



ASTRONAUTICS AND AERONAUTICS, 2010

A CHRONOLOGY

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A CHRONOLOGY: 2010**

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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 year 2010. These summaries provide a day-to-day recounting of major activities, such as administrative developments, Congressional hearings, 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 Program Office, as well as reports and databases on the NASA Web site and the Web sites of select non-U.S. space agencies. Researchers also accessed the Web sites of various federal government agencies and those of congressional committees with jurisdiction over science, aeronautics, and space programs.

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JANUARY 2010

1 January

NASA announced that astronaut John M. Grunsfeld would leave NASA to become Deputy Director of the Space Telescope Science Institute in Baltimore, Maryland. Grunsfeld, a specialist in high-energy cosmic-ray studies and gamma-ray and x-ray astronomy, had entered the astronaut corps in 1992. As an astronaut, he had accrued more than 835 hours in space over the course of five Shuttle missions. Grunsfeld had repaired or upgraded the Hubble Space Telescope (HST) during three of these flights: STS-103 in December 1999, STS-109 in March 2002, and STS-125 in May 2009. During these missions, Grunsfeld had logged more than 58 hours performing eight separate spacewalks. From 2003 to 2004, Grunsfeld had assisted in developing the Vision for Space Exploration while serving as Chief Scientist at NASA Headquarters in Washington, DC. The science operations center for NASA's HST and for NASA's James Webb Space Telescope (JWST), Space Telescope Science Institute, planned to launch JWST in 2014.¹

4 January

Lew Allen Jr., former Director of NASA's Jet Propulsion Laboratory (JPL), died at his home in Potomac Falls, Virginia, of complications from rheumatoid arthritis. Allen had begun his career in public service in 1946, when he joined the U.S. Air Force. In 1973 he had accepted an appointment as Director of the National Security Agency (NSA), and, from 1978 to 1982, he had served as Chief of Staff of the Air Force. After retiring from the Air Force in 1982 as a four-star general, Allen had become the first Director of NASA's JPL hired from outside NASA. While serving as Director of JPL, Allen had invested in research and development (R&D) for planetary science programs and had ushered the uncrewed space program through the development of space-related defense programs. He had overseen the launches of the Galileo mission to Jupiter and the Magellan flight to Venus, as well as the completion of the Infrared Astronomical Satellite sky survey and the Voyager 2 flybys of Uranus and Neptune. He had retired from NASA's JPL in 1990.²

At the annual meeting of the American Astronomical Society, a team of scientists led by William J. Borucki of NASA's Ames Research Center (ARC) announced that NASA's Kepler space telescope had discovered five new exoplanets in the region beyond Earth's solar system. Scientists described the planets, named Kepler 4b, 5b, 6b, 7b, and 8b, as "hot Jupiters," because of their high temperatures and masses. Ranging from approximately the size of Neptune to larger than Jupiter, the planets move in orbits lasting from 3.3 to 4.9 days and have estimated surface temperatures of 2,200°F (1,204.44°C) to 3,000°F (1,648.89°C).

¹ NASA, "NASA Astronaut John Grunsfeld, Instrumental to Hubble Telescope Repair, Will Help Oversee Its Science Operations," news release 10-001, 1 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_01-001_Grunsfeld.html (accessed 11 October 2012); Frank D. Roylance, "Former Astronaut Joins Space Telescope Science Institute," *Baltimore Sun*, 5 January 2010, http://articles.baltimoresun.com/2010-01-05/news/bal-md.briefs050jan05_1_space-telescope-science-institute-hubble-john-m-grunsfeld (accessed 9 November 2012).

² Associated Press, "Lew Allen Jr., Ex-Spy Chief and JPL Director, Dies," 6 January 2010, http://seattletimes.com/html/nationworld/2010717160_apusobitnasaofficial.html (accessed 9 November 2012); Emma Brown, "Air Force Gen. Lew Allen Jr., 84, Headed NASA, NASA Lab," *Washington Post*, 7 January 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/01/06/AR2010010604914.html> (accessed 9 November 2012).

Researchers were surprised by the unexpectedly low densities of four of the planets—they compared the density of Kepler 7b to that of styrofoam. These findings were the result of analysis of the first six weeks of data from the Kepler mission, which had launched on 6 March 2009 to search for an Earth-sized planet in the habitable zone of a Sun-like star. Kepler's photometer had continuously scanned a swath of the sky containing approximately 156,000 stars, searching for a decline in starlight that would indicate the transit of an object around a star. Scientists had also used this data to estimate the size and temperature of planets. In addition to revealing the discovery, Kepler's data indicated that 0.6 of the approximately 43,000 stars observed have a light output approximately as stable as the Sun. A relatively stable star is a prerequisite for an orbiting planet to harbor life forms.³

5 January

NASA Administrator Charles F. Bolden Jr. appointed David D. McBride as Director of NASA's Dryden Flight Research Center (DFRC). As Director, McBride would be responsible for overseeing all aspects of facility management, operations, and strategy at NASA's DFRC. McBride had begun his career with NASA in 1982, as a student in NASA's cooperative education program. He had served as Manager of the Flight Research Program at NASA's DFRC, conducting flight research to increase aerospace capabilities and knowledge. During his tenure, the Flight Research Program had conducted the Active Aeroelastic Wing flight project and the flight of the solar-powered Helios aircraft, as well as completing the Intelligent Flight Control System. McBride had also served as Associate Director of Programs at NASA's DFRC, during which time he had managed all projects supporting aeronautics, exploration, and science. In June 2008, McBride had become Acting Deputy Director of NASA's DFRC, accepting a permanent appointment to that position in January 2009. Since the April 2009 retirement of former Director Kevin L. Petersen, McBride had served as Acting Director of NASA's DFRC.⁴

6 January

The Palo Alto-based satellite provider Space Systems/Loral announced that NASA had awarded Loral a contract to manufacture the propulsion system for its Lunar Atmosphere Dust Environment Explorer (LADEE) satellite. LADEE was a 130-kilogram (286.60-pound) satellite designed to study the lunar atmosphere and atmospheric dust. For the LADEE mission, Loral would modify the propulsion-system hardware that it had designed for its contracted commercial telecommunications satellites and integrate the modified software into NASA's low-cost, general-purpose Modular Common Spacecraft Bus. NASA officials had scheduled the launch of the LADEE mission for 2012.⁵

³ NASA, "NASA's Kepler Space Telescope Discovers Five Exoplanets," news release 10-002, 4 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-002_Kepler_5_Exoplanets.html (accessed 11 October 2012); Peter N. Spotts, "NASA's Kepler Finds Its First Five Planets—An Odd Assortment," *Christian Science Monitor*, 4 January 2010, <http://www.csmonitor.com/Science/2010/0104/NASA-s-Kepler-finds-its-first-five-planets-an-odd-assortment> (accessed 9 November 2012).

⁴ NASA, "NASA Names New Dryden Flight Research Center Director," news release 10-006, 5 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-006_McBride.html (accessed 11 October 2012).

⁵ Peter B. De Selding, "Loral To Supply Propulsion System for Lunar Probe," *Spacenews.com*, 6 January 2010, <http://www.spacenews.com/article/loral-supply-propulsion-system-lunar-probe> (accessed 16 November 2012).

12 January

NASA announced that it had selected nine providers of informal education to receive a total of US\$6.2 million in grants through NASA's Competitive Program for Science Museums and Planetariums. The grant recipients included Challenger Centers, museums, science centers, and other institutions, located in Alaska, Colorado, Florida, Illinois, New York, North Carolina, Oregon, and South Dakota. The grants would fund informal and formal science education opportunities for both students and teachers, including projects inspired by NASA's activities in the fields of engineering, mathematics, science, space, and technology. The grants would range from nearly US\$120,000 to US\$1.15 million, with a maximum five-year period of performance. NASA's Office of Education had collaborated with mission directorates to select the proposals through a merit-based, external-peer-review process. The proposals focused on themes of NASA aeronautics, Earth science, microgravity, space exploration, and space science.⁶

14 January

Russian cosmonauts Oleg V. Kotov and Maxim V. Suraev left the International Space Station (ISS) for a spacewalk to activate the new Poisk docking port, also known as the Mini-Research Module 2. The Poisk module, which is 13 feet long (3.96 meters long) and 8 feet wide (2.44 meters wide), provides a scientific research space, as well as an airlock and docking port. Poisk had arrived at the ISS in November 2009. During the spacewalk, which lasted for 5 hours and 44 minutes, the cosmonauts connected cables between the Poisk and Zvezda modules, positioned docking targets and Kurs aerials, and installed handrails and exit hatches. They also retrieved the Russian science experiment Biorisk-MSN from the exterior of the ISS and dropped two bundles of trash to incinerate in Earth's atmosphere. The spacewalk was Kotov's third and Suraev's first.⁷

15 January

The Aerospace Safety Advisory Panel (ASAP), a congressionally mandated committee of independent aerospace experts, submitted its 2009 annual report to Congress and to NASA Administrator Charles F. Bolden Jr. The report made recommendations on issues related to the safety of NASA's astronauts, contractors, personnel, missions, and programs. The ASAP had studied issues affecting the future of NASA's Human Space Flight Program, including the extension of the Space Shuttle Program beyond 2010; rating requirements for commercial and international spaceflight vehicles that transport humans into space; the necessity of public discourse regarding human spaceflight; the use of robots to explore space, in lieu of human exploration; and NASA workforce-transition issues. The ASAP concluded that NASA should not continue to use the aging Shuttle significantly beyond its current manifest. The panel recommended a continuation of the Constellation Program to meet human spaceflight goals, stating that abandoning that program would probably not be cost-effective. Furthermore, the panel pointed out that, unlike Ares I, none of the available Commercial

⁶ NASA, "NASA's New Museum Grant Allies Will Make the Universe Accessible to Families from Alaska to Florida," news release 10-007, 12 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-007_education_grants.html (11 October 2012).

⁷ Tariq Malik, "Russian Spacewalkers Start Up New Space Docking Port," *Space.com*, 14 January 2010, <http://www.space.com/7777-russian-spacewalkers-start-space-docking-port.html> (accessed 9 November 2012); RIA Novosti, "Russian Cosmonauts Complete Year's First Spacewalk," 14 January 2010, <http://en.rian.ru/science/20100114/157548312.html> (accessed 9 November 2012).

Orbital Transportation Services (COTS) vehicles met rating requirements for safe human spaceflight.⁸

The Indian Space Research Organisation (ISRO) launched a series of sounding rockets to study the effects of a solar eclipse on the atmosphere. The eclipse on 15 January 2010 was the longest annular solar eclipse of the millennium. During an annular eclipse, the Moon's shadow passes across the Earth, causing the Earth's Sun to appear as a blindingly bright ring surrounding the Moon. On 14 January 2010, ISRO had launched from the Vikram Sarabhai Space Centre two Rohini RH-300 Mk-II rockets, which could reach an altitude of 116 kilometers (72.08 miles) above Earth, and two RH-200 rockets, which could reach a peak altitude of 70 kilometers (43.50 miles). On 15 January 2010, ISRO launched three RH-300 Mk-II rockets and two RH-200 rockets from Thumba Equatorial Rockets Launching Station. Also on 15 January, Satish Dhawan Space Centre launched an RH Mk-II rocket that could reach an altitude of 548 kilometers (340.51 miles) above Earth. ISRO officials stated that they planned to launch an 11th rocket on 16 January 2010, to study the after effects of the eclipse. The rockets were gathering data on the effects on Earth's lower and middle atmosphere of the sudden cessation of solar radiation before, during, and after the eclipse.⁹

19 January

NASA Administrator Charles F. Bolden Jr. named William A. Wrobel Director of NASA's Goddard Space Flight Center's (GSFC's) Wallops Flight Facility (WFF). Wrobel replaced former Director John H. Campbell, who had retired in December 2009. Bolden also named Wrobel Director of the Suborbital and Special Orbital Projects Directorate of NASA's WFF, which manages NASA's scientific-balloon and sounding-rocket programs. Wrobel had held positions in the private sector with McDonnell Douglas and Orbital Sciences before coming to NASA in 2006. When appointed Director of NASA's WFF, Wrobel was serving as Assistant Associate Administrator for Launch Services at NASA Headquarters. In that position, he had overseen the acquisition and certification of expendable launch vehicles (ELVs), as well as the administration of the Rocket Propulsion Test Program. Wrobel planned to remain in his position at Launch Services until he had completed several near-term activities and NASA had appointed an acting assistant associate administrator to replace him.¹⁰

21 January

NASA astronaut Jeffrey N. Williams and Russian cosmonaut Maxim V. Suraev successfully moved the Soyuz TMA-16 spacecraft from the Zvezda Service Module of the ISS to the new Poisk docking module. The Poisk module had arrived at the ISS in November 2009, and

⁸ NASA, "Aerospace Safety Advisory Panel Releases Annual Report," news release M10-006, 15 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_M10-006_ASAP_Report.html (accessed 11 October 2012); NASA Aerospace Safety Advisory Panel, "Annual Report for 2009" (report, Washington, DC, 15 January 2010), http://oirr.hq.nasa.gov/asap/documents/2009_ASAP_Annual_Report.pdf (accessed 23 November 2012).

⁹ P. Venugopal, "Ten Rockets Fired To Study Solar Eclipse," *Hindu*, 16 January 2010, <http://www.hindu.com/2010/01/16/stories/2010011661502200.htm> (accessed 16 November 2012); Harmeet Shah Singh, "India Launches Rockets To Study Eclipse," *CNN.com*, 15 January 2010, <http://edition.cnn.com/2010/TECH/space/01/14/india.rockets/> (accessed 16 November 2012).

¹⁰ NASA, "NASA Names New Wallops Flight Facility Director," news release 10-010, 19 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-010_Wrobel.html (accessed 11 October 2012).

cosmonauts Maxim V. Suraev and Oleg V. Kotov had activated it during a spacewalk on 14 January 2010. To complete the Soyuz docking maneuver, Suraev and Williams backed the vehicle away from the ISS to a distance of 30 meters (98.43 feet), turned it in a 90° arc toward the space-facing port, and carefully guided it into the port at the rate of 0.1 meters (0.33 feet) per second. The maneuver, which lasted 21 minutes, cleared the port at the aft end of the Zvezda module for the arrival of an uncrewed Progress cargo ship, scheduled to dock at the ISS on 5 February 2010.¹¹

22 January

NASA introduced software that would give astronauts aboard the ISS direct personal access to the Internet and the World Wide Web. NASA had not previously established a live Internet connection because of security and technical issues. The new Internet connection would enable private communication for astronauts, helping alleviate the feelings of isolation that crew members may experience while on long missions in a closed environment. The new Crew Support LAN would establish the Internet connection whenever the ISS's high-speed Ku-band antenna was communicating with the ground. Using a laptop aboard the ISS, astronauts could remotely interact with a desktop computer on Earth via their keyboard touchpad. In addition to being able to browse the Web and update social media via the new connection, astronauts would continue to have access to official e-mail, Internet Protocol telephone, and limited videoconferencing capabilities. Flight Engineer Timothy J. Creamer, who had helped update the software to establish the new connection, was the first to use the Internet to send a tweet from the ISS. Previously, astronauts had only been able to send tweets from space by e-mailing messages to Mission Control, so that support personnel could post the messages to Twitter.¹²

26 January

NASA announced that the Mars Exploration Rover Spirit was no longer a fully mobile robot and would henceforth be designated a stationary science platform. Spirit, which had landed on Mars in January 2004, had become embedded in a sand trap after its wheels had broken through the surface crust of Mars's soil in May 2009. Rover drivers at NASA's JPL had tried to free Spirit from the sand trap, but their attempts had failed. One of the vehicle's wheels had been nonfunctional since 2006 and another had stopped working in November 2009. NASA officials were opting to cease trying to move the rover and to focus on positioning Spirit so that its solar panels could absorb sufficient sunlight to survive the Martian winter, which would begin in May. During the winter, Spirit would remain in hibernation mode, ceasing all electronic functions except for a daily battery check to determine whether it had sufficient charge to attempt to communicate with Earth. NASA scientists expected that Mars's winter temperatures would be within the range that the rover had been built to withstand. However, they were unsure whether the vehicle's age would affect its ability to maintain the warmth of its critical electronics. If Spirit survived the winter, researchers

¹¹ James Dean, "Soyuz Settles at New Station Docking Port," *Florida Today* (Brevard, FL), 21 January 2010, <http://www.floridatoday.com/content/blogs/space/2010/01/soyuz-settles-in-at-new-station-docking.shtml> (accessed 16 November 2012).

¹² NASA, "NASA Extends the World Wide Web Out Into Space," news release M10-012, 22 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_M10-012_ISS_Web.html (accessed 11 October 2012); Tariq Malik, "NASA Launches Astronaut Internet in Space," *Space.com*, 22 January 2010, <http://www.space.com/7813-nasa-launches-astronaut-internet-space.html> (accessed 22 January 2012).

planned to use it to conduct experiments that required a stationary vehicle, studying Mars's core, soil, and wind.¹³

27 January

NASA Administrator Charles F. Bolden Jr. and Israel Space Agency Director Zvi Kaplan signed a joint statement of cooperation at NASA's ARC. The statement recognized the Israel Space Agency's Israel Network for Lunar Science and Exploration (INLSE) as an affiliate partner with NASA's Lunar Science Institute, making INLSE a member of the NASA Center for Moon Research. INLSE scientists would advance the goals of lunar-science research, using their expertise in advanced multilayer cameras, advanced sensors, automatic vehicle navigation, lasers, lightweight satellites, microsattellites, miniature radar technologies, and propulsion systems for satellites. The agreement established initial goals regarding laser communications, remote sensing, robotics, and other technologies for future lunar missions, as well as education and public outreach.¹⁴

28 January

Two independent teams of scientists reported in the journal *Nature* related findings, the result of their observations of seemingly normal supernovas that emitted mildly relativistic jets similar to those emitted by gamma-ray bursts (GRBs). A study team led by Alicia M. Soderberg of the Harvard-Smithsonian Center for Astrophysics had observed luminous radio emission, with an expansion velocity of 0.85 times the speed of light, from the type-Ibc supernova SN 2009bb. A team led by Zsolt Paragi of the Joint Institute for Very Long Baseline Interferometry had used radio observations to detect the type-Ic supernova SN 2007gr emitting a small amount of ejecta at 0.6 times the speed of light or more. Previously, scientists had only observed GRBs emitting jets at speeds approximating the speed of light. Soderberg's team concluded that a small number of type-Ibc supernovas possess a central engine—an accreting black hole or neutron star—that drives a relativistic outflow of ejecta. Paragi's team concluded that the mildly relativistic outflow of a tiny amount of ejecta is typical of type-Ic supernovas, but that this outflow is difficult to detect with optical observations. The researchers had gathered the study data using a variety of space- and ground-based observational tools, including NASA's Swift satellite.¹⁵

¹³ NASA, "Now a Stationary Research Platform, NASA's Mars Rover Spirit Starts a New Chapter in Red Planet Scientific Studies," news release 10-024, 26 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-024_Spirit.html (accessed 11 October 2012); Peter N. Spotts, "NASA Mars Rover Spirit To Rove No More," *Christian Science Monitor*, 26 January 2010, <http://www.csmonitor.com/Science/2010/0126/NASA-Mars-rover-Spirit-to-rove-no-more> (accessed 9 November 2012).

¹⁴ NASA, "NASA Adds Israeli Technical Expertise to Lunar Science Research at Ames," news release 10-020, 27 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-020_Israel_LSI.html (accessed 11 October 2012); Judy Siegel, "Israeli Experts Work with NASA on Moon Research," *Jerusalem Post*, 28 January 2010, <http://www.jpost.com/HealthAndSci-Tech/ScienceAndEnvironment/Article.aspx?id=167062> (accessed 16 November 2012).

¹⁵ NASA, "Newborn Black Holes May Add Power to Many Exploding Stars," news release 10-025, 27 January 2010, http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-025_SWIFT.html (accessed 11 October 2012); Z. Paragi et al., "A Mildly Relativistic Radio Jet from the Otherwise Normal Type Ic Supernova 2007gr," *Nature* 463, no. 7280 (28 January 2010): 516–518, <http://www.nature.com/nature/journal/v463/n7280/full/nature08713.html> (accessed 16 November 2012); A. M. Soderberg et al., "A Relativistic Type Ibc Supernova Without a Detected γ -Ray Burst," *Nature* 463, no. 7280 (28 January 2010): 513–515, <http://www.nature.com/nature/journal/v463/n7280/full/nature08714.html> (accessed 16 November 2012).

FEBRUARY 2010

1 February

NASA announced that it had signed Space Act Agreements worth a total of US\$50 million with five companies that had participated in an open competition for funds from the American Recovery and Reinvestment Act of 2009. Space Act Agreements provided funding for the advancement of capabilities, system concepts, and technologies that could be used in commercial crew human spaceflight. As its first action pursuant to President Barack H. Obama's new directive to foster commercial human spaceflight capabilities, NASA intended these Space Act Agreements to stimulate commercial spaceflight development, create new markets for economic growth, and encourage the private sector to create new jobs involving analysis, design, engineering, and research. The selected aerospace teams would design crew concepts, technology demonstrations, and investigations for future commercial support of human transportation. The five companies receiving the contracts were Blue Origin, of Kent, Washington (US\$37 million); Boeing Company of Houston, Texas (US\$18 million); Paragon Space Development of Tucson, Arizona (US\$1.4 million); Sierra Nevada Corporation of Louisville, Colorado (US\$20 million); and United Launch Alliance of Centennial, Colorado (US\$6.7 million). These companies also proposed to match funds to offset taxpayer investment. The Commercial Crew and Cargo Program at NASA's JSC would manage the Space Act Agreements, which would fund performance milestones beginning in February 2010.¹⁶

3 February

The House Science and Technology Subcommittee on Space and Aeronautics held a hearing, "Key Issues and Challenges Facing NASA: Views of the Agency's Watchdogs," to prepare to consider legislation to reauthorize NASA. The hearing addressed challenges NASA faced in management, mission execution, and safety oversight, as well as ways that NASA might meet these challenges. Some members expressed particular concern over the future of NASA's Human Space Flight Program, in light of President Barack H. Obama's recent fiscal year (FY) 2011 budget proposal, which would cancel the Constellation Program. Three witnesses from NASA's watchdog organizations provided testimony on their organizations' recent analysis. Paul K. Martin of NASA's Office of the Inspector General (OIG) testified on OIG's annual memorandum, released in November 2009. In that memorandum, OIG had addressed what it viewed as NASA's most serious management and performance issues, including NASA's acquisition and contracting processes; financial management; information technology security; risk management for people, equipment, and missions; and NASA's transition from the Space Shuttle Program to the next generation of space vehicles. Christina T. Chaplain of the Government Accountability Office (GAO) testified regarding GAO's February 2010 report, "Assessment of Selected Large-Scale Projects," which had evaluated 19 NASA projects, based on cost and schedule growth. According to Chaplain, GAO had found that 9 of the 10 NASA projects remaining in the implementation phase for several years had experienced cost growth of 8–68 percent and launch delays of 1–33 months during

¹⁶ NASA, "NASA Selects Commercial Firms To Begin Development of Crew Transportation Concepts and Technology Demonstrations for Human Spaceflight Using Recovery Act Funds," news release C10-004, 1 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_C10-004_Commercial_Crew_Dev.html (accessed 29 November 2012).

the previous three years. GAO also reported concerns about NASA's contract management. Joseph W. Dyer of the ASAP testified that the panel's 2009 annual report, released on 15 January 2010, encouraged NASA to analyze possible effects of extending the Space Shuttle Program; to communicate to Congress and the public the risks of human spaceflight; to establish rating requirements for commercial and international vehicles that transport humans into space; to use robots for space exploration; and to assist workers in the transition from the Space Shuttle Program to its successor.¹⁷

NASA Administrator Charles F. Bolden Jr. appointed Woodrow Whitlow Jr. Associate Administrator for Mission Support at NASA Headquarters. In this position, Whitlow would oversee most of NASA's management operations, including budget and systems support; cross-agency business; human capital; and contract and institutional support functions. Whitlow had begun his career with NASA as a research scientist at NASA's Langley Research Center (LaRC) in 1979. In 1994 he had accepted the position of Director of the Critical Technologies Division in the Office of Aeronautics at NASA Headquarters. In 1998 he had moved to NASA's Glenn Research Center (GRC), where he had served as Director of Research and Technology. Whitlow had also served as Deputy Director of NASA's Kennedy Space Center (KSC), assisting the Director in managing center policy and implementing agency program responsibilities and center missions. Whitlow had been responsible for acquiring launch services; processing, launching and recovering launch vehicles; and processing spacecraft. Since 2005, Whitlow had served as Director of NASA's GRC, and he planned to remain in that position until NASA had named his successor.¹⁸

Robert D. Braun accepted an appointment as NASA's Chief Technologist, principal advisor and advocate for NASA's technology policy and programs. As Chief Technologist, Braun would develop a technology program that would determine the types of technology that NASA would pursue; procedures NASA would follow when engaging with the aerospace community and other government agencies; and NASA's investment strategies, particularly its strategies for investing its own technological capital. Braun's professional experience had included 16 years designing and analyzing planetary exploration and robotic spaceflight systems at NASA's LaRC. He had worked on the Mars Microprobe team, the Mars Sample Return team, and the Mars Surveyor 2001 team. From 1992 to 1997, he had served on the Mars Pathfinder design-and-landing operations team. Braun had also been an independent assessor and a member of the NASA review boards for the Mars Polar Lander, Mars Odyssey, Mars Exploration Rover, Phoenix Mars Scout, Genesis, and Mars Science Laboratory (MSL)

¹⁷ U.S. Congress, House of Representatives, Committee on Science and Technology, Subcommittee on Space and Aeronautics, *Key Issues and Challenges Facing NASA: Views of the Agency's Watchdogs*, 111th Cong., 2nd sess., 3 February 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg54616/pdf/CHRG-111hhrg54616.pdf> (accessed 12 December 2012); U.S. Congress, House of Representatives, Committee on Science and Technology, "Members Question NASA Watchdogs on Challenges Facing Agency," news release, 4 February 2010, <http://archives democrats.science.house.gov/press/PRArticle.aspx?NewsID=2738> (accessed 17 October 2012); U.S. Government Accountability Office, "Assessments of Selected Large-Scale Projects" (report no. GAO-10-227SP, Washington, DC, February 2010), <http://www.gao.gov/new.items/d10227sp.pdf> (accessed 30 January 2013).

¹⁸ NASA, "NASA Administrator Names Woodrow Whitlow Associate Administrator for Mission Support," news release 10-032, 3 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-032_Whitlow.html (accessed 29 November 2012).

flight projects. Braun was teaching aerospace engineering at the Georgia Institute of Technology when NASA offered him the appointment of Chief Technologist. Over the course of his career, Braun had received two NASA Exceptional Achievement Medals, seven NASA Group Achievement Awards, two NASA Inventions and Contributions Team Awards, and the 1999 Lawrence Sperry Award from the American Institute of Aeronautics and Astronautics (AIAA).¹⁹

Iranian state media reported the successful launch of a Kavoshgar-3 research rocket that was carrying an experimental capsule capable of transmitting live pictures, telemetric data, video transmissions, and other observations back to Earth. The 10-foot-long (3.05-meter-long) rocket, which contained a small environmental laboratory carrying a mouse, two turtles, and worms, was the first Iranian spacecraft to bring animals into space. Iranian officials did not report on the nature of the biological research nor the exact time and location of the launch. The Kavoshgar-3, which was capable of carrying satellites, was the successor to the Kavoshgar-1, which had launched in February 2008, and the Kavoshgar-2, which had launched in November 2008. As part of the National Day of Space Technology, Iranian officials also announced the completion of a new domestically built light booster rocket named Simorgh and three satellites called Mesbah-2, Navid-e-Elm-o-Sanat, and Tolo. Officials stated that the Simorgh rocket weighed 220 pounds (99.79 kilograms) and could reach an altitude of 310 miles (498.90 kilometers) above Earth.²⁰

The Russian uncrewed supply vessel Progress M-04M launched aboard a Soyuz rocket from Baikonur Cosmodrome in Kazakhstan at 03:45 (UT). The 24-foot-long (7.32-meter-long) spacecraft carried 2,683 pounds (1,216.99 kilograms) of clothing, food, and equipment to the Expedition 22 crew aboard the ISS. The cargo included 106 pounds (48.08 kilograms) of oxygen and air; 1,940 pounds (879.97 kilograms) of propellant; and 926 pounds (420.03 kilograms) of water. Progress M-04M, flying the first of six resupply missions scheduled for 2010, was the 36th Progress vehicle to dock at the ISS. The spacecraft was scheduled for automated docking at the aft port of the Zvezda module on 5 February 2010 at 04:25 (UT).²¹

NASA announced that it would be extending until 2017 the international Cassini-Huygens Mission to explore Saturn and its moons. NASA's FY 2011 budget included US\$60 million per year for seven years to continue the mission. NASA had launched the Cassini project in October 1997, originally scheduling the mission to conclude in 2008, but had subsequently extended it until September 2010. Since reaching Saturn in 2004, Cassini had orbited the

¹⁹ NASA, "NASA Administrator Names Braun NASA Chief Technologist," news release 10-031, 3 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-031_Braun.html (accessed 29 November 2012); Jeremy Hsu, "Say Hello to NASA's New Tech Guru," *Space.com*, 19 February 2010, <http://www.space.com/7941-nasas-tech-guru.html> (accessed 4 December 2012).

²⁰ Ali Akbar Dareini, "Iran Launches New Research Rocket into Space," *Washington Post*, 3 February 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/02/03/AR2010020300251.html> (accessed 5 December 2012); Alan Cowell, "Iran Says It Sent Animals into Space," *New York Times*, 3 February 2010, http://www.nytimes.com/2010/02/04/world/middleeast/04iran.html?_r=0 (accessed 5 December 2012).

²¹ *Spacewarn Bulletin*, no. 676, 1 March 2010, <http://nssdc.gsfc.nasa.gov/spacewarn/spx676.html> (accessed 28 November 2012); Justin Ray, "Space Station Receives Latest Russian Resupply Ship," *Space.com*, 5 February 2010, <http://www.space.com/7876-space-station-receives-latest-russian-resupply-ship.html> (accessed 6 December 2012).

planet more than 125 times, had flown by Saturn's moon Titan 67 times, and had made eight close flybys of Saturn's moon Enceladus. Equipped with 12 instruments, Cassini had supplied researchers with more than 210,000 images, providing new scientific data about Saturn's rings and Enceladus's water-vapor geysers. The planned mission extension, called the Cassini Solstice Mission, would include an additional 155 rotations around Saturn, 54 flybys of Titan, and 11 flybys of Enceladus. Researchers intended to continue to observe the planet's magnetosphere and rings and to track Saturn's changing seasonal weather patterns as it moved through the northern summer solstice. Because the planet's orbit of the Sun takes almost 30 years, scientists had never observed a complete season on Saturn in detail. Researchers hoped to explore further many questions that Cassini's data had raised, including the causes of Saturn's inconsistent rotation rate and the features of the ocean that scientists believed to be below Enceladus's surface. The Cassini-Huygens project was a cooperative effort between NASA, the European Space Agency (ESA), and the Italian Space Agency.²²

4 February

A team of scientists led by Mark R. Swain of NASA's JPL announced in the journal *Nature* that they had made the first observations of an organic molecule, methane, in the atmosphere of an exoplanet. Using the spectrometer on NASA's Infrared Telescope Facility, Swain's team had measured the dayside emission spectrum for HD 189733b, a Jupiter-sized planet orbiting close to its star in the constellation Vulpecula. Because methane sometimes exists as a by-product of living organisms, scientists were using this research method to observe the atmospheres of Earth-like planets in search of one that might be hospitable to organic or prebiotic molecules. However, whereas scientists had previously used space-based telescopes to detect molecules in the atmospheres of "hot Jupiters," Swain's team had used a ground-based telescope. The team had adopted a method of correcting for the effects of Earth's atmosphere on the telescope's measurements, an innovation that allowed them to use a ground-based instrument. Because the ground-based telescopes were more numerous than space-based telescopes, and many of them were larger, the team's new method would increase the opportunities for this type of research.²³

8 February

Space Shuttle *Endeavour* launched from Cape Canaveral, Florida, at 09:14 (UT), embarking on the STS-130 mission to the ISS, scheduled to last for 13 days. Aboard were Flight Commander George D. Zamka, Pilot Terry W. Virts, and Mission Specialists Robert L. Behnken, Kathryn P. Hire, Nicholas J. M. Patrick, and Stephen K. Robinson. The astronauts

²² NASA, "NASA Extends Cassini's Tour of Saturn, Continuing International Cooperation for World Class Science," news release 10-030, 3 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-030_Cassini_Extended.html (accessed 29 November 2012); Clara Moskowitz, "Cassini Saturn Probe Gets 7-Year Life Extension," *Space.com*, 3 February 2010, <http://www.space.com/7865-cassini-saturn-probe-7-year-life-extension.html> (accessed 7 December 2012).

²³ Mark R. Swain et al., "A Ground-Based Near-Infrared Emission Spectrum of the Exoplanet HD 189733b," *Nature* 463, no. 7281 (4 February 2010): 637–639, <http://www.nature.com/nature/journal/v463/n7281/full/nature08775.html> (accessed 11 December 2012); Peter N. Spotts, "In Distant Planet's Fluorescent Glow, A New Way To Look for Life," *Christian Science Monitor*, 3 February 2010, <http://www.csmonitor.com/Science/2010/0203/In-distant-planet-s-fluorescent-glow-a-new-way-to-look-for-life> (accessed 11 December 2012); Jason Palmer, "Exoplanet Gas Spotted from Earth," *BBC News*, 3 February 2010, <http://news.bbc.co.uk/2/hi/science/nature/8493674.stm> (accessed 11 December 2012).

planned to deliver to the ISS the Tranquility node that ESA had built for NASA, with its attached cupola, as well as experiments, hardware, and supplies. Tranquility, a US\$382 million module that would house the ISS's environmental-control systems, exercise equipment, life-support systems, and robotic-arm-control systems, was 24 feet long (7.32 meters long), 15 feet wide (4.57 meters wide), and weighed approximately 40,000 pounds (18,143.69 kilograms). Furnished with a seven-window observation deck, or cupola, Tranquility would allow ISS crew members unprecedented views of Earth and space. During the STS-130 mission, astronauts planned to perform robotic-arm maneuvers, as well as three spacewalks, to attach Tranquility to the Unity module of the ISS. After Tranquility's installation, the ISS would be 98 percent complete, with all of the major U.S. portions delivered. NASA had scheduled *Endeavour* and its crew to land at Cape Canaveral, Florida, at 03:20 (UT) on 22 February 2010.²⁴

11 February

NASA successfully launched its Solar Dynamics Observatory (SDO) satellite aboard an Atlas V rocket from Cape Canaveral, Florida, at 15:23 (UT). As the centerpiece of NASA's Living With a Star (LWS) heliophysics program, SDO would use a suite of three instruments to observe the Sun from a geosynchronous orbit with a 28.50° inclination. The instrument suite included the Helioseismic and Magnetic Imager (HMI), which would use rapid-cadence magnetic-field measurements to observe the structure and dynamics of the Sun's interior and to measure the direction of its magnetic fields. Every 10 seconds, the Atmospheric Imaging Assembly (AIA), a set of four telescopes, would snap high-resolution solar images across eight wavelength bands. The Extreme Ultraviolet Variability Experiment (EVE) would observe vacillations in the Sun's brightness and radiation output. The US\$848 million satellite, on a mission intended to last a minimum of five years, would monitor the Sun continuously, sending approximately 1.5 terabytes of data per day to SDO's ground station at White Sands, New Mexico. Scientists expected this data to help them develop better forecast models for solar weather events, such as solar flares and coronal mass ejections (CMEs). These solar events could impair satellites and disrupt power grids and global positioning system (GPS) communications on Earth.²⁵

18 February

Two scientists, Marat R. Gilfanov and Ákos Bogdán of the Max Planck Institute for Astrophysics in Germany, announced in the journal *Nature* that they had used data from NASA's Chandra Observatory to discover evidence about the formation of type-1a supernovas. Most astronomers had agreed that a type-1a supernova occurs when a white dwarf star accumulates too much weight to remain stable, and it explodes. However, they had

²⁴ *Spacewarn Bulletin*, no. 676; NASA, "Launch of NASA's Shuttle Endeavour Sparks Early Monday Sunrise," news release 10-037, 8 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-037_Endavour_launch.html (accessed 29 November 2012); Tariq Malik, "Space Shuttle Endeavour Soars in Predawn Launch," *Space.com*, 8 February 2010, <http://www.space.com/7886-space-shuttle-endeavour-soars-predawn-launch.html> (accessed 6 December 2012).

²⁵ *Spacewarn Bulletin*, no. 676; NASA, "NASA Successfully Launches New Eye on the Sun," news release 10-040, 11 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-040_SDO_launch.html (accessed 29 November 2012); Stephen Clark, "Atlas Launches Solar Probe with Down-To-Earth Purpose," *Spaceflight Now*, 11 February 2010, <http://www.spaceflightnow.com/atlas/av021/100211launch/index.html> (accessed 4 December 2012).

not known whether this weight gain resulted from a white dwarf gradually pulling—“accreting”—matter from a nearby star, or from the merging of two white dwarves in a binary system. Gilfanov and Bogdán knew that a white dwarf accreting material produces considerably more x-ray emissions than two merging white dwarves. Therefore, to determine which scenario causes type-1a supernovas, they studied the quantity of x-ray emissions from five elliptical galaxies, as well as from the central region of the Andromeda galaxy. They discovered 30–50 times fewer x-ray emissions than they had expected would occur in an accretion scenario, leading them to conclude that the majority of type-1a supernovas form from merging white dwarves. This research had significant implications for astronomers, who used supernovas as “standard candles”—objects of known brightness—to track cosmic distances. Scientists had generally believed that type-1a supernovas were objects of known brightness and had used them as “standard candles.” However, the merging of two white dwarves of variable brightness could result in type-1a supernovas of inconsistent brightness. In addition to data from NASA’s Chandra Observatory, the researchers had used observations from NASA’s Spitzer Space Telescope (SST) and NASA’s Two Micron All Sky Survey.²⁶

21 February

Space Shuttle *Endeavour* landed at NASA’s KSC at 10:20 p.m. (EST), ending its 14-day STS-130 mission to the ISS. *Endeavour*’s six-member crew included Flight Commander George D. Zamka, Pilot Terry W. Virts, and Mission Specialists Robert L. Behnken, Kathryn P. Hire, Nicholas J. M. Patrick, and Stephen K. Robinson. During the mission, the crew had delivered to the ISS the Tranquility module, with its panoramic seven-window cupola, and had repaired the ISS’s water- and urine-recycling system. The Tranquility module would house the ISS’s gym, environmental-control systems, and life-support equipment. NASA had added an extra day to the astronauts’ busy schedule, which included three spacewalks. During these spacewalks, astronauts Behnken and Patrick had connected Tranquility and its cupola to the ISS and successfully relocated a docking adapter to Tranquility. During the mission, the crew had also transferred equipment racks into the new module and attempted to install on the ISS a workstation to control the robotic arm. STS-130 was the 32nd Space Shuttle mission to the ISS.²⁷

25 February

NASA Administrator Charles F. Bolden Jr. testified before the House Committee on Science and Technology regarding policy changes proposed in President Barack H. Obama’s FY 2011 budget request, as well as key issues that those changes raised. The proposed FY 2011 budget, which requested a US\$19 billion budget for NASA, would cancel the Constellation

²⁶ Marat Gilfanov and Ákos Bogdán, “An Upper Limit on the Contribution of Accreting White Dwarfs to the Type Ia Supernova Rate,” *Nature* 463, no. 7283 (18 February 2010): 924–925, <http://www.nature.com/nature/journal/v463/n7283/full/nature08685.html> (accessed 7 December 2012); NASA, “NASA’s Chandra Reveals Origin of Key Cosmic Explosions,” news release 10-042, 17 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-042_Chandra_cosmic_explosions.html (accessed 29 November 2012).

²⁷ NASA, “Space Shuttle Endeavour Crew Returns to Earth after Delivering the Last Major U.S. Portion of the International Space Station,” news release 10-043, 21 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-043_STS-130_Landing.html (accessed 29 November 2012); Robert Z. Pearlman, “Space Shuttle Endeavour Lands Safely in Florida,” *Space.com*, 21 February 2010, <http://www.space.com/7952-space-shuttle-endeavour-lands-safely-florida.html> (accessed 7 December 2012).

Program to send humans to the Moon. Instead, the budget would allocate to NASA US\$6 billion, which NASA would spend over five years to promote the development and use of commercial human spaceflight vehicles. Ranking Member Ralph M. Hall (R-TX) and other members of the committee expressed deep concern about the implications of cancelling the Constellation Program. Their particular concerns were maintaining NASA's critical workforce; crew safety on commercial vehicles; the uncertain capabilities of the commercial spaceflight industry; the loss of funds already invested in the program; the United States' ceding its role as an international leader in space exploration; and other national security issues. On the previous day, 24 February 2010, Bolden had testified before the Senate Commerce, Science, and Transportation Subcommittee on Science and Space, outlining NASA's goals under the proposed FY 2011 budget. These goals included aeronautics R&D; climate-change research and observations; development of robotic precursor missions to multiple destinations in the solar system; development and demonstration of transformative technologies enabling NASA to pursue new approaches to human spaceflight, with more advanced and sustainable capabilities; extension of the ISS's lifetime to 2020 or beyond; heavy-lift-propulsion R&D; investment in development of commercial crew and further cargo capabilities; investment in education initiatives; and the pursuit of cross-cutting space technology capabilities.²⁸

Aaron Cohen, former Director of NASA's Johnson Space Center (JSC), died of prostate cancer at his home in College Station, Texas. Cohen had begun his 33-year career with NASA in 1962, working on the Apollo Program. He had served as Manager of the Apollo Command and Service Modules from 1969 to 1972. From 1972 to 1982, Cohen had worked as Manager of NASA's Space Shuttle Orbiter Project Office, overseeing the design, development, production, and test flights of the Space Shuttles. He had gone on to become Director of Engineering at NASA's JSC, and NASA had appointed him Director of JSC in 1986. In that role, Cohen had guided NASA's JSC in the wake of the *Challenger* disaster, returned the Space Shuttle to flight, and helped initiate the International Space Station Program. He had served briefly as Acting Deputy Administrator at NASA Headquarters before leaving public service in 1993. Cohen had twice received both the Presidential Rank of Distinguished Executive award and NASA's Distinguished Service Medal. He had also been a member of the National Academy of Engineering and a fellow of the AIAA.²⁹

NASA's Space Shuttle Program conducted the final test firing of a reusable solid rocket motor in Promontory, Utah. ATK Launch Systems, a division of Alliant Techsystems, had

²⁸ U.S. Congress, House of Representatives, Committee on Science and Technology, *NASA's 2011 Budget Request and Issues*, 111th Cong., 2nd sess., 25 February 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg55837/html/CHRG-111hhrg55837.htm> (accessed 12 December 2012); U.S. Congress, Senate, Committee on Commerce, Science and Transportation, Subcommittee on Science and Space, *Challenges and Opportunities in the NASA Fiscal Year 2011 Budget Proposal*, 111th Cong., 2nd sess., 24 February 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111shrg64486/pdf/CHRG-111shrg64486.pdf> (accessed 12 December 2012); U.S. Congress, House of Representatives, Committee on Science and Technology, "Members Question Obama Plan for Human Space Flight," news release, 25 February 2010, <http://gop.science.house.gov/Pressroom/Item.aspx?ID=226#> (accessed 17 October 2012).

²⁹ NASA, "NASA Pioneer Aaron Cohen Dies," news release 10-053, 26 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-053_Cohen_dies.html (accessed 29 November 2012); A. G. Sulzberger, "Aaron Cohen, Official and Engineer with NASA, Dies at 79," *New York Times*, 8 March 2010, <http://www.nytimes.com/2010/03/08/us/08cohen.html> (accessed 4 December 2012).

manufactured and tested the flight-support motor, called FSM-17. FSM-17 was the largest solid rocket motor ever flown, the only motor rated for human spaceflight, and the first rocket motor built for reuse. NASA had used ATK-built motors in Shuttle launches 129 times. Engine tests had served as an engineering basis for the development of reusable solid rocket motors and successful launch systems. Providing an average thrust of 2.6 million pounds (1,179,340 kilograms), the two motors used on a Shuttle launch generated 80 percent of the thrust necessary for the first 2 minutes of flight. During the test firing, 258 instrument channels measured the motor, which was 126 feet long (38.40 meters long) and 12 feet wide (3.66 meters wide). Preliminary results from the 123-second static firing showed that the motor had met all 43 design objectives. Ending a program that had begun in July 1977, the test firing was the 52nd and last test of a flight motor that ATK would conduct for NASA, performed in preparation for the final four Shuttle missions. NASA's Space Shuttle Propulsion Office had overseen the project, managing the Shuttle motor's design, development, manufacturing, assembly, testing, and flight performance.³⁰

MARCH 2010

1 March

NASA Administrator Charles F. Bolden Jr. announced several changes in field center leadership, to take effect immediately. Bolden announced that Patrick E. Scheuermann would replace Arthur E. "Gene" Goldman as Director of NASA's Stennis Space Center (SSC), and that Goldman had accepted an appointment as Deputy Director of NASA's Marshall Space Flight Center (MSFC). Scheuermann had joined NASA in 1988 and had served as Deputy Director of Center Operations at NASA's SSC, Chief Operating Officer of NASA's Michoud Assembly Facility, Associate Director of NASA's SSC, and Deputy Director of NASA's SSC. The recipient of NASA's Outstanding Leadership Medal and NASA's Exceptional Service Medal, Scheuermann had also been a 1998 finalist in NASA's astronaut candidate program. Goldman had served as Deputy Director of SSC from 2006 to 2008 and as Director of SSC since 2008. He had also served for five years as Deputy Manager, and for two years as Manager, of the Space Shuttle Main Engine Project at NASA's MSFC. Bolden also announced the appointment of Ramon "Ray" Lugo III as Acting Director of NASA's GRC, replacing Woodrow Whitlow Jr., who had accepted an appointment in February as Associate Administrator for Mission Support at NASA Headquarters. Lugo had joined NASA in 1975. He had served as Deputy Program Manager of the Launch Services Program at NASA's KSC and, from 2007 to 2010, as Deputy Director of NASA's GRC. Lugo had received two NASA Exceptional Achievement Medals and three NASA Outstanding Leadership Medals.³¹

³⁰ NASA, "NASA's Space Shuttle Program Successfully Conducts Final Motor Test in Utah," news release 10-057, 25 February 2010, http://www.nasa.gov/home/hqnews/2010/feb/HQ_10-057_Shuttle_Engine_Test.html (accessed 29 November 2012).

³¹ NASA, "NASA Announces Agency Center Management Changes," news release 10-054, 1 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_10-054_Centers.html (access 18 December 2012).

3 March

The National Aeronautic Association (NAA) announced that it had awarded the 2009 Robert J. Collier Trophy to NASA's International Space Station Program. Originally commissioned by publisher Robert J. Collier in 1910, the NAA awarded the trophy for the most notable accomplishments in American aeronautics or astronautics. The NAA stated that it had selected the International Space Station Program "for the design, development, and assembly of the world's largest spacecraft, an orbiting laboratory that promises new discoveries for mankind and sets new standards for international cooperation in space." The joint effort of NASA, the Canadian Space Agency (CSA), ESA, the Japan Aerospace Exploration Agency (JAXA), and the Russian federal space agency Roscosmos, the ISS research laboratory operated in microgravity conditions 220 miles (354.06 kilometers) above the surface of Earth. In the nine years that scientists had conducted on-board research, the ISS had hosted more than 400 experiments in fields such as biological science, Earth and space sciences, human life sciences, human physiology, and physical and materials sciences. NAA planned to present the Collier Trophy to the ISS team formally on 13 May 2010. The ISS team included NASA, the Boeing Company, Charles Stark Draper Laboratory, Honeywell, Lockheed Martin, United Space Alliance, and United Technologies.³²

4 March

The third and final Geostationary Operational Environmental Satellite (GOES), known as GOES-P, launched aboard a Delta IV rocket from Cape Canaveral, Florida, at 23:57 (UT). GOES-P would be renamed GOES-15 after reaching its planned final orbit at 22,300 miles (35,888.37 kilometers) above Earth's equator. As part of the GOES-N Series of geostationary weather satellites, GOES-P would remain available for activation in the event that one of the other two GOES satellites had degraded or exhausted its fuel. The GOES-P satellite carried an imager, a sounder, a search-and-rescue transponder, and the Solar X-ray Imager (SXI), as well as a Space Environment Monitor System (SEM), consisting of Extreme Ultraviolet (EUV) sensors, an Energetic X-ray Sensor (XRS), two magnetometers, and an Energetic Particle Sensor (EPS). The EPS was composed of an Energetic Proton Electron and Alpha Detector (EPEAD), a High-Energy Proton and Alpha Detector (HEPAD), a Magnetosphere Electron Detector (MAGED), and a Magnetosphere Proton Detector (MAGPD). Boeing Space and Intelligence Systems had built and launched GOES-P and would transfer engineering control of the satellite to NASA approximately 20 days after launch. NASA would operate the satellite for five months before transferring operational control to the National Oceanic and Atmospheric Administration (NOAA). NASA's GRC had procured and managed the design, development, and launch of the GOES satellites for NOAA on a cost-reimbursable basis, and NASA's Launch Services Program had advised on the satellite's launch.³³

³² NASA, "NASA's International Space Station Program Wins Collier Trophy," news release 10-058, 3 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_10-058_ISS_Collier.html (accessed 18 December 2012); Tom Chao, "Space Station Wins Prestigious Collier Trophy," *Space.com*, 8 March 2010, <http://www.space.com/8004-space-station-wins-prestigious-collier-trophy.html> (accessed 27 December 2012).

³³ *Spacewarn Bulletin*, no. 677, 1 April 2010, <http://nssdc.gsfc.nasa.gov/spacewarn/spx677.html> (accessed 18 December 2012); NASA, "NASA and NOAA's GOES-P Satellite Successfully Launched," news release 10-059, 4 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_10-056_GOES-P_launch.html (accessed 18 December 2012).

11 March

At their meeting in Tokyo, the heads of the ISS partner agencies from Canada, Europe, Japan, the Russian Federation, and the United States issued a joint statement of cooperation. The statement emphasized the importance of maximizing the ISS's potential for educational, engineering, and scientific research through the greatest possible use of its facilities. The heads of ISS partner agencies observed that, with the ISS nearing completion, scientists would soon be able to use the facility fully for on-orbit research in science and technology. They acknowledged that the United States' FY 2011 budget proposal would support continuation of ISS activities until 2020, noting that no technical obstacles prevented continued ISS operations until then. They pledged their intent to urge their respective governments to reach an agreement on the future of the ISS after 2020, so that the ISS could continue to function for as long as it had proven research benefits. Additionally, the joint statement noted that the heads of the agencies were in the process of certifying on-orbit elements of the ISS through 2028. The partners emphasized their goal of increasing the ISS's operational efficiency and use by all possible means, including finding potential methods of promoting efficiency throughout the International Space Station Program, coordinating efforts to improve efficiency, and effectively using essential capabilities, such as space transportation for cargos and crews.³⁴

13 March

The company SpaceX, based in Hawthorne, California, successfully test-fired the first-stage engines of its Falcon-9 rocket at Cape Canaveral Air Force Station in Florida. The 3.5-second-long "hot-fire" test, which engineers considered crucial for confirming flight readiness, assessed ground- and flight-control software, as well as ground-support systems. SpaceX officials stated that the nine Merlin-1C engines, fueled by liquid oxygen and the highly refined kerosene RP-1, appeared to have operated normally throughout the test. SpaceX had attempted to perform the test earlier in the week but had aborted the test before ignition on 9 March because of a malfunctioning helium-line valve. SpaceX had also postponed testing on 11 and 12 March because of inclement weather. NASA had awarded contracts to SpaceX to launch three demonstration flights of the Falcon 9, as well as 12 cargo missions to the ISS. The contracts were worth a total of US\$1.9 billion, with options that could increase the total value to US\$3.1 billion.³⁵

18 March

The Senate Commerce, Science and Transportation Subcommittee on Science and Space held a hearing to assess the commercial space industry's ability to meet America's human spaceflight needs, in light of President Barack H. Obama's proposal to cancel the Constellation Program. In lieu of funding the Constellation Program, the FY 2011 budget proposal would provide US\$6 billion over a period of five years to fund private development of spacecraft to replace the Space Shuttle. The hearing's purpose was to consider whether private industry could provide faster and more cost-effective transportation of crews and

³⁴ NASA, "Heads of Agency International Space Station Joint Statement," news release 10-063, 11 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_10-063_HOA_statement.html (accessed 18 December 2012).

³⁵ Todd Halvorson, "SpaceX Executes Test of Falcon 9's Engines," *Florida Today* (Brevard, FL), 14 March 2010, <http://www.floridatoday.com/article/20100314/NEWS02/3140322/SpaceX-executes-test-Falcon-9-s-engines> (accessed 27 December 2012).

cargo to the ISS; to obtain details on precisely how funding would be allocated; and to understand how commercial spaceflight might fit into NASA's vision and promote its broader goals. The subcommittee considered safety and regulation of commercial spaceflight of key importance, particularly NASA's rating requirement for commercial vehicles that transport humans into space. Chief of NASA's Office of Safety and Mission Assurance Bryan D. O'Connor testified that NASA was working to meet safety goals by developing performance requirements, including safety-risk metrics and a generic set of NASA technical rating requirements applicable to any ISS-bound crew-transport system. Although each of the companies had different projections for the costs, strategies, and time frames for their projects, representatives from SpaceX, Orbital Sciences, and United Launch Alliance all assured the subcommittee that they were developing vehicles that could safely launch to the ISS.³⁶

A team of scientists led by Linhua Jiang of the University of Arizona announced in the journal *Nature* that they had observed a pair of quasars so distant that they must have formed when the universe was less than 1 billion years old. Working with NASA's SST, which uses infrared light to survey the universe, the researchers had studied a total of 21 quasars, including the quasars J0005-0006 and J0303-0019, which appeared to be located 13 billion light-years away, at the edge of the universe. Unlike all previously observed quasars, J0005-0006 and J0303-0019 do not emit hot dust, suggesting that they formed when the universe was so young that dust had not yet begun to coagulate. The researchers also demonstrated that the amount of hot dust in these distant quasars was increasing in tandem with the increase in mass of the quasars' central black holes. J0005-0006 and J0303-0019 had low masses, equivalent to approximately 200 million to 300 million suns. The researchers concluded that the quasars were at an early evolutionary stage and were still accumulating mass and forming dust.³⁷

The Russian Soyuz TMA-16 spacecraft landed in Kazakhstan at 7:24 a.m. (EDT), returning Expedition 22 Commander Jeffrey N. Williams and Flight Engineer Maxim V. Suraev to Earth after 167 days aboard the ISS. Soyuz Commander Suraev had undocked the vehicle from the Poisk module at 4:03 a.m. (EDT), after Williams had transferred command of the ISS to Expedition 23 Commander Oleg V. Kotov. Williams and Suraev had launched aboard the Soyuz TMA-16 on 30 September 2009. As part of the Expedition 21 and 22 crews, they had been on board the ISS when two Space Shuttle flights docked at the station, and they had helped support the ISS's continuing scientific research. Additionally, they had helped install a Russian docking module and the Tranquility module, with its viewing cupola. During their

³⁶ U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science and Space, *Assessing Commercial Space Capabilities*, 111th Cong., 2nd sess., 18 March 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111shrg66983/pdf/CHRG-111shrg66983.pdf> (accessed 7 January 2013); Andy Pasztor, "FAA, NASA Vie for Authority over Commercial Space Safety," *Wall Street Journal*, 19 March 2010, <http://online.wsj.com/article/SB10001424052748704207504575130552501802866.html.html> (accessed 7 January 2013).

³⁷ Linhua Jiang et al., "Dust-Free Quasars in the Early Universe," *Nature* 464, no. 7287 (18 March 2010): 380–383, <http://www.nature.com/nature/journal/v464/n7287/full/nature08877.html> (accessed 7 January 2013); Clara Moskowitz, "Primordial Black Holes Formed Just After Big Bang," *Space.com*, 17 March 2010, <http://www.space.com/8057-primordial-black-holes-formed-big-bang.html> (accessed 7 January 2013); Nancy Atkinson, "Spitzer Spies Earliest Black Holes," *Universe Today*, 17 March 2010, <http://www.universetoday.com/59922/spitzer-spies-earliest-black-holes/> (accessed 7 January 2013).

time aboard the ISS, the crew had completed the American portion of the station. Williams returned from this mission having accumulated 362 days in space. Only three U.S. astronauts had spent more days in space than he had. After the departure of Williams and Suraev, Commander Kotov and Flight Engineers Timothy J. Creamer and Soichi Noguchi occupied the ISS. The ISS partners planned to send three more crew members to the ISS in a Soyuz flight scheduled for 4 April 2010.³⁸

22 March

The commercial spaceflight company Virgin Galactic successfully completed the first “captive carry” test flight of its rocket plane Virgin Space Ship (VSS) Enterprise. VSS Enterprise had been lofted under the wing of its mother ship, known as Virgin Mothership (VMS) Eve or WhiteKnightTwo. The test flight, launched at 7:05 a.m. (PDT) from the Mojave Air and Space Port, lasted for 2 hours and 54 minutes, the first in a series of test flights planned by Virgin Galactic. The company had scheduled additional captive-carry tests, and it would follow these with free-flying glide tests and powered flights. Virgin Galactic planned to use VSS Enterprise to offer space tourists short trips into suborbital altitudes at 62 miles (99.78 kilometers) above Earth. Scaled Composites had designed and built the first model of the SpaceShip Two design—VSS Enterprise—and its mother ship, VMS Eve. Scaled Composites had won the US\$10 million Ansari X Prize in 2004, using smaller prototypes of the vehicle designs.³⁹

23 March

NASA Administrator Charles F. Bolden Jr. testified before the House Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies regarding President Barack H. Obama’s FY 2011 budget request for NASA. In summarizing the budget proposal, Bolden stated, “Beginning in FY 2011, the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems. As the Constellation Program is ended in an orderly manner, NASA will encourage the development of commercial human spaceflight vehicles to safely access low-Earth orbit and will develop new technologies that will lay the foundation for a more exciting, efficient, and robust U.S. human exploration of the solar system than we are currently capable of, while further strengthening the skills of our workforce and our Nation in challenging technology areas. NASA will also invest increased resources in climate change research and observations; aeronautics R&D, including green aviation; space technology development of benefit across the entire space sector; and education with an emphasis on Science, Technology, Engineering and Mathematics (STEM) learning.” Several members of the subcommittee expressed their opposition to the president’s proposal to

³⁸ NASA, “Soyuz Landing Caps Milestone Space Station Mission,” news release 10-066, 18 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_10-066_Soyuz_landing.html (accessed 18 December 2012); Tariq Malik, “Space Station Astronauts make Frigid Landing in Soyuz Spacecraft,” *Space.com*, 18 March 2010, <http://www.space.com/8060-space-station-astronauts-frigid-landing-soyuz-spacecraft.html> (accessed 27 December 2012).

³⁹ W. J. Hennigan, “Virgin Galactic’s First Commercial Spaceship Makes Maiden Flight,” *Los Angeles Times*, 22 March 2010, <http://latimesblogs.latimes.com/technology/2010/03/virgin-galactics-first-commercial-spaceship-makes-maiden-flight.html> (accessed 27 December 2012); Stephen Clark, “Private Spaceliner Takes Off for Inaugural Test Flight,” *Spaceflight Now*, 22 March 2010, <http://www.spaceflighnow.com/news/n1003/22virgingalactic/> (accessed 27 December 2012).

replace the Constellation Program with funding for commercial space transport. In response to this criticism, Bolden stated that NASA believed that the costs and schedule of the Constellation Program were following an unsustainable trajectory, and that commercial vehicles would provide the quickest, most affordable option for transporting astronauts.⁴⁰

24 March

NASA announced that it had awarded a space technology R&D contract with a maximum value of US\$45 million to ERC Incorporated of Huntsville, Alabama. The cost-plus, fixed-fee, indefinite-delivery, indefinite-quantity contract had a base of two years, with three one-year options. In fulfilling the contract, ERC would support the Space Technology Division in the Office of the Director of Exploration Technology at NASA's ARC. The Space Technology Division's mission was to develop technologies used to design and fabricate prototype hypervelocity vehicles that could travel in the atmospheres of Earth and other planets. The contract specified several services that ERC would provide at NASA's ARC. ERC would analyze the aerothermodynamics of entry systems, aeronautics, and space-vehicle trajectories; assist in understanding the chemistry and physics of hypersonic, reacting, and radiating flows; develop, modify, and apply computational fluid-dynamics tools and quantum-computing capabilities; conduct materials-science research and engineer ablative, reusable, and multifunctional thermal protection materials; plan, execute, and analyze experiments and test the thermodynamics of materials; provide educational outreach and internship employment opportunities; and study the mechanisms of prebiotic geochemistry. The contract included a subcontract with Stinger Ghaffarian Technologies of Greenbelt, Maryland.⁴¹

The House Science and Technology Subcommittee on Space and Aeronautics held a hearing on the changes to NASA's exploration programs proposed in President Barack H. Obama's FY 2011 budget request. The subcommittee considered several key aspects of the proposed changes, including cancellation of the Constellation Program; investment in the development of the commercial space transport industry; provision of additional funding to COTS providers; new research and technology programs supporting human space exploration; and plans to conduct precursor robotic missions. The hearing also focused on the current status of the Constellation Program, including the results of the recently conducted Preliminary Design Review; how changes to the Constellation Program would affect NASA's workforce, contractors, and industrial base; and whether work NASA had already completed could be used in the proposed alternative space exploration programs. Associate Administrator of NASA's Exploration Systems Mission Directorate Douglas R. Cooke provided testimony on these issues. Cooke explained the new elements related to space exploration in the FY 2011

⁴⁰ U.S. Congress, House of Representatives, Committee on Appropriations, Subcommittee on Commerce, Justice, Science, and Related Agencies, *Commerce, Justice, Science, and Related Agencies Appropriations for 2011*, Part 7, 111th Cong., 2nd sess., 23 March 2010, 195, http://democrats.appropriations.house.gov/images/stories/pdf/cjs/Hearing_Volumes/CJS_FY11_7.pdf (accessed 7 January 2013); Andy Pasztor, "NASA To Devise New Spending Plan To Placate Congress," *Wall Street Journal*, 23 March 2010, http://online.wsj.com/article/SB10001424052748704896104575139891578682472.html#article_Tabs%3Darticle (accessed 7 January 2013).

⁴¹ NASA, "NASA Awards Space Technology Research and Development Contract," news release C10-014, 24 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_C10-014-STRaD.html (accessed 18 December 2012).

budget request, the status of the Constellation Program, and the responsibilities and reporting schedules of the “Tiger Teams.” NASA had established the Tiger Teams to identify the necessary budget planning and transition efforts for new programs, following the proposed cancellation of the Constellation Program.⁴²

30 March

NASA announced that it had awarded eight contracts to provide spacecraft and services under the Rapid Spacecraft Acquisition III program. The eight contracts had a combined maximum value of US\$4 billion. The Rapid III contracts allowed the government to support its space and technology needs through quick and flexible acquisition of spacecraft and related services. The contracts provided core spacecraft systems, modified to meet specific mission needs. Each fixed-price, indefinite-delivery, indefinite-quantity contract was for one or more core spacecraft. Contract recipients became eligible to compete for future contracts for spacecraft systems. The contractors would be responsible for the design and development of core spacecraft; testing of spacecraft systems; payload integration and testing; launch-operations support; and on-orbit checkout. The contractor would perform most of the work at its own facility. The eight contracts were awarded to Ball Aerospace and Technologies of Boulder, Colorado; General Dynamics Advanced Information Systems of Gilbert, Arizona; Lockheed Martin of Denver, Colorado; Northrop Grumman Space and Mission Systems of Redondo Beach, California; Orbital Sciences of Dulles, Virginia; Surrey Satellite Technology US of Englewood, Colorado; Thales Alenia Space of France; and Thales Alenia Space Italia of Rome.⁴³

APRIL 2010

2 April

A Soyuz-FG rocket launched at 04:04 (UT) from Baikonur Cosmodrome in Kazakhstan, carrying a Russian Soyuz TMA-18 passenger spacecraft bound for the ISS. The craft carried veteran American astronaut Tracy E. Caldwell Dyson, making her first long-term voyage to the ISS, and Russian cosmonauts Alexander A. Skvortsov and Mikhail B. Komienko, both making their first trips into space. Skvortsov was Flight Commander of the Soyuz, scheduled to dock at the ISS on 4 April 2010. Its crew members would join the crew already aboard the ISS—Oleg V. Kotov, Timothy J. Creamer, and Soichi Noguchi—to round out the six-member Expedition 23 crew. The crew planned to engage in scientific research and station upkeep, in addition to welcoming two Space Shuttle missions and the first arrival of a commercially built uncrewed cargo vehicle, SpaceX’s Dragon spacecraft. Officials had also

⁴² U.S. Congress, House of Representatives, Committee on Science and Technology, Subcommittee on Space and Aeronautics, *Proposed Changes to NASA’s Exploration Program: What’s Known, What’s Not, and What Are the Issues for Congress?* 111th Cong., 2nd sess., 22 March 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg55848/pdf/CHRG-111hhrg55848.pdf> (accessed 7 January 2013); U.S. Congress, House of Representatives, Committee on Science and Technology, “Members Question Changes to NASA’s Exploration Program,” press release, 24 March 2010, <http://archives democrats.science.house.gov/press/PRArticle.aspx?NewsID=2787> (accessed 18 December 2012).

⁴³ NASA, “NASA Selects Rapid III Contractors for Space Systems and Services,” news release C10-018, 30 March 2010, http://www.nasa.gov/home/hqnews/2010/mar/HQ_C10-018_RAPID_III.html (accessed 18 December 2012).

scheduled several spacewalks, which the ISS's long-term crew and the astronauts visiting the station would perform during Expedition 23.⁴⁴

5 April

Space Shuttle *Discovery* launched from NASA's KSC at 10:21 (UT) on the STS-131 mission to the ISS, scheduled to last for 13 days. Although NASA engineers saw several pieces of foam fall off *Discovery* during launch, they stated that the falling foam posed little or no risk. The Shuttle, scheduled to dock at the ISS on 7 April 2010, carried seven crew members: Commander Alan G. Poindexter, Pilot James P. Dutton Jr., and Mission Specialists Clayton C. Anderson, Richard A. Mastracchio, Dorothy M. Metcalf-Lindenburger, Stephanie D. Wilson, and Naoko Yamazaki. STS-131 was the first flight for crew members Dutton, Metcalf-Lindenburger, and Yamazaki. The astronauts would deliver 7,700 kilograms (16,975.59 pounds) of equipment and scientific experiments to the ISS, including the new sleeping quarters for the crew, a laboratory freezer, and science racks, all packed inside the Leonardo Multi-Purpose Logistics Module. Leonardo would remain temporarily attached to the ISS from 7 April 2010 to 15 April 2010, while the crew unloaded the supplies. Once the crew had unpacked the module, the ISS's laboratory research facilities would be complete. In addition, the astronauts planned to make three spacewalks to install an extra storage tank for ammonia. They also planned to change a gyroscope on the ISS's truss and retrieve a Japanese science experiment from the ISS's exterior during the spacewalks.⁴⁵

6 April

NASA announced that it had signed a contract modification worth US\$335 million with the Russian federal space agency Roscosmos for the transportation of six NASA astronauts aboard Soyuz flights to the ISS. The firm-fixed-price modification, an increase over the US\$306 million contract signed in 2009, would cover Soyuz support, including launch preparation and training, crew rescue, and landing. The six NASA crew members would launch on four Soyuz flights to the ISS in 2013, returning to Earth on two flights in 2013 and two flights in 2014. The contract stipulated that each crew member would be allowed to carry 110 pounds (49.90 kilograms) of cargo associated with crew transportation on the trip to the ISS, and to carry approximately 37 pounds (16.78 kilograms) of cargo on the return trip to Earth. Additionally, the contract permitted 66 pounds (29.94 kilograms) of trash disposal. The modification, an extension of a previous contract, would allow NASA to maintain astronauts aboard the ISS after the retirement of the Space Shuttle Program, scheduled to occur later in 2010.⁴⁶

⁴⁴ *Spacewarn Bulletin*, no. 678, 1 May 2010, <http://nssdc.gsfc.nasa.gov/spacewarn/spx678.html> (accessed 14 January 2013); NASA, "Crew Lifts Off from Kazakhstan To Join Crewmates Aboard the International Space Station," news release 10-073, 2 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-071_Expedition_23_Launch.html (accessed 14 January 2013); Clara Moskowitz, "New Crew Launches to Space Station on Russian Rocket," *Space.com*, 2 April 2010, <http://www.space.com/8126-crew-launches-space-station-russian-rocket.html> (accessed 18 January 2013).

⁴⁵ *Spacewarn Bulletin*, no. 678; NASA, "NASA's Shuttle Discovery Heads to Station After Predawn Launch," news release 10-176, 5 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-076_sts131_launch.html (accessed 14 January 2013); Robert Block, "Discovery Roars into Orbit," *Orlando Sentinel* (FL), 5 April 2010, http://articles.orlandosentinel.com/2010-04-05/news/os-shuttle-discovery-launches-20100405_1_post-launch-news-conference-shuttle-and-station-crews-shuttle-flight (accessed 16 January 2013).

⁴⁶ NASA, "NASA Extends Contract with Russian Federal Space Agency," news release C10-023, 6 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_C10-023_Soyuz_Extension.html (accessed 14 January 2013);

7 April

NASA's unpiloted aircraft Global Hawk successfully completed its first scientific mission, flying on a 14-hour journey of approximately 4,500 miles (7,242.05 kilometers), at altitudes as high as 60,900 feet (18,562.32 meters). A joint mission between NASA and NOAA, Global Hawk was a robotic plane that could be preprogrammed to fly for as long as 30 hours and as far as 11,000 nautical miles (5,178.51 miles, or 8,334 kilometers). Operators at NASA's DFRC maintained contact with Global Hawk through satellite and line-of-sight communications links and could adjust the plane's course or altitude during flight. The flight was the first of five planned Global Hawk Pacific (GloPac) missions to study the atmosphere over the Pacific and Arctic oceans. While covering more distance and time than any previous science aircraft, Global Hawk would use its 11 instruments to measure and to take samples of aerosols, greenhouse gases, ozone-depleting substances, and components of air quality in the upper troposphere and lower stratosphere. Researchers anticipated that the GloPac flights would allow them to observe the breakup of the polar vortex, a large-scale cyclone in the troposphere and stratosphere. Scientists study the polar vortex, which influences Arctic weather patterns, to understand ozone depletion in the Northern Hemisphere. Additionally, researchers would use the GloPac flights to measure the dust, pollution, and smoke crossing from Asia to North America. As part of a cooperative effort with NASA's Aura Validation Experiment, the GloPac missions would include several flights directly underneath NASA's Aura satellite and other Earth-observing satellites, to calibrate and confirm satellite data.⁴⁷

8 April

Scientists led by Suzanna E. Smrekar of NASA's JPL announced in the online edition of the journal *Science* that their team had found evidence that volcanic activity had occurred on Venus less than 2.5 million years ago, suggesting that the planet may be one of the few in the solar system that is still geologically active. In conducting the study, the researchers had sought to explain why Venus's smooth surface has so few craters. Some scientists had theorized that a single, major, volcanic event had resurfaced the planet, but Smrekar's team found evidence suggesting that numerous smaller eruptions had filled in Venus's craters, and that the planet is still actively resurfacing. Using data from ESA's Venus Express mission, the researchers had collected observations of the compositional differences of lava flows from nine hotspots. NASA's Magellan spacecraft, which had radar-mapped the planet from 1990 to 1994, had originally detected these hotspots. Three of the nine hotspots the researchers observed had high thermal-emissivity patterns, indicating that they were too young to have experienced significant surface weathering. Researchers hoped that the study data would help scientists better understand the interior of Venus, as well as ways in which volcanic gases affect climate change, both on Venus and on Earth.⁴⁸

Mark Matthews, "NASA Extends Deal with Russians for 2013 Astronaut Launches," *Orlando Sentinel* (FL), 6 April 2010, http://blogs.orlandosentinel.com/news_space_thewritestuff/2010/04/nasa-extends-deal-with-russians-for-2013-astronaut-launches.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+news%2Fspace%2Fspace_blog+%28Space+Blog+The+Write+Stuff%29 (accessed 16 January 2013).

⁴⁷ NASA, "NASA's Unpiloted Global Hawk Completes First Science Flight," news release 10-080, 8 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-080_GloPac.html (accessed 14 January 2013).

⁴⁸ Suzanne E. Smrekar et al., "Recent Hotspot Volcanism on Venus from VIRTIS Emissivity Data," *Science* 328, no. 5978 (30 April 2010): 605–608, published online 8 April 2010, <http://www.sciencemag.org/content/328/5978/605.full> (accessed 23 July 2013); NASA, "NASA-Funded Research Suggest Venus Is Geologically

In support of President Barack H. Obama's FY 2011 budget request, NASA Administrator Charles F. Bolden Jr. and Deputy Administrator Lori B. Garver announced new work assignments for NASA field centers. These assignments would facilitate NASA's long-term plans for space exploration and for renewed emphasis on cutting-edge technology and scientific research. The new organizational structure would allow NASA to complete the Space Shuttle manifest; extend use of the ISS to 2020 or beyond; offset many of the job losses that would result from ending the Shuttle and Constellation programs; and develop new approaches to spaceflight that would enable robust near-Earth flight capabilities, as well as spaceflight beyond low-Earth orbit. NASA would expand the number of program offices covering the following areas: commercial spaceflight, exploration technology and development, heavy-lift rockets, research on human health and safety, robotic missions to scout for future human explorations, and rocket-propulsion technology. Under the new plan, NASA would increase funding for the Science and Aeronautics directorates in order to create a Next Generation air-transportation system and to improve Earth-observation capabilities. NASA's JSC would manage the commercial cargo program to resupply the ISS, as well as a new program to develop technologies necessary for trips to Mars or the Moon. NASA's KSC would refurbish the launch complex and establish a program for commercial development of crew-carrying spacecraft. NASA's MSFC and SSC would oversee operations to develop heavy-lift-rocket-propulsion technologies.⁴⁹

13 April

In a ceremony in Honolulu, Simon P. "Pete" Worden, Director of NASA's ARC, and Hawaii's Governor Linda Lingle signed a three-year, nonreimbursable Space Act Agreement to create a partnership for scientific research, space exploration, and education initiatives in the STEM disciplines: science, technology, engineering, and mathematics. The agreement acknowledged that NASA and the state of Hawaii would work together in fields such as advanced aviation, education, science, development of small satellites, and space exploration. The partnership would develop a Hawaii-based program for small spacecraft missions and a student-run satellite project. The first annex of the agreement would initiate a new program called HawaiiSat. Under this program, the University of Hawaii's Hawaii Space Flight Laboratory would train students to design and build small satellites. HawaiiSat would allow NASA to apply insights from the students and their professors to future NASA missions, while also encouraging the next generation of space explorers, engineers, and scientists. The agreement also allowed for NASA and Hawaii to engage in additional collaborations in the future.⁵⁰

Alive," news release M10-081, 8 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-081_Venus_Volcanoes.html (accessed 14 January 2010); Andrea Thompson, "Volcanoes on Venus May Be Young and Active," *Space.com*, 8 April 2010, <http://www.space.com/8177-volcanoes-venus-young-active.html> (accessed 18 January 2013).

⁴⁹ NASA, "NASA Announces Future Work Assignments for Field Centers," news release 10-078, 8 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-078_Work_assignments.html (accessed 14 January 2013); Tariq Malik, "NASA Chief Maps Out Space Agency's Future Beyond Shuttle," *Space.com*, 9 April 2010, <http://www.space.com/8176-nasa-chief-maps-space-agency-future-shuttle.html> (accessed 16 January 2013).

⁵⁰ NASA, "NASA Partners with Hawaii on Space Exploration, Science," news release 10-084, 13 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-084_ARC_Hawaii_SAA.html (accessed 14 January 2013).

NASA announced that, through its Innovative Partnerships Program, it had entered into a three-year, nonreimbursable Space Act Agreement with Chrysler Group to coordinate technologies such as advanced materials, mobility systems, and wireless technologies. The Innovative Partnerships Program allowed NASA to transfer technologies that it had developed for space exploration to real-world applications. NASA and Chrysler would share with one another the skills and expertise that each organization had gained in areas of their common interest, such as materials engineering and development of battery systems, radar, and robotics. Chrysler had previously collaborated with NASA in building the Redstone rockets for the Mercury Project and the boosters for *Apollo 7* and *Apollo 8*.⁵¹

15 April

President Barack H. Obama spoke about his proposals for NASA's human spaceflight program before a White House–convened conference of 200 lawmakers, scientists, and top NASA officials at NASA's KSC. Discussing his FY 2011 budget proposal to cut NASA's Constellation Program, Obama emphasized his commitment to human spaceflight but restated his belief that NASA should focus on deep space missions rather than returning to the Moon or transporting astronauts to and from the ISS. In response to criticisms from Congress, Obama announced some changes to his original budget proposal. He planned to request that NASA continue work on a simplified version of the *Orion* crew capsule that could function as a rescue vehicle for the ISS. He would allocate US\$40 million to help retrain workers at NASA's KSC who would lose their jobs at the end of the Space Shuttle Program. He would fund a US\$1.9 billion upgrade of NASA's KSC and make the center home to NASA's commercial rocket operation. He would grant NASA US\$3 billion to design a heavy-lift rocket that could carry astronauts to asteroids, Mars, or other distant destinations, and he pledged that NASA would complete the design by 2015. He also promised that NASA would have crewed spacecraft orbiting Mars by the mid-2030s and would land on Mars soon after that. Obama stated that his proposals would add US\$6 billion to NASA's budget over five years, to include funding for deep-space robotic probes, an extension of operations aboard the ISS beyond 2020, new climate satellites, and a new space telescope.⁵²

20 April

Space Shuttle *Discovery* landed at NASA's KSC at 13:08 (UT), returning astronauts Alan G. Poindexter, James P. Dutton Jr., Clayton C. Anderson, Richard A. Mastracchio, Dorothy M. Metcalf-Lindenburger, Stephanie D. Wilson, and Naoko Yamazaki from the 15-day STS-131

⁵¹ NASA, "NASA and Chrysler Establish Partnership To Explore Advanced Technologies," news release 10-083, 13 April 2010, http://www.nasa.gov/home/hqnews/2010/apr/HQ_10-083_Chrysler_Partnership.html (accessed 14 January 2013); W. J. Hennigan, "Chrysler Strikes Technology Deal with NASA," *Los Angeles Times*, 13 April 2010, <http://latimesblogs.latimes.com/technology/2010/04/nasa-chrysler-technology-robots.html> (accessed 17 January 2013).

⁵² Kenneth Chang, "Obama Vows Renewed Space Program," *New York Times*, 15 April 2010, http://www.nytimes.com/2010/04/16/science/space/16nasa.html?ref=science&_r=0 (accessed 23 January 2013); Mark K. Matthews, "Obama Unveils NASA 'Vision' in Kennedy Space Center Speech," *Orlando Sentinel* (FL), 16 April 2010, http://articles.orlandosentinel.com/2010-04-16/business/os-obama-speech-kennedy-space-center-20100415_1_orion-capsule-nasa-s-constellation-human-spaceflight (accessed 23 January 2013); Ralph Vartbedian, "Obama Looks To Deeper Space as NASA's Mission," *Los Angeles Times*, 16 April 2010, <http://articles.latimes.com/2010/apr/16/nation/la-na-obama-space16-2010apr16> (accessed 23 January 2013).

mission to the ISS. The returning *Discovery* carried the payload rack from the exterior of the Columbus module and the Japanese Experiment Module SEED (Space Environment Exposure Device) payload. In addition, *Discovery* returned to Earth the Leonardo Multi-Purpose Logistics Module, which had carried almost 8 tons (16,000 pounds, or 7,257.48 kilograms) of supplies to the ISS, and was carrying back to Earth nearly 3 tons (6,000 pounds, or 2,721.56 kilograms) of payload, including the results of scientific experiments, as well as trash. STS-131 was the seventh and final round-trip flight for Leonardo. On its next trip, the crew would attach Leonardo to the ISS to serve as a permanent storage space. During the mission, the astronauts had successfully completed three spacewalks to replace an ammonia coolant tank. Shuttle managers had considered adding an unplanned fourth spacewalk because of a malfunctioning valve on a nitrogen tank, but ultimately had decided against it. Other issues had arisen during the mission, including the failure of *Discovery*'s Ku-Band communications antenna, which transmitted high-bandwidth data. Although the crew members had compensated for the loss of the antenna, ISS officials had responded by adding an extra day to the flight. Furthermore, because of rain, *Discovery* had to wait an additional day before landing.⁵³

21 April

Barcelona Moon Team, a group comprising 10 companies and individuals, announced that it would be the 21st team to enter the competition for the Google Lunar X Prize. Google's US\$30 million competition would award a US\$20 million grand prize to the first privately funded team to build a spacecraft that landed on Earth's Moon, traveled at least 500 meters (1,640.42 feet) on the Moon's surface, and transmitted data, images, and video to Earth. The Google Lunar X Prize also offered a US\$5 million second prize, as well as US\$5 million in bonus prizes. Galactic Suite Moonrace led the Barcelona Moon Team, self-described as "a multidisciplinary joint venture bringing together Spanish entrepreneurial, industrial, and academic capabilities." The team also included the Centre for Aerospace Technology from Barcelona and scientists from the Technical University of Catalonia. Google Lunar X Prize officials had set the deadline for claiming the main prize at 31 December 2012, although they were considering extending the deadline.⁵⁴

22 April

The Senate Appropriations Subcommittee on Commerce, Justice, Science and Related Agencies held a hearing on NASA's FY 2011 budget proposal, focusing on issues of human spaceflight and astronaut safety. NASA Administrator Charles F. Bolden Jr. provided a statement for the subcommittee outlining the budget request and NASA's proposed undertakings in the fields of aeronautics research, construction and environmental compliance and restoration, cross-agency support, education, science, space operations, and space technology. Bolden also testified on the most recent proposals for NASA's human spaceflight program, which President Barack H. Obama had introduced at a conference on 15 April 2010. Bolden stated that, under the proposed budget, NASA would transport astronauts

⁵³ *Spacewarn Bulletin*, no. 678; Robert Z. Pearlman, "Space Shuttle Discovery Lands Safely in Florida," *Space.com*, 20 April 2010, <http://www.space.com/8254-space-shuttle-discovery-lands-safely-florida.html> (accessed 18 January 2013).

⁵⁴ *Space.com*, "First Spanish Team Joins \$30M Lunar X Prize Contest," 25 April 2010, <http://www.spacenews.com/article/first-spanish-team-joins-30m-lunar-x-prize-contest> (accessed 17 January 2013).

into deep space sooner than under the Constellation Program, with a human mission to an asteroid by 2025 and a human mission to orbit Mars by the 2030s. Several members of the subcommittee, including chair Barbara A. Mikulski (D-MD), remained skeptical about the budget proposal. Mikulski and others were primarily concerned about safety issues relating to the replacement of NASA-built spacecraft with commercial vehicles. Bolden testified that NASA would require that commercial spacecraft meet the same rating standards for human safety that NASA requires for its own crew-transport spacecraft. Bolden stated that, by the end of 2010, NASA would have prepared guidelines establishing rating requirements for all vehicles that transport humans into space. While Bolden acknowledged under questioning that he believed that the Ares rocket would be the safest spacecraft, he also stated that the Constellation Program was unsustainable.⁵⁵

28 April

The Russian uncrewed supply vehicle Progress M-05M, or Progress 37, launched aboard a Soyuz rocket from Baikonur Cosmodrome in Kazakhstan at 17:15 (UT). The vessel was transporting 2.6 tons (5,200 pounds, or 2,358.68 kilograms) of food and other supplies for the crew of the ISS. This included 110 pounds (59.90 kilograms) of oxygen and air; 1,918 pounds (870 kilograms) of propellant; 3,301 pounds (1,497.31 kilograms) of hardware and spare parts for science experiments; and 220 pounds (99.79 kilograms) of water. Progress M-05M also carried care packages for the ISS crew, containing items such as books, candy, and movies. On 22 April 2010, the Progress M-03M supply vehicle that had launched on 15 October 2009 had undocked from the Pirs module. Loaded with trash from the ISS, the Progress M-03M had orbited for several days to conduct science experiments before descending to Earth to burn up in the atmosphere. ISS officials had scheduled Progress M-05M to dock at the Pirs module of the ISS on 1 May 2010.⁵⁶

29 April

A NASA balloon that was attempting to launch a gamma-ray space telescope crashed shortly after lifting off from the Alice Springs Balloon Launching Centre outside Alice Springs, Australia. No one was injured when the gondola carrying the US\$2 million Nuclear Compton Telescope (NCT) unexpectedly came loose from its carriage. However, the balloon dragged the payload approximately 450 feet (137.16 meters), damaging a nearby fence and car. Astronomers at the University of California, Berkeley, had built the gamma-ray telescope, and NASA's Columbia Scientific Balloon Facility (CSBF) in Palestine, Texas, had built the 400-foot (121.92-meter) uncrewed balloon. NASA had planned for the balloon to carry the

⁵⁵ U.S. Congress, Senate, Appropriations Committee, Subcommittee on Commerce, Justice, Science and Related Agencies, *Commerce, Justice, Science, and Related Agencies Appropriations for Fiscal Year 2011*, 111th Cong., 2nd sess., 22 April 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111shrg99104420/pdf/CHRG-111shrg99104420.pdf> (accessed 18 January 2013); Kenneth Chang, "Obama's NASA Blueprint Is Challenged in Congress," *New York Times*, 22 April 2010, http://www.nytimes.com/2010/04/23/science/23nasa.html?scp=1&sq=%2b%22space+exploration%22&st=nyt&_r=0 (accessed 23 January 2013); Marc Kaufman, "Obama Plan To End Much of Constellation Program Angers Republican Senators," *Washington Post*, 23 April 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/04/22/AR2010042205372.html> (accessed 23 January 2013).

⁵⁶ *Spacewarn Bulletin*, no. 678; Tariq Malik, "Robotic Russian Cargo Ship Launches Toward Space Station," *Space.com*, 29 April 2010, <http://www.space.com/8309-robotic-russian-cargo-ship-launches-space-station.html> (accessed 18 January 2013); Xinhua News Agency, "Russian Space Freighter Undocks from ISS," 23 April 2010, http://news.xinhuanet.com/english2010/sci/2010-04/23/c_13263469.htm (accessed 18 January 2013).

NCT 120,000 feet (36,476 meters) into the air. NASA officials stated that NASA intended to convene a mishap investigation board. NASA had successfully launched a balloon containing a science project from the Alice Springs Balloon Launching Centre on 15 April 2010, when the Tracking and Imaging Gamma Ray Experiment (TIGRE), a gamma-ray telescope, had launched to an altitude of 127,000 feet (38,709.60 meters) to study emissions from radioactive materials at the center of the galaxy.⁵⁷

Two independent teams of scientists, one led by Humberto Campins of University of Central Florida and one led by Andrew S. Rivkin of Johns Hopkins University, announced in the journal *Nature* that they had made the first direct observations of water ice on the surface of an asteroid. The researchers had used NASA's Infrared Telescope Facility in Hawaii to detect ice and organic compounds on the surface of the asteroid 24 Themis, located in the asteroid belt between Mars and Jupiter. Scientists had previously inferred that water existed on asteroids but had never before directly measured it. The amount of ice cover on 24 Themis's 123-mile-wide (197.95-kilometer-wide) surface surprised the researchers. Scientists had expected that, at a distance of ~3.2 au from the Sun, surface ice on the asteroid would sublimate quickly. After observing the ice cover on 24 Themis, the researchers concluded that the asteroid's surface ice is replenishing, possibly because of a subsurface reservoir. The findings were consistent with the theory that asteroids impacting Earth's surface may have brought the water that currently exists on Earth.⁵⁸

MAY 2010

3 May

President Barack H. Obama appointed NASA Administrator Charles F. Bolden Jr. and Secretary of Commerce Gary F. Locke as co-chairs of the Task Force on Space Industry Workforce and Economic Development. The task force's purpose was to formulate an economic development plan to help NASA prepare its aerospace workers for staffing changes, to encourage economic growth along Florida's Space Coast, and to distribute the US\$40 million that Obama had allocated for economic development. The allocation included funds for training workers affected by the end of the Shuttle Program and by the proposed end of the Constellation Program. NASA had requested a US\$2.5 billion budget to fund the end of the Constellation Program and intended to draw on this budget for the US\$40 million. Senior officials and budget experts serving on the task force would include representatives from the Department of Defense, the Department of Education, the Department of Housing and Urban Development, the Department of Labor, and the Department of Transportation.

⁵⁷ Tariq Malik, "Huge NASA Science Balloon Crashes in Australian Outback," *Space.com*, 29 April 2010, <http://www.space.com/8311-huge-nasa-science-balloon-crashes-australian-outback.html> (accessed 18 January 2013).

⁵⁸ Humberto Campins et al., "Water Ice and Organics on the Surface of the Asteroid 24 Themis," *Nature* 464, no. 7293 (29 April 2010): 1320–1321, <http://www.nature.com/nature/journal/v464/n7293/full/nature09029> (accessed 22 January 2013); Andrew S. Rivkin and Joshua P. Emery, "Detection of Ice and Organics on Asteroidal Surface," *Nature* 464, no. 7293 (29 April 2010): 1322–1323, <http://www.nature.com/nature/journal/v464/n7293/full/nature09028.html> (accessed 22 January 2013); Clara Moskowitz, "Water Ice Discovered on Asteroid for First Time," *Space.com*, 28 April 2010 <http://www.space.com/8305-water-ice-discovered-asteroid-time.html> (accessed 22 January 2013).

The task force would prepare its recommendations by 15 August 2010, and the White House would disband the group by 4 May 2013.⁵⁹

6 May

NASA's *Orion* crew vehicle successfully completed the Pad Abort 1 flight test, the first fully integrated test of *Orion*'s launch-abort system. The flight test was NASA's first test of a U.S.-designed abort system since the Apollo Program. Conducted at the U.S. Army's White Sands Missile Range (WSMR), the test began at 7:00 a.m. (MDT) and lasted for 135 seconds. The abort system, consisting of a fairing assembly and three motors, would allow crew to escape the vehicle in a rocket-launch emergency. The abort motor, the primary motor that would pull the crew module away from the launchpad, produced a momentary 500,000 pounds (226,796.20 kilograms) of thrust during its 6-second burn. The altitude-control motor steered the vehicle on a controlled flight path using eight thrusters that produced 7,000 pounds (3,175.15 kilograms) of thrust. The jettison motor propelled the abort system away from the crew module, creating space for the parachute to deploy and the vehicle to land. After all the motors had successfully fired, the vehicle cruised at 16.20 miles per hour (26.07 kilometers per hour) to land approximately 1 mile (1.61 kilometers) from the launchpad. Although NASA's FY 2011 budget proposal would end the Constellation Program and repurpose the *Orion* vehicle, engineers expected that the launch-abort test results would help them design and analyze safe launch systems for future vehicles used for human spaceflight.⁶⁰

10 May

A team of scientists led by Taotao Fang of the University of California, Irvine announced in the *Astrophysical Journal* that they had discovered evidence that a diffuse, hot web of gases, called the Warm-Hot Intergalactic Medium (WHIM), may contain the so-called missing matter in the nearby universe. The "nearby universe," in the vicinity of Earth's solar system, encompasses a region measuring approximately 1 billion light-years in radius. The "missing matter" is composed of baryons—particles such as neutrons and protons that exist in galaxies, gas clouds, planets, and stars. Scientists had calculated the total amount of baryons that they expected to find, but astronomers had observed only approximately half of that amount of baryons, causing some researchers to theorize that the remaining "missing" matter might be in the WHIM. To locate the WHIM, Taotao Fang's team had looked at x-ray observations from NASA's Chandra X-ray Observatory and from ESA's x-ray space observatory, XMM-Newton. They had studied a supermassive black hole, known as an active galactic nucleus (AGN), which is approximately 2 billion light-years from Earth. The researchers found that

⁵⁹ U.S. Office of the President, Memorandum of May 3, 2010, "Task Force on Space Industry Workforce and Economic Development," *Federal Register* 75, no. 87 (May 6, 2010): 24781–24782; Amy Klumper, "Obama Establishes Florida Space Industry Task Force," *Space News*, 4 May 2010, <http://www.spacenews.com/article/obama-establishes-florida-space-industry-task-force> (accessed 7 February 2013); Tony Romm, "New White House Task Force on NASA To Focus on Job Loss," *The Hill*, 4 May 2010, <http://thehill.com/blogs/hilicon-valley/technology/95809-new-white-house-task-force-on-nasa-to-focus-on-job-loss> (accessed 7 February 2013).

⁶⁰ NASA, "NASA Successfully Tests Orion Launch Abort System," news release 10-109, 6 May 2010, http://www.nasa.gov/home/hqnews/2010/may/HQ_10-109_Orion_Test.html (accessed 30 January 2013); Leonard David, "NASA Test Launches Rocket Escape System for Astronauts," *Space.com*, 6 May 2010, <http://www.space.com/8350-nasa-test-launches-rocket-escape-system-astronauts.html> (accessed 4 February 2013).

x-ray emissions from the AGN were absorbed as they passed through the Sculptor Wall, a huge diffuse structure that spans tens of millions of light-years and contains thousands of galaxies. The researchers concluded that oxygen atoms in the WHIM within the Sculptor Wall had absorbed the x-ray emissions. Using two telescopes, instead of one, and searching the Sculptor Wall, instead of conducting a blind search, enabled Fang's team to uncover the strongest evidence to date of the existence of "missing matter" in the WHIM.⁶¹

NASA announced that it had awarded a sole-source contract to Ball Aerospace and Technology for the Global Precipitation Measurement (GPM) Microwave Imager (GMI) instrument known as Flight Unit 2. NASA's GPM mission would study climate, hydrometeorological processes, and weather, using international satellites to observe global ice, rain, and snow. The GMI instrument, a multichannel, conical-scanning, microwave radiometer, would provide near-global measurements of atmospheric moisture. The GMI would enhance GPM monitoring of hurricanes and midlatitude storms and improve estimations of rainfall accumulation. The performance period of the US\$48.5 million, cost-plus-award fee, incentive-fee contract would last from 9 October 2009 through 31 March 2016. Ball Aerospace and Technology would manufacture, test, and deliver the instrument, support the instrument's integration onto the spacecraft, and provide launch and postlaunch support. Ball Aerospace and Technology would manufacture GMI instrument Flight Unit 2 in series with its identical counterpart, GMI 1. NASA had scheduled GMI Flight Unit 2 to launch as part of the GPM satellite constellation in 2014, on a spacecraft provided by a GPM partner.⁶²

12 May

The Senate Committee on Commerce, Science and Transportation held a hearing on the future of U.S. human spaceflight. NASA Administrator Charles F. Bolden Jr., former astronauts Neil A. Armstrong and Eugene A. Cernan, and others testified on President Barack H. Obama's proposal to cancel the Constellation Program and to rely on commercial spacecraft to transport astronauts to the ISS. In support of the president's proposal, Bolden outlined its highlights, including refashioning the *Orion* crew capsule into an emergency escape vehicle, developing new heavy-lift technologies, assisting displaced workers on Florida's Space Coast, and extending NASA's operations of the ISS. Armstrong and Cernan expressed concern that the United States would lose its leadership position in human spaceflight if NASA did not continue to develop spaceflight technologies. Some members of the committee also expressed doubts, fearing that the president's proposal would lead to job losses. However, committee chair John D. Rockefeller (D-WV) stated his support for the priorities that the proposal set: seeking greater international collaboration, supporting

⁶¹ Taotao Fang et al., "Confirmation of X-Ray Absorption by Warm-Hot Intergalactic Medium in the Sculptor Wall," *Astrophysical Journal* 714, no. 1715 (10 May 2010): 1715–1724, http://iopscience.iop.org/0004-637X/714/2/1715/pdf/0004-637X_714_2_1715.pdf (accessed 7 February 2013); *Space.com*, "Huge Chunk of Universe's Missing Matter Found," 11 May 2010, <http://www.space.com/8386-huge-chunk-universe-missing-matter.html> (accessed 7 February 2013).

⁶² NASA, "NASA Awards Global Precipitation Measurement Microwave Imager," news release C10-029, 10 May 2010, http://www.nasa.gov/home/hqnews/2010/may/HQ_C10-029_GPM_Imager_Contract.html (accessed 30 January 2013).

commercial spaceflight, and developing new technologies for exploration beyond low-Earth orbit. He added, “NASA cannot continue down the same path in my judgment.”⁶³

14 May

Space Shuttle *Atlantis* lifted off from NASA’s KSC at 18:20 (UT) on the STS-132 mission to the ISS. *Atlantis* transported six astronauts: Commander Kenneth T. Ham, Pilot Dominic A. Antonelli, and Mission Specialists Stephen G. Bowen, Michael T. Good, Garrett E. Reisman, and Piers J. Sellers. The astronauts would deliver to the ISS the Russian-built Mini Research Module-1, or Rassvet, which crew members would use as a laboratory to conduct research in biological science, biotechnology, educational research, and fluid physics. It would also serve as a storage space and a docking port for the Russian Soyuz and Progress vehicles. Rassvet contained a pressurized compartment with eight workstations, featuring facilities such as a box to separate experiments from the in-cabin environment, incubators for high- and low-temperature experiments, and a vibration-isolation platform. It had four additional workstations outfitted with mechanical adapters to install payloads into racks and shelves. In addition to Rassvet, STS-132 would deliver cargo, critical spare parts, and 10 experiments to the ISS. The experiments included Cube Lab, a low-cost platform for commercial and educational projects; Genara-A, a European experiment on plant growth without gravity; Ferulate, a Japanese experiment on cell walls in microgravity; and the Smoke and Aerosol Measurement experiment, to follow up on previous tests of smoke-detection technology. NASA had scheduled *Atlantis* to dock with the ISS on 16 May 2010.⁶⁴

20 May

JAXA launched its Akatsuki satellite and five smaller piggyback satellites aboard an H-2A rocket from Tanegashima Space Center at 21:58 (UT). Akatsuki, also called Planet-C or Venus Climate Orbiter, was the first interplanetary weather satellite. Using two short-wavelength infrared cameras, Akatsuki would study Venus’s low-altitude clouds and its distribution of carbon monoxide and water vapor, in addition to charting the planet’s surface in search of active volcanoes. Akatsuki would observe Venus’s super-rotating, upper-atmosphere clouds and monitor sulfur-dioxide levels with a long-wavelength-infrared imager, and would use a wide-field-of-view camera to search for evidence of lightning. In addition to Akatsuki, the H-2A’s payload included an experimental satellite known as the Interplanetary Kite-craft Accelerated by Radiation of the Sun (IKAROS), the first propellant-free craft to enter deep space. IKAROS’s super-thin solar sail could propel the satellite either by using pressure created by the solar particles or by using electricity generated by its solar cells. Additionally, JAXA launched the Unitec-1 satellite, which would test several engineering

⁶³ U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, *The Future of Human Space Flight*, 111th Cong., 2nd sess., 12 May 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111shrg66487/pdf/CHRG-111shrg66487.pdf> (accessed 4 February 2013); Bart Jansen, “Space Pioneers Criticize Budget,” *Florida Today* (Brevard, FL), 13 May 2010, <http://www.floridatoday.com/article/20100513/NEWS02/5130313/1006/NEWS01/Space+pioneers+criticize+budget> (accessed 4 February 2013).

⁶⁴ *Spacewarn Bulletin*, no. 679, 1 June 2010, <http://nssdc.gsfc.nasa.gov/spacwarn/spx679.html> (accessed 30 January 2013); NASA, “NASA’s Space Shuttle Atlantis Lifts Off To Put Finishing Touches on the International Space Station,” news release 10-113, 14 May 2010, http://www.nasa.gov/home/hqnews/2010/may/10-113_STS-132_Launched.html (accessed 30 January 2013); NASA, “NASA’s Shuttle Atlantis Bringing a New ‘Dawn’ for Space Station Science,” news release 10-114, 18 May 2010, http://www.nasa.gov/home/hqnews/2010/may/HQ_10-114_STS-132_Science_Info.html (accessed 30 January 2013).

technologies; the Waseda-Sat2 satellite, built by students at Waseda University to observe Earth; the Negai satellite, which would verify an advanced information-processing system in space; and the K-Sat satellite, which would observe Earth, perform high-speed communications, and conduct a communications experiment for super-small positioning satellites.⁶⁵

21 May

GAO responded to a 12 March 2010 request from 17 members of Congress, who had asked GAO to investigate whether NASA staff had broken the law by planning for the aftermath of the Constellation Program. The members of Congress questioned whether NASA had complied with the Congressional Budget Impoundment Control Act of 1974 (Pub. L. No. 93-344, 88 Stat 297) and with restrictions in the FY 2010 appropriation for exploration, which prohibited NASA from using funds appropriated for exploration to end any of the Constellation Program's activities, programs, or projects or to create any new activities, programs, or projects. In February 2010, after the release of the president's FY 2011 budget proposal, NASA had established nine study teams to evaluate implementation strategies for the proposed space-exploration policies. The teams had worked for 4 to 6 weeks preparing planning documents for the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP). GAO found that the study teams had not violated the law because they had not awarded any contracts, created any new programs, hired or permanently reassigned any staff, or set up any new program offices and, therefore, they had not created any new programs, projects, or activities (PPAs). The report also noted that NASA had established the planning teams at the request of OMB and OSTP and that, "as part of the appropriations process, agencies must engage in various types of planning activities."⁶⁶

24 May

NASA announced that it was officially ending operations for its Phoenix Mars Lander after failing to reestablish contact with the spacecraft following the Martian winter. NASA's Mars Odyssey had flown over the Phoenix landing site 61 times in a final listening campaign, preceded by 150 flights in three previous campaigns, all of which had failed to detect a transmission from the lander. Images of Phoenix taken with Odyssey's High Resolution Imaging Science Experiment (HiRISE) camera showed that Phoenix's shadow had changed, indicating that during the winter its solar arrays had broken off under the weight of carbon-dioxide-ice accumulation. Anticipating such damage, NASA officials had not expected Phoenix to survive the winter. Phoenix had landed on Mars on 25 May 2008, completing its initial three-month mission and remaining active for an additional two months. Phoenix had made important scientific discoveries, which included studying the Martian soil chemistry, observing falling snow, confirming that Mars has deposits of underground water ice, and

⁶⁵ *Spacewarn Bulletin*, no. 679; Jonathan Amos, "Japan Launches Akatsuki Probe to Venus," *BBC News*, 20 May 2010, <http://www.bbc.co.uk/news/10135158> (accessed 4 February 2013).

⁶⁶ U.S. Government Accountability Office, "National Aeronautics and Space Administration—Constellation Program and Appropriations Restrictions" (report no. B-319488, part I, Washington, DC, 21 May 2010), <http://www.gao.gov/assets/390/388911.pdf> (accessed 4 February 2013); Robert Block, "Watchdog: NASA Plans for Constellation Alternative Not Illegal," *Orlando Sentinel* (FL), 25 May 2010, http://blogs.orlandosentinel.com/news_space_thewritestuff/2010/05/watchdog-nasa-plans-for-constellation-alternative-not-illegal.html (accessed 4 February 2010).

identifying the presence of calcium carbonite, which suggests that thawed water is occasionally present on Mars. Phoenix's most notable achievement was the discovery of perchlorate, an oxidizing chemical that some microbes on Earth eat and some find toxic. This finding had influenced new astrobiological research. NASA officials stated that researchers' analysis of Phoenix's scientific discoveries would continue for some time after the end of the mission.⁶⁷

26 May

The House Committee on Science and Technology held a hearing to review NASA's Human Spaceflight Program and its budget, cost, schedule, and potential impacts. During the hearing, the committee members examined the proposed goals and changing strategies of NASA's human spaceflight programs included within the FY 2011 budget. The committee also reviewed the challenges and risks that NASA would have to address in implementing the proposed changes. NASA Administrator Charles F. Bolden Jr. testified before the committee on NASA's progress developing plans to implement the proposed initiatives. He also provided details regarding the most recent updates to President Barack H. Obama's budget proposal, which included restructuring the *Orion* crew capsule as an emergency escape vehicle for the ISS, developing new heavy-lift technologies to reach beyond low-Earth orbit, and assisting NASA workers through the program transitions. Several members of the committee, including its chair Barton J. Gordon (D-TN), expressed concern about the proposed changes, particularly the costs of the new programs. Gordon worried that budget projections were too low and that the FY 2011 proposal had not allocated funds adequate to finance its ambitious goals. Former NASA astronauts Neil A. Armstrong and Eugene A. Cernan also testified in favor of maintaining NASA's current human spaceflight program.⁶⁸

Space Shuttle *Atlantis* landed at NASA's KSC at 8:48 a.m. (EDT), returning six astronauts from a 12-day, 4.8 million-mile (7,724,851-kilometer) mission to the ISS. *Atlantis*'s crew for mission STS-132 was Commander Kenneth T. Ham, Pilot Dominic A. Antonelli, and Mission Specialists Stephen G. Bowen, Michael T. Good, Garrett E. Reisman, and Piers J. Sellers. While aboard the ISS, the astronauts had delivered and installed the Russian Mini Research Module-1, known as Rassvet, which would serve as a research module, storage space, and docking port for Soyuz and Progress spacecraft. The astronauts also had conducted three spacewalks to install a backup Ku-band antenna, replace six solar-array batteries, and install parts on the Canada's Special Purpose Dexterous Manipulator (Dextre) robotic arm. In keeping with its plans to end the Space Shuttle Program, NASA had scheduled STS-132 as *Atlantis*'s final flight. However, NASA would still process *Atlantis* to serve as a possible rescue vehicle during *Endeavour*'s final launch. NASA officials were also

⁶⁷ NASA, "Phoenix Mars Lander Does Not Phone Home, New Image Shows Damage," news release 10-120, 24 May 2010, http://www.nasa.gov/home/hqnews/2010/may/10-120_Phoenix_Finished.html (accessed 30 January 2013).

⁶⁸ U.S. Congress, House of Representatives, Committee on Science and Technology, *Review of the Proposed National Aeronautics and Space Administration Human Spaceflight Plan*, 111th Cong., 2nd sess., 26 May 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111hrg57174/pdf/CHRG-111hrg57174.pdf> (accessed 4 February 2013); Kenneth Chang, "NASA Finds New Criticism and Skepticism Before Congress," *New York Times*, 26 May 2010, http://www.nytimes.com/2010/05/27/science/space/27nasa.html?scp=1&sq=%2b%22low+earth+orbit%22&st=nyt&_r=0 (accessed 4 February 2013).

seeking permission from the Obama administration to conduct one additional resupply mission to the ISS using *Atlantis*.⁶⁹

NASA announced that Dominic L. Pudwell Gorie and John D. “Danny” Olivas were leaving the astronaut corps. Gorie’s last day at NASA would be 25 May 2010, and Olivas’s last day would be 4 June 2010. Gorie had flown on four Shuttle missions, traveling more than 18 million miles (28,968,190 kilometers) in space. He had served as Pilot on STS-91 in 1998 and STS-99 in 2000, and Commander of STS-108 in 2001 and STS-123 in 2008. Olivas was a veteran of two Shuttle flights and had spent 668 hours in space. He had served as Mission Specialist on STS-117 in 2007 and STS-128 in 2009. Over the course of five spacewalks, Olivas had accrued 34 hours of extravehicular time in space.⁷⁰

27 May

NASA announced that it had selected five proposals for airborne-science missions for the Earth System Science Pathfinder Program’s new Earth Venture project series. The selected proposals would be the first investigations in the new series of Venture-class missions—small, low-to-moderate-cost, targeted-research investigations supporting NASA’s larger mission goals. NASA would award each competitively selected recipient no more than US\$30 million over five years, to include all costs from initial development and deployment through data analysis. NASA officials stated that the venture-class missions would complement the missions of NASA’s Earth-observing satellites, providing data that researchers could use to characterize important phenomena, identify changes in Earth’s system, and improve computer modeling. The elected missions were “Airborne Microwave Observatory of Subcanopy and Subsurface,” with Mahta Moghaddam of the University of Michigan as Principal Investigator; “Airborne Tropical Tropopause Experiment,” with Eric J. Jensen of NASA’s ARC as Principal Investigator; “Carbon in Arctic Reservoirs Vulnerability Experiment,” with Charles E. Miller of NASA’s JPL as Principal Investigator; “Deriving Information of Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality,” with James H. Crawford of NASA’s LRC as Principal Investigator; and “Hurricane and Severe Storm Sentinel,” with Scott A. Braun of NASA’s GSFC as Principal Investigator.⁷¹

Two teams of scientists, one team led by John W. Holt of the University of Texas at Austin’s Institute for Geophysics and the other led by Isaac B. Smith of the University of Texas, Austin, announced in the journal *Nature* that they had used data from NASA’s Mars Reconnaissance Orbiter (MRO) to determine that depositional forces, rather than catastrophic forces, had formed two notable features of Mars’s polar ice cap—the Chasma Boreale canyon and the spiraling troughs that are cut in the ice. Using data from the Shallow Radar

⁶⁹ NASA, “Space Shuttle Atlantis Returns Home After Its Final Mission,” news release 10-124, 26 May 2010, http://www.nasa.gov/home/hqnews/2010/may/HQ_10-124_Atlantis_Landing.html (accessed 30 January 2013); William Harwood, “For Atlantis, A Flight Path to Retirement,” *New York Times*, 26 May 2010, <http://www.nytimes.com/2010/05/27/science/space/27shuttle.html?src=mv&r=0> (accessed 4 February 2013).

⁷⁰ NASA, “Veteran Astronauts Gorie and Olivas Leave NASA,” news release 10-123, 26 May 2010, http://www.nasa.gov/home/hqnews/2010/may/HQ_10-123_Astronauts_Retire.html (accessed 30 January 2013).

⁷¹ NASA, “NASA Takes to the Air with New ‘Earth Venture’ Research Projects,” news release 10-127, 27 May 2010, http://www.nasa.gov/home/hqnews/2010/may/Hq_10-127_Venture_Program.html (accessed 30 January 2013).

(SHARAD) aboard NASA's MRO, Holt's team had performed stratigraphic analysis of the exposed portions of Chasma Boreale, a basin 500 kilometers (310.69 miles) long, as much as 100 kilometers (62.14 miles) wide, and almost two kilometers (1.24 miles) deep. By analyzing the radar data, the researchers had determined that Chasma Boreale is an old feature, and that the topography that existed before the beginning of the accumulation of the northern polar layered deposits (NPLD) influenced the successive episodes of deposit and erosion that shaped the modern canyon. Using data from NASA's MRO to analyze the troughs that spiral out from the center of the Martian polar ice cap, Smith's team found that the troughs had formed after 75 percent of the NPLD had accumulated, and that their morphology had quickly stabilized. Over the last 2 million years, approximately, they had migrated about 65 kilometers (40.39 miles) northward and 600 meters (1,968.50 feet) in altitude. The researchers' analysis of the radar images showed that atmospheric depositions and wind transport had caused the troughs' migration. The teams' research answered scientists' decades-old questions about the Martian polar ice cap and provided new insights about climate change on Mars.⁷²

28 May

NASA announced the appointment of Kenneth R. Human as Associate Director of NASA's SSC. As Associate Director, Human would assist Director Patrick E. Scheuermann and Deputy Center Director Richard J. Gilbrech in managing NASA's SSC. Human had joined NASA in 1978 as an attorney advisor. NASA had named him Acting Chief Counsel in 1984 and, two years later, had appointed him Chief Counsel. In 2007 Human had become Deputy Manager of the External Integration Office at NASA's JSC. In that role, he had developed international collaborations and partnerships with the Canadian, European, Japanese, and Russian space agencies, in support of the International Space Station Program. Human had received many awards, including the NASA Exceptional Service Medal.⁷³

JUNE 2010

1 June

A Soyuz TMA-17 spacecraft landed outside Zhezkazgan, Kazakhstan, at 11:25 p.m. (EDT), returning three ISS crew members to Earth. Commander Oleg V. Kotov of Russia and Flight Engineers Timothy J. Creamer of the United States and Soichi Noguchi of Japan had spent 163 days in space during their mission. They had launched from the Baikonur Cosmodrome on 21 December 2009 to take part in the Expedition 22 and Expedition 23 missions aboard the ISS. During their time on the ISS, they had completed the U.S. portion of the ISS laboratory facilities, hosted three Space Shuttle missions, and received and installed the American Tranquility module and the Russian Rassvet module. Creamer had a career total of

⁷² J. W. Holt et al., "The Construction of Chasma Boreale on Mars," *Nature* 465, no. 7297 (27 May 2010): 446–449, <http://www.nature.com/nature/journal/v465/n7297/full/nature09050.html> (accessed 7 February 2013); Isaac B. Smith et al., "Onset and Migration of Spiral Troughs on Mars Revealed by Orbital Radar," *Nature* 465, no. 7297 (27 May 2010): 450–453, <http://www.nature.com/nature/journal/v465/n7297/full/nature09049.html> (accessed 7 February 2013); NASA, "NASA Spacecraft Penetrates Mysteries of Martian Ice Cap," news release 10-122, 26 May 2010, http://www.nasa.gov/home/hqnews/2010/may/HQ_10-122_MRO_On_Ice_Cap.html (accessed 30 January 2013).

⁷³ NASA, "NASA Names New Associate Director of Stennis Space Center," news release RS-10-126, 28 May 2010, <http://www.nasa.gov/centers/stennis/news/newsreleases/2010/RS-10-126.html> (accessed 7 February 2013).

163 days in space, Kotov had a career total of 330 days, and Noguchi had a career total of 177 days.⁷⁴

3 June

The Moscow-based Institute of Medical and Biological Problems began its Mars-500 project, a 520-day simulation of a spaceflight to Mars. During the study, six participants from China, Europe, and Russia would be confined to a simulated spaceship for 250 days, would “land” on an imitation Mars for 30 days, and then would spend 240 days “returning” to Earth. The participants, who would have no contact with the outside world except for limited e-mail use, would have the same restricted diet and schedule as an actual interplanetary traveler. The study, the longest of its kind, would assess the effects of confinement, fatigue, and stress on astronauts traveling to Mars. Researchers would monitor the participants’ hormone levels, mood, sleep quality, and stress levels, as well as the effects of various dietary supplements. The Institute of Medical and Biological Problems performed the study in Moscow in cooperation with China and ESA. A U.S. research team, funded by the NASA-supported National Space Biomedical Research Institute, was also working on the project.⁷⁵

4 June

SpaceX successfully test-launched a Falcon-9 rocket carrying a mock-up spacecraft from Cape Canaveral, Florida, at 18:45 (UT). The test marked the first flight of a commercially developed rocket capable of carrying humans into space. The 735,000-pound (333,390.40-kilogram), 154-foot (46.94-meter) rocket had nine first-stage engines. During the test, the first-stage engines burned for 3 minutes before dropping off, and the second-stage Merlin engine put the payload into its orbital altitude 155 miles (249.45 kilometers) above Earth. Although the second stage spun slightly when the rocket reached orbit, and the first stage broke up when it fell to the ocean, SpaceX officials considered the test highly successful. NASA officials were also pleased with the launch. NASA planned to use commercially developed vehicles to transport cargo and crew to the ISS. In 2006 NASA had awarded SpaceX a US\$278 million contract for demonstration flights. If the tests were successful, NASA would award SpaceX a US\$1.6 billion contract for 12 cargo flights to the ISS. SpaceX planned to execute a second test launch of the Falcon 9 during the summer of 2010.⁷⁶

⁷⁴ NASA, “International Space Station Expedition 23 Crew Lands Safely,” news release 10-129, 1 June 2010, http://www.nasa.gov/home/hqnews/2010/jun/HQ_10-129_Soyuz_Lands.html (accessed 19 February 2013).

⁷⁵ Jonathan Amos, “Volunteers To Begin Mars500 Isolation,” *BBC News*, 3 June 2010, <http://www.bbc.co.uk/news/10197470> (accessed 26 March 2013); Eric Berger, “Six Men Begin 520-Day Mars Mission Without Leaving Earth,” *Houston Chronicle*, 2 June 2010, <http://www.chron.com/news/houston-texas/article/Six-men-begin-520-day-Mars-mission-without-1704452.php> (accessed 26 March 2013); Vladimir Isachenkov, “Six Researchers To Put Coping Skills To Test in 520-Day Simulation of Flight to Mars,” *Washington Post*, 4 June 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/06/03/AR2010060304286.html> (accessed 26 March 2013).

⁷⁶ *Spacewarn Bulletin*, no. 680, 1 July 2010, <http://nssdc.gsfc.nasa.gov/spacwarn/spx680.html> (accessed 19 February 2013); Kenneth Chang, “Private Rocket Has Successful First Flight,” *New York Times*, 4 June 2010, <http://www.nytimes.com/2010/06/05/science/space/05rocket.html?ref=science&r=0> (accessed 26 March 2013); Robert Block, “SpaceX Falcon 9 Makes It To Orbit in Historic First Launch,” *Orlando Sentinel* (FL), 4 June 2010, http://articles.orlandosentinel.com/2010-06-04/news/os-spacex-rocket-launch-20100604_1_spacex-falcon-international-space-station-rocket (accessed 26 March 2013).

10 June

South Korea attempted to launch a weather satellite, Science Technology Satellite No. 2, aboard the Korea Space Launch Vehicle-1 (KSLV-1, or Naro-1) from the Naro Space Center; however, the launch failed 137 seconds after liftoff. Before its first-stage rockets combusted, the 100-kilogram (220.46-pound) rocket reached an altitude of 70 kilometers (43.50 miles) and broke the sound barrier. Russia's Khrunichev Space Center had built the liquid-fueled first-stage engine as part of a joint project with the Korea Aerospace Institute, which had built the solid-fuel second-stage engine. South Korea's previous attempt to launch the Naro rocket in August 2009 had failed when two fairings did not separate at the right time. The South Korean government had spent nearly US\$1 billion on its satellite program and had hoped to launch a satellite from its own territory. Only nine nations had launched rockets from their homelands.⁷⁷

14 June

NASA announced that it had appointed two new program managers for its Constellation Program. Based at NASA's JSC, the Constellation Program was responsible for administering programs to launch humans beyond low-Earth orbit and developing new launch vehicles and spacecraft. NASA appointed Lawrence D. Thomas as Manager and Charles M. Stegemoeller as Deputy Program Manager. Thomas had begun his career with NASA in 1983 as an Aerospace Systems Engineer at NASA's MSFC. While at NASA's MSFC, he had served as Manager of the Systems Engineering and Analysis Office for the Second Generation Reusable Launch Vehicle Program Office, as well as Chief of the Systems Engineering Division, Spacecraft and Vehicle Systems Department. Thomas also had served as Manager of the Vehicle Analysis and Integration Office in the International Space Station Program at NASA's JSC. At the time of his appointment, he was serving as the Deputy Program Manager of the Constellation Program. Stegemoeller had joined NASA in 1985 and had served in the Space Station Freedom Program and the NASA/Mir Program at NASA's JSC. He had also served as Associate Director of the Office of Bioastronautics within the Space Life Sciences Directorate. At the time of his appointment, he was serving as Director of the Program Planning and Control Office for the Constellation Program.⁷⁸

15 June

The Russian Soyuz TMA-19 spacecraft, bound for the ISS, launched from Baikonur Cosmodrome on a Soyuz-FG rocket at 21:35 (UT). Russian Commander Fyodor N. Yurchikhin and NASA astronauts Douglas H. Wheelock and Shannon Walker were aboard the Soyuz. They planned to dock at the ISS on 17 June 2010, joining the Expedition 24 crew, which included NASA astronaut Tracy E. Caldwell Dyson and Russian cosmonauts Mikhail B. Kornienko and Alexander A. Skvortsov. Walker, Wheelock, and Yurchikhin would remain aboard the ISS for five-and-a-half months, performing station maintenance and working on the ISS's scientific research projects. They planned to move their Soyuz to the

⁷⁷ Donald Kirk, "Why Did South Korea's Rocket Launch Fail?" *Christian Science Monitor*, 11 June 2010, <http://www.csmonitor.com/World/2010/0611/Why-did-South-Korea-s-rocket-launch-fail> (accessed 28 March 2013); *Korea Herald*, "South Korean Space Rocket Crashes," 10 June 2010, <http://nwww.koreaherald.com/view.php?ud=20100610000805> (accessed 28 March 2013).

⁷⁸ NASA, "NASA Appoints Constellation Program Managers," news release 10-145, 14 June 2010, http://www.nasa.gov/home/hqnews/2010/jun/HQ_10-145_NASA_Constellation_Management.html (accessed 26 March 2013).

new Mini-Research Module's docking port and to perform three spacewalks. They would also host two Space Shuttle missions and witness a change of station command at the start of Expedition 25, which officials had scheduled for 24 September 2010.⁷⁹

NASA announced that it had awarded the Space Network Ground Segment Sustainment Project contract to General Dynamics C4 Systems. The Space Network Ground Segment is part of NASA's Space Network, which provides spacecraft in low-Earth or near-Earth orbit with global space-to-ground telecommunications and tracking coverage. Its facilities are located at the White Sands Complex in New Mexico, the Guam Remote Ground Terminal in Guam, and the Space Network Expansion East in Maryland. The cost-plus-award fee, indefinite-delivery, indefinite-quantity contract had a performance period from 21 June 2010 through 20 June 2017. Its total value, including options, was approximately US\$642.2 million. Under the terms of the contract, General Dynamics would modernize the ground segment of NASA's Space Network. This would include creating more flexible architecture, implementing new ways to support spacecraft with satellites, integrating NASA's Space Communications and Navigation networks, replacing obsolete systems, and responding to customer requirements and technological advances. Additionally, General Dynamics would expand and improve communication methods between the Space Network Ground System and the Space Network user control centers.⁸⁰

22 June

A team of scientists led by Francis M. McCubbin of the Carnegie Institution's Geophysical Laboratory announced in the *Proceedings of the National Academy of Sciences of the United States of America* that the team had discovered that the interior of Earth's Moon has more indigenous water than scientists had previously believed. For 40 years, scientists had thought that the Moon had almost no water; however, since 2008, researchers had used calculations and probe observations to determine that the Moon's surface has water and ice. McCubbin's team had studied samples of a lunar meteorite and of rocks brought back from the Apollo mission. Using secondary ion mass spectrometry, they had analyzed sections of the water-bearing mineral apatite in the samples. The researchers concluded that the water content of the samples was greater than previous scientific estimates of lunar water by at least two orders of magnitude. They also determined that, while water is still relatively scarce on the Moon, it is ubiquitous throughout the lunar interior. Furthermore, the researchers' findings indicated that the water had been preserved from magmatic processes that had occurred while the Moon was forming, indicating that water is a native substance on the Moon. The NASA Astrobiology Program, Mars Fundamental Research Program, and the Lunar Advanced

⁷⁹ *Spacewarn Bulletin*, no. 680; NASA, "New Space Station Crew Members Launch from Kazakhstan," news release 10-143, 15 June 2010, http://www.nasa.gov/home/hqnews/2010/jun/10-143_Soyuz_Exp24.html (accessed 19 February 2013); Tariq Malik, "New Space Station Crew Blasts Off on Soyuz Spaceship," *Space.com*, 15 June 2010, <http://www.space.com/8607-space-station-crew-blasts-soyuz-spaceship.html> (accessed 27 March 2013).

⁸⁰ NASA, "NASA Awards Space Network Ground Segment Sustainment Contract," news release C10-034, 15 June 2013, http://www.nasa.gov/home/hqnews/2010/jun/HQ_C10-034_SGSS_Announcement.html (accessed 19 February 2013).

Science and Exploration Research Program in NASA's Planetary Division in Washington, DC, had funded the research.⁸¹

25 June

NASA announced that it had awarded a contract for support of ISS mission integration services to Barrios Technology of Houston, Texas. Under the contract, Barrios Technology would provide engineering and technical services for the International Space Station Program, including the products and services that NASA would need to carry out international program integration, ISS mission integration and operations, mission planning, and Russian language and logistics services. The fixed-price, indefinite-delivery, indefinite-quantity contract covered a base period from 1 October 2010 through 31 December 2015, as well as offering two one-year options: Option 1 covered 1 January 2016 through 31 January 2016, and Option 2 covered 1 January 2017 through 31 December 2017. The value of the contract's base period was US\$185.5 million, with Option 1 valued at US\$42.7 million and Option 2 valued at US\$45 million. Barrios Technology would perform the majority of the contract work at NASA's JSC and KSC, with additional work in Kazakhstan and Russia. TechTrans International was a major subcontractor for Barrios Technology.⁸²

27 June

NASA ended operations for its first Tracking and Data Relay Satellite, TDRS-1. The satellite had launched in April 1983, during *Challenger's* maiden voyage, STS-6. From 1983 to 1998, NASA had used TDRS-1 as part of a nine-satellite communication system for navigating, receiving data and sending commands, and talking with crews in orbit. TDRS-1's range had extended over a former dead zone above the Indian Ocean, providing global-communications coverage for the ISS and for low-Earth orbiting satellites. TDRS-1 had been the first satellite to support launches from NASA's KSC. In 1998 NASA had reassigned TDRS-1 to support the National Science Foundation's (NSF's) U.S. Antarctic Program and other scientific operations. Because its orbit allowed communication with the North Pole and South Pole, TDRS-1 had facilitated innovations in communications such as the first pole-to-pole phone call, the first Internet connection and the first live Webcast from the North Pole, and the first global television event from the South Pole Station. TDRS-1 had also provided a communications link during a medical emergency at NSF's Antarctic Amundsen-Scott South Pole Station and had supported astronomy and astrophysics research from the South Pole. TRW, which later had become Northrop Grumman, had built TDRS-1 for NASA.⁸³

⁸¹ Francis M. McCubbin, "Nominally Hydrous Magmatism on the Moon," *Proceedings of the National Academy of Sciences of the United States of America* 107, no. 25 (22 June 2010): 11223–11228, <http://www.pnas.org/content/107/25/11223.full> (accessed 27 March 2013); NASA, "Research Suggests Water Content of Moon Interior Underestimated," news release 10-144, 14 June 2010, http://www.nasa.gov/home/hqnews/2010/jun/HQ_10-144_Water_In_Moon.html (accessed 19 February 2013); Denise Chow, "Moon Has 100 Time More Water, New Study Suggests," *Space.com*, 14 June 2010, <http://www.space.com/8593-moon-100-times-water-study-suggests.html> (accessed 27 March 2013).

⁸² NASA, "NASA Awards Space Station Mission Integration Contract," news release C10-038, 25 June 2010, http://www.nasa.gov/home/hqnews/2010/jun/HQ_C10-038_ISS_Integration.html (accessed 19 February 2013).

⁸³ NASA, "NASA Retires First Data Relay Satellite After Stellar Career," news release 10-154, 25 June 2010, http://www.nasa.gov/home/hqnews/2010/jun/10-154_TDRS_Retirement.html (accessed 19 February 2013).

28 June

The White House released the National Space Policy of the United States of America, a set of principles, goals, and guidelines governing the United States' space programs. Every presidential administration since President Dwight D. Eisenhower had updated the National Space Policy. The Obama administration's update revised some of the policies of the Bush administration, placing greater emphasis on expanding international collaboration in space, and including consideration of an arms-control treaty to curtail the development of space weapons. Obama's revised space policy also encouraged expansion of the United States' commercial spaceflight industry, instructing federal agencies to purchase from the spaceflight industry and to develop governmental space systems only when such development was in the national interest and no suitable commercial alternative was available. The new policy also outlined goals for expanding the use of weather satellites and robotic spacecraft, extending the use of the ISS, and reducing orbital debris.⁸⁴

30 June

The Russian uncrewed cargo-delivery vehicle Progress M-06M, or Progress 38, launched aboard a Soyuz rocket from Baikonur Cosmodrome at 15:35 (UT). The spacecraft would deliver 2.5 tons (5,000 pounds, or 2,267.96 kilograms) of supplies to the crew of the ISS. It carried 2,667 pounds (1,209.73 kilograms) of dry cargo, including scientific equipment, spare parts, and other supplies; 110 pounds (49.90 kilograms) of oxygen; 220 pounds (99.79 kilograms) of water; and 213 pounds (96.62 kilograms) of personal items for the six-person crew. The vehicle was also transporting 1,918 pounds (869.99 kilograms) of propellant to fuel the ISS's maneuvering thrusters. Progress M-06M was scheduled to dock at the ISS on 2 July 2010 and to remain at the station for two months.⁸⁵

JULY 2010

1 July

NASA Space Shuttle Program managers announced that they would be delaying the final launches to the ISS and extending the Space Shuttle Program into 2011. Officials postponed *Discovery's* STS-133 mission, originally scheduled to launch on 16 September 2010, so that NASA would have more time to prepare equipment. The STS-133 mission would deliver to the ISS a refitted cargo pod and a robot named Robonaut 2. NASA rescheduled the launch for 1 November 2010, pushing back the STS-134 launch of *Endeavour*. NASA had previously scheduled STS-134, intended as the final Space Shuttle flight, for late November 2010. STS-134 would deliver NASA's Alpha Magnetic Spectrometer (AMS) astrophysics experiment to the ISS. Officials rescheduled STS-134 for the next available launch date, 26

⁸⁴ U.S. Office of the President, "National Space Policy of the United States of America" (report, Washington DC, June 2010), http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf (accessed 27 March 2013); Bart Jansen, "Cooperation at Heart of New Space Policy," *Florida Today* (Brevard, FL), 29 June 2010, http://www.floridatoday.com/article/20100629/NEWS02/6290323/1006/NEWS01/Cooperation+at+heart+of+new+space+policy?nclick_check=1 (accessed 26 March 2013); William J. Broad and Kenneth Chang, "Obama Reverses Bush's Space Policy," *New York Times*, 28 June 2010, http://www.nytimes.com/2010/06/29/science/space/29orbit.html?ref=science&_r=0 (accessed 26 March 2013).

⁸⁵ *Spacewarn Bulletin*, no. 680; Tariq Malik, "New Robotic Cargo Ship Launches to Space Station," *Space.com*, 30 June 2010, <http://www.space.com/8685-robotic-cargo-ship-launches-space-station.html> (accessed 29 March 2013).

February 2011. NASA had also requested approval to add a final mission for *Atlantis* to deliver cargo and supplies to the ISS. However, to launch that mission in June 2011, NASA would need to receive permission from the White House by August 2010. Although NASA had originally scheduled the ending of the Space Shuttle Program for September 2010, many officials had anticipated launch slips. President Barack H. Obama's FY 2011 budget proposal had included US\$600 million to cover the costs of extending the Shuttle launch schedule.⁸⁶

7 July

NASA announced that it had awarded four contracts to develop, provide, and maintain crew robotics and vehicle equipment. After a full and open competition, NASA granted three of the contracts to ATK Space Systems of Brigham City, Utah; Oceaneering International of Houston, Texas; and Wyle Integrated Science, also of Houston, Texas. Officials limited the fourth contract competition to educational and nonprofit institutions and awarded that contract to the University of Alabama. The contract recipients would provide equipment for the ISS, the Space Shuttle, and other advanced development programs. The equipment would include crew health and conditioning systems, materials for the spacecraft flight crew, and materials for spacewalk activities. The cost-plus-fixed-fee, performance-based contracts had a combined total value that would not exceed US\$70 million. The contracts would run through June 2015, with the work conducted at the contractors' and subcontractors' facilities.⁸⁷

8 July

A team of scientists led by Manfred W. Pakull of the University of Strasbourg in France announced in the journal *Nature* that they had discovered the most powerful jets ever observed coming from a type of black hole called a microquasar. The strong jets of fast-moving particles are heating the interstellar gas around the black hole and forming a hot-gas bubble, 1,000 light-years wide and growing at the rate of almost 1 million kilometers per hour (621,371.20 miles per hour), making it the largest such bubble that scientists had ever seen. Black holes release a large amount of energy as they pull in matter, but scientists had believed that the black holes release that energy predominantly in the form of radiation. However, the newly discovered microquasar is releasing energy as collimated jets of super-fast particles. These unusually long jets, which measure approximately 300 parsecs, indicate the power of the microquasar. Named S26, the microquasar is located 12 million light-years away from Earth, in the spiral galaxy NGC 7793. Although it weighs only a few solar masses, S26 is emitting an amount of energy equivalent to the output of black holes with over a million solar masses. Researchers believe that S26's jets have been active for at least 200,000 years. Pakull's team had conducted their research using optical, radio, and x-ray data from NASA Chandra X-ray Telescope and the European Southern Observatory's Very Large Telescope (VLT). The team believed that their observations would help astronomers

⁸⁶ NASA, "NASA Updates Shuttle Target Launch Dates for Final Two Flights," news release 10-157, 1 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-157_STS_Launch_Dates.html (accessed 22 April 2013); Tariq Malik, "NASA Delays Space Shuttle Program's End to 2011," *Space.com*, 1 July 2010, <http://www.space.com/8694-nasa-delays-space-shuttle-program-2011.html> (accessed 12 April 2013).

⁸⁷ NASA, "NASA Awards Crew Robotics and Vehicle Equipment Contracts," news release C10-039, 7 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_C10-039_CRAVE_Contract.html (accessed 4 April 2013).

understand the similarities among the small black holes that formed from exploding stars and the supermassive black holes at the center of galaxies.⁸⁸

9 July

NASA announced that Administrator Charles F. Bolden Jr. had appointed Ramon “Ray” Lugo III to a permanent position as Director of NASA’s GRC. Lugo had served as Acting Director of NASA’s GRC since March 2010. As Director, he would be responsible for planning, organizing, and leading the missions at NASA’s GRC, including research, technology, and systems-development programs in aeronautical propulsion, microgravity sciences, space communications, space power, and space propulsion. Lugo had begun his career at NASA in 1975. He had served NASA as Executive Director of the Cape Canaveral Spaceport Management Office, Director of Expendable Launch Vehicle Services, Manager of the Facilities and Support Equipment Division in the Space Station Project Office, Chief of the Business Office in the Joint Performance Management Office, and Deputy Manager of the Launch Services Program at NASA’s KSC. In 2007 NASA had appointed Lugo Deputy Director of GRC. Lugo had received two NASA Exceptional Achievement Medals for his contributions to the Galileo mission and the ISS redesign, as well as three NASA Outstanding Leadership Medals for his work in the Expendable Launch Vehicle Program.⁸⁹

10 July

A team of scientists led by Jeffrey L. Linsky of the University of Colorado, Boulder, announced in the *Astrophysical Journal* that the team had found evidence that a gas giant exoplanet named HD 209458b is orbiting so close to its star that its atmosphere is evaporating into space and being swept behind the planet like a comet’s tail. The planet is located so close to its star that its atmosphere is 2,000°F, and its orbit is only 3.5 days. In 2003 scientists using the Space Telescope Imaging Spectrograph (STIS) aboard NASA’s HST had observed that the heat from the star is evaporating HD 209458b’s atmosphere. Researchers had speculated that the dissipating atmosphere might be blowing out behind the planet in a tail, but STIS lacked the spectrographic detail to observe this. Linsky’s team had used the new Cosmic Origins Spectrograph (COS) aboard NASA’s HST to observe the planet during transit, when it passes in front of its star, and to study the dip in starlight that occurs at that time. When the researchers excluded the planet’s atmosphere from the data, the starlight dipped only about 1.5 percent, but when they included the atmosphere, the dip was 8 percent. This indicated that the atmosphere was bloated. COS data showed that solar winds from the star were driving the evaporated atmospheric material into a tail at varying

⁸⁸ Manfred W. Pakull et al., “A 300-Parsec-Long Jet-Inflated Bubble around a Powerful Microquasar in the Galaxy NGC 7793,” *Nature* 466, no. 7303 (8 July 2010): 209–212, <http://www.nature.com/nature/journal/v466/n7303/full/nature09168.html> (accessed 16 April 2013); Denise Chow, “Black Hole Blows Massive Gas Bubble,” *Space.com*, 7 July 2010, <http://www.space.com/8719-black-hole-blows-massive-gas-bubble.html> (accessed 16 April 2013); Nancy Atkinson, “Powerhouse Black Hole Blows a Huge Bubble,” *Universe Today*, 7 July 2010, <http://www.universetoday.com/67926/powerhouse-black-hole-blows-a-huge-bubble/> (accessed 16 April 2013).

⁸⁹ NASA, “NASA Names Lugo as Director of Glenn Research Center,” news release 10-162, 9 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-162_NASA_Glenn_Director_Named.html (accessed 4 April 2013).

velocities up to 22,000 miles per hour (35,405.57 kilometers per hour), and that even the planet's heavier elements, like carbon and silicon, were being heated enough to evaporate.⁹⁰

13 July

NASA announced plans to create three new Centennial Challenges—prize competitions for companies, groups, and individuals working outside the aerospace industry without government funding. The purpose of NASA's Centennial Challenges was to inspire creative problem solving among citizens and to encourage competitiveness, innovation, and the growth of new industries. NASA had offered 19 Centennial Challenges since 2005, awarding US\$4.5 million in prizes to 13 different teams. NASA had previously announced plans to hold two Centennial Challenges in 2010 and one in 2011. The newly announced Challenges would have a total prize value of US\$5 million. The first would be the Nano-Satellite Launch Challenge, in which a team could win US\$2 million for placing a small satellite in Earth-orbit twice in one week. This challenge would motivate participants to create commercial nanosatellite-delivery systems and low-cost launch technologies. In Night Rover Challenge, the team that demonstrated a solar-powered vehicle that could operate in darkness using its own stored energy would win a US\$1.5 million purse. This challenge's objective would be to encourage the development of innovative energy-storage techniques for electric vehicles and renewable-energy systems that NASA could use either in extreme space environments or on Earth. The Sample Return Robot Challenge would award a US\$1.5 million purse to the team that developed a robot that could locate and retrieve geologic samples from various terrains without human control. This challenge would stimulate the development of automatic-navigation and robotic-manipulator technologies.⁹¹

15 July

Virgin Galactic's suborbital spaceship VSS Enterprise, one of the fleet of SpaceShipTwo commercial spacecraft, successfully completed its first crewed test flight. During the 6-hour, 12-minute flight, the spacecraft did not attempt to enter space but remained attached to its mothership, VMS Eve. Two crew members rode aboard VSS Enterprise, and three crew members flew in VMS Eve. Virgin Galactic reported that automated sensors had evaluated the spacecraft's systems, as had onboard crews and ground crews, and had determined that the spacecraft had achieved all flight objectives. The test flight was the third captive-carry test of VSS Enterprise and the 33rd flight of VMS Eve. Virgin Galactic was developing the spacecraft to carry space tourists on flights that would reach suborbital altitudes for a few minutes, providing an experience of weightlessness and views of Earth and space.⁹²

⁹⁰ Jeffrey L. Linsky et al., "Observations of Mass Loss from the Transiting Exoplanet HD 209458b," *Astrophysical Journal* 717, no. 2 (10 July 2010): 1291–1299, http://iopscience.iop.org/0004-637X/717/2/1291/pdf/0004-637X_717_2_1291.pdf (accessed 12 April 2013); NASA, "NASA Finds Super Hot planet with Unique Comet-Like Tail," news release 10-167, 15 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-167_Hubble_Finds_Planet.html (accessed 4 April 2013); Clara Moskowicz, "Scorched Alien Planet has a Comet Tail," *Space.com*, 15 July 2010, <http://www.space.com/8765-scorched-alien-planet-comet-tail.html> (accessed 12 April 2013).

⁹¹ NASA, "NASA Announces Three New Centennial Challenges," news release 10-162, 13 July 2013, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-162_New_Centennial_Challenges.html (accessed 4 April 2013).

⁹² Clara Moskowicz, "Virgin Galactic's Private Spaceship Makes First Crewed Flight," *Space.com*, 16 July 2010, <http://www.space.com/8777-virgin-galactic-private-spaceship-crewed-flight.html> (accessed 10 April 2013).

19 July

NASA announced that OpenStack, a recently introduced open-source cloud-computing initiative, had selected NASA's Nebula cloud-computing technology to contribute to the initiative. OpenStack, the first large-scale, open-source cloud-computing project of its kind, would unite more than 25 companies to encourage the development of cloud-computing standards for interoperability and portability. Cloud computing is a method of delivering resources such as software, storage, and virtual computing power over the Internet. NASA had developed the Nebula platform as an agency-wide program to accommodate researchers' large-scale data sets using a technology with powerful bandwidth, computing capability, and storage. OpenStack had selected Nebula because of its high-quality code and massively scalable architecture. NASA officials expected that participation in OpenStack would allow them to ensure that the products and services powered by the initiative met federal interoperability, portability, and security requirements.⁹³

The Houghton-Mars Project, HMP-2010, began a three-week study of future planetary-exploration concepts. NASA scientists joined the team of international researchers at Houghton Crater on Devon Island in the Canadian Arctic. Devon Island has the geological features, microbiology, and polar-desert environment suitable for analog studies of Mars and the Moon. During HMP-2010, NASA would conduct studies of remotely operated robots, in support of the Exploration Technology Development Program in the Exploration Systems Mission Directorate and of the Moon and Mars Analog Mission Activities Program in the Science Mission Directorate. The Intelligent Robotics Group at NASA's ARC had developed the robots, called K10s, to map the above-ground and below-ground structures of Houghton Crater and to characterize its landscape, rocks, and soil. The robots' instrument suite included 3-D-scanning lidar, color imagers, ground-penetrating radar, and spectrometers. Researchers would experiment with using robots to perform on-site follow-up work between crewed space missions and to move surface systems, such as crew rovers, from one location to another. In addition, the researchers would investigate possible uses of ground robots to explore unknown terrain and to identify unseen obstacles and alternative safe routes for astronauts. NASA's Lunar Surface Systems (LSS) Project would conduct a study using a robot programmed to follow a fixed route and a specific schedule for conducting scientific tasks, such as gathering samples or capturing images. The LSS project aimed to discover ways that robots could alleviate astronauts' repetitive, tedious, or time-consuming tasks, as well as gathering data to supplement that collected by humans.⁹⁴

22 July

The journal *Science* published online the work of a team of scientists led by Jan Cami, of the University of Western Ontario, Canada, and the SETI (Search for Extraterrestrial Intelligence) Institute. The team announced that it had made the first observations of C₆₀ and C₇₀ molecules in space. C₆₀ molecules, known as "buckminsterfullerenes," or "buckyballs," are composed of 60 carbon atoms arranged in a spherical pattern of hexagons and pentagons. C₇₀,

⁹³ NASA, "NASA's Cloud Computing Technology To Play Key Role in New Open Source Initiative," news release 10-172, 19 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-172_Nebula_Initiative.html (accessed 5 April 2013).

⁹⁴ NASA, "NASA Simulates Space Exploration at Remote Arctic Crater Site," news release 10-179, 26 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-179_Arctic_Crater.html (accessed 5 April 2013).

also a fullerene, is a similar, slightly elongated molecule. The largest observed molecules in space, fullerenes are approximately 1 nanometer in diameter, three times the size of a water molecule. Scientists had first predicted the existence of buckyballs in 1970 and had first produced them in the laboratory in 1985. Since then, researchers had observed them on Earth in candle soot, meteorites, and rock. Scientists had theorized that buckyballs exist in space, but they had not previously succeeded in observing them. Cami's team had found the spectral signature of buckyballs serendipitously, while they were using the spectroscopy instrument on NASA's SST to observe the planetary nebula Tc 1. A planetary nebula is the cloud of jettisoned dust and gas that surrounds a white dwarf star. The planetary nebula Tc 1 is 6,500 light-years away from Earth, in the constellation Ara. The researchers believed that the buckyballs in Tc 1 had formed less than 100 years ago, when the dying star emitted a burst of carbon-rich material. They predicted that the buckyballs would be undetectable 100 years from now. The team's research proved that, under the right conditions, buckyballs form naturally in space.⁹⁵

23 July

GAO responded to a 12 March 2010 request from 17 members of Congress asking GAO to investigate whether NASA staff had broken the law while planning for the aftermath of the Constellation Program. The members of Congress questioned whether NASA's obligation of appropriations for exploration was consistent with the Congressional Budget Impoundment Control Act of 1974 (Pub. L. No. 93-344, 88 Stat 297) and with restrictions in the FY 2010 appropriation for exploration. The FY 2010 appropriation restrictions prohibited NASA from using exploration funds either to end or to create new PPAs under the Constellation Program. The provisions of the Impoundment Control Act required government agencies, including NASA, to make funds available for obligation and expenditure. GAO reported that, after analyzing NASA's financial data, it had found that NASA had not withheld exploration funds from obligation. GAO found that NASA's spending of exploration funds during FY 2010 had been consistent with its spending in FY 2008 and FY 2009. Furthermore, GAO found that NASA had continued to obligate funds to the Constellation Program's PPAs and had not taken action to end the Constellation Program, its PPAs, or any of its major contracts. GAO's response was the second part of a two-part report. GAO had issued the first part of the report on 21 May 2010.⁹⁶

NASA's Mars rover Curiosity successfully completed its first test-drive in a clean room at NASA's JPL. The US\$2.3 billion rover, which was approximately 80–90 percent complete, drove approximately 3 feet (0.91 meters) back and forth. NASA had previously tested Curiosity's wheels on a riser, but this was the first fully integrated test of the rover on solid

⁹⁵ Jan Cami et al., "Detection of C60 and C70 in a Young Planetary Nebula," *Science* 329, no. 5996 (3 September 2010): 1180–1182; published online 22 July 2010, <http://www.sciencemag.org/content/329/5996/1180.full> (accessed 3 July 2013); NASA, "NASA Telescope Finds Elusive Buckyballs in Space for the First Time," news release 10-174, 22 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-174_Buckyballs.html (accessed 5 April 2013); J. R. Minkel, "Astronomers Find Largest Molecules Ever Known in Space," *Space.com*, 22 July 2010, <http://www.space.com/8804-astronomers-find-largest-molecules-space.html> (accessed 17 May 2010).

⁹⁶ U.S. Government Accountability Office, "National Aeronautics and Space Administration—Constellation Program and Appropriations Restrictions" (report no. B-320091, Part II, Washington, DC, 23 July 2010), <http://www.gao.gov/assets/390/389548.pdf> (accessed 10 April 2013).

ground. Technicians had not yet installed Curiosity's sophisticated software, so they gave basic movement commands to the rover through electrical wiring. NASA planned to conduct more advanced movement tests, including turns and inclines, once engineers had installed Curiosity's electronics. NASA had scheduled Curiosity's launch for 25 November 2011, as part of a mission for NASA's MSL. Curiosity would land on Mars in August 2012 and would conduct tests of the Martian rock and soil, assisting in the ongoing study of the planet's geological history and habitability.⁹⁷

27 July

Two Russian cosmonauts, Fyodor N. Yurchikhin and Mikhail B. Kornienko, left the ISS at 12:11 a.m. (EDT) for a 6-hour-and-42-minute spacewalk. The cosmonauts removed a broken camera that the crew had used to help dock the uncrewed cargo ships called Automated Transfer Vehicles (ATVs). They also routed cables to connect the command-and-data-handling computers to the Rassvet module and to set up Rassvet's Kurs automatic docking system. Yurchikhin and Kornienko successfully completed the spacewalk's entire planned itinerary, although they did lose two objects, which floated away into space. The cosmonauts believed that the lost items were a washer and a tool used to install cables.⁹⁸

AUGUST 2010

2 August

NASA and ESA announced that they had selected five scientific instruments for the ExoMars Trace Gas Orbiter (EMTGO), the first step in their joint program for the exploration of Mars. Scheduled for launch in 2016, the orbiter would be the first in a series of cooperative Mars missions, culminating in a mission scheduled to take place in the 2020s. The final mission would return collected samples to Earth. Using instruments 1,000 times more sensitive than any previous Martian orbiter, EMTGO would study chemicals in the Martian atmosphere, particularly methane, and serve as a communications relay for future missions on Mars's surface. NASA and ESA had selected the five instruments for the orbiter from 19 proposals submitted from around the globe. The five instruments, chosen because they offered the best science value at the lowest risk, were the ExoMars Climate Sounder (EMCS), an infrared radiometer; the High Resolution Solar Occultation and Nadir Spectrometer (NOMAD), which detected and mapped atmospheric elements; the High Resolution Stereo Color Imager (HiSCI), a four-color, stereo-imaging camera; the Mars Atmospheric Trace Molecule Occultation Spectrometer (MATMOS), which detected atmospheric components in low concentrations; and the Mars Atmospheric Global Imaging Experiment (MAGIE), a wide-angle, multispectral camera.⁹⁹

⁹⁷ Denise Chow, "New Mars Rover Takes First Drive . . . on Earth," *Space.com*, 23 July 2010, <http://www.space.com/8817-mars-rover-takes-drive-earth.html> (accessed 12 April 2013); Stephen Clark, "Curiosity Goes for a Spin," *Spaceflight Now*, 23 July 2010, <http://www.spaceflightnow.com/news/n1007/23curiosity/> (accessed 12 April 2013).

⁹⁸ Clara Moskowitz, "Despite Losing Tools, Cosmonauts Complete Spacewalk," *Space.com*, 27 July 2010, <http://www.space.com/8831-losing-tools-cosmonauts-complete-spacewalk.html> (accessed 12 April 2013).

⁹⁹ NASA, "NASA and ESA's First Joint Mission to Mars Selects Instruments," news release 10-181, 2 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-181_Joint_Mars_Mission.html (accessed 17 April 2013).

6 August

Three teams of scientists, one led by James A. Slavin of NASA's GSFC, one by Louise M. Prockter of NASA's GFC, and one by Ronald J. Vervack Jr. of the Johns Hopkins University Applied Physics Laboratory (APL), published papers in the journal *Science* detailing their research on the planet Mercury. The researchers used data that NASA's Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER) spacecraft had gathered on its third and final flyby of Mercury in September 2009. Slavin's team reported new data on the timescale of substorms in Mercury's magnetic field. They had observed that Mercury's magnetic substorms were similar to Earth's substorms but approximately 10 times stronger and 50 times shorter. Studying volcanism on Mercury, Prockter's team had found evidence of the most recent volcanic activity observed on the planet. MESSENGER had captured images of a young impact basin with a smooth inner floor. The researchers believed that lava flows had formed the basin. MESSENGER's images also showed a large volcanic vent located to the northeast of the basin. Vervack's team had used MESSENGER's Mercury Atmospheric and Surface Composition Spectrometer (MASCS) to study Mercury's exosphere, or thin atmosphere, recording the first observations of emissions from ionized calcium in the planet's exosphere. In the first study ever done of the exosphere over Mercury's north and south poles, the team had found distinct distributions of calcium, magnesium, and sodium, indicating that multiple processes in Mercury's exosphere control the distribution of single elements.¹⁰⁰

10 August

Scientists led by Warren R. Brown of the Harvard-Smithsonian Center for Astrophysics announced in the *Astrophysical Journal Letters* that their team had determined that an encounter with the Milky Way galaxy's central black hole is propelling the star HE 0437-5439 out of the galaxy. Scientists had previously determined that HE 0437-5439 is 200,000 light-years from the Milky Way's center and moving at 1.6 million miles per hour (2.57 million kilometers per hour), but they had not known the age of the star or where it originated. If it had travelled from the Milky Way's core to its present location, HE 0437-5439 must have survived 100 million years. However, HE 0437-5439's mass and blue color indicated a star that had burnt out at the age of 20 million years. This contradiction had led some scientists to speculate that the star had originated in the Large Magellanic Cloud. Brown's team had made their determination using the Advanced Camera for Surveys on NASA's HST. From 2006 to 2009, the researchers had measured changes in the star's position, and they found that the star's velocity vector pointed straight from the center of the Milky Way. The researchers concluded that HE 0437-5439 had likely been part of a triple-star system 100 million years ago. As the system travelled past the galaxy's black hole, the outer star had fallen into the black hole, transferring its momentum to the other two stars and giving them

¹⁰⁰ Louise M. Prockter et al., "Evidence for Young Volcanism on Mercury from the Third MESSENGER Flyby," *Science* 329, no. 5992 (6 August 2010): 668–671, <http://www.sciencemag.org/content/329/5992/668.full> (accessed 4 April 2013); James A. Slavin et al., "MESSENGER Observations of Extreme Loading and Unloading of Mercury's Magnetic Tail," *Science* 329, no. 5992 (6 August 2010): 665–668, <http://www.sciencemag.org/content/329/5992/665.full> (accessed 4 April 2013); Ronald J. Vervack Jr. et al., "Mercury's Complex Exosphere: Results from MESSENGER's Third Flyby," *Science* 329, no. 5992 (6 August 2010): 672–675, <http://www.sciencemag.org/content/329/5992/672.full> (accessed 4 April 2013); NASA, "MESSENGER Spacecraft Reveals New Information about Mercury," news release 10-170, 15 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/10-170_Messenger_New_Info.html (accessed 4 April 2013).

enough velocity to escape the galaxy's gravitational field. As they shot toward the galaxy's edge, the stars had merged to form the superstar HE 0437-5439.¹⁰¹

NASA Administrator Charles F. Bolden Jr. and Israel Space Agency Director General Zvi Kaplan met at NASA Headquarters to sign a joint statement of intent to increase their agencies' collaboration on civil space activities that would facilitate scientific cooperation and inspire the future generation of engineers and scientists. NASA and the Israel Space Agency agreed to select new joint projects in the fields of Earth and space sciences, life sciences, space exploration, and other areas of mutual interest. The agencies identified several potential topics for cooperative activity, including hydrological research, launch and range safety, planetary science research through NASA's Lunar Science Institute, and space geodesy—the science of making space-based observations of Earth's crust, gravitational field, polar movement, and tides. Additionally, the agencies agreed to expand the Israel Space Agency's participation in the Global Learning and Observations to Benefit the Environment (GLOBE) educational program, and to increase Israel's research and educational experiments aboard the ISS.¹⁰²

12 August

The company SpaceX, based in Hawthorne, California, successfully completed the first high-altitude drop test of its Dragon spacecraft. The test, which occurred over the Pacific Ocean near Morro Bay, California, assessed the craft's parachute deployment systems and recovery operations. After a helicopter dropped Dragon from an altitude of 14,000 feet (4,267.20 meters), the spacecraft's three main parachutes deployed, slowing the craft to a descent of 16–18 feet per second (4.88–5.49 meters per second). SpaceX technicians successfully recovered the Dragon capsule by boat after it landed. In 2008 NASA had awarded SpaceX a US\$1.6 billion contract to conduct 12 resupply missions to the ISS. Dragon would function as an uncrewed cargo vessel on these missions, but SpaceX had designed the craft to be able to transport crews, as well. SpaceX planned eventually to compete for NASA contracts to carry astronauts to the ISS.¹⁰³

15 August

NASA began its Genesis and Rapid Intensification Processes (GRIP) mission, a six-week study of how tropical storms develop, form into hurricanes, rapidly intensify, weaken, and die out. The first major U.S.-based hurricane field study that NASA had conducted in nine years, GRIP would study hurricanes for 20 hours at a time, providing sustained, continuous

¹⁰¹ Warren R. Brown et al., "A Galactic Origin for HE 0437-5439, the Hypervelocity Star Near the Large Magellanic Cloud," *Astrophysical Journal Letters* 719, no. 1 (10 August 2010): L23, https://www.cfa.harvard.edu/~wbrown/Files/pm_hvs3.pdf (accessed 2 May 2013); NASA, "NASA's Hubble Shows Hyperfast Star was Booted from Milky Way," news release 10-175, 22 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-175_Hubble_Milky_Way.html (accessed 5 April 2013); Denise Chow, "Superfast Star Shot Out of Milky Way," *Space.com*, 22 July 2010, <http://www.space.com/8801-superfast-star-shot-milky.html> (accessed 2 May 2013).

¹⁰² NASA, "NASA and Israel Space Agency Sign Statement of Intent for Future Cooperation," news release 10-189, 11 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-189_Israel_Signing.html (accessed 17 April 2013).

¹⁰³ W. J. Hennigan, "SpaceX Successfully Drop-Tests Dragon Capsule," *Los Angeles Times*, 20 August 2010; Stephen Clark, "SpaceX: Dragon Testing Will Determine Launch Schedule," *Spaceflight Now*, 20 August 2010, <http://www.spaceflightnow.com/falcon9/002/100820update/> (accessed 26 April 2013).

data on a hurricane's formation and evolution. The National Hurricane Center would use the data to make earlier weather forecasting predictions, to improve forecasting of rapid changes in storm strength, and to determine the amount of coastline requiring storm watches and warnings. NASA would use three satellites to collect data for GRIP. The Aqua satellite would provide infrared, microwave, and visible data on air pressure, air temperature, cloud-ice content, convection, precipitation, and sea-surface temperature. The SeaCloud satellite would collect information on clouds, including their altitude, rainfall intensity, and temperature. The Tropical Rainfall Measuring Mission (TRMM), a joint project between NASA and JAXA, would collect data on rainfall and on the location of powerful thunderstorms called "hot towers." NASA would also use three aircraft for the mission: a DC-8, a Global Hawk, and a WB-57. These aircraft would carry a suite of 15 instruments to make observations of aerosols, air pressure, air temperature, cloud droplet and aerosol concentrations, humidity, lightning, water vapor, wind direction, and wind speed.¹⁰⁴

The President's Task Force on Space Industry Workforce and Economic Development, established in May 2010 to create an economic development strategy for Florida's Space Coast region, released its report to President Barack H. Obama. Cochaired by NASA Administrator Charles F. Bolden Jr. and Commerce Secretary Gary F. Locke, the task force had created a plan to use US\$40 million in federal funds to help Florida's Space Coast adjust to the end of the Space Shuttle Program. After examining the Space Coast's development priorities, economic assets, and employment requirements, and considering suggestions submitted by the public, the task force recommended awarding US\$35 million in grants to aviation, solar power, and life sciences companies that would create jobs and foster economic development. It also recommended using the remaining US\$5 million to fund a new Commercial Spaceflight Technical Center to facilitate commercial rocket launches out of NASA's KSC. Overall, the task force recommended that the Obama administration sustain regional investments that are already underway, such as job retraining programs; encourage business growth and hold job fairs for workers, to develop awareness of opportunities for immediate employment; invest in economic growth initiatives, offering grants through a new competitive fund; and build lasting business infrastructure through public-private partnerships.¹⁰⁵

¹⁰⁴ NASA, "NASA To Fly Into Hurricane Research This Summer," news release 10-160, 7 July 2010, http://www.nasa.gov/home/hqnews/2010/jul/HQ_10-160_GRIP_Research.html (accessed 3 May 2013); Pete Spotts, "At Height Hurricane Season, Research Teams Take on Storms," *Christian Science Monitor*, 5 August 2010.

¹⁰⁵ Presidential Task Force on Space Industry Workforce and Economic Development, "Report to the President" (Washington, DC, August 2010), http://www.nasa.gov/pdf/475699main_Space_Industry_Report_to_the_President.pdf (accessed 16 May 2010); NASA, "Space Coast Task Force Delivers Economic Strategies Report," news release 10-194, 17 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-194_Space_Task_Force.html (accessed 17 April 2013); Bart Jansen, "Space Industry Jobs Panel Gives Push to \$35M in Grants," *Florida Today* (Brevard, FL), 16 August 2010; Mark K. Matthews, "\$5 Million Center To Support Commercial Rockets Urged for Space Coast," *Orlando Sentinel* (FL), 16 August 2010.

16 August

Astronauts Tracy E. Caldwell Dyson and Douglas H. Wheelock successfully completed their third spacewalk in 10 days to repair a failed cooling-system pump on the ISS. The pump, part of a system that uses liquid ammonia to cool the ISS's onboard systems, had failed on 31 July 2010 when an electrical short had tripped a circuit breaker, leaving the American segment of the ISS with one cooling pump instead of two. To prevent the cooling system from overheating, the crew had turned off some of the ISS's experiments and systems and had operated other systems without backup. ISS managers noted that repairing a failed ammonia pump was one of most troublesome repairs for astronauts. The cumbersome pumps weigh 780 pounds (353.80 kilograms) and measure 5.5 feet long (1.68 meters long), 4 feet wide (1.22 meter wide), and 3 feet tall (0.94 meters tall), making them difficult to replace. Caldwell Dyson and Wheelock had made their first spacewalk to repair the pump on 1 August 2010. At 8 hours and 3 minutes, this event set the record for the longest spacewalk in the history of the ISS. However, the repair was unsuccessful. The astronauts had been unable to remove a stuck hose, which leaked a flurry of potentially toxic ammonia. During the second spacewalk, on 11 August 2010, which lasted 7 hours and 26 minutes, the astronauts successfully removed the failed pump after Wheelock used force to pry the stuck hose loose. During the third spacewalk, lasting 7 hours and 20 minutes, the astronauts installed a new pump without experiencing any ammonia leakage. ISS managers planned to have the cooling system operating fully by 19 August 2010.¹⁰⁶

20 August

A team of researchers led by Eric Jullo of NASA's JPL announced in the journal *Science* that they had refined the estimate of dark energy's equation-of-state parameter by approximately 30 percent, using a new geometric testing technique based on strong gravitational lensing in galaxy clusters. The term "dark energy" refers to the force that scientists believe is accelerating the expansion of the universe, and "the equation-of-state parameter" refers to the parameter for the rate of that expansion. The researchers had examined 34 images taken by NASA's HST and by ground-based telescopes, observing the distortion of light from distant galaxies as it passed by the massive galaxy cluster Abell 1689. This distortion, known as "gravitation lensing," is dependent on the mass of the galaxy cluster, the distance the light has travelled, and the distribution of dark energy. Because the researchers were able to measure the first two factors, they could calculate the third factor. The work of Jullo's team supported previous research indicating that the universe is flat and will continuously expand forever. By combining their new method of characterizing dark energy with other models, the team produced a more precise estimate of the equation-of-state parameter and devised a new way to extract information about dark energy.¹⁰⁷

¹⁰⁶ Tariq Malik, "Space Station Astronauts Remove Faulty Pump in Urgent Repairs," *Space.com*, 11 August 2010, <http://www.space.com/8929-space-station-astronauts-remove-faulty-pump-urgent-repairs.html> (accessed 15 May 2013); Mark K. Matthews, "Astronauts Fix Cooling Pump in Third Spacewalk," *Orlando Sentinel* (FL), 16 August 2010; Marcia Dunn, "Spacewalking Astronauts Plug in New Cooling Pump," Associated Press, 17 August 2010.

¹⁰⁷ Eric Jullo et al., "Cosmological Constraints from Strong Gravitational Lensing in Clusters of Galaxies," *Science* 329, no. 5994 (20 August 2010): 924–927, <http://www.sciencemag.org/content/329/5994/924.abstract?sid=c00158a1-efa9-43e7-a9eb-72cb87e910d0> (accessed 3 May 2013); Howard Falcon-Iang, "Fate of Universe Revealed by Galactic Lens," *BBC News*, 19 August 2010; Clara Moskowitz, "Dark Energy Mystery Illuminated by Cosmic Lens," *Space.com*, 19 August 2010, <http://www.space.com/8983-dark-energy-mystery-illuminated->

26 August

The journal *Science* published the work of a team of scientists led by Matthew J. Holman of the Harvard-Smithsonian Center for Astrophysics, confirming for the first time that NASA's Kepler Space Telescope had discovered a previously unknown planetary system. The Kepler mission had observed more than 156,000 stars, searching for the periodic dimming of starlight that indicates that a planet is transiting in front of the star. By June 2010, the research team had collected Kepler's first 43 days of data; from that data, they had compiled a list of more than 700 planetary candidates. The first confirmed planetary system consisted of two planets orbiting the star Kepler-9. Named Kepler-9b and Kepler-9c, the two planets are slightly smaller than Saturn. The researchers had determined the planets' size by measuring the amount of light that the planets blocked as they transited the star. They had determined the planets' mass by measuring the planets' gravitational interaction with each other. Both planets are too close to their star to be habitable. Kepler-9b has an orbit of 19.2 days and is about 740 K (872.30°F or 466.85°C), and Kepler-9c has a 38.9-day orbit and is 540 K (512.30°F or 266.85°C). In addition to the confirmed planets, the researchers also identified a smaller candidate planet, with a radius approximately 1.5 times that of Earth, which appeared to be orbiting the star in only 1.6 days.¹⁰⁸

30 August

NASA announced that its Commercial Reusable Suborbital Research Program (CRuSR) had awarded contracts for experimental vehicle-test flights to Armadillo Aerospace of Rockwell, Texas, and Masten Space Systems of Mojave, California. The total value of the contracts was approximately US\$475,000. CRuSR encouraged commercial entities to develop reusable systems for transportation to near-space altitudes between 65,000 and 350,000 feet (19,812 and 106,680 meters). The program's mission was to achieve frequent, low-cost, and regular entry into near-space, with easily recoverable intact payloads. Armadillo would conduct three test flights of its Super-Mod vehicle from Spaceport America in New Mexico. During the first two flights, Super-Mod would fly to an altitude of approximately 9 miles (14.48 kilometers), and during the third flight, it would reach an altitude of approximately 25 miles (40.23 kilometers). Masten would conduct four tests of its Xaero vehicle at the Mojave Spaceport in California. During the first two flights, Xaero would reach approximately 3 miles (4.83 kilometers) above Earth. During the second two flights, it would reach an approximate altitude of 18 miles (28.97 kilometers), with the engines shut down during flight. Armadillo and Masten would also modify their vehicles to mount three antennas for the

cosmic-lens.html (accessed 3 May 2010); *Universe Today*, "Astronomers Now Closer to Understanding Dark Energy," 19 August 2010, <http://www.universetoday.com/71565/astronomers-now-closer-to-understanding-dark-energy/> (accessed 3 May 2013).

¹⁰⁸ Matthew J. Holman et al., "Kepler-9: A System of Multiple Planets Transiting a Sun-Like Star, Confirmed by Timing Variations," *Science* 300, no. 6000 (1 October 2010): 51–54, published online 26 August 2010, <http://www.sciencemag.org/content/330/6000/51.full> (accessed 5 June 2013); NASA, "NASA's Kepler Mission Discovers Two Planets Transiting Same Star," news release 10-197, 26 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-197_Kepler_Results.html (accessed 17 April 2013); Denise Chow, "Newfound Alien Planets May Include Smallest One Yet," *Space.com*, 26 August 2010, http://www.nytimes.com/2010/08/27/science/space/27planet.html?_r=3&ref=science& (accessed 5 June 2013).

Automatic Dependent Surveillance-Broadcast (ADS-B) payload, which uses global-navigation satellite systems to chart a vehicle's position.¹⁰⁹

31 August

Astronauts Linda M. Godwin and Scott D. Altman announced that they would be leaving NASA. Godwin had begun working at NASA in the Payload Operations Division in 1980. In 1985 NASA had selected her as an astronaut. Over the course of her career, Godwin had spent 38 days in space and 10 hours spacewalking. She had flown aboard STS-37 in 1991, STS-59 in 1994, STS-76 in 1996, and STS-108 in 2001. During STS-59, she had served as Payload Commander. Godwin had also served in technical positions in NASA's Astronaut Office. At the time of her retirement, she was serving as Assistant to the Director of Exploration in the Flight Crew Operations Directorate. Altman had joined NASA in 1995 and had spent 51 days in space. He had served as Pilot on both STS-90 in 1998 and STS-106 in 2000, and as Commander on STS-109 and STS-125, the final missions to NASA's HST. Altman had served temporarily as Deputy Director of the Requirements Division of the Explorations Systems Mission Directorate at NASA Headquarters. His final appointment at NASA had been as Chief of the Exploration Branch of the Astronaut Office. Altman would join the private sector after leaving NASA.¹¹⁰

NASA and ATK Aerospace Systems successfully completed a full-scale test of DM-2, a five-segment, first-stage solid rocket motor, in Promontory, Utah. The test was the most heavily instrumented rocket-motor test that NASA had ever conducted, with over 760 instruments measuring 53 performance objectives. Engineers chilled the motor to 40°F for the 2-minute test to assess the performance of the motor and materials under cold-weather conditions. The largest and most powerful solid rocket motor designed for flight, DM-2 could produce approximately 22 million horsepower (16,405,400 kilowatts) and 3.6 million pounds (1.6 million kilograms) of thrust. The 154-foot (46.94-meter) motor, which NASA had originally built for the Ares-1 rocket, was similar to the Space Shuttle's rocket motor. NASA had upgraded it with the additions of a fifth segment, a bigger nozzle throat, and improved insulation and liner.¹¹¹

NASA announced that it had extended its Space Program Operations Contract with United Space Alliance of Houston, Texas. The cost-reimbursement contract extension, which included award and performance fees, was valued at US\$909,593,590. United Space Alliance would support flight operations for the International Space Station Program and the Space Shuttle Program, providing astronaut and flight-controller training, flight-crew-equipment processing, flight operations, launch and recovery, mission design and planning, system integration, vehicle processing, and vehicle-sustaining engineering. The contractor would

¹⁰⁹ NASA, "NASA Selects Two Firms for Experimental Space Vehicle Test Flights," new release 10-203, 30 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-203_CRuSR_Awards.html (accessed 17 April 2013).

¹¹⁰ NASA, "Astronauts Linda Godwin and Scott Altman Leave NASA," news release 10-204, 31 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-204_Astronauts_Retire.html (accessed 17 April 2013).

¹¹¹ NASA, "NASA and ATK Successfully Test Five-Segment Solid Rocket Motor," news release 10-202, 31 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_10-202_DM-2_Test.html (accessed 17 April 2013); Clara Moskowitz, "NASA Tests New Rocket Motor Despite Uncertain Future," *Space.com*, 31 August 2010, <http://www.space.com/9041-nasa-tests-rocket-motor-uncertain-future.html> (accessed 1 May 2013).

perform the work at its facilities in Houston, Texas, and Huntsville, Alabama, as well as at NASA's KSC. Subcontractors would perform additional work in Huntington Beach, California; Houston, Texas; and Cape Canaveral, Florida. NASA had awarded subcontracts to Barrios Technology of Houston, Texas; Bastion Technologies of Houston, Texas; Boeing Company of Houston Texas; Lockheed Martin Commercial Space Systems of Newton, Pennsylvania; and Pratt Whitney Rocketdyne of Canoga Park, California.¹¹²

SEPTEMBER 2010

2 September

NASA announced that it had selected the five scientific experiments that its new spacecraft Solar Probe Plus would perform while flying directly into the Sun's atmosphere. Part of NASA's Living with a Star (LWS) Program, Solar Probe Plus would study the solar atmosphere more directly than any previous probe, helping scientists characterize, understand, and forecast the Sun's radiation environment. A panel of scientists from NASA and other institutions had chosen the five experiments, which would gather data that would help answer two major questions in the field of solar physics: why is the outer atmosphere of the Sun hotter than its visible surface, and what force drives solar winds—the stream of charged particles flowing outward from the Sun? The five investigations selected were the Fields Experiment, which would detect space dust and measure the atmospheric plasma's electric and magnetic fields, radio emissions, and shock waves; the Integrated Science Investigation of the Sun (ISIS), which would use two instruments to monitor the Sun's highly accelerated electrons, ions, and protons; the Solar Winds Electrons Alphas and Protons Investigation (SWEAP), which would catch and count the electrons, helium ions, and protons in solar wind; and the Wide-Field Imager (WFI) telescope, which would create three-dimensional images of the Sun's corona and of the solar wind and shocks. In addition, the Heliospheric Origins with Solar Probe Plus (HeliOSPP) investigation would independently assess the mission's scientific performance and act as the mission's advocate in the community. NASA would award the selected investigators a combined total of approximately US\$180 million.¹¹³

7 September

The Rocket City Space Pioneers, a team of business, educational, and nonprofit organizations from Huntsville, Alabama, announced that they had entered the competition for the Google Lunar X Prize. To win the competition's grand prize, a contestant team would have to design a spacecraft capable of landing on the surface of the Moon, moving 500 meters (1,640.42 feet) on the Moon's surface, and transmitting a signal back to Earth. The Google Lunar X Prize offered a US\$20 million grand prize to the first team to demonstrate their vehicle before the end of 2015, in addition to smaller prizes for other achievements. To date, more than 20 teams had entered the competition. The company Dynetics led the Rocket City Space Pioneers, in partnership with Andrews Space, Draper Laboratory, Spaceflight Services, Teledyne Brown Engineering, the University of Alabama in Huntsville, and the Von Braun

¹¹² NASA, "NASA Extends Contract with United Space Alliance," news release C10-050, 31 August 2010, http://www.nasa.gov/home/hqnews/2010/aug/HQ_C10-050_SPOC_Extension.html (accessed 17 August 2010).

¹¹³ NASA, "NASA Selects Investigations for First Mission To Encounter the Sun," news release 10-208, 2 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_10_208_Solar_Probe_Plus.html (accessed 8 May 2013).

Center for Science & Innovation. The team planned to build a low-cost lander-rover system that could make a soft landing on the Moon, or other bodies, and conduct commercial and scientific missions. The rover would measure approximately 30 centimeters (11.81 inches) by 30 centimeters by 15 centimeters (5.91 inches) and weigh less than 10 kilograms (22.05 pounds).¹¹⁴

10 September

The journal *Science* published recent research findings on the Martian atmosphere's carbon and oxygen, reported by a team of scientists led by Paul B. Niles of NASA's JSC. Using data gathered by the Evolved Gas Analyzer on NASA's Phoenix Mars Lander, the team had measured Mars's atmospheric isotopes and had found signs that, in the recent geological past, Mars had experienced volcanic activity and had possessed liquid surface water. The researchers had studied the isotopes carbon-12 and carbon-13, as well as oxygen-16 and oxygen-18. Although Mars's atmosphere is 95 percent carbon dioxide, the carbon dioxide that builds up in its atmosphere dissipates into space because the planet has low gravity and no magnetic shield. Because carbon-12 is one of the lighter isotopes, it dissipates more quickly than the heavier carbon-13. Therefore, scientists would expect to find a high ratio of carbon-13 to carbon-12, unless some activity on the planet had replenished the amount of carbon-12 in the atmosphere. However, according to Phoenix's measurements, the ratio of carbon-13 to carbon-12 indicated that volcanic activity on Mars had renewed the supply of carbon-12 in the planet's atmosphere. The researchers had not found similar evidence of volcanism in the proportions of oxygen isotopes, indicating that oxygen-18 had enriched the oxygen in the carbon dioxide when the carbon dioxide had interacted with liquid surface water.¹¹⁵

The Russian uncrewed freighter Progress M-07, or Progress 39, launched aboard a Soyuz rocket from Baikonur Cosmodrome in Kazakhstan at 10:22 (UT), after a two-day delay resulting from high winds. The spacecraft carried a total of 2.5 tons (2,267.96 kilograms, or 5,000 pounds) of supplies for the six-person crew of the ISS. The supplies included 110 pounds (49.90 kilograms) of oxygen and air, 1,918 pounds (869.99 kilograms) of propellant, 375 pounds (170.10 kilograms) of water, and 2,645 pounds (1,199.75 kilograms) of life-support gear, spare parts, equipment for experiments, and other hardware. Progress 39 was scheduled to dock at the ISS on 12 September 2010 in the Zvezda module's port, which the former supply ship Progress 38 had vacated on 31 August 2010. Progress 38 had burned up in Earth's atmosphere, as planned, on 6 September 2010. Progress 39 would remain docked at the ISS until 20 December 2010.¹¹⁶

¹¹⁴ Google Lunar X Prize Foundation, "Rocket City Space Pioneers Enter \$30 Million Google Lunar X PRIZE Competition," news release, 7 September 2010, <http://www.googlelunarxprize.org/media/press-releases/rocket-city-space-pioneers-enter-30-million-google-lunar-x-prize-competition> (accessed 16 May 2013).

¹¹⁵ Paul B. Niles et al., "Stable Isotope Measurements of Martian Atmospheric CO₂ at the Phoenix Landing Site," *Science* 329, no. 5997 (10 September 2010): 1334–1337, <http://www.sciencemag.org/content/329/5997/1334.full> (accessed 8 May 2013); NASA, "NASA Data Shed New Light About Water and Volcanoes on Mars," news release 10-216, 9 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_10-216_Mars_Water.html (accessed 8 May 2013).

¹¹⁶ *Spacewarn Bulletin*, no. 683, 1 October 2010, <http://nssdc.gsfc.nasa.gov/spacewarn/spx683.html> (accessed 3 April 2013); Tariq Malik, "Russian Cargo Ship Blasts Off for Space Station," *Space.com*, 10 September 2010, <http://www.space.com/9102-russian-cargo-ship-blasts-space-station.html> (accessed 24 May 2013).

13 September

Clarence A. “Sy” Syverston, who had served as Director of NASA’s ARC from 1977 to 1984, died at the age of 84. Syverston had begun working at NASA’s ARC in 1948. He had served as Director of Astronautics and, from 1969 to 1977, as ARC’s Deputy Director. During his career at NASA’s ARC, Syverston had led the 3.5-Foot Hypersonic Wind Tunnel Branch; developed advanced aircraft, such as the M2 and XB-70 Valkyrie; and performed work on reentry vehicles, laying the foundation for the design of the Space Shuttle. While Syverston was Director, NASA’s ARC had pioneered research on vertical-lift aircraft, constructed the world’s largest wind tunnel, launched the Kuiper Airborne Observatory, consolidated a partnership with NASA’s DFRC, and prepared Galileo for launch. In addition to winning many awards during his career, Syverston had been elected to the NASA Ames Hall of Fame, inducted as a Fellow of the AIAA, and inducted as a member of the National Academy of Engineering.¹¹⁷

14 September

NASA announced that it had extended the Vehicle Sustaining Engineering Contract with the Boeing Company for engineering support of the ISS. Lasting five more years and costing an additional US\$1.25 billion, the contract would have a total value of US\$16.2 billion through the end of FY 2015. NASA had originally awarded the contract to Boeing in January 1995. Although the contract extension would end on 30 September 2015, it stipulated that the contractor assess the feasibility of continuing to use the ISS’s primary structural hardware through the end of 2028. The contractor would sustain the engineering of the ISS’s hardware and software, as well as supporting the hardware and software that NASA had provided to other ISS partner agencies. Additionally, the contractor would provide end-to-end subsystems management for most of the ISS’s systems, including the electrical, electronic, and electromechanical parts; environmental and electromagnetic effects; and materials and processes. Boeing would perform the work at NASA’s JSC, KSC, and MSFC, as well as at other sites.¹¹⁸

15 September

The Boeing Company announced that it had entered into an agreement with the company Space Adventures to carry commercial passengers to the ISS. Boeing had received a US\$18 million NASA contract in February 2010 to research the development of a rocket to transport astronauts and had begun building a spacecraft capable of transporting seven crew members. The spacecraft, named Crew Space Transportation-100 (CST-100), could launch aboard a variety of different types of rockets. Boeing stated that the company hoped to begin launching its vehicle in 2015 from NASA’s KSC. The terms of the agreement that Boeing and Space Adventures had reached depended on NASA awarding Boeing a contract to transport astronauts to the ISS after the end of the Space Shuttle Program. If Boeing won the contract to transport crew to the ISS on CST-100, then Space Adventures would sell to space tourists any seats on the spacecraft not needed for crew members. Space Adventures had

¹¹⁷ NASA, “NASA statement from Ames Research Center Director S. Pete Worden on the passing of Clarence “Sy” Syvertson,” news release, 15 September 2010, <http://www.nasa.gov/centers/ames/news/features/2010/syverston.html> (accessed 15 May 2013).

¹¹⁸ NASA, “NASA Extends International Space Station Contract,” news release C10-051, 14 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_C10-051_Boeing_ISS_Contract.html (accessed 8 May 2013).

previously sold seven flights aboard the Russian Soyuz vehicles to space tourists. Officials for Space Adventures estimated that the price of seats aboard CST-100 would be comparable to the price of seats on the Soyuz—the most recent price for a seat on Soyuz was US\$40 million. By accepting commercial passengers aboard flights to the ISS, NASA would lower its operational costs for transporting astronauts.¹¹⁹

16 September

NASA's Lunar Reconnaissance Orbiter (LRO) completed the one-year exploration phase of its mission. During this phase, LRO had flown in a polar orbit, at an altitude of 31 miles (49.89 kilometers), collecting data on the Moon's surface, radiation levels, and temperatures. LRO had launched from NASA's KSC on 18 June 2009, equipped with a suite of seven scientific instruments, as well as its companion probe, the Lunar Crater Observation and Sensing Satellite (LCROSS). In October 2009, LCROSS had plunged to the lunar surface, creating an impact plume that permitted LRO to detect water ice on the Moon's surface. Since beginning to collect data in September 2009, LRO had made new observations of the Apollo landing site and the lunar terrain. It had gathered evidence that the Moon's permanently shadowed regions are colder than Pluto, and that they may possess hydrogen and water. LRO had also found evidence that the lunar surface has many thrust faults, indicating that the Moon may have contracted recently. In addition, LRO had located Lunokhod 1, a Soviet rover that had been lost for 40 years. Once they had located the rover, researchers began using Lunokhod 1 to gather data on the motion and position of the Moon. During the exploration phase of its mission, NASA's Exploration System Mission Directorate had managed LRO. Once LRO entered the science phase of its mission, the Science Mission Directorate at NASA's Headquarters would begin to manage it. During the science phase, LRO would spend up to four years continuing to map the lunar surface and to gather data to answer specific research queries.¹²⁰

NASA announced that it would award NASA Launch Services II (NLS II) contracts to four companies: Lockheed Martin Space Systems of Denver, Colorado; Orbital Sciences of Dulles, Virginia; Space Exploration Technologies of Hawthorn, California; and United Launch Services of Littleton, Colorado. The NLS II contracts would cover an array of services for NASA's Earth-observing, exploration, planetary, and scientific satellites. Administered by the Launch Services Program Office at NASA's KSC, the contracts would meet the needs of NASA's Exploration Systems Mission Directorate, Science Mission Directorate, and Space Operations Mission Directorate, as well as fulfilling NASA's responsibilities to provide launch services for other government agencies. The multiple-award, indefinite-delivery, indefinite-quantity contracts would enable NASA to order launch services for as many as 70 missions, over a period of 10 years, for a maximum cumulative value of US\$15 billion. The

¹¹⁹ W. J. Hennigan, "Boeing Enters Space Tourism Partnership," *Los Angeles Times*, 15 September 2010, <http://articles.latimes.com/2010/sep/15/business/la-fi-boeing-space-20100916> (accessed 17 May 2013); Marc Kaufman, "Boeing, Partner Plan To Carry Travelers to Space Station with New Spaceship," *Washington Post*, 15 September 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/09/15/AR2010091504961.html> (accessed 17 May 2013).

¹²⁰ NASA, "NASA's Lunar Spacecraft Completes Exploration Mission Phase," news release 10-223, 15 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_10-223_LRO_Success.html (accessed 8 May 2013); *Space.com*, "NASA's Lunar Reconnaissance Orbiter Gets New Moon Mission," 16 September 2010, <http://www.space.com/9129-nasa-lunar-reconnaissance-orbiter-moon-mission.html> (accessed 15 May 2013).

selected contractors would deliver NASA payloads weighing a minimum of 550 pounds (249.48 kilograms) into a circular orbit at least 124 miles high (199.56 kilometers), at an inclination of 28.5 degrees. The contractors would also have the opportunity to offer NASA vehicles that could carry larger payloads or reach higher orbits. Additionally, contractors would have an annual opportunity to offer new launch services that had not been available at the time of the original contract award.¹²¹

21 September

The Multilateral Coordination Board (MCB), composed of representatives from the ISS partner agencies, met by videoconference to discuss the future of the ISS and its scientific experiments. The representatives from CSA, ESA, NASA, Roscosmos, and the Japanese Ministry of Education, Culture, Sports, and Technology (MEXT) held periodic meetings to coordinate activities and operations on the ISS. During this meeting, MEXT affirmed its commitment to continue ISS operations until after 2016, and Roscosmos assured the partners of its commitment until 2020. CSA, ESA, and NASA confirmed that they were working with their respective governments to ensure their continued participation in ISS operations. The MCB also discussed increasing the ISS's operational efficiency and using the ISS's enhanced research, technology development, and other capabilities to advance future exploration beyond low-Earth orbit. Each partner agency discussed its current ISS research and the potential societal impacts of that research: CSA was conducting health and life science research; ESA was engaged in a fluid physics experiment; MEXT was gathering x-ray data; NASA was conducting biomedical research; and Roscosmos was studying how humans adapt to long-term space travel.¹²²

25 September

The ISS Expedition 24 crew, consisting of Russian Commander Alexander A. Skvortsov, American Flight Engineer Tracy E. Caldwell Dyson, and Russian Flight Engineer Mikhail B. Kornienko, landed near Arkalyk, Kazakhstan, at 1:23 a.m. (EDT). The crew had departed the ISS aboard the Soyuz TMA-18 spacecraft at 10:02 p.m. (EDT) on 24 September 2010. They had delayed their departure for one day because of a problem with the hatch sensor, which had prevented the hooks on the Poisk docking port from opening. To circumvent the faulty sensor, the crew members had used jumper cables to retract the hooks. Caldwell Dyson, Kornienki, and Skvortsov had launched for the ISS from Baikonur Cosmodrome in Kazakhstan in April 2010. During their 174 days aboard the ISS, Kornienko had conducted a spacewalk to work on the new Russian Rassvet module, and Caldwell Dyson and fellow astronaut Douglas H. Wheelock had conducted three unplanned spacewalks to fix a broken cooling pump. Before his return to Earth, Skvortsov had transferred command of the ISS to Wheelock, who had remained aboard the ISS with American Flight Engineer Shannon Walker and Russian Flight Engineer Fyodor N. Yurchikhin.¹²³

¹²¹ NASA, "NASA Awards Launch Services Contracts," news release C10-053, 16 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/C10-053_Launch_Services_Contract.html (accessed 24 May 2013).

¹²² NASA, "International Partners Discuss Space Station Extension and Use," news release 10-228, 22 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_10-226_MCB_Meeting.html (accessed 8 May 2013).

¹²³ NASA, "International Space Station Expedition 24 Crew Lands Safely," news release 10-231, http://www.nasa.gov/home/hqnews/2010/sep/10-231_Soyuz_Lands.html (accessed 8 May 2013); Clara

27 September

NASA announced that it had awarded a six-month contract extension to Lockheed Martin Integrated Systems of Houston, Texas, for cargo mission services to the ISS. The US\$13 million extension brought the total value of the cost-plus-award-fee, fixed-price contract to US\$405 million. NASA had originally awarded the contract on 5 November 2003. The extension would fund Lockheed Martin's work through 31 March 2001, including services related to launch integration, ground processing, in-orbit operation analysis, and cargo return. The contractor would implement the management, planning, support, processing, and analysis of the delivery of NASA's cargo, in addition to performing tasks such as labeling cargo and sustaining engineering. NASA would transport the cargo aboard the Space Shuttle, ESA's ATVs, JAXA's H-II Transfer Vehicles, and Roscosmos's Soyuz and Progress spacecraft. The contractor would perform work at NASA's JSC and KSC, as well as other locations. The major subcontractors were Bastion Technologies of Houston, Texas; Teledyne Brown Engineering of Huntsville, Alabama; and United Space Alliance of Houston, Texas.¹²⁴

29 September

NASA announced that it had modified its contract with Pratt & Whitney Rocketdyne of Canoga Park, California, for support of the Space Shuttle's main engine. The Shuttle's three main liquid-propellant rocket engines, which were each 14 feet long (4.27 meters long) and 7.5 feet wide (2.29 meters wide) at the nozzle exit, produced a combined total thrust of 1.2 million pounds (544,311 kilograms). The US\$60.3 million modification would continue Pratt & Whitney Rocketdyne's prelaunch, launch, and landing support from 1 October 2010 through 31 March 2011, reflecting NASA's extension of the Shuttle's flight manifest into FY 2011. With the modification, the total value of the contract became US\$2.25 billion.¹²⁵

A team of astronomers led by Steven S. Vogt of the University of California, Santa Cruz, and R. Paul Butler of the Carnegie Institution of Washington, DC, announced that the Lick-Carnegie Exoplanet Survey had observed two new planets orbiting the star Gliese 581. The *Astrophysical Journal* would publish the team's research. Funded by NASA and the NSF, the team had used 11 years of observations from the High Resolution Echelle Spectrometer (HIRES) on the Keck I telescope in Hawaii. Measuring the star's radial velocity, in search of changes that would indicate an orbiting planet's gravitational pull, the researchers had determined that six planets orbit Gliese 581, which is located 20 light-years away, in the constellation Libra. Gliese 581's planetary system was the largest that astronomers had observed, besides our own. One of the newly discovered planets, Gliese 581g, is in the so-called habitable zone of the star, an area where conditions could support the requirements for life, particularly liquid surface water. With a 37-day orbit around its dim red dwarf star, Gliese 581g has an estimated surface temperature between -24°F and 10°F. The planet is

Moskowitz, "Soyuz Capsule Lands Safely with Russian-U.S. Crew," *Space.com*, 25 September 2010, <http://www.space.com/9187-soyuz-capsule-lands-safely-russian-crew.html> (accessed 24 May 2013).

¹²⁴ NASA, "NASA Extends Space Station Cargo Mission Services Contract," news release C10-061, 27 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_C10-061_ISS_Extension.html (accessed 8 May 2013).

¹²⁵ NASA, "NASA Awards Space Shuttle Main Engine Contract Modification," news release C10-062, 29 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_C10-062_SSME_Mod.html (accessed 8 May 2013).

tidally locked to its star, meaning that one side is always facing the star. The researchers noted that this feature would be conducive to fostering life because it creates stable climates. The planet's mass, three times that of Earth, indicates that it is a rocky planet with sufficient gravity to retain an atmosphere. Gliese 581g is the most Earth-like planet yet discovered. Its existence indicates that many other potentially habitable planets may be present in the Milky Way.¹²⁶

30 September

NASA announced that it had extended the Extravehicular Space Operations Contract with Hamilton Sundstrand Space Systems International of Houston, Texas, which provides technical support for the spacesuits used on the ISS and Space Shuttle flights. The contractor and its subcontractors would manage engineering for the hardware systems used on spacewalks and for supporting enhancements. NASA would also use the contractor's engineering management for flight and spacewalk readiness, safety and mission assurance, and the achievement of flight milestones and mission goals. The cost-plus-award-fee contract, with a maximum value of US\$728.9 million, consisted of a base contract worth US\$315.5 million, for work performed from 1 October 2010 through 30 September 2015; a one-year option worth US\$8.6 million, for Shuttle mission support beginning 1 October 2010; two one-year options for Space Shuttle extravehicular activity support from 1 October 2010 through 30 September 2012; and five one-year options for ISS work from 1 October 2015 through 30 September 2020. The contract also included an indefinite-delivery, indefinite-quantity option with a maximum value of US\$90 million and a fixed price of US\$140,000 for a 30-day phase-in period.¹²⁷

OCTOBER 2010

1 October

Chang'e 2, an uncrewed Chinese lunar probe, launched aboard a Long March-3C rocket from Xichang Space Center in Sichuan Province at 10:59 (UT). Chang'e 2 would study the Bay of Rainbows, or Sinus Iridium, a region of the Moon measuring 147 miles wide (236.57 kilometers wide). Dipping down to its closest lunar approach, 9 miles (14.48 kilometers) from the Moon's surface, Chang'e 2 would take high-resolution photographs of possible landing sites for the Chang'e 3 probe, which China planned to launch in 2013. Afterwards, Chang'e 2 would maneuver into orbit at an altitude of 62 miles (99.78 kilometers), where it would collect data on the Moon's soil and surface. China had originally built Chang'e 2 as a ground spare for Chang'e 1, the country's first lunar probe, which had launched in October

¹²⁶ Steven S. Vogt et al., "The Lick-Carnegie Exoplanet Survey: A 3.1 M_{\oplus} Planet in the Habitable Zone of the Nearby M3V Star Gliese 581," *Astrophysical Journal* 723, no. 1 (15 October 2010): 954–965, http://iopscience.iop.org/0004-637X/723/1/954/pdf/0004-637X_723_1_954.pdf (accessed 8 May 2013); NASA, "NASA and NSF-Funded Research Finds First Potentially Habitable Exoplanet," news release 10-237, 29 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_10-237_Exoplanet_Findings.html (accessed 8 May 2013); Jeanna Bryner, "Odds of Life on Newfound Earth-Size Planet '100 Percent', Astronomer Says," *Space.com*, 29 September 2010, <http://www.space.com/9225-odds-life-newfound-earth-size-planet-100-percent-astronomer.html> (accessed 23 May 2013).

¹²⁷ NASA, "NASA Awards Shuttle and Space Station Spacesuit Contract," news release C10-064, 30 September 2010, http://www.nasa.gov/home/hqnews/2010/sep/HQ_C10-064_Spacesuits.html (accessed 8 May 2013).

2007. For this flight, engineers had refitted the probe with updated and improved instruments, including cameras with a peak resolution of 10 meters (32.81 feet). News media reported that the probe had cost US\$134 million. China had scheduled Chang'e 2's mission to last for six months; however, the probe had enough fuel to operate for longer.¹²⁸

At a meeting of the International Astronautical Conference in Prague, representatives from NASA, ESA, and Roscosmos agreed to update the launch manifest for vehicles traveling to the ISS. NASA's target launch date for STS-134, the last planned Space Shuttle flight, was 27 February 2011. STS-134 would deliver to the ISS the Alpha Magnetic Spectrometer (AMS), an instrument that detected cosmic-ray particles. Scientists would use the AMS to conduct research on matter and on the origin and structure of the universe. Arianespace's target date for launching ESA's ATV-2 was 15 February 2011. Also known as Johannes Kepler, ATV-2 would deliver cargo to the ISS, as well as periodically boosting the ISS's orbit while docking at the space station. Roscosmos agreed to continue investigating options for launching and landing Soyuz vehicles traveling to and from the ISS.¹²⁹

6 October

NASA announced that the Wilkinson Microwave Anisotropy Probe (WMAP) had concluded its nine-year mission to measure slight temperature variations in the cosmic microwave background (CMB)—the remnant of the first light to exist independently in the universe, 380,000 years after the Big Bang. Using measurements of the CMB, the WMAP mission had calculated that the universe is 13.75 billion years old, allowing for an error margin of 1 percent. The Guinness Book of World Records had declared WMAP's calculation the most accurate measure of the universe's age. WMAP also had confirmed the existence of dark energy, a form of energy that is accelerating the expansion of the universe. WMAP had calculated that dark energy accounts for 72 percent of the cosmos, while dark matter accounts for 23 percent and normal matter comprises only 4.6 percent of the cosmos. Additionally, WMAP's observations had supported the theory of inflation, which proposed that the universe had expanded rapidly during the first trillionth of a second that it existed. Launched on 30 June 2001, WMAP had traveled approximately 930,000 miles (1,496,690 kilometers) from Earth to the Earth–Sun L2, or Lagrange point, a gravitationally stable location where spacecraft follow Earth's orbit around the Sun. WMAP, the first spacecraft to use the L2 point, had made its last observations on 20 August 2010. On 8 September 2010, it had left its working orbit to enter a parking orbit around the Sun. NASA scientists planned to continue analyzing the WMAP data for two more years.¹³⁰

¹²⁸ *Spacewarn Bulletin*, no. 684, 1 November 2010, <http://nssdc.gsfc.nasa.gov/spacewarn/spx684.html> (accessed 3 April 2013); *Space.com*, "China Launches Second Robotic Moon Probe," 1 October 2010, <http://www.space.com/9242-china-launches-robotic-moon-probe.html> (accessed 7 June 2010); *Space.com*, "China's New Lunar Probe To Scout the Moon's 'Bay of Rainbows'," 1 October 2010, <http://www.space.com/9243-china-lunar-probe-scout-moon-bay-rainbows.html> (accessed 7 June 2010).

¹²⁹ NASA, "International Partners Update Space Station Launch Manifest," news release 10-242, 1 October 2010, http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-242_Updated_Station_Manifest.html (accessed 20 May 2010).

¹³⁰ NASA, "NASA's WMAP Project Completes Satellite Operations Mission Observed Universe's Oldest Lightest," news release 10-244, 6 October 2010, http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-244_WMAP.html (accessed 20 May 2010); Stephen Clark, "WMAP Finishes Nine-Year Probe of Infant Universe," *Spaceflight Now*, <http://spaceflightnow.com/news/n1010/06wmap/> (accessed 5 June 2010).

7 October

The Russian spacecraft Soyuz TMA-1M launched at 23:10 (UT) from Baikonur Cosmodrome in Kazakhstan aboard a Soyuz-FG rocket. The vehicle carried NASA astronaut Scott J. Kelly and Russian cosmonauts Alexander Y. Kaleri and Oleg I. Skripochka to the ISS to join the Expedition 25 crew. Station Commander Douglas H. Wheelock, astronaut Shannon Walker, and cosmonaut Fyodor N. Yurchikhin were already aboard the ISS. This spaceflight was the first for Skripochka, the third for Kelly, and the fifth for Kaleri. During their time aboard the ISS, the crew would host two Space Shuttle visits and the dockings of two uncrewed cargo ships. Skripochka and Yurchikhin would perform a spacewalk to maintain the hardware and science experiments on the Russian segment of the ISS. Soyuz TMA-1M, scheduled to dock at the ISS on 9 October 2010, featured some upgrades over previous Soyuz spacecraft: it had a new electronic cooling device, as well as updated control, data-processing, guidance, and navigation systems. The avionics and computer improvements allowed the vehicle to operate with less input from the crew.¹³¹

10 October

Virgin Galactic successfully conducted the first solo test flight of its commercial spacecraft, SpaceShipTwo, or VSS Enterprise, from the Mojave Air and Space Port in California. The mothership WhiteKnightTwo, or VMS Eve, carried SpaceShipTwo, piloted by two crew members, to an altitude of 45,000 feet (13,716 meters). After WhiteKnightTwo released it, SpaceShipTwo glided for 11 minutes down to a safe runway landing. The test proved that Virgin Galactic had met the goals for the successful release and gliding of its spacecraft, as well as confirming that all of the systems had worked, both before and after the release of the craft. The test evaluated the vehicle's handling and stall characteristics, its stability and control characteristics, and its lift-to-drag ratio, as well as permitting the vehicle to practice its landing approach. Scaled Composites of California had developed the six-seated craft, which was based on the SpaceShipOne model that had won the 2004 Ansari X Prize. Virgin Galactic planned to use SpaceShipTwo to transport customers on rides into suborbital space.¹³²

¹³¹ *Spacewarn Bulletin*, no. 684; NASA, "New Space Station Crew Members Launch from Kazakhstan," news release 10-252, http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-252_Soyuz_Launch.html (accessed 20 May 2010); Denise Chow, "Soyuz Rocket Launches New Crew Toward Space Station," *Space.com*, 7 October 2010, <http://www.space.com/9286-soyuz-rocket-launches-crew-space-station.html> (accessed 12 June 2010).

¹³² Leonard David, "Virgin Galactic's Private Spaceship Makes First Solo Glide Flight," *Space.com*, 10 October 2010, <http://www.space.com/9301-virgin-galactic-private-spaceship-solo-glide-flight.html> (accessed 14 June 2013); Mark Sappenfield, "Virgin Galactic Glides Closer to \$200,000-A-Seat Space Shot," *Christian Science Monitor*, 11 October 2010, http://www.csmonitor.com/Science/2010/1011/Virgin-Galactic-glides-closer-to-200-000-a-seat-space-shots?sms_ss=twitter&at_xt=4cb39557d5b19947,0 (accessed 14 June 2013).

11 October

President Barack H. Obama signed the National Aeronautics and Space Administration Authorization Act of 2010 (Pub. L. No. 111-267, 124 Stat. 2805), which reauthorized the agency for three fiscal years. The law authorized US\$19 billion for FY 2011, US\$19.45 billion for FY 2012, and US\$19.96 for FY 2013, to fund aeronautics, education, exploration, science, and space operations. The law also added one additional Space Shuttle flight to the manifest of flights that would take place before the 2011 ending of the Space Shuttle Program. It extended NASA's use of the ISS through at least 2020. It authorized NASA to update launch facilities, as well as to continue to develop new technologies and robotic exploration missions. The bill would end the Constellation Program, the mission to send astronauts to the Moon, which an independent review panel had determined was underfunded and unsustainable. In its place, the bill authorized NASA to develop a new heavy-lift rocket for deep space missions, with the ultimate goal of sending a crewed flight to an asteroid by 2025 and a crewed mission to Mars in the 2030s. To free NASA's resources for development of the heavy-lift rocket, the bill authorized NASA to foster the development of commercial spacecraft to transport cargo and crews to the ISS.¹³³

15 October

NASA announced that it had awarded Innovative Lunar Demonstrations Data (ILDD) contracts to the six American companies competing for the Google Lunar X Prize, a competition to land a vehicle on the Moon. These six companies were Astrobiotic Technology of Pittsburgh, Pennsylvania; The Charles Stark Draper Laboratory of Cambridge, Massachusetts; Dynetics of Huntsville, Alabama; Earthrise Space of Orlando, Florida; Moon Express of San Francisco, California; and Team FREDNET, The Open Space Society of Huntsville, Alabama. Under the multiple-award, firm-fixed price, indefinite-delivery/indefinite-quantity contracts, NASA would purchase data that the contractors had produced during the development of robotic lander vehicles. NASA would issue delivery orders for data associated with system integration and testing, launches, in-space maneuvers, braking burns, lunar landing, and other capabilities. NASA would use this data to develop affordable and sustainable lander systems for use in both human and robotic missions to asteroids, the Moon, and other destinations. The maximum total value of the contracts was US\$30.1 million over a maximum period of five years. For each contract, NASA agreed to purchase a minimum value of US\$10,000 and a maximum value of US\$10.01 million. The Lunar Lander Project Office at NASA's JSC managed the contracts.¹³⁴

20 October

The journal *Nature* published the work of a group of astronomers led by Matthew D. Lehnert of the Paris Observatory in France, a team that had observed the oldest and most distant galaxy yet found. Researchers had first identified galaxy UDFy-38135539 as a candidate

¹³³ William Harwood, "President Obama Signs Space Program Agenda into Law," *Spaceflight Now*, 11 October 2010, <http://www.spaceflightnow.com/news/n1010/11sign/> (accessed 21 June 2013); Tariq Malik, "President Obama Signs New Vision for U.S. Space Exploration into Law," *Space.com*, 11 October 2010, <http://www.space.com/9305-president-obama-signs-vision-space-exploration-law.html> (accessed 21 June 2013).

¹³⁴ NASA, "NASA Awards Contract for Innovative Lunar Demonstrations Data," news release 10-259, 15 October 2010, http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-259_ILDD_Award.html (accessed 21 June 2013); *Space.com*, "NASA To Spend Up to \$30 Million on Private Moon Data," 16 October 2010, <http://www.space.com/9343-nasa-spend-30-million-private-moon-data.html> (accessed 6 June 2013).

galaxy when examining images that the Wide Field Camera 3 on NASA's HST had taken of the Fornax Constellation. To refine their calculations of UDFy-38135539, Lehnert's team had used the ground-based Very Large Telescope (VLT), which could detect near-infrared light. They had determined that the galaxy is more than 13 billion light-years from Earth. Formed just 600 million years after the Big Bang, the galaxy had emerged during the universe's so-called epoch of reionization, the period when ultraviolet light emerging from forming galaxies had ionized the early universe's atomic fog of hydrogen and helium. During this period, the universe had become more transparent, and light had become visible. The researchers noted that UDFy-38135539 was the first galaxy astronomers had discovered that was old enough to have been part of this process. The researchers had also detected evidence that the UDFy-38135539 galaxy alone could not have ionized the intergalactic medium surrounding it, indicating that it was probably next to other galaxies that researchers had not yet detected or characterized.¹³⁵

NASA announced that it had selected United Launch Services of Littleton, Colorado, to launch the Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft on an Atlas V-401 rocket. The total cost of the launch, which NASA had scheduled for November 2013, was US\$187 million. The MAVEN mission would study Mars's atmosphere to understand how climate change had caused the planet's atmosphere to thin and its surface water to dry up. The mission had passed a confirmation review, formally designated "Key Decision Point C," on 4 October 2010. The review panel had set the mission's cost and schedule and had authorized it to continue into its development phase, approving its budget, detailed plans, instrument suite, and risk-factor analysis. NASA's GSFC would manage the MAVEN mission. The mission's principal investigator would be at the University of Colorado at Boulder's Laboratory for Atmospheric and Space Physics. Excluding the launch-services contract and a telecommunications-relay package, MAVEN would cost US\$438 million.¹³⁶

26 October

Moon Express, a privately funded company headquartered in San Francisco, California, and providing lunar transportation and data services, announced that it had entered the Google Lunar X Prize. Moon Express became the twenty-fourth team worldwide, and the sixth American team, to enter the US\$30 million global competition. The Google Lunar X Prize would award a grand prize of US\$20 million to the first team to place a robot on the Moon's surface, move it 500 meters (1,640.42 feet), and transmit video and images from the robot to Earth. The X Prize Foundation offered an additional US\$10 million in other prizes. On 15

¹³⁵ M. D. Lehnert et al., "Spectroscopic Confirmation of a Galaxy at Redshift $z = 8.6$," *Nature* 467, no. 7318 (21 October 2010): 940–942, published online 20 October 2010, <http://www.nature.com/nature/journal/v467/n7318/full/nature09462.html> (accessed 14 June 2010); Pete Spotts, "Astronomers Build on a Hubble Find, Report Light from Oldest Galaxy," *Christian Science Monitor*, 20 October 2010, <http://www.csmonitor.com/Science/2010/1020/Astronomers-build-on-a-Hubble-find-report-light-from-oldest-galaxy> (accessed 14 June 2013); Jonathan Amos, "Galaxy Is Most Distant Object Yet," *BBC News*, 20 October 2010, <http://www.bbc.co.uk/news/science-environment-11580789> (accessed 14 June 2010).

¹³⁶ NASA, "NASA's Mars Atmosphere Mission Given the Green Light To Proceed to Development," Goddard Release No. 10-087, 5 October 2010, <http://www.nasa.gov/centers/goddard/news/releases/2010/10-087.html> (accessed 7 June 2013); NASA, "NASA Awards Launch Services Contract for Maven Mission," news release C10-065, 21 October 2010, http://www.nasa.gov/home/hqnews/2010/oct/HQ_C10-065_Maven_Services.html (accessed 21 May 2013).

October 2010, NASA had awarded the American Google Lunar X Prize contestant teams, including Moon Express, ILDD contracts to purchase the technical data acquired through the development of robotic lunar-landing technology. NASA would use the data from the ILDD contracts to develop future lander vehicles and robot systems.¹³⁷

27 October

NASA announced that two satellites that had launched in 2007, and had completed their original missions, were beginning new missions to study solar wind. NASA had launched the satellites as part of the five-satellite Time History of Events and Macroscale Interactions during Substorms (THERMIS) mission, which had studied the effects of geomagnetic substorms on Earth's magnetosphere. NASA had named the new mission Acceleration, Reconnection, Turbulence and Electrodynamics of Moon's Interaction with Sun (ARTEMIS). The two satellites would study the ways that solar wind—the stream of charged particles that flow outward from the Sun—affects the surface of the Moon. Unlike Earth, which has a magnetic field that shields it from solar wind, the Moon lacks global magnetism. Therefore, solar wind can alter, electrify, or erode the lunar surface. The ARTEMIS satellites were beginning their new mission from the L1 and L2 Lagrange points, areas in space where Earth's gravity and the Moon's gravity balance each other. After conducting the first exploration of the Earth–Moon Lagrange points, the satellites would move closer to the Moon to observe its surface. The ARTEMIS mission was conducted jointly by NASA's GSFC, NASA's JPL, the Space Sciences Laboratory at the University of California, Berkeley, and the University of California, Los Angeles.¹³⁸

The Russian uncrewed freighter Progress M-08M, or Progress 40P, launched aboard a Soyuz-U rocket from Baikonur Cosmodrome in Kazakhstan at 15:11 (UT). Progress M-08M was scheduled to arrive at the ISS on 23 October 2010 with 2.5 tons (5,000 pounds, or 2,267.96 kilograms) of supplies for the crew. The payload included 499 kilograms (1,100.11 pounds) of oxygen, 870 kilograms (1,918.02 pounds) of propellant, 226 kilograms (498.24 pounds) of water, and 1,272 kilograms (2,804.28 pounds) of food, spare parts, and supplies. The Progress's cargo also included data-transmission equipment and hardware for the ISS's Coulomb Crystal experiment and Molniya-Gamma experiment. Progress M-08M would remain docked at the ISS until January 2011. The ISS had jettisoned Progress M-05M on 25 October 2010 to clear docking space for Progress M-08M.¹³⁹

¹³⁷ Google Lunar X Prize Foundation, "Moon Express Enters \$30 Million Google Lunar X Prize Competition," press release, 26 October 2010, <http://www.googlelunarxprize.org/media/press-releases/moon-express-enters-30-million-google-lunar-x-prize-competition> (accessed 5 June 2013).

¹³⁸ NASA, "Two NASA Spacecraft Begin New Exploration Assignments," news release 10-282, 27 October 2010, http://www.nasa.gov/home/hqnews/2010/oct/HQ_10-282_ARTEMIS.html (accessed 30 May 2013).

¹³⁹ *Spacewarn Bulletin*, no. 684; Justin Ray, "Cargo Craft Begins Pursuit of International Space Station," *Spaceflight Now*, 27 October 2010, <http://www.spaceflightnow.com/station/exp25/101027prog40p/> (accessed 7 June 2013).

NOVEMBER 2010

2 November

NASA and its international partners commemorated 10 years of continuous human occupation aboard the ISS on the anniversary of the 2 November 2000 arrival of the Expedition 1 crew. Construction on the US\$100 billion laboratory had begun in 1998, but the ISS did not have a permanent crew for the first two years. Since the arrival of Expedition 1, more than 196 people had visited the ISS. Orbiting at an altitude of 220 miles (354.06 kilometers) above Earth, the ISS had travelled a total of 1.5 billion miles (2,414,016,000 kilometers) in 10 years and had completed 57,361 rotations around Earth. With the ISS nearing completion, and fewer building projects to work on, recent ISS crews were devoting more time to scientific research. Crew members had conducted more than 600 scientific experiments aboard the ISS's laboratory, including projects in such fields as biology, Earth and space sciences, human physiology, and physical and materials sciences. On 25 October 2010, the ISS had set the record for the longest continuously occupied spacecraft in history.¹⁴⁰

10 November

Orbital Sciences, in conjunction with its engine supplier Aerojet and engineers from NASA's SSC, test-fired the liquid-fuel AJ26 engine that would power the first stage of Orbital's Taurus II launch vehicle. The test, conducted on the E-1 test stand at NASA's SSC, supported NASA's efforts to encourage commercial spaceflight capable of traveling to the ISS. NASA had granted Orbital a contract to provide eight cargo missions to the ISS through 2015. Operators at NASA's SSC had spent two years modifying the E-1 test stand to accommodate the AJ26. The 10-second, short-duration readiness test verified the engine's start and shutdown sequences, test-stand operations, and ground-test engine controls. After the joint operations team had reviewed all the testing data, Orbital planned to conduct two further tests, a 50-second, hot-fire acceptance test and a hot-fire test to evaluate the tuning of the engine's control valve.¹⁴¹

A team of researchers, led by Douglas P. Finkbeiner of the Harvard-Smithsonian Center for Astrophysics, announced in the *Astrophysical Journal* that they had discovered a previously undetected structure at the center of the galaxy. The structure, which may be millions of years old, consists of two clearly defined gamma-ray bubbles, each spreading 25,000 light-years north and south of the galactic center and covering half of the visible Milky Way, from the constellation Virgo to the constellation Grus. Gamma rays are the most energetic form of light, and the gamma-ray bubbles' energy output is equivalent to 100,000 supernovas. The researchers had detected the bubbles using NASA's Fermi Gamma-ray Space Telescope's Large Area Telescope (LAT), the most sensitive and highest-resolution gamma-ray detector

¹⁴⁰ NASA, "NASA Administrator Statement on 10th Anniversary of Crews Aboard the International Space Station," news release 10-287, 2 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_10-287_ISS_Milestone.html (accessed 11 June 2013); Clara Moskowitz, "Looking Back: A Decade of Astronauts on the International Space Station," *Space.com*, 2 November 2010, <http://www.space.com/9444-decade-astronauts-international-space-station.html> (accessed 14 June 2013).

¹⁴¹ NASA, "NASA Test Fires New Rocket Engine for Commercial Space Vehicle," news release 10-296, 10 November 2010, <http://www.space.com/9444-decade-astronauts-international-space-station.html> (accessed 11 June 2013).

in use. Previous scientific data had indicated the possible existence of the gamma-ray bubbles. However, scientists had never actually observed the bubbles because the fog of gamma-ray energy diffused throughout the universe obscures them. Using various estimates of the gamma-ray fog to refine their models continually, the LAT team had succeeded in isolating the emission of the bubbles. Although the researchers had not determined the bubbles' origin, they had ruled out the possibility that dark matter had caused them. The research team had concluded that only a large and relatively fast surge of energy could have created bubbles with such clearly defined edges. The team suggested that the Milky Way's central black hole might have previously had jets, which had formed the bubbles when they shot out energy. Alternatively, the team proposed that a burst of star formation might have produced them.¹⁴²

NASA Administrator Charles F. Bolden Jr. announced that he had implemented administrative changes in response to the James Webb Space Telescope (JWST) Independent Comprehensive Review Panel's (ICRP's) report on the status of NASA's next-generation space telescope. The ICRP had issued its final report on 29 October 2010. Bolden had commissioned the panel in response to a request from Senator Barbara A. Mikulski (D-MD), Chair of the Senate Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies. Mikulski had expressed her concern at the escalating costs of NASA's JWST. In a 29 June 2010 letter to Bolden, Mikulski had requested that he form a panel to examine the root causes of JWST's cost growth and schedule delays, to review plans to complete its development, to assess changes that could reduce costs, and to calculate the minimum cost to launch the telescope. The ICRP had found that the JWST project's technical performance was above average, with no technical delays. The panel attributed the project's growth and schedule delays to inadequate budgeting and poor management performance. The ICRP considered 2015 the earliest possible date for the launch of the telescope. However, to launch JWST in 2015, NASA would need to add approximately US\$250 million to the mission's FY 2011 budget and another US\$250 million to JWST's projected FY 2012 budget. Although the ICRP had not suggested how NASA might meet these funding needs, the panel had recommended management changes that would prevent further cost increases. Bolden had responded by reorganizing the project's management at NASA Headquarters and at NASA's GSFC. He had assigned a new senior manager at NASA Headquarters, who would report directly to the NASA Associate Administrator, and he had reorganized the project office at NASA's GSFC, so that the office reported directly to the Director of NASA's GSFC.¹⁴³

¹⁴² Meng Su et al., "Giant Gamma-Ray Bubbles from Fermi-LAT: Active Galactic Nucleus Activity or Bipolar Galactic Wind?" *Astrophysical Journal* 724, no. 2 (10 November 2010): 1044–1082, http://iopscience.iop.org/0004-637X/724/2/1044/pdf/0004-637X_724_2_1044.pdf (accessed 20 June 2013); NASA, "NASA's Fermi Telescope Discovers Giant Structure in Our Galaxy," news release 10-295, 9 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_10-295_FERMI.html (accessed 11 June 2013); Dennis Overbye, "Bubbles of Energy Are Found in Galaxy," *New York Times*, 9 November 2010, http://www.nytimes.com/2010/11/10/science/space/10galaxy.html?_r=2& (accessed 20 June 2013).

¹⁴³ James Webb Space Telescope Independent Comprehensive Review Panel (JWST ICRP), "Final Report" (Washington, DC, 29 October 2010), http://www.nasa.gov/pdf/499224main_JWST-ICRP_Report-FINAL.pdf (accessed 14 June 2013); NASA, "NASA Administrator Bolden Statement on the Webb Telescope," news release 10-297, 10 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_10-297_JWST.html (accessed 11 June 2013); Pete Spotts, "NASA's Next Big Space Telescope in Financial Trouble," *Christian*

12 November

The NASA Office of the Inspector General (OIG) issued a report titled “NASA’s Top Management and Performance Challenges.” While noting that NASA had recently made significant improvement in its management practices, OIG still found six management challenges that NASA needed to address. The first challenge concerned the future of human spaceflight and the difficult transition facing NASA’s management with the end of the Space Shuttle Program. The second challenge involved acquisition and project management and ensuring that NASA paid all its contracts. The third challenge related to the effective management of NASA’s infrastructure and facilities, including NASA’s 5,400 buildings and structures. The fourth challenge involved NASA’s human capital—in particular, the challenge of balancing the workforce structure during the changes to the Space Shuttle Program and Constellation Program. The fifth challenge pertained to the security of NASA’s information technology, especially the protection of sensitive information. The sixth challenge related to NASA’s financial management. When considering each management challenge, OIG had looked at several factors: the significance of the issue in relation to NASA’s mission; whether the management issue was systemic; whether the issue might involve the risk of abuse, fraud, or waste; and NASA’s previous attempts to address the issue. Because NASA’s financial managers had made efforts to address known weaknesses, NASA’s financial auditors issued a “qualified opinion” regarding NASA’s FY 2010 financial statement. Although NASA would ultimately aim to achieve from its auditors an “unqualified opinion,” the auditors’ determination represented progress. For the previous seven years, the auditors had given NASA “disclaimers of opinion.”¹⁴⁴

15 November

Russian cosmonauts Fyodor N. Yurchikhin and Oleg I. Skripochka left the ISS at 9:53 a.m. (EDT) to conduct orbital maintenance work. The spacewalk was Skripochka’s first. The cosmonauts spent approximately 6.5 hours completing several tasks, including installing a new maintenance workstation for spacewalking crews and a new science experiment that would test the effects of the space environment on various materials. In addition, the two collected insulation samples from the oxygen-generation machine. Researchers would examine the samples for evidence of microorganisms. The cosmonauts also removed a science experiment that had tested the Internet-based control system for the ISS’s robotic arm. Yurchikhin and Skripochka attempted to move a television camera located on a docking module, but a piece of insulation prevented the cosmonauts’ installing it in its new location. Russian mission control postponed completion of the task until a future spacewalk.¹⁴⁵

18 November

NASA released its initial analysis of the data from the Deep Impact spacecraft’s 4 November 2010 flyby of Hartley 2, a comet with a 6.5-year orbit. Deep Impact had flown within 435

Science Monitor, 11 November 2010, <http://www.csmonitor.com/Science/2010/1111/NASA-s-next-big-space-telescope-in-financial-trouble> (accessed 14 June 2013).

¹⁴⁴ NASA Office of Inspector General, “NASA’s Top Management and Performance Challenges” (report, Washington, DC, 12 November 2010), <http://oig.nasa.gov/NASA2010ManagementChallenges.pdf> (accessed 14 June 2013).

¹⁴⁵ Clara Moskowitz, “Spacewalking Cosmonauts Upgrade International Space Station,” *Space.com*, 15 November 2010, <http://www.space.com/9532-spacewalking-cosmonauts-upgrade-international-space-station.html> (accessed 14 June 2013).

miles (700.06 kilometers) of the comet Hartley 2, as part of the US\$45 million mission extension known as EPOXI—a combination of the acronyms for the mission’s two parts, the Extrasolar Planet Observations and Characterization (EPOCh) and the Deep Impact Extended Investigation (DIXI). The mission extension had repurposed Deep Impact after the probe had completed its initial mission of observing the comet Tempel 1 in 2005. Hartley 2 differs from Tempel 1, having 100 times less volume, as well as more variation in its carbon-dioxide-powered jets. Hartley 2 has a 1.25-mile-long (2.01-kilometer-long) nucleus shaped like a peanut, which has a smooth, narrow middle and wider, rougher ends. On the smooth-surfaced midsection of Hartley 2, as on Tempel 1, water evaporates below the surface and then rises up through the dust, creating water vapor. However, on the rough-surfaced ends of Hartley 2, carbon dioxide erupts through the surface and forcefully belches out soft, fluffy snowballs of water ice. EPOXI’s data provided the first observations of jets driven by carbon dioxide, rather than by water, the first evidence linking jets to particular topographical features, and the first observation of individual chunks of ice around a comet. An additional peculiarity of the comet is that its jets erupt from all sides, even the sides that Earth’s Sun does not heat. Scientists hoped that studying comets’ ancient component parts would teach them more about the formation of Earth’s solar system and of the planets that revolve around Earth’s Sun.¹⁴⁶

20 November

A Minotaur-4 rocket successfully launched from the Alaska Aerospace Corporation’s Kodiak Launch Complex at 01:25 (UT) as part of mission STP-S26 of the U.S. Air Force’s Space Test Program. The rocket delivered its payload of seven satellites into an orbit 404 miles (650.18 kilometers) above Earth. The seven satellites carried a total of 16 different experiments. Aboard the US\$170 million mission were two small NASA satellites designed to provide reliable and cost-effective research. NASA’s Organism/Organic Exposure to Orbital Stresses (O/OREOS) nanosatellite weighed 5.5 kilograms (12.13 pounds) and carried two biological experiments. One of these would test microbial growth and reproduction in space, and the other would test the effect of space conditions on inanimate organic matter. NASA was also launching the Fast Affordable Science and Technology Satellite (FASTSAT), a 140-kilogram (308.65-pound) microsatellite that carried six experiments. Developed for less than US\$12 million, FASTSAT would operate for 180 days, testing a Miniature Star Tracker and a Threat Detection System for the Air Force Research Laboratory. FASTSAT also carried three atmospheric experiments: the Miniature Imager for Neutral Ionosphere Atoms and Magnetospheric Electrons (MINI-ME), the Plasma and Impedance Spectrum Analyzer (PISA), and the Thermosphere Temperature Imager (TTI). Additionally, FASTSAT would release NanoSail-D2, a replacement for the failed NanoSail-D. The 8.5-pound (3.86-kilogram) satellite would deploy itself using its 10-square-meter (32.81-square-foot) solar

¹⁴⁶ NASA, “NASA EPOXI Flyby Reveals New Insights into Comet Features,” news release 10-291, 4 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_10-293_Bolden_Statement_on_EPOXI.html (accessed 11 June 2013); NASA, “NASA Spacecraft Sees Cosmic Snow Storm During Comet Encounter,” news release 10-304, 18 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_10-304_EXPOXI_Results.html (accessed 11 June 2013); Mike Wall, “Rare Close Encounter with Comet Hartley 2 Surprises and Thrills Scientists,” *Space.com*, 4 November 2010, <http://www.space.com/9470-rare-close-encounter-comet-hartley-2-surprises-thrills-scientists.html> (accessed 19 June 2013).

sail, which “sails” on photons from Earth’s Sun, demonstrating a technology that might possibly bring future satellites back to Earth.¹⁴⁷

22 November

NASA announced that it had awarded a one-year contract extension to United Space Alliance of Houston, Texas, for mission and flight-crew-operations support, both for the ISS and for future human space exploration activities that would occur after the retirement of the Space Shuttle. The contractor would develop and execute the ground-based capabilities for human spaceflight operations, including training of crews and flight controllers, mission planning and preparation, and real-time mission execution. The US\$165 million extension, covering the period from 1 October 2011 through 30 September 2012, represented the exercise of an option under the terms of the Integrated Mission Operations Contract, which had initially spanned the period of 1 November 2008 through 30 September 2008. Including the extension, the value of the contract totaled US\$373 million.¹⁴⁸

GAO released a report, commissioned at the request of Congressman Barton J. “Bart” Gordon (D-TN), assessing NASA’s plans for its transition, from reliance on United Launch Alliance’s medium-class launch vehicle Delta II, to new launch technologies. Since 1998, NASA had launched nearly 60 percent of its science satellites aboard the Delta II; however, the rocket had only three more NASA missions on its manifest before it ended production. Because no other vehicle currently certified for science missions compared to Delta II, either in cost or in performance, NASA was facing a potential gap in its launch capabilities, including the possibility of attendant design challenges, delays, and funding issues. This gap would affect the 12 to 14 science missions that NASA had scheduled to launch through 2020. To acquire new medium-class launch capability, NASA planned to certify the ISS resupply vehicles that SpaceX and Orbital Science were currently developing for NASA—SpaceX’s Falcon 9 and Orbital Science’s Taurus 2. However, NASA would need at least three years and approximately US\$25 million to certify these rockets. GAO concluded that NASA had taken adequate steps to address potential risks and to ensure the success of the last Delta II missions, and that NASA had a reasonable plan for addressing the medium-class capability gap. However, GAO cautioned that NASA had not developed detailed estimates of the time and money required to resolve potential technical issues that could arise during the certification process. GAO recommended that NASA perform a detailed cost estimate based on experiences with previous launch-vehicle certifications, and that NASA budget for potential additional costs.¹⁴⁹

¹⁴⁷ *Spacewarn Bulletin*, no. 685, 1 December 2010, <http://nssdc.gsfc.nasa.gov/spacewarn/spx685.html> (accessed 3 April 2013); Mike Wall, “Rocket Loaded with Solar Sail and Satellites Blasts Off from Alaska,” *Space.com*, 19 November 2010, <http://www.space.com/9570-rocket-loaded-solar-sail-satellites-blasts-alaska.html> (accessed 14 June 2013).

¹⁴⁸ NASA, “NASA Extends Contract for Mission, Crew Operations Support,” news release C10-071, 22 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_C10-071_ISS_Support.html (accessed 11 June 2013).

¹⁴⁹ U.S. Government Accountability Office, “Medium Launch Transition Strategy Leverages Ongoing Investments But Is Not Without Risk” (report no. GAO-11-107, Washington, DC, November 2010), <http://gao.gov/assets/320/312657.pdf> (accessed 21 June 2013); Stephen Clark, “GAO: Medium-Class Missions Face Cost, Schedule Concerns,” *Spaceflight Now*, 23 November 2010, <http://spaceflightnow.com/news/n1011/23mediumgao/> (accessed 21 June 2013).

25 November

Russian cosmonaut Fyodor N. Yurchikhin and NASA astronauts Douglas H. Wheelock and Shannon Walker returned from their mission to the ISS, landing their Soyuz spacecraft outside of Arkalyk, Kazakhstan, at 11:46 p.m. (EST). They had launched for the ISS aboard Soyuz TMA-19 on 15 June 2010 from Baikonur Cosmodrome in Kazakhstan. During their 161 days aboard the ISS serving as members of Expeditions 24 and 25, the crew members had contributed to more than 120 microgravity experiments in such fields as biology and biotechnology, Earth and space sciences, physical and materials sciences, and technology development. Additionally, the crew had experienced an unplanned shutdown of 50 percent of the ISS's external cooling system. In response to this event, NASA astronauts Douglas H. Wheelock and Tracy E. Caldwell Dyson had conducted three emergency spacewalks, successfully replacing a broken pump module. Wheelock, Walker, and Yurchikhin had undocked from the ISS at 8:23 p.m. (EST), leaving NASA astronaut Scott J. Kelly and Russian cosmonauts Alexander Y. Kaleri and Oleg I. Skripochka as the remaining crew aboard the ISS. Yurchikhin had logged a total of 371 days in space during his career, and Walker had logged 163 days. Wheelock had spent 178 days in space during his career.¹⁵⁰

30 November

NASA announced that it had extended a contract modification to ATK Launch Systems for support of the Space Shuttle's solid rocket motor during prelaunch through postlaunch. The Space Shuttle's solid rocket motors operated in conjunction with the main engines during the first 2 minutes of flight, to thrust the spacecraft against Earth's gravitational pull. These were the only solid rocket motors approved for human spaceflight. The US\$42.1 million modification was for services effective 1 October 2010 through 31 December 2011, reflecting NASA's extension of the Space Shuttle launch schedule into FY 2011. The contractor would complete the processing of the flight hardware after the last Space Shuttle flight, in addition to performing postflight activities, such as cleaning and preserving the reusable motors. ATK Launch Systems would perform the majority of this work at its facility in Brigham City, Utah. The modification brought the total potential value of the cost-plus-award fee, incentive-fee contract to US\$4.13 billion.¹⁵¹

DECEMBER 2010

1 December

The Senate Committee on Commerce, Science, and Transportation held a hearing on the implementation of the NASA Authorization Act of 2010 (Pub. L. No. 111-267, 124 Stat 2805, October 11, 2010). The committee expressed concerns over delays in NASA's implementation of programs mandated by the Act, particularly delays related to human spaceflight. As part of a compromise worked out between Congress and the Obama administration, the Authorization Act had terminated NASA's Constellation Program and

¹⁵⁰ NASA, "Soyuz Landing Caps Space Station's First Decade of Expeditions," new release 10-312, 25 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_10-312_Expedition_25_Lands.html (accessed 11 June 2013).

¹⁵¹ NASA, "NASA Awards Space Shuttle Reusable Solid Rocket Motor Contract Modification," news release C10-075, 30 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_C10-075_RSRM.html (accessed 11 June 2013).

redirected NASA's efforts to developing a heavy-lift rocket and a crew capsule based on the *Orion* spacecraft. The committee members were worried that NASA was reluctant to carry out its new missions and may have been impeding the development of new technology or attempting to use preexisting commercial rockets, instead. NASA Chief Financial Officer Elizabeth M. Robinson addressed these concerns in her testimony before the committee. She stated that NASA's efforts to implement the provisions of the Authorization Act were constrained because Congress had not yet passed a FY 2011 budget to fund NASA programs. Until Congress enacted a FY 2011 law, NASA was operating under a continuing resolution at FY 2010 funding levels. Robinson testified that, although the Authorization Act of 2010 called for the cancellation of the Constellation Program, language in the continuing resolution had specifically prohibited NASA from cancelling the program.¹⁵²

8 December

SpaceX successfully conducted a test launch and splashdown landing of its Dragon spacecraft, the first time that a private company had sent a rocket and capsule into space and returned them to Earth. The 147-foot (44.81-kilometer) Falcon 9 lifted off for a 3-hour-and-19-minute flight from NASA's KSC at 10:43 a.m. (EST). The Dragon capsule separated from its rocket and orbited Earth twice at an altitude of 186 miles (299.33 kilometers), performing a series of maneuvers that mimicked a rendezvous with the ISS. During the flight, Dragon's electrical-power system, flight software, and navigation-and-control equipment were also tested. Dragon landed in the Pacific Ocean 500 miles (804.67 kilometers) off the coast of California, less than 0.5 miles (0.80 kilometers) from its targeted landing spot. The test was Falcon 9's second test launch, but the first time it had launched a fully functional spacecraft capsule. The event was the first of three demonstrations that NASA had contracted SpaceX to perform. SpaceX held a US\$1.6 billion NASA contract for 12 cargo-resupply missions to the ISS. Company officials stated that they eventually planned to convert the Dragon capsule to carry crewed missions to the ISS and to other destinations in space.¹⁵³

9 December

NASA announced that, in addition to two contracts it had awarded on 22 November 2010 to companies that would conduct 12-month-long studies identifying advanced aircraft concepts, it had awarded a third similar US\$5.29 million contract to a team led by the Boeing Company of Huntington Beach, California. In November, NASA had awarded a contract

¹⁵² U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, *Transition and Implementation: The NASA Authorization Act of 2010*, 111th Cong., 2nd sess., 1 December 2010, <http://www.gpo.gov/fdsys/pkg/CHRG-111shrg71257/pdf/CHRG-111shrg71257.pdf> (accessed 8 July 2013); Kenneth Chang, "Senators Push NASA To Carry Out Revamping," *New York Times*, 1 December 2010, http://www.nytimes.com/2010/12/02/science/space/02nasa.html?_r=0 (accessed 28 June 2013); Amy Svitak, "Senators Vow To Enforce NASA Authorization Act," *Space.com*, 3 December 2010, <http://www.space.com/9628-senators-vow-enforce-nasa-authorization-act.html> (accessed 28 June 2013).

¹⁵³ Kenneth Chang, "Private Spacecraft Returns Safely From Orbit," *New York Times*, 8 December 2010, http://www.nytimes.com/2010/12/09/science/space/09rocket.html?_r=3&ref=science& (accessed 28 June 2013); Todd Halvorson, "Dragon Spacecraft Debut 'Mind Blowing'," *Florida Today* (Brevard, FL), 9 December 2010, <http://www.floridatoday.com/article/20101209/NEWS02/12090312/1006/NEWS01/Dragon+spacecraft+debut+proves+to+be++mind+blowing+> (accessed 28 June 2013); Pete Spotts, "'Too Good to be True': SpaceX Mission Appears Nearly Flawless," *Christian Science Monitor*, 8 December 2010, <http://www.csmonitor.com/USA/2010/1208/Too-good-to-be-true-SpaceX-mission-appears-nearly-flawless> (accessed 28 June 2013).

worth US\$2.99 million to a team led by Lockheed Martin of Palmdale, California, and a contract worth US\$2.65 million to a team led by Northrop Grumman of El Segundo, California. In awarding these contracts, NASA was seeking a concept for an aircraft capable of integrating NASA's emissions, noise, and fuel-burn reduction goals, while operating safely within a modernized air-traffic-management system. The airliner, which must be ready to enter service in 2025, would be capable of carrying 50,000 to 100,000 pounds (22,679.62 to 45,359.24 kilograms) of cargo, payload, or passengers. It would have a range of approximately 7,000 miles (11,265.41 kilometers) and the ability to fly at 85 percent of the speed of sound. NASA's Environmentally Responsible Aviation Project, part of the Aeronautics Research Mission Directorate's Integrated Research Program, was sponsoring the contracts. The project's mission was to develop technology to reduce fuel consumption by 50 percent, reduce harmful emissions by 50 percent, and reduce the area affected by airport noise by 83 percent.¹⁵⁴

10 December

NASA announced that it had awarded a contract to Lockheed Martin of Gaithersburg, Maryland, for services that would support cargo missions to the ISS. The cost-plus-award-fee contract had a total potential value of US\$171 million. The three-month phase-in period, which would begin on 1 January 2011, and the three-year basic period, which would begin on 1 April 2011, had a total estimated value of US\$85 million. The contract also included four one-year extension options with a total value of US\$86 million, as well as provisions for the contractor to provide similar services for future spacecraft traveling to the ISS. Lockheed Martin would perform the work at NASA's JSC, including support for the planning, coordination, preparation, and packing of standardized containers that NASA, its partner agencies, and commercial companies would use to transport cargo to the ISS. The contractor would also process flight-crew equipment, including audio and video equipment, batteries, clothing and personal hygiene items, crew survival equipment, housekeeping items, and laptop computers.¹⁵⁵

NASA announced that astronaut Alan G. Poindexter had resigned to take a position as the Dean of Students and Executive Director of Programs at the Naval Postgraduate School in Monterey, California. NASA had selected Poindexter as an astronaut candidate in 1998. He had served as Lead Support Astronaut in the Astronaut Office Shuttle Operations Branch at NASA's KSC and as a spacecraft communicator, as well as flying on two spaceflights. Poindexter had served as Pilot on STS-122, a 2008 mission to deliver ESA's Columbus laboratory to the ISS. In 2010 he had served as Commander of STS-131, which had delivered

¹⁵⁴ NASA, "NASA Selects Companies for Advanced Aircraft Concepts Study," news release C10-072, 22 November 2010, http://www.nasa.gov/home/hqnews/2010/nov/HQ_C10_072_ARMED_Advanced_Concepts.html (accessed 11 June 2013); NASA, "NASA Selects Boeing for Advanced Aircraft Vehicle Concepts," news release C10-076, 9 December 2010, http://www.nasa.gov/home/hqnews/2010/dec/HQ_C10-076_Advcd_Aircraft.html (accessed 24 June 2010).

¹⁵⁵ NASA, "NASA Awards Space Station Cargo Mission Services Contract," news release C10-079, 10 December 2010, http://www.nasa.gov/home/hqnews/2010/dec/HQ_C10-079_ISS_Cargo_Services.html (accessed 24 June 2013).

more than 13,000 pounds (5,896.70 kilograms) of hardware and other supplies to the ISS. Altogether, Poindexter had logged over 669 hours in space.¹⁵⁶

13 December

NASA Administrator Charles F. Bolden Jr. announced that he had named Waleed Abdalati as NASA's Chief Scientist. Effective 3 January 2011, Abdalati would serve as the Administrator's principal advisor on NASA's science programs, strategic planning, and related investments. As the representative of all of NASA's scientific endeavors, he would ensure that science missions complied with and fulfilled the White House's science objectives. He would work closely with the White House's Office of Science and Technology Policy (OSTP) and with the Office of Management and Budget (OMB), advocating for NASA's science missions within the scope of larger government science agendas. Abdalati had previously served NASA from 1998 to 2008, holding positions related to program management, scientific management, and science research. He had led the Cryospheric Sciences Branch at NASA's GSFC and had managed the Cryospheric Sciences Program at NASA Headquarters. Before returning to NASA, he had served as Director of the Earth Science and Observation Center and as Associate Professor in the Geography Department at the University of Colorado at Boulder.¹⁵⁷

NASA announced that Voyager 1, the spacecraft that was 10.80 billion miles (17.38 billion kilometers) from Earth's Sun and traveling toward interstellar space, had reached a region at the solar system's edge where the outward velocity of the Sun's solar wind is zero. Solar wind is hot, ionized gas that streams out from the Sun, forming a bubble of charged particles known as the heliosphere. It flows at supersonic speed until it crosses a shockwave known as the termination shock. It then enters a region known as the heliosheath, the outer skin of the heliosphere, where the solar wind slows down and heats up. Voyager 1, which had launched on 5 September 1977, had crossed the termination shock in December 2004. In June 2010, scientists monitoring Voyager 1's Low-Energy Charged Particle Instrument (LECP) had detected that the solar wind's net outward velocity was zero. They had monitored the data for four months to ensure that the measurements were consistent. The data showed that the solar wind, which Voyager 1 had observed moving at 130,000 miles per hour (209,214.70 kilometers per hour) in August 2007, had slowed by approximately 45,000 miles per hour (72,420.48 kilometers per hour) each year until reaching zero. Scientists believed that solar wind does not have outward velocity in this region because it is colliding with the cold gas and dust of interstellar space, causing it to turn sideways and coil back around the heliosphere, eventually forming a comet-like tail. The researchers estimated that Voyager 1 would reach interstellar space in approximately four years.¹⁵⁸

¹⁵⁶ NASA, "Astronaut Alan Poindexter Leaves NASA," news release 10-331, 10 December 2010, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-331_Poindexter_Departs.html (accessed 24 June 2013).

¹⁵⁷ NASA, "NASA Names Waleed Abdalati as Agency's New Chief Scientist," news release 10-332, 13 December 2010, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-332_Chief_Scientist.html (accessed 24 June 2013).

¹⁵⁸ NASA, "NASA Probe Sees Solar Wind Decline En Route to Interstellar Space," news release 10-334, 13 December 2010, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-334_Voyager_Voyages.html (accessed 27 June 2013); Thomas H. Maugh II, "From Voyager 1 Comes Cutting-Edge Science on Solar Wind," *Los Angeles Times*, 14 December 2010, <http://articles.latimes.com/2010/dec/14/science/la-sci-voyager-20101215> (accessed 27 June 2013).

15 December

Soyuz TMA-20 launched aboard a Soyuz rocket from Baikonur Cosmodrome in Kazakhstan at 19:09 (UT), carrying NASA astronaut Catherine Grace “Cady” Coleman, Russian cosmonaut Dmitry Y. Kondratyev, and ESA astronaut Paolo A. Nespoli to the ISS. The spaceflight was the first for Kondratyev, the second for Nespoli, and the third for Coleman. The Soyuz, commanded by Kondratyev, was scheduled to dock at the ISS on 17 December 2010. The crew would join fellow Expedition 26 members Commander Scott J. Kelly and Flight Engineers Alexander Y. Kaleri and Oleg I. Skripochka. The Expedition 26 crew would perform scientific research, station maintenance, and educational outreach. They would host a Space Shuttle mission, scheduled for February 2011, as well as three resupply vehicles. The JAXA H-II Transfer Vehicle, or Kounotori, and the Russian Progress 41 were scheduled to arrive at the ISS in January 2011, and ESA’s ATV would arrive in February 2011. Additionally, Kondratyev and Skripochka would conduct two spacewalks to install an antenna and to work on the outside of the Russian modules of the ISS. Coleman, Kondratyev, and Nespoli would stay aboard the ISS for approximately 5.5 months before returning to Earth.¹⁵⁹

16 December

NASA announced that Associate Deputy Administrator Charles H. Scales would be retiring, and that NASA had appointed Richard J. Keegan Jr. to replace him. Scales had begun his career with NASA as a student in the Cooperative Education Program. He had served as a Communications Specialist at NASA’s MSFC, Deputy Director in the Office of Center Operations at NASA’s MSFC, Director of the Center Operations Directorate at NASA’s GRC, and as NASA’s Associate Administrator for the Office of Institutions and Management. Scales had served as Associate Deputy Administrator since April 2007. Keegan had served at NASA’s GSFC and at NASA Headquarters, where he had held various senior business management positions. He had served as Director of NASA’s Office of Program and Institutional Integration and as the first Associate Administrator of the Mission Support Directorate. In his role as Associate Deputy Administrator, Keegan would assist the Administrator and Deputy Administrator in carrying out NASA’s day-to-day operations across a range of institutional and workforce issues.¹⁶⁰

20 December

NASA announced that it had issued delivery orders to three of the six companies that had received ILDD contracts in October 2010. The ILDD contracts were firm-fixed price, indefinite-delivery, indefinite-quantity awards for data on vehicle and robotic lunar-landing technology. The total potential value of all of the maximum five-year period contracts was US\$30.1 million. NASA had asked each ILDD contractor to identify their top risks in a System Definition Review (SDR) package, and then to propose plans for delivering data that

¹⁵⁹ *Spacewarn Bulletin*, no. 686, 1 January 2011, <http://nssdc.gsfc.nasa.gov/spacewarn/spx674.html> (accessed 1 July 2013); NASA, “Newest Space Station Crew Members Launch from Kazakhstan,” news release 10-330, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-330_New_ISS_Crew.html (accessed 24 June 2013); Denise Chow, “Russia’s Soyuz Blasts Off with New Crew for Space Station,” *Space.com*, 15 December 2010, <http://www.space.com/10491-russia-soyuz-blasts-crew-space-station.html> (accessed 27 June 2013).

¹⁶⁰ NASA, “Keegan Named NASA’s Associate Deputy Administrator,” news release 10-283, 16 December 2010, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10283_New_Deputy_Associate_Administrator.html (accessed 24 June 2013).

would address at least one of their SDR risk items. The delivery orders that NASA had issued, each valued at US\$500,000, were for data that captured the results of these proposals. NASA would use the data to develop affordable and sustainable lander systems for space exploration. Under the ILDD contracts, NASA could issue future delivery orders for data associated with system testing and integration, launching, in-space maneuvers, braking burns, lunar landing, and other enhanced capabilities. The three companies selected were Astrobiotic Technology of Pittsburgh, Pennsylvania; Dynetics of Huntsville, Alabama; and Moon Express of San Francisco, California.¹⁶¹

Felisa Wolfe-Simon, leader of a team of researchers funded by NASA's Astrobiology Program, responded to criticisms of her research in an interview published online by the journal *Science*. In its online edition of 2 December 2010, *Science* had published the team's paper announcing the discovery of microbes that could build cellular components out of arsenic. The paper had detailed the discovery of a strain of bacteria known as GFAJ-1 that appeared to be able to substitute arsenic for phosphorus in the production of biomolecules. Phosphorus, along with carbon, hydrogen, oxygen, and sulfur, is one of the six elements that form the building blocks of all known life on Earth. Phosphorus forms the chemical backbone of DNA and RNA and comprises the phospholipids in cell membranes and the energy-carrying molecules in cells. However, the researchers had reported that when they isolated GFAJ-1 in a phosphorus-poor, but arsenic-rich, environment, the microbes had constructed biomolecules out of arsenic, rather than from the chemically similar phosphorus. The research, which had the potential to expand the definition of life, affected the scientific study of Earth's evolution, biogeochemical cycles, disease migration, Earth-system research, microbiology, and organic chemistry, as well as astrobiology. After the paper's publication, however, some members of the scientific community had pointed out potential flaws in the study. Among other questions, they asked whether the researchers had thoroughly washed the DNA of the tested cells to remove arsenic contamination. Wolfe-Simon defended her research techniques and encouraged other scientists to conduct further research on GFAJ-1 and its properties.¹⁶²

30 December

NASA announced that it had awarded a US\$31.2 million contract to Lockheed Martin Space Systems Company (LMSSC) of Greenbelt, Maryland, to provide Systems Engineering In-Space Servicing (SEISS) using CSA's Dextre. Dextre, a robotic system aboard the ISS, carried out maintenance and servicing tasks that otherwise would require astronauts to perform spacewalks. Under the 18-month, sole-source, cost-plus-fixed-fee contract, LMSSC would provide engineering support for two demonstrations that would use Dextre to test new

¹⁶¹ NASA, "NASA Selects Companies for Further Lunar Demonstrations Data," news release 10-344, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-344_ILDD_Selections.html (accessed 24 June 2013).

¹⁶² Felisa Wolfe-Simon et al., "A Bacterium That Can Grow by Using Arsenic Instead of Phosphorus," *Science* 332, no. 6034 (3 June 2011): 1163–1166, published online 2 December 2010, <http://www.sciencemag.org/content/332/6034/1163.full> (accessed 28 June 2013); Elizabeth Pennisi, "Discoverer Asks for Time, Patience Over Arsenic Bacteria Controversy," *Science* 330, no. 6012 (24 December 2010): 1734–1735, published online 20 December 2010, <http://news.sciencemag.org/sciencenow/2010/12/arsenic-researcher-asks-for-time.html> (accessed 1 July 2013); NASA, "NASA-Funded Research Discovers Life Built with Toxic Chemical," news release 10-320, http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-320_Toxic_Life.html (accessed 24 June 2013).

robotic service capabilities. The first demonstration would test in-orbit refueling and repair tasks, such as locating, accessing, and uncapping valves and transferring simulated liquid fuel. The second demonstration would use Dextre to test and evaluate various instruments, sensors, and tools, supporting capabilities for in-orbit autonomous rendezvous and capture capabilities. LMSSC would define and verify requirements, design hardware, support development of both flight and ground hardware and software, and support mission planning. NASA's GSFC would develop both of the demonstrations' payloads.¹⁶³

¹⁶³ NASA, "NASA Awards Systems Engineering Contract for In-Space Servicing," news release C10-081, 30 December 2013, http://www.nasa.gov/home/hqnews/2010/dec/HQ_C10-081_Systems_Engineering.html (accessed 24 June 2013).

TABLE OF ABBREVIATIONS

AAS	American Astronautical Society
ADS-B	Automatic Dependent Surveillance-Broadcast
AGN	active galactic nucleus
AIA	Atmospheric Imaging Assembly
AIAA	American Institute of Aeronautics and Astronautics
AMS	Alpha Magnetic Spectrometer
APL	Applied Physics Laboratory (at Johns Hopkins University)
ARC	Ames Research Center
ARTEMIS	Acceleration, Reconnection, Turbulence and Electrodynamics of Moon's Interaction with Sun
ASAP	Aerospace Safety Advisory Panel
ATV	Automated Transfer Vehicle
CMB	cosmic microwave background
CME	coronal mass ejection
COS	Cosmic Origins Spectrograph
COTS	Commercial Orbital Transportation Services
CR	continuing resolution
CRuSR	Commercial Reusable Suborbital Research Program
CSA	Canadian Space Agency
CSBF	Columbia Scientific Balloon Facility
CST	Crew Space Transportation
DFRC	Dryden Flight Research Center
DIXI	Deep Impact Extended Investigation
EDT	Eastern Daylight Time
ELV	expendable launch vehicle
EMCS	ExoMars Climate Sounder
EMTGO	ExoMars Trace Gas Orbiter
EPEAD	Energetic Proton Electron and Alpha Detector
EPOCh	Extrasolar Planet Observations and Characterization
EPOXI	Extrasolar Planet Observations and Characterization and the Deep Impact Extended Investigation
EPS	Energetic Particle Sensor
ESA	European Space Agency
EST	Eastern Standard Time
EUV	Extreme Ultraviolet
EVE	Extreme Ultraviolet Variability Experiment
FASTSAT	Fast Affordable Science and Technology Satellite
FY	fiscal year
GAO	Government Accountability Office

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GLOBE	Global Learning and Observations to Benefit the Environment
GloPac	Global Hawk Pacific
GMI	Global Precipitation Measurement Microwave Imager
GOES	Geostationary Operational Environmental Satellite
GPM	Global Precipitation Measurement
GPS	global positioning system or global positioning satellite
GRB	gamma-ray burst
GRC	Glenn Research Center
GRIP	Genesis and Rapid Intensification Processes
GSFC	Goddard Space Flight Center
HeliosPP	Heliospheric Origins with Solar Probe Plus
HEPAD	High-Energy Proton and Alpha Detector
HIRES	High Resolution Echelle Spectrometer
HiRISE	High Resolution Imaging Science Experiment
HiSCI	High Resolution Stereo Color Imager
HMI	Helioseismic and Magnetic Imager
HMP	Haughton-Mars Project
HST	Hubble Space Telescope
ICRP	Independent Comprehensive Review Panel
IKAROS	Interplanetary Kite-craft Accelerated by Radiation of the Sun
ILDD	Innovative Lunar Demonstrations Data
INLSE	Israel Network for Lunar Science and Exploration
ISA	Israel Space Agency
ISA	Italian Space Agency
ISIS	Integrated Science Investigation of the Sun
ISRO	Indian Space Research Organisation
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
JWST	James Webb Space Telescope
KSC	Kennedy Space Center
KSLV	Korea Space Launch Vehicle
L1 and L2	Lagrange points
LADEE	Lunar Atmosphere Dust Environment Explorer
LaRC	Langley Research Center
LAT	Large Area Telescope
LCROSS	Lunar Crater Observation and Sensing Satellite
LECP	Low-Energy Charged Particle Instrument
LMSSC	Lockheed Martin Space Systems Company
LRO	Lunar Reconnaissance Orbiter

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LSS	Lunar Surface Systems
LWS	Living With a Star
MAGED	Magnetosphere Electron Detector
MAGIE	Mars Atmospheric Global Imaging Experiment
MAGPD	Magnetosphere Proton Detector
MASCS	Mercury Atmospheric and Surface Composition Spectrometer
MATMOS	Mars Atmospheric Trace Molecule Occultation Spectrometer
MAVEN	Mars Atmosphere and Volatile Evolution
MCB	Multilateral Coordination Board
MDT	Mountain Daylight Time
MESSENGER	Mercury Surface, Space Environment, Geochemistry and Ranging
MEXT	Ministry of Education, Culture, Sports, and Technology (Japan)
MINI-ME	Miniature Imager for Neutral Ionosphere Atoms and Magnetospheric Electrons
MRO	Mars Reconnaissance Orbiter
MSFC	Marshall Space Flight Center
MSL	Mars Science Laboratory
NAA	National Aeronautic Association
NASA	National Aeronautics and Space Administration
NCT	Nuclear Compton Telescope
NLS	NASA Launch Services
NOAA	National Oceanic and Atmospheric Administration
NOMAD	High Resolution Solar Occultation and Nadir Spectrometer
NPLD	northern polar layered deposits
NSA	National Security Agency
NSBRI	National Space Biomedical Research Institute
NSF	National Science Foundation
O/OREOS	Organism/Organic Exposure to Orbital Stresses
OIG	Office of the Inspector General
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
PDT	Pacific Daylight Time
PISA	Plasma and Impedance Spectrum Analyzer
PPAs	programs, projects, or activities
R&D	research and development
SDO	Solar Dynamics Observatory
SDR	System Definition Review
SEED	Space Environment Exposure Device
SEISS	Systems Engineering In-Space Servicing
SETI	Search for Extraterrestrial Intelligence

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SEM	Space Environment Monitor System
SHARAD	Shallow Radar
SSC	Stennis Space Center
SST	Spitzer Space Telescope
STEM	science, technology, engineering, and mathematics
STIS	Space Telescope Imaging Spectrograph
SWEAP	Solar Winds Electrons Alphas and Protons Investigation
SXI	Solar X-ray Imager
THERMIS	Time History of Events and Macroscale Interactions during Substorms
TIGRE	Tracking and Imaging Gamma Ray Experiment
TDRS	Tracking and Data Relay Satellite
TRMM	Tropical Rainfall Measuring Mission
TTI	Thermosphere Temperature Imager
UT	Universal Time
VLT	Very Large Telescope
VMS	Virgin Mothership
VSS	Virgin Space Ship
WFF	Wallops Flight Facility
WFI	Wide-Field Imager
WHIM	Warm-Hot Intergalactic Medium
WMAP	Wilkinson Microwave Anisotropy Probe
WSMR	White Sands Missile Range
XRS	Energetic X-ray Sensor

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