* (accessed 29 June 2009).

11 April

Russian space officials and officials from the French rocket company Arianespace signed an agreement in Moscow allowing Russia to launch medium-weight satellite payloads from ESA's spaceport in Kourou, French Guiana. Under the agreement, Europe would provide 344 million euros to build a launchpad for Russian Soyuz rockets, and Russia would erect a tower for the launchpad, ship the rockets from Russia, and make any changes to the rockets necessary for them to operate in the equatorial climate. Locating launches at the equator would allow Russia to increase the weight of its payloads from 1.6 tonnes (1,600 kilograms or 1.7 tons) to about 3 tonnes (3,000 kilograms or 3.3 tons). The arrangement also filled a niche that Arianespace's two rocket fleets did not. Arianespace Vega rockets launched small scientific satellites weighing no more than 1.5 tonnes (1,500 kilograms or 1.65 tons) into a low orbit. The two models of Ariane 5 rockets could launch payloads weighing 6.6 tonnes (6,600 kilograms or 7.3 tons) or 10 tonnes (10,000 kilograms or 11 tons), respectively, into geostationary transfer orbit. Expecting to launch three or four Soyuz rockets per year, beginning in 2008, Arianespace had already booked three launches from Kourou using the Russian Soyuz rocket—launches of one Australian telecommunications satellite and two French scientific satellites.[771]

12 April

The Apstar 6 satellite launched aboard a Chinese Long March 3B rocket from Xichang Satellite Launch Center in China's Sichuan Province. The 4.8-tonne (4,800-kilogram or 5.3-ton) satellite carried 38 C-band and 12 Ku-band transponders. Replacing the ageing Apstar 1A, the craft would provide digital, multimedia transmissions to Australia, India, and countries in eastern Asia. The satellite was the first Western-built, commercial telecommunications spacecraft to carry almost no U.S.-made components, as well as the first commercial Chinese satellite with an antijamming payload. Hong Kong–based APT Satellite Company had requested that Alcatel Space include the antijamming technology in response to the threat of satellite-signal piracy, which had occurred several times over the previous two years. The new Alcatel Spacebus 4000 C1 satellite platform selected for Apstar 6 included no U.S. parts subject to the export controls of the U.S. Department of State. Because the U.S. government had refused to grant export licenses for U.S. satellite parts destined for launch in China, Alcatel Space had substituted European, Russian, and other non-U.S. components.[772]

13 April

NASA announced that the U.S. Senate had confirmed the nomination of Michael D. Griffin as NASA's 11th Administrator. Griffin replaced Sean O'Keefe, who had resigned in February to become Chancellor of Louisiana State University. Since 2004, Griffin had served as the Space Department Head at Johns Hopkins University Applied Physics Laboratory in Baltimore, Maryland. Before holding that position, he had served as President and Chief Operating Officer of In-Q-Tel and had held several positions within Orbital Sciences Corporation. Earlier in his career, he had served as Chief Engineer at NASA and as Deputy for Technology at the Strategic Defense Initiative Organization. Griffin held a doctorate in aeronautical engineering and five master's degrees, credentials that had led Senator Barbara A. Mikulski of Maryland, ranking Democrat on the Appropriations Subcommittee, which oversees NASA, to introduce Griffin as

[771] Maggie McKee, "Russian Rockets To Launch from South American Base," *New Scientist*, 13 April 2005.
[772] *Spacewarn Bulletin*, no. 618, 1 May 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx618.html* (accessed 8 September 2009); Peter B. de Selding, "Apstar 6 Launched from China," *Space News*, 13 April 2005.

the ideal person to lead NASA. During his confirmation hearing before the Senate Commerce, Science and Transportation Committee, Griffin had stated that, as Administrator, he would reevaluate NASA's decision not to send astronauts to repair and service the HST. He had named his priorities for NASA, including the Space Shuttles' safe return to flight. Furthermore, he had stated that he planned to speed up NASA's development of a replacement craft for the Shuttle, so that the United States could continue to send humans into space. Griffin had stated that the United States' dependence on other nations to ferry astronauts to space was unacceptable in terms of national security. Griffin had also testified that he supported President George W. Bush's Vision for Space Exploration, which included returning humans to the Moon and, ultimately, sending human explorers to Mars and beyond.[773]

14 April

NASA's Space Shuttle Program reached another milestone: filling a 154-foot-high (47-meter-high) external tank with fuel and oxygen. The test, intended to assure engineers that all changes to the tank operated as expected, marked the first time since *Columbia*'s accident that NASA had prepared an external tank for flight. The foam was necessary to keep the liquid fuel cool and to reduce ice build-up on the tank, but NASA and Lockheed Martin had redesigned the tank to reduce the amount of foam debris during launch. Changes to the tank design included removing the foam from the bipod ramp and replacing the foam with heaters. The designers had also added a "drip-lip" to reduce ice accumulation on the joints that permit the adjustment of the tank's fuel line. In a dress rehearsal for *Discovery*'s upcoming launch, engineers pumped more than 500,000 gallons of fuel into the tank, monitoring the tank and the Shuttle's systems down to the T-minus 31-second mark in a mock countdown. N. Wayne Hale Jr., Deputy Manager of the Space Shuttle Program and Chair of NASA's Mission Management Team, remarked on the outstanding performances of the newly modified external tank, the Shuttle, and the launchpad.[774]

15 April

Soyuz TMA-6 launched from Baikonur Cosmodrome in Kazakhstan carrying the Expedition 11 crew of three to the ISS. Russian Commander Sergei K. Krikalev and American Flight Engineer John L. Phillips would replace Leroy Chiao and Salizhan S. Sharipov. Italy's Roberto Vittori, also aboard, would conduct scientific experiments at the ISS before returning to Earth with Chiao and Sharipov.[775]

The Demonstration of Autonomous Rendezvous Technology (DART) spacecraft, a NASA technology demonstrator, launched from Vandenberg Air Force Base, California, aboard a

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[773] NASA, "Michael D. Griffin To Become NASA Administrator," news release 05-250, 13 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05250_griffin_confirmed.html* (accessed 29 June 2009); Warren E. Leary, "NASA Nominee Says He'll Reassess Decision Not To Send Astronauts To Fix Hubble Telescope," *New York Times*, 13 April 2005.

[774] Philip Chien, "NASA Tests Tank on Space Shuttle," *Washington Times*, 15 April 2005; William Harwood, "NASA Managers Elated with Shuttle Fueling Test," *Spaceflight Now*, 15 April 2005; Kelly Young, "Shuttle's External Fuel Tank Tested Successfully," *New Scientist*, 15 April 2005, *http://www.newscientist.com/article/dn7270-shuttles-external-fuel-tank-tested-successfully.html* (accessed 25 November 2009); *Physorg.com*, "NASA Puts Space Shuttle External Tank to the Test," 15 April 2005, *http://www.physorg.com/news3738.html* (accessed 25 November 2009).

[775] *Spacewarn Bulletin*, no. 618; Chris Kridler, "Soyuz Rocket Blasts Off to Station," *Florida Today* (Brevard, FL), 15 April 2005.

Pegasus-XL HAPS rocket released from an L-1011 cargo aircraft. NASA intended the launch to test the 360-kilogram (793.76-pound or 0.4-ton or 0.36-tonne) satellite's video-guidance-system technology, which would enable DART to rendezvous with an experimental military communications satellite and maneuver around it. The technology would allow future spacecraft to approach and dock with another craft automatically.[776]

17 April
The *Soyuz* TMA-6 crew arrived at the ISS. After greeting the new arrivals, the Expedition 10 crew held a safety briefing to familiarize the Expedition 11 crew and Roberto Vittori, the Italian astronaut visiting the ISS, with emergency escape procedures. The mission was Commander Sergei K. Krikalev's third long-term space assignment and his second aboard the ISS. Krikalev was the first person to serve more than one tour at the station.[777]

22 April
NASA announced that it had awarded Rice University's Carbon Nanotechnology Laboratory (CNL) an US$11 million contract to produce a prototype power cable constructed of carbon nanotubes. The engineers expected the so-called quantum wires to conduct electricity up to 10 times better than copper, at 1/6th the weight. NASA anticipated that the technology would help return humans to the Moon and enable travel to Mars and beyond. Richard E. Smalley, the project's Lead Investigator, explained that the Space Shuttle's primary power-distribution system accounted for almost 7 percent of its weight. However, NASA's next generation of human and robotic spacecraft would need far more power to support additional instrumentation and broadband communications, requiring a copper power-distribution system that would account for up to 25 percent of the craft's weight. Under the contract, CNL would provide NASA with a 1-meter (3.2-foot) prototype of quantum wire by 2010, a task requiring major breakthroughs in the production of nanotubes. To date, scientists had succeeded in producing wires no longer than several centimeters. At the time NASA awarded the contract, only armchair nanotubes—a type comprising 2 percent of all nanotubes— were suitable for use as quantum wires. Researchers at CNL planned to grow these nanotubes like crystals, placing "seeds" in a laboratory reactor and pumping in a source of carbon, such as carbon monoxide, with the hope of creating perfect, long armchair nanotubes each time. The researchers would then twist the tubes together to produce a quantum wire according to NASA's specifications.[778]

NASA announced the establishment of the DART Mishap Investigation Board to determine why the DART spacecraft had failed to complete its mission on 15 April. Initially, NASA had believed that DART had come within 300 feet (91.4 meters) of the target satellite before low fuel readings prompted it to abort its mission. However, NASA spokesperson Kimberly D. Newton later explained that new data had indicated that DART had bumped the satellite, boosting its orbit by as much as 5.75 miles (9.3 kilometers). However, DART had abandoned its target

[776] *Spacewarn Bulletin*, no. 618; Chris Kridler, "Failed DART Spacecraft Bumped Its Satellite Target," *Florida Today* (Brevard, FL), 26 April 2005.
[777] NASA, "11th Crew Arrives at Space Station" (International Space Station Status Report SS05-020, 17 April 2005), *http://www.nasa.gov/home/hqnews/2005/apr/HQ_ss05020_ISS_status_report.html* (accessed 29 June 2009); John Kelly, "New Crew Arrives at Station," *Florida Today* (Brevard, FL), 17 April 2005.
[778] NASA, "NASA Awards $11 Million "Quantum Wire" Contract to Rice," news release J05-018, 22 April 2005, *http://www.nasa.gov/centers/johnson/news/releases/J05-018.html* (accessed 9 September 2009); Amit Asaravala, "NASA Funds 'Miracle Polymer'," *Wired News*, 28 April 2005.

approximately halfway through its 24-hour mission. The Board consisted of seven voting members from NASA's MSFC, NASA's GSFC and ARC; the Defense Advanced Research Projects Agency; and the U.S. Air Force Space Command. NASA assigned eight federal employees to serve as advisors to the Board—six from MSFC, and one each from NASA's JSC and NASA Headquarters. NASA selected Scott D. Croomes of MSFC to chair the Board and Kerry L. Remp of GRC to serve ex officio, to assure that board activity conformed to NASA's procedural requirements.[779]

24 April

The Expedition 10 crew, American astronaut Leroy Chiao and Russian cosmonaut Salizhan S. Sharipov, returned to Earth from the ISS aboard *Soyuz* TMA-5 after almost 193 days in space. Together with Italian astronaut Roberto Vittori, who had conducted scientific experiments at the ISS after his arrival on 17 April with Expedition 11, the crew landed on target in north-central Kazakhstan. Although the crew and recovery team encountered no major problems, weeks of heavy snow and rain had caused flooding in the steppes, complicating the recovery. Only three of the 10 recovery helicopters were able to land in the wet conditions. During their mission, Chiao and Sharipov had maintained ISS systems and conducted scientific research. They had replaced critical hardware in the Joint Quest Airlock, repaired U.S. spacesuits, completed two spacewalks to prepare the ISS for the arrival of a new European cargo spacecraft during the next year, and submitted a scientific research paper on the use of ultrasound in space. Chiao had voted in the U.S. presidential election the previous November, the first astronaut to do so in space. Vittori had spent 10 days in space, eight of them aboard the ISS, and had performed 22 experiments, including tests of astronaut fatigue, research on the durability of components of microsatellites, research into the electromagnetic waves that emanate from Earth and may be related to earthquakes, and experiments growing shoots as a potential food source for people in orbit.[780]

25 April

NASA celebrated the HST's 15th anniversary with the release of new images of the Eagle Nebula and the Whirlpool galaxy (spiral galaxy M51), two of the most well-known objects that the Hubble had observed to date. The new images, made with the HST's newest camera, the Advanced Camera for Surveys (ACS), were among the largest and sharpest the Hubble had yet captured, so sharp that, even if enlarged to billboard size, the image would preserve the stunning details. The new image of the Eagle Nebula revealed ultraviolet light originating from a group of massive hot stars and sculpting a tall, dense tower of gas. The new image of the Whirlpool galaxy, in addition to displaying its classic features, revealed a companion galaxy located at the

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[779] NASA, "NASA Announces Dart Mishap Investigation Board Members," news release 05-105, 22 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05105_DART_mishap_board.html* (accessed 29 June 2009); NASA Engineering and Safety Center, *NESC Review of Demonstration of Autonomous Rendezvous Technology (DART) Mission Mishap Investigation Review Board (MIB)* (NESC Request No. 05-020-E, NASA Langley Research Center, Hampton, VA, December 2006), *http://klabs.org/richcontent/Reports/Failure_Reports/dart/167813main_rp-06-119_05-020-e_dart_report_final_dec_27.pdf* (accessed 18 November 2009); Chris Kridler, "Failed DART Spacecraft Bumped Its Satellite Target," *Florida Today* (Brevard, FL), 26 April 2005.

[780] NASA, International Space Station Status Report SS05-020a, 24 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_ss05020a_ISS_status_report.html* (accessed 29 June 2009); Shamil Zumatov for Reuters, "Russian, U.S., Italian Space Crew Return to Earth," 25 April 2005; Agence-France Presse, "Astronauts Home Safely from International Space Station," 26 April 2005.

end of one of the Whirlpool galaxy's arms. The launch of the HST in 1990 had ushered in a new era in astronomy. Before the existence of the HST, no telescope had viewed the universe in visible light from above Earth's atmosphere, which blurs light and causes images to appear fuzzy. Among its many achievements, the HST had helped astronomers calculate the precise age of the universe; helped confirm the existence of dark energy; detected small protogalaxies; proved the existence of supermassive black holes; provided sharp views of a comet hitting Jupiter; and demonstrated that the process of planetary system formation is common throughout the galaxy.[781]

NASA announced the establishment of the Exploration Systems Advisory Committee (ESAC), composed of leading experts from government, academia, and industry. NASA named Lester L. Lyles, a former commander of the U.S. Air Force Materiel Command to chair ESAC. Lyles had extensive experience managing large, high-technology organizations involving aeronautical and astronautical research, development, acquisition, and logistics. The committee would provide advice and recommendations to NASA's Associate Administrator for Exploration Systems, including input regarding plans, policies, programs, and other matters pertinent to the directorate's responsibilities.[782]

26 April

Spaceway 1, a DirecTV satellite, launched from Sea Launch's Odyssey floating platform at the equator aboard a Zenit-3SL rocket. Sea Launch used a self-propelled launch platform and a command ship that had sailed from Long Beach, California, to the equator. At the equator, the physics of Earth's rotation make it possible to launch heavier payloads than elsewhere. Sea Launch announced that the 13,376-pound (6,067.3-kilogram or 6.1-tonne) satellite was the heaviest commercial satellite ever launched.[783]

27 April

NASA announced that on 25 April its Deep Impact spacecraft had successfully photographed comet Tempel 1, Deep Impact's target destination. The craft's Medium Resolution Instrument had captured the image on its first attempt. The image was the first of thousands that NASA planned for the craft to capture over the following 10 weeks. The images would aid Deep Impact's navigators, engineers, and scientists, as they plotted the craft's final trajectory toward its encounter with Tempel 1, scheduled for 4 July.[784]

30 April

USA 182, a National Reconnaissance Office (NRO) classified military satellite, launched atop a Titan 4B rocket from Cape Canaveral Air Station in Florida. The rocket was the last Titan to launch from the Florida coast, signaling the end of the historic program after five decades and 168 launches. Only one Titan remained, scheduled for a July launch from Edwards Air Force

[781] NASA, "Hubble Celebrates 15th Anniversary with Spectacular New Images," news release 05-104, 25 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05104_HST_anniversary.html* (accessed 29 June 2009).
[782] NASA, "NASA Establishes Exploration Systems Advisory Committee," news release 05-106, 25 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05106_esac_meeting.html* (accessed 29 June 2009).
[783] *Spacewarn Bulletin*, no. 618; Associated Press, "DirecTV Satellite Launched from Sea Launch Ocean Platform," 27 April 2005.
[784] NASA, "NASA's Deep Impact Spacecraft Spots Its Quarry, Stalking Begins," news release 05-108, 27 April 2005, *http://www.nasa.gov/home/hqnews/2005/apr/HQ_05108_Deep_Impact_Image.html* (accessed 29 June 2009).

Base in California. The United States was retiring the Titan, which had begun as a two-stage intercontinental ballistic missile in the 1950s and had made its first launch from Cape Canaveral in 1959, in favor of the less-expensive and more modular Atlas 5 and Delta 4 rocket series, which could fulfill the need for heavy-lifting to space. Titan 2 missiles had served as the boosters for NASA's Gemini missions, and various Titan 3 and Titan 34D rockets had launched satellites, as had Titan 4, the largest and most powerful version in the program. Titan rockets had also launched space probes—Viking to Mars, Voyager to the outer planets, and Cassini to Saturn.[785]

MAY 2005

2 May
Lockheed Martin and the Boeing Company announced the formation of a joint venture called United Launch Alliance, combining the production, engineering, testing, and launch operations associated with U.S. government launches of Boeing Delta and Lockheed Martin Atlas rockets. The merger ended a two-year legal battle between the two largest government contractors, in which Lockheed Martin had accused Boeing of cheating to win rocket-launch work. The venture eliminated market competition for launching weather satellites for NOAA, scientific satellites for NASA, spy satellites for the National Security Agency, and communications satellites for the U.S. Air Force. According to the agreement, the joint venture would produce both Boeing's Delta and Lockheed's Atlas rockets, consolidating production at Boeing's Decatur, Alabama, facility. Lockheed's Denver, Colorado, office would serve as headquarters, housing the engineering and administrative functions. Lockheed Martin's Vice President of Financial Strategies Jeffrey D. MacLauchlan remarked that the preservation of the two separate rocket families was the crux of the venture's appeal to the federal government.[786]

3 May
The National Institute of Aerospace (NIA) in Hampton, Virginia, released a report commissioned by the U.S. Senate Appropriations Subcommittee on Commerce, Justice and Science, which had concluded that, to keep pace with Europe, the U.S. government would need to spend more on aeronautics, not less. The report, "Responding to the Call: Aviation Plan for American Leadership," recommended that, over the next five years, the U.S. government should restore NASA's aeronautics funding to 1998 levels, a goal that implied a spending level approximately twice that of President George W. Bush's proposal for FY 2006. The study team comprised more than 250 of the nation's top aviation experts representing industry and academia. NIA President and Executive Director Robert Lindberg remarked that the United State's aviation capabilities had eroded, despite the position of aviation as a critical component in the U.S. balance of trade. The report of more than 1,000 pages provided detailed investment plans, budgets, and needs assessments for seven aeronautics sectors: airspace systems, aviation safety and security,

[785] *Spacewarn Bulletin*, no. 618; Justin Ray, "Reality Realized: Titan Has Left Cape Canaveral," *Spaceflight Now*, 30 April 2005.
[786] Lockheed Martin, "Boeing, Lockheed Martin To Form Launch Services Joint Venture," news release, 2 May 2005, *http://www.lockheedmartin.com/news/press_releases/2005/BoeingLockheedMartin FormLaunchServi.html* (accessed 17 September 2009); Renae Merle, "Boeing, Lockheed Join Rocket Division," *Washington Post*, 3 May 2005.

subsonic aircraft, supersonic aircraft, hypersonic technologies, rotorcraft, and workforce and education.[787]

4 May

After a delay of more than one year, ESA's Mars Express deployed the first of three booms that form the craft's Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS). The MARSIS booms would search for evidence of water under the surface of Mars. The deployment marked the beginning of a 10-day sequence, originally scheduled for April 2004. NASA's JPL had conducted an investigation that had warned of the possibility that one or more of the antenna components could swing back and hit the spacecraft, a risk that had caused ESA to delay the deployment. Although an ESA review board had concluded that, even if such an event were to occur, the risk of damaging Mars Express remained low, scientists had voiced concerns that a strike from any of the booms could damage delicate instruments on board the orbiter. According to Mars Express Mission Manager Fred Jansen, engineers had analyzed the problem over the past year to assure themselves that any existing risks would not affect the spacecraft. As deployment commenced, telemetry data indicated that the first boom, which formed half of MARSIS's primary antenna, had deployed successfully. ESA had scheduled the second half of the antenna to deploy four days later.[788]

5 May

The Indian Space Research Organisation (ISRO) successfully launched its Cartosat-1 Earth-mapping and remote-sensing satellite aboard a Polar Satellite Launch Vehicle-C6 (PSLV-C6) from the newly built launchpad at Satish Dhawan Space Centre in Sriharikota, Andhra Pradesh, India. The 1.56-tonne (1,560-kilogram or 1.72-ton) Cartosat-1, the heaviest payload that the PSLV had ever ferried to space, carried two f/4.5 Panchromatic cameras, which together would enable the production of a stereoscopic image at a resolution of 2.5 meters (8.2 feet). ISRO planned to use the images to generate digital terrain-elevation maps, which would aid in assessing and monitoring land use, forest cover, and river flow. The launch vehicle also carried into orbit HAMSat, a 43-kilogram (0.043-tonne or 0.047-ton) microsatellite designed to relay amateur VHF radio communications.[789]

6 May

Alliant Techsystems announced the successful completion of the first in a series of ground tests for solar-sail technology, developed to enable solar-powered interplanetary probes and solar observatories. At NASA's GRC's Plum Brook Station in Ohio, NASA engineers fully deployed a 20 x 20 meter (65.6 x 65.6 feet) version of the solar-sail system, in a 100-foot-diameter (30.5-meter-diameter) vacuum chamber, to test the system's functional deployment and attitude control. The test marked a critical milestone in the development of in-space propulsion technology using the Sun's energy, instead of fuel propellant, to provide thrust. The In-Space

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[787] National Institute of Aerospace, "NIA Releases Congressionally-Requested Aviation Plan," 3 May 2005, *http://www.nianet.org/pressreleases/AviationPlan_050305.php* (accessed 16 September 2009); Allison Connolly, "Survey: NASA Can't Afford To Fall Behind in Aeronautics," *Virginian Pilot* (Hampton Roads, VA), 4 May 2005.
[788] *BBC News*, "First Marsis Radar Boom Deployed," 6 May 2005; Maggie McKee, "Mars Express To Deploy 'Divining Rod' at Last," *New Scientist*, 4 May 2005.
[789] *Spacewarn Bulletin*, no. 619, 1 June 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx619.html* (accessed 17 September 2009); K. S. Jayaraman, "India Launches Cartosat-1 Satellite," *Space News*, 6 May 2005.

Propulsion Program of NASA's Science Mission Directorate was developing the solar-sail propulsion system.[790]

9 May

NASA launched a 40 million-cubic-foot (12.2 million-cubic-meter) balloon, the Deep Space Test Bed facility, from Fort Sumner, New Mexico, carrying an automobile-sized aluminum gondola containing scientific experiments prepared by university and elementary school students. NASA had collaborated with the students to carry out research to analyze characteristics of Earth's atmosphere from the unique laboratory traveling 30 miles (48.3 kilometers) above Earth. The primary payload was the High Energy Replicated Optics (HERO), a hard x-ray–focusing telescope. Engineers from NASA's MSFC had designed HERO to create images from high-energy x-ray light. Undergraduate students from Pennsylvania State University, Montana State University, the University of Alabama, and Auburn University in Alabama had prepared experiments for the new laboratory. The experiments would identify pollution-related aerosols in the atmosphere, measure radiation and its impact on the integrity and behavior of the balloon, measure the external temperature of the balloon material, and gather magnetic-field data. Students from eight grade schools had prepared experiments to observe the effect of the flight environment on microscopic organisms and seeds, placing their experiments in brick-size plastic containers inside two large containers on board the balloon.[791]

12 May

NASA Administrator Michael D. Griffin, who had been in his new position for only one month, appeared as the sole witness before the U.S. Senate Appropriations Subcommittee on Commerce, Justice, and Science, to testify regarding NASA's FY 2006 budget request. Key issues that the panel discussed with Griffin included several related to the Space Shuttle Program: the four-year gap between the planned decommissioning of the Space Shuttle in 2010 and the first scheduled flight of the new Crew Exploration Vehicle (CEV) in 2014; the United States' obligation to complete the ISS before the retirement of the Space Shuttle; and servicing the HST. In his responses, Griffin stated that, in mid-July, he would release a plan for the first flight of the new CEV. He suggested that, if the ISS partners postponed some scheduled on-board scientific research, they could complete the ISS before the Shuttle's retirement, without cancelling any research programs. Regarding the HST, Griffin stated his opposition to a robotic servicing mission and said that he wished to assess the first two Shuttle flights before making a decision. The panel also discussed recommended cuts in Earth Science research. Griffin responded that NASA had listened to the concerns of the scientific community and was reexamining that area. Griffin clarified that NASA would not cut science programs to fund the spaceflight program.[792]

17 May

President of Canadian Arrow Geoff Sheerin and Indian-American entrepreneur Chirinjeev Kathuria joined forces to create a new corporation called PlanetSpace. The company's goal was

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[790] Alliant Techsystems, "ATK and NASA Successfully Test First Solar Sail Propulsion System," news release, 6 May 2005, *http://atk.mediaroom.com/index.php?s=118&item=447* (accessed 16 September 2009).
[791] NASA, "NASA and Students Partner for High Altitude Research," news release 05-121, 11 May 2005, *http://www.nasa.gov/home/hqnews/2005/may/HQ_05121_Student_Experiments.html* (accessed 14 September 2009).
[792] Richard M. Jones for the American Institute of Physics, "New NASA Administrator Appears Before Senate Appropriators," *FYI Bulletin* 69, 17 May 2005, *http://www.aip.org/fyi/2005/069.html* (accessed 17 September 2009).

to make spaceflight available to the public within two years. Canadian Arrow was creating a rocket based on the German World War II V-2 rocket. Although the company had not completed its rocket in time to compete for the US$10 million X Prize in 2004, it had successfully completed a drop test of the vehicle in August 2005 and expected to complete the rocket within one year. PlanetSpace planned to charge US$250,000 per person for a suborbital flight that would include 14 days of training and 15 minutes of flight time. The rocket would launch from a Canadian site with a pilot and two passengers and would reach a maximum velocity of four times the speed of sound. The rocket would coast to a maximum height of 70 miles (112 kilometers), providing a few minutes of weightlessness and a view of the curving Earth with a black sky above. Finally, a crew capsule would separate from the rocket during its descent and would parachute down to a water landing.[793]

19 May

NASA's JPL released a series of images that Mars Global Surveyor (MGS) had captured on 20 and 21 April, which showed, for the first time, NASA's Mars Odyssey and ESA's Mars Express spacecraft orbiting Mars. MGS had orbited the planet since 1997, Mars Odyssey had arrived in 2001, and Mars Express had arrived in late 2003. MGS and Mars Odyssey followed similar near-polar orbits, sometimes passing within 9 miles (15 kilometers) of each other, but Odyssey orbited higher than MGS to prevent collision. MGS had captured two images of Odyssey 7.5 seconds apart—the first from a distance of 56 miles (90 kilometers) and the second from 84 miles (135 kilometers). The following day, MGS had captured an image of Mars Express from a distance of 155 miles (249 kilometers).[794]

NASA and the Florida Space Research Institute (FSRI) announced the third Centennial Challenges competition: the Moon Regolith Oxygen (MoonROx) challenge. The MoonROx challenge would require teams to develop hardware, within mass and power limits, able to extract a minimum of 5 kilograms (0.005 tonnes or 0.006 tons) of breathable oxygen from simulated lunar soil—a volcanic ash called JSC-1—within a period of 8 hours. The first team to accomplish the oxygen-production goal before June 2008 would win US$250,000. Existing state-of-the-art technologies were incapable of extracting oxygen from simulated lunar soil. FSRI Executive Director Samuel T. Durrance remarked that oxygen-extraction technologies would be critical for robotic and human missions to the Moon.[795]

20 May

NASA launched a new environmental satellite for NOAA, aboard a Boeing Delta 2 7320-10 expendable launch vehicle, from Vandenberg Air Force Base in California. The NOAA-18 (N), the fourth in the series of five Polar Orbiting Environmental Satellites (POES) carrying improved imaging and sounding capabilities, would improve weather forecasting and monitor

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[793] PlanetSpace, "Canadian Arrow Partners with Leading American Entrepreneur To Launch First Commercial Passengers to Space," news release, 17 May 2005, *http://www.planetspace.org/pdf/ps-press-rel-001.pdf* (accessed 17 September 2009); Alan Boyle, "Space Partners Plan Flights in 2007," *MSNBC.com*, 18 May 2005, *http://www.msnbc.msn.com/id/7879142/* (accessed 17 September 2009).

[794] Tariq Malik, "New Photos Are First of Spacecraft Orbiting Mars," *Space.com*, 20 May 2005, *http://www.space.com/missionlaunches/050519_mgs_orbiters.html* (accessed 16 September 2009).

[795] NASA, "NASA Announces New Centennial Challenge," news release 05-128, 19 May 2005, *http://www.nasa.gov/home/hqnews/2005/may/HQ_05128_Centennial_Challenge.html* (accessed 14 September 2009); Jeremy McGovern, "Astro Bytes: Extracting Oxygen from 'Lunar' Soil," *Astronomy News*, 24 May 2005.

environmental events globally, collecting data about Earth's surface and atmosphere. The craft also carried instruments used in COSPAS-SARSAT, the international Search-and-Rescue Satellite-Aided Tracking System (COSPAS is the Russian acronym for "Cosmicheskaya Sistema Poiska Avariynyh Sudo," which means "Space System for the Search of Vessels in Distress"). Established in 1982, COSPAS-SARSAT had saved 5,000 lives in the United States and 18,000 worldwide.[796]

21 May

A California Launch Vehicle Education Initiative (CALVEIN) research team successfully launched and recovered the Prospector 6 (P6) test vehicle at the Mojave Test Area owned and operated by the Reaction Research Society. The test was part of a joint industry/academic effort to develop a low-cost Nanosat Launch Vehicle, a booster capable of delivering 22-pound (10-kilogram) payloads to low Earth orbit. Researchers at Garvey Spacecraft Corporation of Long Beach, California, and California State University at Long Beach had designed and built the partially reusable 27-foot (8-meter) P6 test vehicle, which had flown to just under 3,000 feet (914 meters), a milestone toward the team's goal. P6 had also carried student payloads from across the country: a mini-DV camera to capture on-board video of the entire flight sequence; a real-time telemetry system that adapted off-the-shelf Wi-Fi technology to relay key propulsion-system parameters; and a measurement-logging package to record acceleration, pressure, and temperature data that the research team would use to assess the vehicle's performance.[797]

23 May

NASA announced results of the Cassini probe's first radio occultation observations of Saturn's rings, atmosphere, and ionosphere, which had taken place on 3 May. Scientists had labeled the seven main rings in the order of discovery; however, from the planet outward, the rings are labeled D, C, B, A, F, G, and E. During the experiment, Cassini had been occulted—hidden—behind the planet's rings. The craft had simultaneously transmitted Ka, X, and S, three radio signals of different frequencies—the first occultation experiment to do so. NASA's ground-based Deep Space Network had received the signals, but their passage through Saturn's ring material had affected their strength—the denser the ring, the weaker the signal. Cassini's radio signals had revealed Saturn's ring structure with clarity never before seen, in particular the structure of ring B, which had eluded previous robotic explorers. Cassini had revealed ring B's composition as a thick, 5,000-kilometer-wide (3,100-mile-wide) core, containing several bands of material nearly 4 times as dense as that found in ring A, and nearly 20 times as dense as ring C. Cassini had also shown that the structure of ring B varies dramatically, contrasting sharply with the relatively flat structure of ring A and the wavy structure of ring C.[798]

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[796] *Spacewarn Bulletin*, no. 619; NASA, "NASA Successfully Launches Environmental Satellite," news release 05-129, 20 May 2005, *http://www.nasa.gov/home/hqnews/2005/may/HQ_05129_ NOAA_ success.html* (accessed 14 September 2009).

[797] Leonard David, "High Hopes for Low-Cost Rocket After Successful Launch Test," *Space.com*, 27 May 2005, *http://www.space.com/missionlaunches/050526_prospector6_test.html* (accessed 16 September 2009).

[798] NASA, "Cassini Radio Signals Decipher Structure of Saturn's Rings," news release 05-130, 23 May 2005, *http://www.nasa.gov/home/hqnews/2005/may/HQ_05130_Cassini.html* (accessed 14 September 2009); David Whitehouse, "Cassini Makes Detailed Ring Map," *BBC News*, 25 May 2005.

24 May

NASA announced that scientists had finally agreed that Voyager 1, launched in 1977, had reached the solar system's final frontier, passed through the termination shock region—the point at the edge of the solar system where the solar wind slows abruptly, and entered the heliosheath—a frontier of unknown thickness defining the border with interstellar space. In November 2003, the Voyager team had announced unusual events in the mission's history, signaling that Voyager 1 had reached the edge of the solar system. However, scientists disagreed as to whether the craft had actually encountered termination shock or was merely approaching the region at the edge of interstellar space. NASA explained that scientists had based the evidence that Voyager 1 had encountered termination shock on the craft's measurement of a sudden increase in the strength of the magnetic field carried by the solar wind, combined with an inferred decrease in speed, which happens when the solar wind slows down. Additionally, Voyager had observed an increase in the number of high-speed, electrically charged electrons and ions, as well as a burst of plasma-wave noise, which scientists had expected to occur when Voyager 1 passed the termination shock. Eric Christian, Discipline Scientist for the Sun-Solar System Connection Research Program at NASA Headquarters, remarked that Voyager's observations over the past few years had shown that termination shock is far more complicated than previously thought. When Voyager 1 entered the heliosheath, the craft was 8.7 billion miles (14 kilometers) away from Earth, the farthest any human-made object had traveled.[799]

25 May

Khrunichev Center announced that it had signed a contract with Russia's defense ministry, valid through 2010, to research, develop, and flight-test the Angara launch vehicle. The Angara project included a series of liquid oxygen/kerosene expendable launch vehicles. The Khrunichev Center intended for Angara 5 to have greater capabilities than the company's existing Proton rocket and to be far more environmentally friendly. In addition, the Angara 5 would launch exclusively from Plesetsk, rather than from the Baikonur Cosmodrome in Kazakhstan. According to the contract, near the end of 2006, the Khrunichev Center would launch the first vehicle carrying a Russian government payload.[800]

26 May

NASA returned *Discovery* to the Vehicle Assembly Building from its launchpad, to attach a newer fuel tank and booster set to the Space Shuttle. While *Discovery* was sitting on the launchpad, NASA had determined that ice could break off the outside of its external fuel tank and could prove as lethal as the falling foam insulation that had led to the demise of *Columbia*. To minimize the risk of such debris striking the orbiter's fragile heat shield, NASA had decided to install an additional heater on the fuel tank. Ice forms on the external tank when the fuel is extremely cold, and a heater would reduce the amount of ice build-up on the tank.[801]

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[799] NASA, "Voyager Spacecraft Enters Solar System's Final Frontier," news release 05-131, 24 May 2005, *http://www.nasa.gov/home/hqnews/2005/may/HQ_05131_Voyager_agu.html* (accessed 14 September 2009); Guy Gugliotta, "Voyager at Edge of Solar System," *Washington Post*, 25 May 2005.

[800] Dmitry Pieson, "Khrunichev, Defense Ministry To Build Angara Jointly," *Aerospace Daily and Defense Report*, 27 May 2005.

[801] Irene Mona Klotz, "Shuttle Heads Back to Workshop," *BBC News*, 27 May 2005; "Shuttle Rolls Back to Hangar," *Washington Post*, 27 May 2005.

JUNE 2005

7 June
France and the United States agreed to establish a Space Shuttle landing site in southern France. NASA Administrator Michael D. Griffin and French Ambassador Jean-David Levitte signed the agreement, which covered NASA's Space Shuttle support for the ISS. Under the agreement, France would permit Shuttles encountering problems during launch to land at Istres Air Base 125, near Marseilles, and allow the U.S. government to conduct additional support activities for Space Shuttles on French soil, such as weather monitoring and search-and-rescue operations.[802]

8 June
The Stafford-Covey Return to Flight Task Group (SCTG) provided an update on NASA's efforts to comply with the *Columbia* Accident Investigation Board's (the CAIB's) recommended safety and operational practices for Shuttle launches. The Task Group stated that it had approved NASA's efforts regarding five of the CAIB's critical recommendations, bringing the total number of CAIB recommendations with which NASA had complied to 12. Among the five recommendations that NASA had implemented were the installation of cameras on the Shuttle to observe critical events and steps to ensure that budgetary issues and other outside pressures would not influence flight schedules in the future. The Task Group stated further that, although NASA had not yet complied with three of the CAIB recommendations, it saw no circumstances that might prevent NASA's planned launch of Space Shuttle *Discovery* in July 2005. The three CAIB recommendations that NASA had not yet implemented were establishing in-orbit repair techniques for the orbiter, preventing catastrophic debris from falling off the orbiter's fuel tank during launch, and fortifying the orbiter against debris impacts.[803]

13 June
Scientists announced that they had found the most Earth-like planet ever before observed. Experts described the discovery as a milestone in efforts to find extraterrestrial life. Scientists led by Eugenio J. Rivera of the University of California, Santa Cruz, had discovered the planet, called GJ 876 d, orbiting the star GJ 876, which is 15 light-years from Earth. The planet, with a mass seven times that of Earth, is mostly composed of silicates, iron, and nickel—compositional matter more similar to that of Earth than the material of any other planet yet discovered. However, the planet is unlikely to support life, because estimated temperatures on the side of the planet facing the star are around 400° to 700°F—temperatures too hot for liquid water. Experts described the scientists' method of discovering the planet as a significant demonstration of the state-of-the art technologies for finding exoplanets—planets outside the solar system—that are as small as Earth. The scientists had used a spectrometer to discover GJ 876d, which is the smallest exoplanet yet found. Using the spectrometer had enabled them to observe changes in the exoplanet's reflected light. They had used the data to measure the planet's gravitational effects on the movements of its accompanying star.[804]

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[802] NASA, "U.S. and France Agree To Establish NASA Shuttle Landing Site," news release 05-143, 7 June 2005.
[803] Mark Carreau, "Shuttle Safety Issues Unresolved," *Houston Chronicle*, 9 June 2005; Warren E. Leary, "NASA Near to Meeting Safety Requirements for Launching in July," *New York Times*, 9 June 2005.
[804] John Johnson Jr., "Distant Object May Be a Planet Similar to Ours," *Los Angeles Times*, 14 June 2005; Eugenio J. Rivera et al., "A ~7.5 Earth-Mass Planet Orbiting the Nearby Star, GJ 876," *Astrophysical Journal* 634, no. 1 (20 November 2005): 625–640.

14 June
During a hearing of the House Science Subcommittee on Space and Aeronautics—*Live from Space: The International Space Station*—NASA astronaut John L. Phillips became the first person to provide congressional testimony while in space. The Subcommittee on Space and Aeronautics had convened the hearing to gather information on numerous topics concerning the ISS, such as current activities on the ISS, scientific and research accomplishments resulting from ISS operations, and long-term human spaceflight. At the time of the hearing, Phillips was aboard the ISS serving as a member of Expedition 11, along with Russian cosmonaut Sergei K. Krikalev. Former ISS crew members E. Michael Fincke and Peggy A. Whitson also provided testimony at the hearing.[805]

21 June
The Planetary Society and Cosmos Studios launched Cosmos 1, the first solar-powered spacecraft, at 3:46 p.m. (EDT), on a Volna rocket from a Russian submarine in the Barents Sea. Russian Space Agency officials, however, were not certain that the spacecraft had attained orbit. The spacecraft's sponsors, the Planetary Society and Cosmos Studios, are U.S. nonprofit organizations that seek to increase the public's knowledge of and involvement in space exploration. The late American scientist Carl Sagan had helped found the Planetary Society, and Ann Druyan—Sagan's widow—had founded Cosmos Studios. The two organizations had designed the craft and launched the mission to demonstrate the feasibility of solar power technology as an effective means of space travel. The pressure of solar light particles—photons—on the spacecraft's large, triangular, mirror-like "solar sails" were to propel the engineless, fuel-free Cosmos 1.[806]

22 June
The Russian Space Agency announced that the launch of Cosmos 1 had failed. According to the agency, the rocket that had launched the spacecraft had experienced failure 83 seconds after ignition. Consequently, the experimental solar-powered spacecraft had crashed soon after its launch.[807]

During its 179th meeting, held at the European Space Operations Centre in Darmstadt, Germany, the ESA Council elected Sigmar Wittig as its Chair, effective 1 July 2005. Wittig, head of the German delegation to ESA and the Chair of the Executive Board of the German Aerospace Center (Deutsche Zentrum für Luft- und Raumfahrt), replaced Per Tegnér of Sweden, whose term of office was ending on 30 June 2005. The ESA Council is ESA's governing body and provides policy guidelines for ESA's space programs.[808]

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[805] NASA, "NASA Astronaut Gives First Congressional Testimony from Space," news release 05-152, 14 June 2005; U.S. Congress, House of Representatives, Committee on Science and Technology, Subcommittee on Space and Aeronautics, *Live from Space: The International Space Station*, 109th Cong., 1st sess., 14 June 2005, 3.
[806] John Antczak for Associated Press, "Solar Sail Spacecraft Launched from Russian Submarine," 21 June 2005; The Planetary Society, "Projects: Solar Sailing," *http://planetary.org/programs/projects/ solar_sailing/* (accessed 10 August 2009).
[807] David Holley and Alex Raksin, "Solar Craft Falls Short of Cosmos," *Los Angeles Times*, 23 June 2005.
[808] ESA, "German Chair for ESA Council," ESA news release 35-2005, 22 June 2005, *http://www.esa.int/esaCP/Pr_35_2005_p_EN.html* (accessed 11 August 2009); ESA, "What is ESA?" *http://www.esa.int/SPECIALS/About_ESA/ SEMW16ARR1F_0.html* (accessed 11 August 2009).

23 June

The American Academy of Arts and Sciences released "United States Space Policy: Challenges and Opportunities," a research paper highly critical of the Vision for Space Exploration. In the paper, former Director of NASA's JSC George W. S. Abbey and former White House science advisor Neal F. Lane stated that the Vision for Space Exploration does not address major obstacles to the United States' progress in space exploration and science. Those problems include predicted shortfalls in the U.S. engineering and science workforce and declining international cooperation on existing and planned space missions. Abbey and Lane also stated that the United States would be unlikely to realize the Vision's objectives because of the diminishing U.S. commitment to the country's commercial space industry and the declining role of basic science in the U.S. space program and in the national economy. NASA officials did not comment on the paper, stating that they had not yet seen it.[809]

NASA-funded physicists at the Massachusetts Institute of Technology announced that they had created the first superfluid, a form of matter that flows without internal mechanical resistance or viscosity. The scientists had created the superfluid by cooling a gas of lithium atoms to nearly absolute zero (approximately -459°F), applying a magnetic field, to get the atoms of the gas to form pairs without creating molecules, and then using a laser to stir the gas. The last step produced vortexes—or microscopic whirlpools—throughout the resulting fluid. The vortexes provided conclusive evidence of superfluidity because, whereas rotating a container of normal fluid causes the fluid to spin, rotating a container of superfluid does not cause the frictionless superfluid to spin but, instead, produces vortexes in the superfluid that continue to spin as long as the fluid remains a superfluid. Experts described the research as a major breakthrough in physics. The findings could lead to the development of products such as room-temperature superconductors, which could help in other applications, such as transporting energy and assisting in medical diagnostics.[810]

27 June

The Stafford-Covey Return to Flight Task Group (SCTG) announced that it considered the Space Shuttle *Discovery* safe enough to fly again, even though NASA had not undertaken some steps recommended by the CAIB to ensure the Shuttle's safe launch. NASA had planned to launch *Discovery* as the first Shuttle flight since the *Columbia* accident in 2003 and had established the Task Group to review NASA's compliance with the CAIB's critical recommendations. Task Group members stated that, although NASA had not complied with all of the CAIB's 15 critical recommendations, the Space Shuttle was ready to resume flight, and NASA was responsible for making the final decision to launch the Shuttle. NASA Administrator Michael D. Griffin was unclear about how the Task Group's findings would influence Shuttle launch plans.[811]

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[809] John Schwartz, "Report Says Space Program Is Lacking Money and Focus," *New York Times*, 23 June 2005; George W. S. Abbey and Neal F. Lane, "United States Space Policy: Challenges and Opportunities" (Occasional Paper, American Academy of Arts and Sciences, Cambridge, MA, 2005), 1–2.

[810] NASA, "Whirling Atoms Dance into Physics Textbooks," news release 05-163, 24 June 2005; M. W. Zwierlein et al., "Vortices and Superfluidity in a Strongly Interacting Fermi Gas," *Nature* 435, no. 7045 (23 June 2005): 1047–1051.

[811] Traci Watson, "Safety Panel: NASA Failed To Fix Critical Issues with Shuttle," *USA Today*, 28 June 2009.

28 June
The House Committee on Science held a hearing entitled *The Future of NASA* in preparation for a subcommittee to consider, on the following day, legislation reauthorizing NASA's aeronautics, human spaceflight, and science programs through FY 2006 (H.R. 3070). President George W. Bush had requested US$16.5 billion in funding for NASA for FY 2006. NASA Administrator Michael D. Griffin provided testimony to the committee about NASA's intentions regarding issues contained in the President's budget request, including NASA's plans for human and robotic space exploration, the Crew Exploration Vehicle (CEV), and Space Shuttle safety. Griffin told the committee that, despite the fact that NASA had not yet complied with all 15 of the CAIB's critical recommendations, NASA was preparing to launch Shuttle *Discovery* on 13 July 2005, pending the results of NASA's own inspection. Furthermore, Griffin discussed President Bush's intention to amend the Iran Nonproliferation Act, which had effectively prevented NASA from purchasing or bartering for space on Russian spacecraft. The amendment of the act would permit NASA to send astronauts to the ISS after April 2006.[812]

30 June
An international group of astronomers led by Debra A. Fischer of San Francisco State University announced that they had discovered the largest solid core yet found in an exoplanet. The planet, called HD 149026b, has a solid core that is approximately 70 times larger than Earth's mass. The discovery was the first observational evidence of the core accretion theory of planetary formation, which posits that planets begin as small rock-ice cores and acquire additional mass through gravitational attraction of gas and other matter. The competing gravitational instability theory holds that planetary formation occurs after the rapid gravitational collapse of large gas clouds. Fischer and the other astronomers reported that they had determined that the mechanism of gravitational instability was unlikely to have produced the large, rocky core of HD 149026b.[813]

JULY 2005

4 July
NASA's Deep Impact spacecraft, created to analyze the comet Tempel 1, successfully completed a planned crash into Tempel 1, becoming the first mission to probe beneath the surface of a comet. Astronomers believe that analyzing comets can help them better understand the solar system's formation and evolution, because comets are composed of materials from distant regions of the solar system, which formed 4.5 billion years ago. The Deep Impact spacecraft—one of a series of low-cost space science ventures developed under the NASA Discovery Mission—consisted of two vehicles: an impactor and a flyby vehicle. NASA had designed the impactor to crash into Tempel 1, thereby exposing the comet's internal material, and to capture images of the comet until just seconds before impact. NASA intended the flyby vehicle to capture images of Tempel 1's substrata, the internal material of the comet that the

[812] U.S. Congress, House of Representatives, Committee on Science, *The Future of NASA*, 109th Cong., 1st sess., 28 June 2005, 3–5; Guy Gugliotta, "NASA Says Shuttle Should Be Ready on July 13," *Washington Post*, 29 June 2009.
[813] NASA, "NASA Researchers Discover Planet with Largest Solid Core," news release 05-169, 30 June 2005; Bun'ei Sato et al., "The N2K Consortium. II. A Transiting Hot Saturn Around HD 149026 with a Large Dense Core," *Astrophysical Journal* 633, no. 1 (1 November 2005): 465–473.

impactor's crash would expose, and to conduct chemical analyses of comet debris ejected during the crash.[814]

7 July

NASA scientists announced the first measurements ever taken of changes in sea level that were unrelated to changes in land height. Although researchers believed that rising sea levels were related to global warming, they were unsure of how much sea levels had changed, the degree to which sea-level changes were attributable to upward and downward land movements, and the causes of those changes. However, using data from numerous satellites, NASA scientists had discovered that global sea levels had increased during the previous 50 years, at an estimated rate of 1.8 millimeters (0.07 inches) annually, and that the rate of increase had accelerated to 3 millimeters (0.12 inches) annually in the previous 12 years. The scientists attributed half of the rise in sea levels to the expansion of water from warmer ocean temperatures and the remainder to various other sources, such as the melting of ice covers in Antarctica, Greenland, and elsewhere.[815]

10 July

JAXA launched its Suzaku astronomy satellite at 3:30 a.m. (GMT) from Uchinoura Space Center (formerly called the Kagoshima Space Center) on an M-5 rocket. Suzaku, known as Astro-E2 before the launch, was JAXA's replacement for its first Astro-E satellite, which had been lost during launch in 2000. JAXA and the Japanese Institute of Space and Astronautical Science had built the satellite to monitor space in conjunction with NASA's Chandra X-ray Observatory and ESA's XMM-Newton. The Suzaku satellite was equipped with three telescopes: a Hard X-ray Detector, an X-ray Spectrometer, and an X-ray Imaging Spectrometer.[816]

14 July

Maciej Konacki of the California Institute of Technology reported the first discovery of a planet occupying an orbit among three stars. The planet, dubbed HD 188753, has a mass that is slightly larger than Jupiter. HD 188753 closely orbits a primary star, along with a pair of similarly sized stars. According to scientists, Konacki's findings challenged conventional scientific understanding of the architecture of planetary systems. Scientists had believed that other planetary systems have a structure like Earth's solar system, in which only planets—and not stars—orbit a star. Konacki's research cast doubt on conventional theories of planetary system development, because his findings provided the first evidence that a planet could develop and survive in a gravitationally complex stellar system. According to conventional scientific theory, HD 188753's two companion stars would have burned away the primary star's surrounding gas and dust, which would have provided the materials to form the new planet. In addition, although other existing theories had suggested that a planet of HD 188753's size could have migrated to the massive star from elsewhere, those theories had posited incorrectly that the secondary pair of

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[814] Guy Gugliotta, "NASA Succeeds in Crashing Craft into Comet," *Washington Post*, 5 July 2005; NASA, "Deep Impact: Mission to a Comet, Spacecraft and Instruments," *http://www.nasa.gov/mission_pages/deepimpact/mission/index.html* (accessed 12 June 2009).

[815] Juliet Eilperin, "NASA Able To Pinpoint Changes in Sea Levels," *Washington Post*, 8 July 2005; NASA, "NASA Satellites Measure and Monitor Sea Level," news release 05-175, 7 July 2005.

[816] *Spacewarn Bulletin*, no. 621, 1 August 2005, *http://nssdc.gsfc.nasa.gov/spacewarn/spx621.html* (accessed 12 June 2009); NASA, "Suzaku: Mission Overview," 3 June 2009, *http://www.nasa.gov/ mission_pages/astro-e2/main/index.html* (accessed 12 June 2009).

stars would have prevented HD 188753 from orbiting the primary star as closely as does. HD 188753 completes a single orbit in 3.4 Earth days.[817]

20 July
Researchers at NASA's GRC successfully tested a new type of fire detector, which could significantly reduce false alarms in the baggage and cargo compartments of commercial aircraft. Whereas most fire detectors only detect smoke particles, the GRC-developed sensor system—called the MicroElectroMechanical Systems (MEMS)—could compare gas concentrations and smoke-particle dimensions in the environment to those commonly found in fires. The MEMS was equipped with carbon dioxide and carbon monoxide sensors, a smoke-particle detector, and integrated software, elements that, collectively, rendered it less vulnerable to false alarms than smoke-sensing detectors, which can give false alarms when sensing dust and other airborne particles. According to the FAA, the ratio of false alarms to actual fires on aircraft was around 100 to 1.[818]

26 July
NASA's Space Shuttle *Discovery* lifted off from NASA's KSC in Florida at 10:39 a.m. (EDT) in NASA's first Space Shuttle launch since the February 2003 *Columbia* tragedy. Although officially designated STS-114, NASA had frequently referred to the *Discovery* mission as the Return to Flight Mission. In addition, STS-114 was the first step toward implementation of the Vision for Space Exploration, the U.S. space policy calling for human and robotic missions to the Moon, Mars, and other planets in the solar system. The primary objectives of STS-114 were to test and evaluate new safety procedures at the ISS and to conduct construction and maintenance tasks at the ISS. Mission crew members were Commander Eileen M. Collins, Pilot James M. Kelly, Mission Specialists Charles J. Camarda, Wendy B. Lawrence, Stephen K. Robinson, and Andrew S. W. Thomas, and Japanese astronaut Soichi Noguchi, also a Mission Specialist.[819]

27 July
NASA announced that it would once again ground the Space Shuttle fleet, because mission personnel had discovered that Shuttle *Discovery* had experienced a problem similar to the one that had fatally damaged *Columbia*. Specifically, analysts had discovered that, during launch, *Discovery*'s external fuel tank had shed portions of foam insulation. At least one of the pieces of insulation had come from the same area of the tank as the foam that had ended the *Columbia* mission. Although the problem did not affect *Discovery*'s launch, the Shuttle's crew had spent much of their first full day in orbit closely examining the orbiter's exterior to determine the extent of the problem.[820]

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[817] John Noble Wilford, "Discovery of a First: A World with 3 Suns," *New York Times*, 15 July 2005; Maciej Konacki, "An Extrasolar Giant Planet in a Close Triple-Star System," *Nature* 436, no. 7048 (14 July 2005): 230–233.
[818] NASA, "New NASA Design Concept Smokes Out False Alarms," news release 05-191, 20 July 2005.
[819] NASA, "NASA Launches Space Shuttle Return to Flight Mission," news release 05-203, 26 July 2005; NASA, "STS-114: Return to Flight," *http://www.nasa.gov/returntoflight/main/index.html* (accessed 19 June 2009); NASA, "Return to Flight: Mission Overview," *http://www.nasa.gov/returntoflight/crew/index.html* (accessed 19 June 2009).
[820] Michael Cabbage and Robyn Shelton, "NASA Grounds Shuttles," *Orlando Sentinel* (FL), 28 July 2005.

29 July
A group of astronomers led by Michael E. Brown of the California Institute of Technology announced the discovery of a new planet in the solar system. The scientists had temporarily called the planet 2003 UB313 until the International Astronomic Union could formally approve the name that the scientists had proposed, but had not yet disclosed to the public. Although the scientists did not yet know the planet's exact size, they believed it was larger than Pluto, which astronomers estimate is 1,400 miles (2,300 kilometers) in diameter. In addition, the newly discovered planet, which the scientists believed to be composed of rock and ice, was the furthest known object in the solar system, with a 560-year elliptical orbit around the Sun at distances ranging from 3.3 to 9 billion miles (5.3 to 14 billion kilometers) from the Sun. By comparison, Pluto's orbit ranges from 2.7 to 4.6 billion miles (4.3 to 7.4 billion kilometers) from the Sun. The astronomers had also discovered that the orbit of 2003 UB313 is quite different from that of most planets in the solar system—it possesses an orbit skewed at an angle 44º from Earth's orbit, whereas most planets orbit in planes that are close to that of Earth.[821]

30 July
Space Shuttle *Discovery* astronauts, Stephen K. Robinson of NASA and Soichi Noguchi of JAXA, completed a spacewalk during which they tested new prototype methods to repair heat-resistant tiles on the orbiter's exterior. Robinson applied an experimental compound inside cracks in damaged panels, and Noguchi applied a thick, dark-colored paint to thermal protection tiles, to replace cracked or missing black surface coatings. NASA had developed the repair techniques in response to recommendations from the *Columbia* Accident Investigation Board. During the spacewalk, the two astronauts also performed several tasks to upgrade the ISS, such as replacing a broken GPS antenna and installing a bracket designed to hold a toolbox and parts kit for use during future spacewalks.[822]

AUGUST 2005

1 August
Space Shuttle *Discovery* astronauts Soichi Noguchi of JAXA and Stephen K. Robinson of NASA performed the second of three scheduled spacewalks for STS-114. The two astronauts conducted tests on materials designed to service the orbiter's heat-shielding tiles and replaced a 600-pound (272.2-kilogram) gyroscope on the exterior of the ISS. The device was one of four gyroscopes that help maintain the station's orientation in space.[823]

3 August
Space Shuttle *Discovery* astronauts Soichi Noguchi and Stephen K. Robinson completed a final spacewalk during which Robinson performed an unprecedented maneuver to complete a critical operation of the orbiter's thermal protection system. The principle objective of the spacewalk

[821] Kenneth Chang and Dennis Overbye, "Planet or Not, Pluto Has Far-Out Rival," *New York Times*, 30 July 2005; NASA, "World Book at NASA: Pluto," *http://www.nasa.gov/worldbook/pluto_worldbook.html* (accessed 2 July 2009); Richard A. Kerr, "Newfound 'Tenth Planet' Puts Pluto Behind the Eight Ball," *Science* 309, 5736 (5 August 2005): 859.
[822] Warren E. Leary, "Astronauts Test Repair Methods on Heat Tiles," *New York Times*, 31 July 2005; Guy Gugliotta, "NASA Adds One Day to Shuttle's Mission," *Washington Post*, 31 July 2005.
[823] NASA, "STS-114 MCC Status Report #13," 1 August 2005, *http://www.nasa.gov/returntoflight/ news/STS-114-13.html* (accessed 24 June 2009).

was to remove two pieces of protruding heat shielding—called gap fillers—from the bottom of the orbiter. NASA was concerned that the fillers might add extra heat to the orbiter's heat-shielding tiles upon reentry into Earth's atmosphere, thereby threatening the mission. Astronauts James M. Kelly and Wendy B. Lawrence used the robotic arms of the Shuttle and those of the ISS to lower Robinson to the underside of *Discovery*, while Noguchi monitored the operation. Despite concerns that Robinson might lose communication with the other astronauts, the operation was a success. The maneuver was the first time that an astronaut had worked on the underside of an orbiter while in space. During the spacewalk, Noguchi and Robinson also installed an external stowage platform and a new iteration of an experiment to test materials in the environment of space.[824]

Astronomers using NASA's Spitzer Space Telescope (SST) detected, for the first time, a large population of black holes known as type-2 quasars. Quasars—supermassive black holes—are the universe's brightest objects. Although scientists had observed the light from type-1 quasars, they had never before been able to detect type-2 quasars because, despite the brightness of type-2 quasars, the gas and dust rings that surround them obscure the quasars' visible light and block their emission of x-rays. Space telescopes and other scientific instruments rely on x-ray emissions to detect and to analyze these celestial phenomena. However, Alejo Martínez-Sansigre of the University of Oxford led a team of astronomers who used the SST to detect infrared light emitted by type-2 quasars, thereby capturing evidence of 21 quasars. The research also indicated that the growth of black holes has been concentrated in obscure regions of the universe and has tended to occur in the cores of forming galaxies during brief, highly productive periods. The new data suggested that thousands more such quasars might exist in the universe.[825]

9 August

The Space Shuttle *Discovery* returned to Earth, landing at California's Edwards Air Force Base at 5:11 a.m. (PDT). The mission—officially designated STS-114—was NASA's first Shuttle mission since the February 2003 loss of *Columbia*. The Shuttle's successful reentry was particularly important, because the *Columbia* accident had occurred during the reentry phase of its mission. The mission's primary objectives were to test and evaluate new safety procedures for Shuttle missions and to continue construction and maintenance of the ISS. Soichi Noguchi and Stephen K. Robinson had performed some of the ISS and Shuttle maintenance tasks during three spacewalks on 30 July, 1 August, and 3 August. The total duration of STS-114 was 13 days, 21 hours, and 32 minutes.[826]

12 August

NASA launched its Mars Reconnaissance Orbiter (MRO) at 7:43 a.m. (EDT) from Cape Canaveral Air Force Station in Florida on an Atlas 5 launch vehicle. The occasion marked the first time that NASA had used an Atlas 5 to launch an interplanetary mission. NASA had designed the MRO to conduct highly detailed analyses of Mars's atmosphere, surface, and

[824] NASA, "NASA's Spacewalking Astronaut Completes Unique Repair," news release 05-212, 3 August 2005; NASA, "Space Shuttle Mission Archives: STS-114," *http://www.nasa.gov/mission_pages/shuttle/shuttlemissions/archives/sts-114.html* (accessed 24 June 2009).
[825] NASA, "NASA's Spitzer Finds Hidden, Hungry Black Holes," news release 05-211, 3 August 2005; Alejo Martínez-Sansigre et al., "The Obscuration by Dust of Most of the Growth of Supermassive Black Holes," *Nature* 463, no. 7051 (4 August 2005): 666–669.
[826] NASA, "Space Shuttle Mission Archives: STS-114."

subsurface. From low orbit, the MRO would evaluate landing sites for future Mars missions and search for sites where water might have previously existed. NASA planned to examine the MRO data to seek evidence of previous life on the planet and to study planetary climate change. After two years of gathering data, the MRO would relay the information to Earth, using two robotic probes scheduled to arrive on Mars in 2008 and 2010.[827]

16 August

Russian cosmonaut and ISS crew member Sergei K. Krikalev set a world record of 748 days for total time spent in space. Krikalev had begun his cosmonaut training in 1985 and had first served as a crew member of Russia's *Mir* space station in 1988. Krikalev had served on the *Mir* crew again in 1991 and had later become a member of the first ISS crew comprising both Russian cosmonauts and U.S. astronauts. In addition, he had been the first Russian to travel on a NASA Space Shuttle, achieving that distinction on Shuttle *Discovery* in 1994. The ISS partners had scheduled Krikalev's return to Earth for October 2005—by then he would have spent 814 days in space.[828]

NASA scientists led by Karel J. Schrijver announced the results of their research on the development of better methods of forecasting solar storms. Radiation from solar storms—extremely powerful explosions in the Sun's atmosphere—can affect unprotected astronauts and airplane passengers, as well as satellites. In the past, scientists had usually analyzed changes in solar magnetic fields to forecast solar storms (also called solar flares), but this method had demonstrated limited reliability. However, a team of NASA scientists using NASA's Solar and Heliospheric Observatory (SOHO) had found that strong electrical currents in the solar atmosphere—currents associated with changes in solar magnetic fields—are the primary drivers of solar flares. Therefore, observing the electrical currents is a more reliable method of forecasting solar flares than the method previously used. The researchers had also discovered that solar flares are strongest and most likely to occur in regions of the Sun where electrical currents accumulate until they have reached an explosive threshold. According to Schrijver and the other researchers, these findings would enable scientists better to forecast periods of potentially hazardous space weather.[829]

17 August

The Stafford-Covey Return to Flight Task Group (SCTG) released its final report on NASA's efforts to meet the CAIB's recommendations for resuming piloted Shuttle flights. Former NASA Administrator Sean O'Keefe had established the task group to provide an independent assessment of NASA's implementation of the CAIB's 15 critical recommendations. In the final report, the CAIB concluded that NASA had met or exceeded 12 of the 15 recommendations and had made substantive progress on the remaining three. The task group explained that the final three recommendations were of a type that would be nearly impossible to complete. However,

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[827] NASA, "NASA's Multipurpose Mars Mission Successfully Launched," news release 05-218, 12 August 2005; Thomas H. Maugh II, "New Mars Orbiter Embarks on Ambitious Fact-Finding Mission," *Los Angeles Times*, 13 August 2005.

[828] Mark Carreau, "Russian Cosmonaut Sets a World Record of 748 Days in Space," *Houston Chronicle*, 17 August 2005.

[829] NASA, "NASA Scientists Closer to Timely Space Weather Forecasts," news release 05-226, 16 August 2005; Carolus J. Schrijver et al., "The Nonpotentiality of Active-Region Coronae and the Dynamics of the Photospheric Magnetic Field," *Astrophysical Journal* 628, no. 1 (20 July 2005): 501–513.

major media highlighted an appendix of the document in which seven of the 28-member task group provided a highly critical assessment of NASA's management. These seven task force members claimed that some of the same organizational behaviors of NASA managers that had contributed to the destruction of Space Shuttle *Columbia* had also jeopardized the July 2005 Space Shuttle *Discovery* mission. They stated further that NASA had failed to address the problem of *Discovery*'s loss of foam insulation from its fuel tank and had failed to take steps to protect the Space Shuttles from the damage caused by such debris.[830]

18 August

A group of scientists led by David N. Burrows of Pennsylvania State University announced that they had found evidence of black holes behaving in a manner previously unknown. Using observations from NASA's Swift satellite, the scientists had discovered newly formed black holes that were simultaneously consuming matter while propelling away other material. They also observed that, after the black holes had emerged from large star explosions, the energy from the black holes' initial formative activities had caused several subsequent explosions during the following minutes, with a gamma-ray burst (GRB) from the first explosion followed by x-ray flares from later explosions. Previously, scientists had believed that black holes and GRBs were only associated with single explosions of collapsing stars, rather than with a rapid succession of explosions. The scientists had been able to conduct their analyses because NASA's Swift satellite could observe GRBs within minutes after their occurrence, whereas other satellites had only been able to observe GRBs hours after they had occurred.[831]

24 August

NASA and NOAA announced their joint development of procedures to improve the accuracy of medium-range weather forecasts in the Northern Hemisphere. NASA and NOAA scientists had incorporated into weather prediction models the data from the Atmospheric Infrared Sounder (AIRS) on NASA's Aqua satellite, improving the accuracy range of experimental six-day weather forecasts of the Northern Hemisphere by 6 hours. Observers called this improvement of 4 percent a significant development in weather forecasting. NASA had launched Aqua on 4 May 2002, enabling the AIRS to produce three-dimensional maps of air and surface temperature, cloud properties, and water vapor. Moreover, the instrument had a spectral resolution more than 100 times greater than that of other infrared sounders.[832]

SEPTEMBER 2005

6 September

Scientists published the first research findings from NASA's Deep Impact mission, which had revealed important and unexpected findings about comets. On 4 July 2005, a probe from the Deep Impact spacecraft had performed a planned crash into the comet Tempel 1, while various observatories and the spacecraft's observational vehicle analyzed the impact. One of the most

[830] Return to Flight Task Group, *Final Report of the Return to Flight Task Group* (Washington, DC, July 2005); John Schwartz, "Minority Report Faults NASA as Compromising Safety," *New York Times*, 18 August 2005.
[831] D. N. Burrows et al., "Bright X-ray Flares in Gamma-Ray Burst Afterglows," *Science* 309, no. 5742 (16 September 2005): 1833–1835; NASA, "NASA's Swift Satellite Finds Newborn Black Holes," news release 05-229, 18 August 2005.
[832] NASA, "NASA/NOAA Announce Major Weather Forecasting Advancement," news release 05-231, 24 August 2005; NASA JPL, "AIRS: Overview," *http://airs.jpl.nasa.gov/overview/ overview/* (accessed 2 July 2009).

important findings was the presence of organic material in the comet, a discovery that supported theories that comets may have seeded Earth with the chemical precursors to life. However, scientists were surprised to find that the frozen comet contained minerals that require liquid water, not frozen water, to form. Scientists also puzzled over the presence of minerals that form in warmer temperatures than those present in the outer margins of the solar system, where they believed that comets had originated. Just as surprising to researchers was the discovery that the comet was not composed of solid ice, but that, instead, it had a fragile shell of ice covering a highly porous interior composed largely of dust.[833]

9 September

NASA Deputy Administrator and former astronaut Frederick D. Gregory announced his resignation from NASA. Gregory, who had become Deputy Administrator in 2002, stated that he was leaving the post so that a younger and more motivated individual could have the experience of serving. During his 31-year career with NASA, Gregory had served as Associate Administrator for Space Flight and Associate Administrator for NASA's Office of Safety and Mission Assurance. Gregory also had logged 455 hours in space as an astronaut, and in 1989 he had become the first African American to command a Space Shuttle mission. In his resignation letter to President George W. Bush, Gregory stated that he would remain Deputy Administrator until NASA had a confirmed successor.[834]

The GAO issued a report detailing numerous problems with NASA's financial management operations—problems that could threaten NASA's major programs. The report addressed NASA's implementation of its Integrated Financial Management Program (IFMP)—NASA had begun implementing the IFMP in 2000 as a single accounting system to replace 11 separate accounting systems. At the request of the U.S. Congress, in 2003 GAO had examined NASA's progress on IFMP implementation and had recommended that NASA make 45 changes to the program. In its assessment of NASA's efforts to implement those recommended changes, GAO stated that NASA had made slow progress and still needed to implement most of the recommendations. The report also stated that NASA's financial management problems were in danger of threatening its capacity to manage its programs and to allocate its budget to projects and programs. NASA responded that it had made significant improvements under the IFMP and had made progress on more of GAO's recommendations than GAO had indicated in its report.[835]

12 September

Astronomers announced the detection of the most distant explosion ever observed, at approximately 12.6 billion light-years from Earth—a gamma-ray burst (GRB) occurring after a massive star's collapse and transformation to a black hole. The explosion, which astronomers had named GRB 050904, had occurred nearly 1.1 billion years after the Big Bang, which itself had happened 13.7 billion years ago. The astronomers used ground-based telescopes and

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[833] Kenneth Chang, "Composition of a Comet Poses a Puzzle for Scientists," *New York Times*, 7 September 2005; John Johnson Jr., "Snowy Dirtball Is Melting Old Theories," *Los Angeles Times*, 7 September 2005.

[834] NASA, "NASA Deputy Administrator Frederick Gregory Resigns," news release 05-258, 9 September 2005; Mark Carreau, "NASA Deputy Administrator Resigns," *Houston Chronicle*, 10 September 2005.

[835] U.S. Government Accountability Office, "Business Modernization: Some Progress Made Toward Implementing GAO Recommendations Related to NASA's Integrated Financial Management Program" (report no. GAO-05-799R, Washington, DC, 9 September 2005); Tamara Lytle, "NASA Still Can't Balance Its Books, Auditors Say," *Orlando Sentinel* (FL), 28 October 2005.

NASA's Swift satellite to detect GRB 050904's emitted infrared light. Because the event had occurred so far away, the infrared light had just begun to reach Earth. However, the explosion was not the most distant object or event that astronomers had ever observed. Scientists had detected a quasar and a galaxy located 12.7 billion light-years from Earth.[836]

18 September
Scientists announced that NASA's Cassini spacecraft had detected water vapor on Enceladus, one of Saturn's moons. Scientists described this as one of the most important findings in planetary science, because the discovery suggested that liquid water might exist on Enceladus. Liquid water is a prerequisite for the formation of life. Scientists had already known that Enceladus has a crystalline ice covering, the most reflective type of surface in the solar system, making Enceladus the brightest object in the solar system with the exception of the Sun. In addition, scientists had already known that diminutive Enceladus, which is only 310 miles (500 kilometers) in diameter, is the smallest object in the solar system to have volcanic activity. However, scientists were surprised to discover water vapor over Enceladus's south pole, and they were unable to explain the finding. NASA and ESA had launched Cassini in 1997 to survey Saturn and its moons.[837]

19 September
NASA Administrator Michael D. Griffin released to the public NASA's detailed master plan for meeting goals established under the Vision for Space Exploration, including transporting humans to the Moon, Mars, and elsewhere in the solar system. The US$104 billion plan, called the Exploration System Architecture Study, addressed the technologies and strategies that NASA planned to use to transport crews to the ISS, the Moon, and Mars. NASA proposed to replace the Space Shuttles with a Crew Exploration Vehicle (CEV) similar in design to the *Apollo* and *Soyuz* spacecraft, but incorporating new fuels and technologies.[838]

William W. Parsons replaced Thomas Q. Donaldson as Director of NASA's SSC. Parsons had served as Director of SSC from August 2002 to May 2003 before leaving SSC to serve as Space Shuttle Program Manager from May 2003 to September 2005. Donaldson had left SSC to serve on a Federal Emergency Management Agency special assignment concerning recovery efforts for areas affected by Hurricane Katrina in August 2005.[839]

25 September
The U.S. Air Force launched the most technologically advanced GPS satellite ever developed, the GPS IIR-14, on a Delta-2 rocket at 11:37 p.m. (EDT) from Cape Canaveral Air Force Station in Florida. The GPS IIR-14 was the first of eight satellites planned for the new GPS, which the Air Force had created to provide improved encryption and GPS antijamming capabilities for the

[836] Guy Gugliotta, "Satellite Detects Massive Explosion," *Washington Post*, 13 September 2005; NASA, "Most Distant Explosion Detected, Smashes Previous Record," news release 05-259, 12 September 2005.
[837] Guy Gugliotta, "Water Vapor Discovered on Tiny Moon of Saturn," *Washington Post*, 19 September 2005.
[838] NASA, "NASA Releases Plans for Next Generation Spacecraft," news release 05-226, 19 September 2005; NASA, "NASA's Exploration Systems Architecture Study," November 2005, *http://www.nasa.gov/exploration/news/ESAS_report.html* (accessed 10 July 2009).
[839] NASA History Division, "NASA Center Directors," *http://www.hq.nasa.gov/office/pao/History/ director.html* (accessed 9 July 2009); NASA, "NASA Names New Stennis Center Director," news release 05-260, 13 September 2005.

U.S. military, as well as an improved GPS signal for civilian users. At the time of the launch, the GPS constellation consisted of 28 satellites, which the Air Force was operating for both civilian and military users.[840]

28 September
The FAA issued the first airworthiness certificate for a civil UAV—the General Atomics Altair. The UAV had a wingspan of 86 feet (26.2 meters), could fly to an altitude of 52,000 feet (9.8 miles or 15.8 kilometers), and could remain airborne for more than 30 hours. General Atomics and NASA had jointly built the Altair to perform scientific and commercial research.[841]

30 September
The Russian Space Agency launched the crew of ISS Expedition 12 in a *Soyuz* spacecraft at 11:55 p.m. (EDT) from Baikonur Cosmodrome in Kazakhstan. The members of Expedition 12 were American astronaut Commander William S. McArthur Jr. and Russian cosmonaut Valery I. Tokarev. The two men would replace the crew of Expedition 11, comprising Russian cosmonaut Commander Sergei K. Krikalev and American astronaut John L. Phillips. The ISS partners planned for the new crew to remain at the station for nearly six months. The launch also included American executive Gregory Olsen, who would conduct scientific experiments under a commercial contract with the Russian Space Agency. Olsen planned to return to Earth with the Expedition 11 crew on 10 October 2005.[842]

OCTOBER 2005

3 October
Lesa B. Roe replaced the retiring Roy D. Bridges Jr. as Director of NASA's LaRC. Roe, who had begun working with NASA in 1987, had served as LaRC's Deputy Director since June 2004. Before that, she had been LaRC's Associate Director for Business Management since August 2003. Bridges had served as Director of LaRC from June 2003 until his retirement from NASA.[843]

Astronomers announced that they had discovered the source of short gamma-ray bursts (GRBs), which had been an enigma for decades. Gamma rays are the most energetic and deadly form of electromagnetic radiation. Although scientists had already discovered that supernovas cause long GRBs, which last for approximately 2 seconds, they had remained uncertain of the causes of short GRBs, which last less than 1 second. Using data from numerous NASA satellites, 130 astronomers from around the world found that short GRBs originate from neutron stars and not—as some theories had suggested—from supernovas. More specifically, satellite data showed that short GRBs originate from collisions involving a neutron star and either another neutron star

[840] Lockheed Martin, "First Modernized GPS Satellite Built by Lockheed Martin Launched Successfully by the U.S. Air Force," news release, 26 September 2005, *http://www.lockheedmartin.com/news/press_releases/2005/FIRSTMODERNIZEDGPSSATELLITEBUILTBYL.html* (accessed 28 January 2010).
[841] FAA, "FAA Certifies First Civil Unmanned Aerial Vehicle," news release AOC 34-05, 28 September 2005, *http://www.faa.gov/news/press_releases/news_story.cfm?newsid=5780&print=go* (accessed 28 January 2010).
[842] NASA, "Expedition 12 on the Way to International Space Station," news release 05-292, 30 September 2005.
[843] NASA, "Langley Center Director Lesa B. Roe," 3 October 2005, *http://www.nasa.gov/centers/langley/about/roe_bio.html* (accessed 13 July 2009); NASA, "Gen. Roy D. Bridges Named Langley Center Director," news release 03-042, 13 June 2003.

or a black hole. However, the data was not conclusive regarding the exact type of collision that causes short GRBs, because the brevity of these events makes them difficult to observe directly.[844]

8 October

ESA's CryoSat spacecraft was destroyed during a failed launch from Russia's Plesetsk Cosmodrome. ESA had intended CryoSat as one of a series of Earth-observation spacecraft called Earth Explorers. ESA had built CryoSat to monitor the thickness of land and sea ice, to determine whether climate change is reducing Earth's ice masses. Initial assessments of the launch failure indicated that the rocket launching the satellite had experienced a problem with its on-board flight-control system, a problem that had prevented the rocket's upper stage from separating from its second stage.[845]

10 October

JAXA successfully tested an experimental aircraft capable of flying at Mach 2, which is twice the speed of sound. JAXA launched the aircraft, formally known as the Scaled Experimental Supersonic Transport (SST), on a rocket from Australia's Woomera Test Range at 7:06 a.m. (local time). After its release from the rocket, the SST flew for nearly 15 minutes at speeds of Mach 1.9 to 2 (1,446 to 1,522 miles per hour or 2,327 to 2,449 kilometers per hour) and at altitudes ranging from 12 to 19 kilometers (7.5 to 11.8 miles). Mitsubishi Heavy Industries had developed the SST as part of a US$10 million program to create an aircraft capable of transporting 300 passengers between Los Angeles and Tokyo in approximately 4 hours.[846]

The crew of Expedition 11 returned to Earth aboard a Russian *Soyuz* spacecraft, landing at 9:09 p.m. (EDT) in Kazakhstan. The members of Expedition 11 were Russian cosmonaut Commander Sergei K. Krikalev and American astronaut John L. Phillips. The two men had spent 179 days in space, during which time they had performed a variety of scientific experiments and maintenance tasks at the ISS. Accompanying Krikalev and Phillips on their return was American contractor Gregory Olsen, who had spent eight days on the ISS performing research under a commercial agreement with the Russian Space Agency.[847]

12 October

The China National Space Administration (CNSA) launched its second piloted spacecraft, the *Shenzhou 6*, on a Long March 2F rocket from Jiuquan, China, at 1:00 a.m. (GMT). The *Shenzhou 6* carried taikonauts Fei Junlong and Nie Haisheng. The CNSA planned for them to remain in low Earth orbit for five days. The CNSA provided few details about the mission and declined to publicize information, such as the taikonauts' names and the spacecraft's scheduled return date,

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[844] Luigi Pir, "Short-Burst Sources," *Nature* (London) 437, no. 7060 (6 October 2005): 822–823; Dennis Overbye, "Scientists Trace Gamma Rays to Collision of Dead Stars," *New York Times*, 6 October 2005.

[845] ESA, "CryoSat Mission Lost Due to Launch Failure," ESA news release 44-2005, 8 October 2005. *http://www.esa.int/esaCP/SEMR3Q5Y3EE_index_0.html* (accessed 14 July 2009); *New York Times*, "Arctic Study Satellite Crashes into Ocean," 9 October 2005.

[846] Meraiah Foley, "Flying High: Speedy Japanese Jet Passes Test," *Houston Chronicle*, 11 October 2005; JAXA, "Flight Trial Result of Scaled Experimental Supersonic Transport," news release, 10 October 2005, *http://www.jaxa.jp/press/2005/10/20051010_sst_e.html* (accessed 15 July 2009).

[847] NASA, "Expedition 11 Safely Returns from International Space Station," news release 05-340, 10 October 2005.

until hours before the launch. According to a CNSA spokesperson, Junlong and Haisheng would conduct scientific experiments while in orbit.[848]

13 October

Scientists published research based on data from NASA's Chandra X-ray Observatory, which provided the first observational evidence that black holes not only destroy stars, but also create them. Sergei Nayakshin of the University of Leicester in the United Kingdom and Rashid A. Sunyaev of the Max Planck Institute for Astrophysics in Garching, Germany, compared x-ray emissions from stars in the Orion nebula with x-ray emissions from stars orbiting within one light-year of the central Milky Way's black hole Sagittarius A*. According to current scientific theories, a black hole's immense gravity is able to pull millions of stars close to the black hole and to destroy stars. However, Nayakshin and Sunyaev had discovered that Sagittarius A* is not consuming its surrounding stars. Furthermore, the number of stars near the black hole is around 10,000, far less than scientists would expect if the black hole's gravity had drawn the stars toward it. Therefore, the scientists had concluded that the Chandra data supports an alternative theory of why stars are near black holes. This theory holds that dust around a black hole creates dense gas clouds. The gravity of the clouds counteracts the gravity of the black hole, thereby creating an environment in which stars form.[849]

14 October

NASA announced findings from its investigation into the causes of the foam loss on *Discovery*'s external tank during the Space Shuttle's launch in July 2005, a problem similar to the one that had caused the destruction of Space Shuttle *Columbia* in February 2003. A team of NASA investigators stated that they had uncovered several possible factors that may have caused a 3-foot (0.9-meter) portion of insulating foam to separate from *Discovery* during launch. They reported that the most likely cause was inadequate methods of applying and repairing the foam on *Discovery*'s external tank. The investigators stated that workers might have sprayed the foam in a manner that introduced fissures into it and might have crushed the foam while standing on it in the course of conducting the repairs on *Discovery*. Although the foam debris had not damaged *Discovery*, the incident had prompted NASA to suspend Shuttle launches until May 2006, so that engineers could identify the problem and correct it.[850]

17 October

The crew members of China's *Shenzhou 6* returned to Earth safely, landing at 8:33 p.m. (GMT) at Siziwang Banner in China's Inner Mongolia Autonomous Region. During the five-day mission, which was China's second piloted space mission, the *Shenzhou 6* had flown 3.25 million kilometers (2 million miles) in low Earth orbit. Although the CNSA provided few details about the mission, Chinese news outlets reported that crew members Fei Junlong and Nie Haisheng had practiced several procedures that astronauts must perform when living in the

[848] Howard W. French, "On Live Television, 2 Chinese Astronauts Begin 5 Days in Low Orbit of Earth," *New York Times*, 12 October 2005; China National Space Administration, "Shenzhou-6 To Take Off Wednesday Morning," news release, 11 October 2005.

[849] NASA, "NASA's Chandra Reveals New Star Generation," news release 05-344, 10 October 2005; Sergei Nayakshin and Rashid Sunyaev, "The 'Missing' Young Stellar Objects in the Central Parsec of the Galaxy: Evidence of Star Formation in a Massive Accretion Disc and a Top-Heavy Initial Mass Formation," *Monthly Notices of the Royal Astronomical Society: Letters* 364, no. 1 (13 October 2005): L23–L27.

[850] Guy Gugliotta, "Discovery Launch Is Still On for May," *Washington Post*, 15 October 2005.

environment of space, such as changing their spacesuits, testing their blood pressure, and moving about the spacecraft.[851]

19 October
NASA researchers announced the possible discovery of oxygen sources on the Moon, which astronauts might be able to use in future human explorations. Using NASA's HST, the researchers had examined the first high-resolution ultraviolet images of the Moon ever captured. The images had revealed high concentrations of a mineral called ilmenite in an area called the Aristarchus Plateau. Human visitors to the Moon could conceivably use ilmenite—composed of iron, oxygen, and titanium—as a source of oxygen, by extracting the oxygen from the mineral through chemical or heating processes. However, the NASA scientists stated that they would continue evaluating the findings, as well as their potential usefulness for future lunar missions.[852]

31 October
Scientists using the HST announced that they had discovered two additional moons orbiting Pluto, increasing the number of Pluto's known moons to three. Planetary scientists with the Johns Hopkins Applied Physics Laboratory had found two moons, of approximately 30 to 100 miles (48 to 161 kilometers) in diameter, orbiting Pluto at distances of 30,000 miles (48,000 kilometers) and 40,000 miles (64,000 kilometers), respectively. Because of Pluto's diminutive size, elliptical orbit, and compositional material, scientists continued to debate whether or not Pluto is a planet. Some experts believed that the discovery of the two additional moons, provisionally named P1 and P2, supported the classification of Pluto as a planet.[853]

NOVEMBER 2005

2 November
The FAA announced that it would install a new runway safety system at the nation's airports to reduce the likelihood of runway collisions between aircraft. The system—Airport Surface Detection Equipment, Model X (ASDE-X)—combined data from radar and airplane transponders to provide air traffic controllers with a continuously updated map of airport-surface operations, even during conditions of poor visibility, such as night and bad weather. Previously, most airports had relied on radar-based systems, which were susceptible to providing poor or false information during darkness and inclement weather and were unable to detect near collisions on intersecting runways. The FAA stated that it would begin installing the ASDE-X at 14 of the nation's busiest airports in January 2006.[854]

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[851] China National Space Administration, "Shenzhou-6 Spacecraft Lands Safely," news release, 17 October 2005, *http://www.cnsa.gov.cn/n615709/n620682/n639462/54429.html* (accessed 16 July 2009); Xinhua News Agency, "China's Shenzhou-6 Spacecraft Lands Safely After Successful Mission," 17 October 2005.
[852] Warren E. Leary, "Hubble Telescope Turns to Moon and Sees Possible Oxygen Source," *New York Times*, 20 October 2005; Mark Carreau, "Lunar Observations Yield Signs of Oxygen-Bearing Minerals," *Houston Chronicle*, 20 October 2005.
[853] Dennis O'Brien, "Hubble Spots Two Moons Orbiting Smallest Planet," *Baltimore Sun* (MD), 1 November 2005.
[854] Mac Daniel, "FAA Is Set to Improve Ground Radar at Logan," *Boston Globe*, 3 November 2005; FAA, "Major Airports to Receive New Runway Safety System," news release AOC 38-05, 2 November 2005, *http://www.faa.gov/news/press_releases/news_story.cfm?newsid=5784* (accessed 28 January 2010).

7 November
Both crew members of the ISS, NASA astronaut William S. McArthur Jr. and Russian cosmonaut Valery I. Tokarev, performed a spacewalk to prepare the ISS for the first assembly work since the 2003 accident of Space Shuttle *Columbia*, which had led to the suspension of construction on the station. The two removed broken and disused equipment and installed a new television camera, designed to aid in the assembly of additional truss segments for the ISS. McArthur and Tokarev were performing these tasks to prepare the ISS for the future installation of a new solar power module, planned for 2006.[855]

9 November
ESA successfully launched the Venus Express on a Soyuz-Fregat rocket from Baikonur Cosmodrome in Kazakhstan at 4:33 a.m. (CET). ESA had created the spacecraft to analyze Venus's atmosphere, chemistry, and structure, while the craft was orbiting the planet. ESA planned to use the analysis of Venus's surface and its hot, stormy atmosphere to study climate change on Earth, as well as to help determine why Venus had evolved so differently from Earth, despite numerous structural similarities between the two planets. The spacecraft was ESA's second probe designed to orbit a specific planet, the first being Mars Express, which ESA had launched in 2003.[856]

18 November
ISS Expedition 12 crew members William S. McArthur Jr. and Valery I. Tokarev left the ISS temporarily unoccupied so that they could relocate the orbiting station's *Soyuz* spacecraft from the *Pirs* module's docking compartment to the *Zarya* module's docking port. The *Soyuz* spacecraft had remained docked at the ISS to serve as a return vehicle to Earth and an emergency escape vehicle. McArthur and Tokarev were relocating the *Soyuz* so that *Pirs* could serve as an airlock for future spacewalks.[857]

22 November
President George W. Bush signed into law Pub. L. No. 109-108, legislation that provided US$16.5 billion in appropriations to NASA for FY 2006. In the bill's conference report, Congress noted some specific programs that it wanted NASA to pursue. For example, Congress specified that NASA use the funds to develop the Crew Exploration Vehicle and Crew Launch Vehicle, as described in the Exploration Systems Architecture Study, NASA's master plan for meeting the goals of the Vision for Space Exploration. Moreover, Congress also directed NASA to make more effective use of NASA Television—NASA's own television station, which it had primarily used for internal communications—to promote public knowledge about and interest in space exploration.[858]

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[855] NASA, "International Space Station Status Report: SS05-051," status report SS05-052, 8 November 2005, *http://www.nasa.gov/home/hqnews/2005/nov/HQ_SS05052_station_status-html* (accessed 19 July 2009); Mark Carreau, "Camera Installed, Despite a Few Snags," *Houston Chronicle*, 8 November 2005.
[856] ESA, "Venus Express En Route To Probe the Planet's Hidden Mysteries," ESA news release 50-2005, 9 November 2005, *http://www.esa.int/esaCP/SEM56Q638FE_index_0.html* (accessed 19 July 2009); Melissa Eddy for Associated Press, "European Space Agency Launches Venus Probe," 9 November 2005.
[857] NASA, "International Space Station Status Report: SS05-054," status report SS05-054, 18 November 2005.
[858] H.R. Rep. 109-272, at 169 (2005) (Conf. Rep.); NASA, "NASA Administrator's Statement of Passage of FY 2006 Budget," news release 05-407, 16 November 2005.

President George W. Bush signed into law Pub. L. No. 109-112, the Iran Nonproliferation Act, which effectively allowed U.S. astronauts to continue flying on Russian spacecraft, thereby maintaining the United States' access to the ISS. The terms of the original act, passed in 2000, did not permit U.S. government agencies to make "extraordinary payments" to Russia, including purchasing space on *Soyuz* spacecraft, unless the President of the United States had certified that Russia was not exporting missile and nuclear technologies to Iran. However, at the time that Congress had passed the original act, Russia had an agreement with the United States to provide 11 free voyages on *Soyuz* spacecraft to U.S. astronauts, so that NASA did not have to purchase space on *Soyuz*. In September 2005, American astronaut William S. McArthur Jr. had become the 11th U.S. passenger on a *Soyuz*, and, subsequently, Russia had required payment for any carriage of U.S. astronauts. Therefore, NASA had asked Congress to amend the act so that it could buy space on Russian spacecraft.[859]

23 November
Former NASA astronaut Michael L. Coats became Director of NASA's JSC, replacing Jefferson D. Howell Jr., who had left to become a visiting professor at the University of Texas in Austin. Coats had begun working at NASA in 1978 and had flown three Space Shuttle missions before retiring from NASA in 1991. Before becoming JSC Director, Coats had worked for Lockheed Martin in Denver, Colorado.[860]

26 November
JAXA's Hayabusa spacecraft successfully landed on the asteroid Itokawa, marking the first landing of a Japanese spacecraft on an extraterrestrial body. JAXA had created the spacecraft to collect samples from the asteroid—named after Japanese space scientist Hideo Itokawa. Scientists had theorized that asteroids are composed of material that has remained unchanged since the solar system's formation, and they hoped that analyzing the composition of that material could provide information about the origins of celestial bodies. JAXA planned for a capsule with samples from Itokawa to launch from the asteroid within a few days and to land in the Australian outback in June 2007.[861]

29 November
Shana L. Dale became Deputy Administrator of NASA, replacing Frederick D. Gregory, who had announced his resignation from NASA in September 2005. Before joining NASA, Dale had worked at the Office of Science and Technology Policy, serving as Chief of Staff, General Counsel, and, finally, as Deputy Director for Homeland and National Security. In addition, Dale had served as Staff Director for the House Subcommittee on Space and Aeronautics from 1995 to 2000.[862]

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[859] Guy Gugliotta, "U.S. Access to Space Station Is Preserved," *Washington Post*, 11 November 2005.
[860] NASA JSC, "NASA Names Former Astronaut New Johnson Center Director," news release J05-055, 7 November 2005; NASA History Division, "NASA Center Directors," 14 April 2009, *http://www.hq.nasa.gov/office/pao/History/director.html* (accessed 21 July 2009).
[861] George Nishiyama for Reuters, "Update 1–Japan Probe Lands and Collects Samples on Asteroid," 26 November 2005.
[862] NASA, "Dale Sworn In as NASA Deputy Administrator," media advisory M05-186, 29 November 2005; NASA, "Griffin Applauds Confirmation of Dale as NASA Deputy Administrator," news release 05-386, 4 November 2005.

The NASA Advisory Council (NAC), responsible for providing counsel and policy advice to the NASA Administrator on important programs and issues, held its first meeting after its organizational restructuring. NASA had restructured the NAC to provide it with better support as NASA implemented the Vision for Space Exploration. Under the reorganization, the NAC had incorporated standing committees that it had previously chartered. The six committees composing the restructured Council were Aeronautics, Audit and Finance, Exploration, Human Capital, Science, and Space Operations. Each committee was responsible for examining particular subject areas and providing findings to the full Council, which would consider the findings and supply specific recommendations to the Administrator. Former U.S. Senator and Apollo program astronaut Harrison H. Schmitt chaired the 24-member NAC, which also included former Apollo program astronaut Neil A. Armstrong, the first person to walk on the Moon.[863]

30 November
ESA announced that its Mars Express spacecraft had discovered ancient geological structures and ice reservoirs—but not liquid water—below Mars's surface. Mars Express, equipped with radar capable of conducting subsurface analyses of the planet, had detected a crater approximately 250 kilometers wide (155 miles wide) below the planet's surface, as well as 1.8 kilometers (1.1 miles) of subsurface water ice near its north pole. However, the spacecraft had not detected the liquid water necessary to support life. Even deep below the surface of Mars, the planet's polar temperatures decline to -129ºC (-200ºF), preventing its ice from melting. Scientists regarded the discovery of subsurface ice as evidence that Mars's environment was unable to harbor life.[864]

DECEMBER 2005

6 December
NASA announced a major discovery: images from the Cassini spacecraft had revealed geological activity on Saturn's moon Enceladus. ESA, the Italian Space Agency, and NASA had jointly created Cassini to study Saturn and its moons. Although scientists had previously believed that Enceladus is too small to be geologically active, data from Cassini had revealed that the moon is one of the solar system's most geologically dynamic objects. The images showed surface features such as deep canyons and flowing material, a south polar hot spot, and jets of icy particles supplying matter to one of Saturn's rings.[865]

7 December
The FAA announced that it would deploy a new communications system—called the En Route Communications Gateway (ECG)—in all 20 en route, air traffic–control centers (formally called

[863] NASA, "New NASA Advisory Council Holds Inaugural Meeting," news release 05-416, 29 November 2005; NASA, "NASA Advisory Council (NAC)," 19 July 2009, *http://www.nasa.gov/offices/nac/home/ index.html* (accessed 22 July 2009).
[864] John Johnson, "European Mars Express Show[s] That the Red Planet Was Not as Warm or Wet as Previously Thought," *Los Angeles Times*, 1 December 2005; "Radar Provides Deeper View of Ice on Mars," *Nature* 438, no. 7068 (1 December 2005): 545.
[865] NASA, "NASA's Cassini Images Reveal Spectacular Evidence of an Active Moon," news release 05-422, 6 December 2005; Jeffrey S. Kargel, "Enceladus: Cosmic Gymnast, Volatile Miniworld," *Science* 311, no. 5766 (10 March 2006): 1389–1391.

Air Route Traffic Control Centers) in the continental United States. En route centers manage high-altitude air traffic between airports and serve as the National Airspace System's hubs. The FAA had designed ECG to communicate data from existing radar sites and other legacy sources to the en route centers, as well as to enable future air traffic–communications systems to receive radar and other data through the Internet. Lockheed Martin had designed the ECG as a replacement for the Peripheral Adaptor Module Replacement Item, which was susceptible to system-wide outages.[866]

9 December

ESA and JAXA performed the first bidirectional, optical, interorbital communication, a form of communication in which satellites use lasers to transmit and receive commands and data over long distances. Laser-based communications have numerous advantages over communications using radio waves, including freedom from interference and higher data-transmission speeds and volumes. ESA and JAXA performed the communication between ESA's Advanced Relay and Technology Mission satellite and JAXA's Optical Inter-Orbit Communications Engineering Test Satellite. Previously, ESA and JAXA had conducted unidirectional, optical communications between their satellites, but this event was the first bidirectional form of this type of communication.[867]

14 December

JAXA officials announced that the agency would delay the Hayabusa spacecraft's return to Earth by two years. JAXA had created Hayabusa to collect samples from the asteroid Itokawa, and Hayabusa had successfully landed on the asteroid in November 2005. However, problems with the spacecraft's thrusters had prevented a probe containing samples from launching during a period when the asteroid's alignment with Earth and the Sun provided an opportunity for the probe to return to Earth successfully. In addition, JAXA officials reported that they were uncertain whether Hayabusa's probe had actually collected samples from the asteroid.[868]

15 December

NASA announced that it would remove the potentially problematic foam insulation ramps from the Space Shuttles' external fuel tanks before the next Shuttle launch, which NASA had scheduled for 2006. NASA had examined the foam ramps after a portion of foam had separated from *Discovery* during its July 2005 launch, nearly striking the Shuttle. The event was similar to the one that had contributed to the destruction of *Columbia* in 2003. Engineers had designed the foam ramps—formally called Protuberance Air Loads (PALs)—to protect Shuttle tanks' fuel-pressurization lines and electrical cables from potentially damaging winds during launch. NASA

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[866] FAA, "FAA Deploys New Communications Gateway at Air Traffic Control Centers," news release AOC 41-05, 7 December 2005; Lockheed Martin, "FAA, Lockheed Martin Complete National Rollout of New Radar Data Communications Gateway," news release, 8 December 2005, *http://www.lockheedmartin.com/news/press_releases/2005/FAALOCKHEEDMARTINCOMPLETENATIONALRO.html* (accessed 28 January 2010).

[867] ESA, "Successful Optical Data Relay Link Between OICETS and Artemis," *http://www.esa.int/esaCP/SEMIJVVLWFE_index_0.html* (accessed 27 July 2009); JAXA, "Toward the Era of Optical Communications in Space," news release, 9 December 2005, *http://www.jaxa.jp/press/2005/12/20051209_oicets_e.html* (accessed 27 July 2009).

[868] Guy Gugliotta, "Japan to Wait Two Years Before Starting Space Probe's Return," *Washington Post*, 15 December 2005; JAXA, "Status of the Hayabusa," news release, 14 December 2005, *http://www.jaxa.jp/press/2005/12/20051214_hayabusa_e.html* (accessed 28 July 2009).

technicians remained unsure of why the foam ramp had separated from *Discovery*, but inspections conducted in November 2005 had revealed small cracks in a PAL. The PAL with the cracks was on a tank that NASA had tested before *Discovery*'s launch but had not used for that mission.[869]

22 December
Scientists using NASA's HST announced the discovery of two new rings and two new moons around the planet Uranus. The newly discovered rings—faint bands of dust that undergo continual change, with dust spiraling out of the rings—are replenished by debris from collisions between asteroids and the newly discovered Uranian moon called Mab. The discovery of the rings increased the number of known Uranian rings to 13. The discovery of the two moons, which the scientists named Cupid and Mab after mythological and Shakespearean characters, increased the number of known Uranian moons to 27, the most of any planet in the solar system. Scientists also remarked that the orbits of known Uranian moons had changed since Voyager 2 had last observed them in 1986. Scientists described the dynamic nature of Uranus's moons and rings as indicative of dynamism throughout the solar system. Scientists hoped that observing Uranus would help them better understand this dynamism.[870]

25 December
Woodrow Whitlow Jr. became Director of NASA's GRC, replacing the retiring Julian M. Earls. Whitlow had served as Deputy Director of NASA's KSC since September 2003. Before that, he had served as Director of Research and Technology at GRC. Whitlow, who held bachelor's, master's, and doctoral degrees in aeronautics and astronautics from the Massachusetts Institute of Technology, had begun working for NASA in 1979 as a research scientist at LaRC.[871]

28 December
ESA launched the satellite Giove A on a Soyuz-Fregat rocket at 5:19 a.m. (UT) from Baikonur Cosmodrome in Kazakhstan. The satellite was the first component of a satellite navigation system called Galileo. According to ESA's plan, the Galileo system would consist of 30 satellites and would commence operations by 2008. ESA had created Galileo to reduce European dependence on the United States for satellite navigation services and to provide more accurate civilian services than the GPS, a system that the U.S. military had created. According to ESA, users who had mobile phones with integrated chips would be able to use Galileo to find directions to particular destinations, such as parks and restaurants. Galileo would be capable of providing civilian users with real-time positioning accuracy to within 1 meter (3.28 feet). Civilian services from the GPS were accurate to nearly 5 meters (16 feet).[872]

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[869] Warren E. Leary, "NASA Plans To Remove Some Foam from Shuttle," *New York Times*, 16 December 2005; Michael Cabbage, "Shuttle To Lose Fuel-Tank Foam," *Orlando Sentinel* (FL), 16 December 2005.
[870] Mark R. Showalter and Jack J. Lissauer, "The Second Ring-Moon System of Uranus: Discovery and Dynamics," *Science* 311, no. 5763 (17 February 2006): 973–977; Frank D. Roylance, "Hubble Images Show More Rings, Moons Around Uranus," *Baltimore Sun* (MD), 23 December 2005.
[871] NASA Glenn Research Center, "Center Director: Dr. Woodrow Whitlow Jr.," 10 July 2008, *http://www.nasa.gov/centers/glenn/about/bios/whitlowbio.html* (accessed 31 July 2009).
[872] Molly Moore, "With Satellite Launch, E.U. Positions Itself to Compete," *Washington Post*, 29 December 2005; ESA, "First Galileo Satellite on Orbit to Demonstrate Key Technologies," ESA news release 61-2005, 28 December 2005, http://www.esa.int/esaCP/Pr_61_2005_p_EN.html (accessed 31 July 2009).

29 December

The FAA published the first proposed regulations on commercial human spaceflight, a growing industry often referred to as space tourism. The Commercial Space Launch Amendments Act of 2004 (Pub. L. No. 108-492) required the U.S. Department of Transportation, which oversees the FAA, to implement regulations on commercial human spaceflights. Congress had passed the bill for to establish a balanced and clear regulatory regime that promoted the development of the growing commercial human spaceflight industry. Most of the FAA's proposed regulations addressed passengers' informed consent and crew members' qualifications, as well as the training of both passengers and crew. The proposed regulations would remain subject to public comment for 60 days (until 27 February 2006). The FAA was required to issue the final regulations by 23 June 2006.[873]

30 December

President George W. Bush signed into law Pub. L. No. 109-155, the National Aeronautics and Space Administration Authorization Act of 2005, which authorized NASA's appropriations for fiscal years 2006 through 2010 and directed NASA to pursue particular programs during that period. More specifically, the new law directed NASA's Administrator to ensure that NASA would pursue a balanced set of programs related to aeronautics research and development, human spaceflight, and scientific research—including robotic missions to the Moon. Among the specific programs the law directed NASA to pursue was the launch of the Crew Exploration Vehicle (CEV) at a date as close to 2010 as possible, and the landing of Americans on the Moon by 2020. Both objectives were components of the Vision for Space Exploration. Moreover, the law specifically authorized appropriations for only two years—US$17.9 billion for FY 2007 and US$18.7 billion for FY 2008.[874]

[873] Darlene Superville for the Associated Press, "Gov't Issues Proposed Space Tourism Rules," 29 December 2005; Human Space Flight Requirements for Crew and Space Flight Participants, 70 Fed. Reg. 77, 262 (29 December 2005) (to be codified at 14 C.F.R. pt. 401, 415 et al.).
[874] H.R. Rep. 109-354, at 22 (2005) (Conf. Rep.).

APPENDIX A: TABLE OF ABBREVIATIONS

AATT	Advanced Air Transportation Technologies
ACES	Altus Cumulus Electrification Study
ACS	Advanced Camera for Surveys
ADEOS	Advanced Earth Observing Satellite
ADS-B	Automatic Dependent Surveillance Broadcast
AIRS	Atmospheric Infrared Sounder
AlSAT	Algerian satellite
AML	acute myelogenous leukemia
AMP	Avionics Modernization Program
AOD	Aircraft Operations Division
ARC	Ames Research Center
ASAP	Aerospace Safety Advisory Panel
ASDE	Airport Surface Detection Equipment
ASI	Agenzia Spaziale Italiana—Italian Space Agency
ATV	Automated Transfer Vehicle
AU	astronomical units
AURA	Association of Universities for Research in Astronomy
AWACS	Airborne Warning and Control System
BAT	Burst Alert Telescope
BEC	Bose-Einstein condensate
BeppoSAX	"Beppo," nickname of physicist Giuseppe Occhialini—Satellite per Astronomia X—Italian for "X-Ray Astronomy Satellite"
BOOMERANG	Balloon Observation of Millimetric Extragalactic Radiation and Geophysics
CAIB	*Columbia* Accident Investigation Board
CAPPS	checkout, assembly, and payload-processing services
CALVEIN	California Launch Vehicle Education Initiative
CBERS	China-Brazil Earth Resources Satellite
CCD	charged-coupled device
CDT	Central Daylight Time
CERES	Clouds and the Earth's Radiant Energy System
CET	Central European Time
CEV	Crew Exploration Vehicle
CHIPSat	Cosmic Hot Interstellar Plasma Spectrometer
CIP	Current Icing Potential
CNSA	China National Space Administration
CNL	Carbon Nanotechnology Laboratory Rice University
COBE	Cosmic Background Explorer
COMINT	Communications Intelligence
CONTOUR	Comet Nucleus Tour
CONTOUR MIB	Comet Nucleus Tour Mishap Investigation Board

APPENDIX A: TABLE OF ABBREVIATIONS

COSPAS-SARSAT	Cosmicheskaya Sistema Poiska Avariynyh Sudo—Russian for "Space System for the Search of Vessels in Distress"—Search-and-Rescue Satellite-Aided Tracking System
CP violation	charge-party violation
CPAF	cost-plus-award-fee
CREAM	Cosmic Ray Energetics and Mass
CRV	crew return vehicle
CSA	Canadian Space Agency
CSOC	consolidated space operations contract
CST	Central Standard Time
DART	Demonstration for Autonomous Rendezvous Technology
DC	Docking Compartment
DEM	digital-elevation-model
DFRC	Dryden Flight Research Center
DMC	Disaster Monitoring Constellation
DMSP	Defense Meteorological Satellite Program
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DS	Deep Space
DSCS	Defense Satellite Communications Systems
DTUSAT	Danish Technical University satellite
EADS	Aeronautic Defence and Space Company
ECG	En Route Communications Gateway
EDMS	Emissions and Dispersion Modeling System
EELV	Evolved Expendable Launch Vehicle
EDD	Boeing Electronic Dynamic Devices Inc.
EDT	Eastern Daylight Time
EKV	exoatmospheric kill vehicle
EMU	Extravehicular Mobility Unit
ENSO	El Niño Southern Oscillation
EO	Earth Observing
EOS	Earth Observing System
ESA	European Space Agency
ESA SPC	Science Programme Committee of the European Space Agency
ESAC	Exploration Systems Advisory Committee
EST	Eastern Standard Time
ESTOL	extremely short takeoff and landing
EU	European Union
EUSO	Extreme Universe Space Observatory
Eutelsat	European Telecommunications Satellite Organization
EUVE	Extreme Ultraviolet Explorer
EVA	extravehicular activity

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FAA	Federal Aviation Administration
FLEVO	Facility for Liquid Experimentation and Verification in Orbit
FSRI	Florida Space Research Institute
FTS	Fourier Transform Spectrometer
FUSE	Far Ultraviolet Spectroscopic Explorer
GALEX	Galaxy Evolution Explorer
GAO	U.S. General Accounting Office or Government Accountability Office (name change effective 7 July 2004)
GCM	General Circulation Model
GP-B	Gravity Probe B
GISS	Goddard Institute for Space Studies
GLOBE	Global Learning and Observations to Benefit the Environment
GLONASS	Global Satellite Navigation System
GMD	Ground-based Midcourse Defense
GPM	Global Precipitation Measurement
GPRA	Government Performance and Results Act
GMI	Global Precipitation Measurement Microwave Imager
GMT	Greenwich Mean Time
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GRB	gamma-ray bursts
GRC	Glenn Research Center
GSA	U.S. General Services Administration
GSAT	geosynchronous satellite
GSFC	Goddard Space Flight Center
GSLV	Geosynchronous Satellite Launch Vehicle
HALOE	Halogen Occultation Experiment
HERO	High Energy Replicated Optics
HESSI	High Energy Solar Spectroscopic Imager
HETE	High Energy Transient Explorer Mission
HHT	Hilbert-Huang Transformation
HiPEP	High Power Electric Propulsion
HSSSI	Hamilton Sundstrand Space Systems International
HST	Hubble Space Telescope
HZE-particle	high-energy charged particle
IBEX	Interstellar Boundary Explorer
IBIS	Imager on Board the Integral Satellite
ICBM	intercontinental ballistic missile
ICESat	Ice Cloud and Land Elevation Satellite
IDIQ	indefinite quantity/indefinite delivery
IDP	interplanetary dust particle

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IFMP	Integrated Financial Management Program
IGS	Information Gathering Satellite
ILS	International Launch Services
IMAGE	Imager for Magnetopause to Aurora Global Exploration
IMCE	International Space Station Management and Cost Evaluation Task Force
INSAT	Indian National Satellite
INTEGRAL	International Gamma Ray Astrophysics Laboratory
IPIC	ISS payload-integration contract
ISAS	Institute of Space and Astronautical Science
ISC	Inertial Stellar Compass
ISRO	Indian Space Research Organisation
ISS	International Space Station
ISTAR	Integrated System Test of an Air-breathing Rocket
ISTP	Integrated Space Transportation Plan
IVVF	Independent Verification and Validation Facility
JAXA	Japan Aerospace Exploration Agency
JEM-PM	Japanese Experiment Module-Pressurized Module
JIMO	Jupiter Icy Moons Orbiter
Joint STARS	Joint Surveillance Target Attack Radar System
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
JST	Japan Standard Time
JSF	Joint Strike Fighter
JWST	James Webb Space Telescope
KAITSAT	Korea Aerospace Institute of Technology satellite
KICS	Kennedy Space Center Integrated Communications Services
KSC	Kennedy Space Center
L2	second Lagrange point
LAGEOS	Laser Geodynamics Satellite
LaRC	Langley Research Center
LEE	latching-end effector
LeRC	Lewis Research Center
LISA	Laser Interferometer Space Antenna
LOE	level of effort
LPT	Low Power Transceiver
LRO	Lunar Reconnaissance Orbiter
M4	Messier 4
MAESTRO	Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation

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MAP	Microwave Anisotropy Probe
MARSIS	Mars Advanced Radar for Subsurface and Ionosphere Sounding
MBS	Mobile Base System
MBSAT	Mobile Broadcasting Satellite
MC2A	Multi-Sensor Command and Control Aircraft
MDA	Missile Defense Agency
MEIDEX	Mediterranean Israeli Dust Experiment
MEIT	Multi-Element Integrated Test
MEMS	MicroElectroMechanical Systems
MER	Mars Explorer Rover
MESSENGER	Mercury Surface, Space Environment, Geochemistry, and Ranging
METSAT	Indian meteorological satellite
MGS	Mars Global Surveyor
MIB	Mishap Investigation Board
MIDEX	Medium-Class Explorer
MILSATCOM	Military Satellite Communications
MIMOSA	Micromeasurements of Satellite Acceleration
MISSE	Materials International Space Station Experiments
MLS	Microwave Limb Sounder
MLTI	Mesosphere and Lower Thermosphere/Ionosphere
MOA	Memorandum of Understanding
MoonROx	Moon Regolith Oxygen
MOPITT	Measurements of Pollution in the Troposphere
MOST	Microvariability and Oscillation of Stars
MPLM	Multi-Purpose Logistics Module
MSFC	Marshall Space Flight Center
MT	Mobile Transporter
MRO	Mars Reconnaissance Orbiter
NAC	NASA Advisory Council
NACA	National Advisory Committee for Aeronautics
NAI	NASA Astrobiology Institute
NAIT	NASA Accident Investigation Team
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NAVSEA	Naval Sea Systems Command
NBL	Neutral Buoyancy Laboratory
NCAM	National Consortium for Aviation Mobility
NCS	NICMOS Cooling System
NASDA	National Space Development Agency of Japan
NEAR	Near Earth Asteroid Rendezvous
NEP	nuclear electric propulsion
NESC	NASA Engineering and Safety Center
NEXIS	Nuclear Electric Xenon Ion System

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NEXT	NASA Evolutionary Xenon Thruster
NextGen	Next Generation Air Transportation System
NGA	National Geospatial-Intelligence Agency
NGST	Next Generation Space Telescope
NIA	National Institute of Aerospace
NIAA	National Institute of Aerospace Associates
NICMOS	Near-Infrared Camera and Multi-Object Spectrometer
NIMA	National Imagery and Mapping Agency
NISC	National Invasive Species Council
NMOC	Naval Meteorology and Oceanography Command
NOAA	National Oceanic and Atmospheric Administration
NORAD	North American Aerospace Defense Command
NOSS	Naval Ocean Surveillance System
NRC	National Research Council
NRO	National Reconnaissance Office
NSC	National Security Council
NSCOR	NASA Specialized Center of Research
NSF	National Science Foundation
NSPD	National Security Presidential Directive
NSRL	NASA Space Radiation Laboratory
NTSB	National Transportation Safety Board
OBPR	Office of Biological and Physical Research
OCO	Orbiting Carbon Observatory
OIG	Office of Inspector General
OMB	Office of Management and Budget
OSC	Office of Space Commercialization, U.S. Department of Commerce
OSP	Orbital Space Plane
P1	Port 1 Truss
PAD	Pad Abort Demonstration
PAL	Protuberance Air Load
PDT	Pacific Daylight Time
PMA	Pressurized Mating Adapter
PMRF	Pacific Missile Range Facility
PNNL	Pacific Northwest National Laboratory
POA	Payload Orbital Replacement Unit Accommodation
POES	Polar Orbiting Environmental Satellite
PPR	Pho-Radiometer
PSLV	Polar Satellite Launch Vehicle
PST	Pacific Standard Time
QASAR	Quality and Safety Achievement Recognition Award
QuikSCAT	Quick Scatterometer

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QuikTOMS	Quick Total Ozone Mapping Spectrometer
RBC3	Rocket Based Combined Cycle Consortium
RCC	reinforced carbon-carbon
ReMAP	Research Maximization and Prioritization Task Force
RFP	request for proposals
RLV	reusable launch vehicle
RNP	Required Navigation Performance
ROKVISS	Robotic Components Verification on the ISS
RSRM	reusable solid rocket motor
RTG	radioisotope thermoelectric generator
S Zero	Starboard Zero
S0	Starboard Zero
S1	Starboard 1
SAGE	Stratospheric Aerosol and Gas Experiment
SAIC	Science Applications International Corporation
SARSAT	Search-and-Rescue Satellite-Aided Tracking System
SATS	Small Aircraft Transportation System
SciSat 1	Scientific Satellite
SCTG	Stafford-Covey Return to Flight Task Group
SERPL	Space Experiment Research and Processing Laboratory
SERVIR	Sistema Regional de Visualización y Monitoreo—Spanish for "Regional Visualization and Monitoring System"; *servir* is Spanish for "to serve"
SETI	Search for Extraterrestrial Intelligence
SFLC	Space Flight Leadership Council
SFOC	spaceflight operations contract
SIAT	Space Shuttle Independent Assessment Team
SIRTF	Space Infrared Telescope Facility
SLEP	Service Life Extension Program
SLI	Space Launch Initiative
SMART	Small Mission for Advanced Research in Technology
SMCDS	Space Mission Communications and Data Services
SMEX	Small Explorer Program
SOFC	solid oxide fuel cells
SOHO	Solar and Heliospheric Observatory
SORCE	Solar Radiation and Climate Experiment
Space PCC	Space Policy Coordinating Committee
SPC	Science Programme Committee of the European Space Agency
SPI	SPectrometer on INTEGRAL
SRM	solid rocket motor
SRTM	Shuttle Radar Topography Mission
SSBD	Shaped Sonic Boom Demonstration

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SSC	Stennis Space Center
SST	Scaled Experimental Supersonic Transport
SST	Spitzer Space Telescope
SVMF	Space Vehicle Mockup Facility
SWAS	Submillimeter Wave Astronomy Satellite
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TES	thermal emission spectrometer
THEMIS	Time History of Events and Macroscale Interactions during Substorms
TIGER	Trans-Iron Galactic Element Recorder
TIGER	Transient Ionospheric Glow Emission in Red
TIMED	Thermosphere Ionosphere Mesosphere Energetics and Dynamics
TLE	transient luminous event
TOMS	Total Ozone Mapping Spectrometer
TRMM	Tropical Rainfall Measuring Mission
UAV	uninhabited aerial vehicle
ULDB	Ultra-Long Duration Balloon
UNESCO	United Nations Education, Scientific and Cultural Organization
USA	United Space Alliance
USERS	Unmanned Space Experiment Recovery System
USGS	United States Geological Survey
USRP	Undergraduate Student Research Program
UT	Universal Time
UVOT	Ultraviolet/Optical Telescope
VASIMR	Variable Specific Impulse Magnetoplasma Rocket
VISAR	Video Image Stabilization and Registration
VSB-30	Veículo de Sondagem Booster-30 (Sounding Booster Vehicle)
WFF	Wallops Flight Facility
XMM-Newton	X-Ray Multi-Mirror Newton scientific satellite
XRT	X-ray Telescope
XSS-10	Experimental Spacecraft System

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