National Aeronautics and Space Administration

2011 NASA Strategic Plan

www.nasa.gov

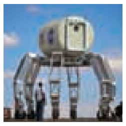
The future of aeronautics and space exploration is built on sound strategic planning and the commitment of our employees and partners. The images on the cover show activities that contribute to achieving our strategic goals, artist concepts of future missions or innovative ideas, and our education efforts.

Aerospace engineer Rod Chima works with the Large-Scale Low-Boom supersonic inlet model in the Glenn Research Center's 8' x 6' Supersonic Wind Tunnel. Gulfstream Aerospace Corporation and the University of Illinois–Urbana Champaign partnered with Glenn to test the model with micro-array flow control to try to alleviate the thunder-like sonic booms produced by supersonic aircraft. (Credit: NASA/B.R. Caswell)

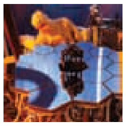
On May 17, 2010, NASA Astronaut Steve Bowen, STS-132 mission specialist, participates in the mission's first session of extravehicular activity as construction and maintenance continue on the International Space Station.

Dr. Heather Oravec, a postdoctoral researcher at the Glenn Research Center, works with a new device developed there that tests lunar soil strength. Called a vacuum bevameter, the device measures the characteristics of lunar soil simulants, or lunar regolith, in a vacuum chamber at specific temperatures while accounting for lunar gravity. The system may be used to predict strength characteristics of lunar regolith in previously unexplored regions of the Moon. (Credit: NASA/M.M. Murphy, Wyle Information Systems, LLC)

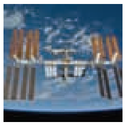
Leland Melvin, Associate Administrator for the Office of Education and former astronaut, high-fives fifth- through 12th-graders at the Minority Student Education Forum. The forum was part of our Summer of Innovation initiative and the Federal Educate to Innovate campaign to increase the number of future scientists, mathematicians, and engineers. (Credit: NASA/C. Huston)



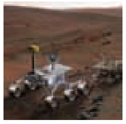
Our heavy-lift rover Tri-ATHLETE, or All-Terrain Hex-Legged Extra-Terrestrial Explorer, carries a logistics module mockup during the summer 2010 DesertRATS field test. The spider-like Tri-ATHLETE can roll or climb over uneven terrain to deliver a load to its destination. DesertRATS, or Research and Technology Studies, offers a chance for a team of engineers, astronauts, and scientists to conduct technology development research in the Arizona desert, a good stand-in for destinations for future planetary exploration missions. (Credit: NASA)



An engineer works with the fully functional, one-sixth scale model of the James Webb Space Telescope mirror in the optics testbed. This large, infrared-optimized telescope will search for the first galaxies that formed in the early universe. It will peer through dusty clouds to see the birth of stars and planetary systems. (Credit: NASA)

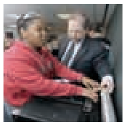


A crew member from STS-132 photographed the International Space Station on May 23, 2010, after the Space Shuttle undocked and began separation. (Credit: NASA)



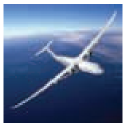
An artist's concept of the Mars Science Laboratory rover, *Curiosity* (left), compares it with the much-smaller *Spirit*, one of the twin Mars Exploration Rovers. Mars Science Laboratory, in development at the Jet Propulsion Laboratory, will assess whether Mars ever was, or is still today, an environment able to support microbial life. (Credit: NASA/JPL–Caltech)

Solar Probe Plus, its primary solar panels retracted into the shadows of its protective solar shield, approaches the Sun in this artist's concept. Managed by the Goddard Space Flight Center, Solar Probe Plus will repeatedly sample the near-Sun environment, revolutionizing our knowledge and understanding of coronal heating and the origin and evolution of the solar wind. (Credit: NASA/JHU–APL)

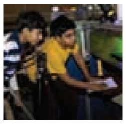


Kenneth Silberman, an engineer at the Goddard Space Flight Center (right), guides a student from the Maryland School for the Blind through an exploration of one of several tactile, scale models. During the visit to NASA Headquarters, one of several events sponsored by the Equal Opportunity and Diversity Management Division during National Disability Employment Awareness Month, students from the school met with representatives from each Mission Directorate. (Credit: NASA/P.E. Alers)

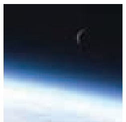
Life aboard the International Space Station always requires the crew members to put our core values—safety, integrity, teamwork, and excellence—into action. The International Space Station brings together people from many backgrounds and nations in a relatively small working and living environment to achieve a wide variety of science and engineering goals. In this photo Naoko Yamazaki, Japan Aerospace Exploration astronaut (center), joins NASA astronauts T.J Creamer (back left), Alan Poindexter (STS-131 commander, back right), and Stephanie Wilson (lower right) in the busy Destiny Laboratory. (Credit: NASA)



The SUGAR Volt is a twin-engine ultra-fuel efficient aircraft concept with a hybrid propulsion system that combines gas turbine and battery technology, a tube-shaped body and a truss-braced wing mounted to the top of the aircraft. This aircraft is designed to fly at Mach 0.79 carrying 154 passengers 3,500 nautical miles. This concept was one of four designs presented to us in April 2010 for our NASA Research Announcement-funded studies into advanced subsonic aircraft that could enter service in the 2030 to 2035 time frame. (Credit: NASA/The Boeing Company)



Two seventh grade boys conduct an experiment in the Ames Research Laboratory's Fluid Mechanics Laboratory on the effects of airflow resistance (or drag) on automobiles. They have placed a toy truck in the tank on the right and added a dye to the water to show the flow around the vehicle. The boys were preparing for the Santa Clara Valley [California] Science Engineering Fair–2010 Synopsys Championship. (Credit: NASA/E. James)



A last quarter crescent Moon above Earth's horizon is featured in this image photographed by an Expedition 24 crew member on the International Space Station on September 5, 2010. (Credit: NASA)

Message From the Administrator

February 14, 2011

In 2010, the President and Congress unveiled an ambitious new direction for NASA, laying the groundwork for a sustainable program of exploration and innovation. This new direction extends the life of the International Space Station, supports the growing commercial space industry, and addresses important scientific challenges while continuing our commitment to robust human space exploration, science, and aeronautics programs. The strong bipartisan support for the NASA Authorization Act of 2010 confirms our essential role in addressing the Nation's priorities.

This is a year that will see additional discoveries from our premiere science missions and advances in aviation technology. It is a year that will see the end of the Space Shuttle Program, the completed construction of the International Space Station, and progress in developing a new space transportation system. It also is a year that we are certain will see continued success in commercial space efforts to bridge the gap in U.S. human space flight to low Earth orbit.

This Strategic Plan outlines our long-term goals as an agency and describes how we will accomplish these goals over the next decade or more. Our goals cover more than flagship missions and cutting-edge technology development. We are committed to working smarter, doing business differently, and being transparent in our operations. Continuous improvement in our program management, in particular, is essential to our future success, and we will keep the public's trust through transparency and accountability for our actions. We will continue to adhere to our core values of safety, integrity, teamwork, and excellence while we foster the pioneering, innovative, and partnering spirit that drives us and continues to advance our Nation.

We will continue to reach out to our international partners, educators, industry, the public, and other stakeholders. NASA will be a leader in research and development and in innovative business and communications practices. Overall, NASA is a multi-mission agency that addresses complex national challenges, enables new markets, performs cutting-edge research, inspires and educates, and opens new frontiers.

The Nation has high expectations of NASA—as it should. That expectation is cast in the legacy of those who built, tested, and flew the missions of yesterday and is a sign of confidence in each of us here now. I am proud of what we have accomplished throughout our history as an agency, and I believe that the future holds many good things. With our past accomplishments in mind, we shift our focus forward on the bold new direction set by the President. We embrace the challenge, and we look forward to sharing this adventure with the American people.

Charles F. Bolden, Jr.
Administrator

Photo above: Administrator Charles Bolden speaks during a ceremony for winners and participants of NASA's 2009 Centennial Challenges, held on February 26, 2010, at NASA Headquarters in Washington, D.C. The competition addresses a range of technical challenges that support our missions in aeronautics and space, with a goal of encouraging novel solutions from non-traditional sources like individual inventors, student groups, and small, private companies. (Credit: NASA/P.E. Alers)

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The NASA Hubble Space Telescope image captures the chaotic activity atop a three-light-year-tall pillar of gas and dust that is being eaten away by the brilliant light from nearby bright stars. The pillar also is being assaulted from within, as infant stars buried inside it fire off jets of gas that can be seen streaming from towering peaks. This turbulent cosmic pinnacle lies within a tempestuous stellar nursery called the Carina Nebula, located 7,500 light-years away in the southern constellation Carina. Taken in April 2010, the image celebrates the 20th anniversary of Hubble's launch and deployment into an orbit around Earth. (Credit: NASA/European Space Agency/M. Livio/Hubble 20th Anniversary Team, Space Telescope Science Institute)

NASA

Vision, Mission, and Values

Since its establishment, the National Aeronautics and Space Administration (NASA) has helped to spur profound changes in our knowledge, culture, and expectations. Congress enacted the National Aeronautics and Space Act of 1958 "to provide for research into problems of flight within and outside Earth's atmosphere" and to ensure that the United States conducts activities in space devoted to peaceful purposes for the benefit of humanity. We have since been instrumental in numerous scientific discoveries and technological advances that have advanced humankind, while inspiring the Nation and the world to imagine that much more is possible.

Congress and the Administration continue their support of NASA through legislation and policies that recognize the importance of U.S. leadership in the areas of our Mission.[1] In 2006, the Administration published the National Aeronautics Research and Development Policy, guiding the Nation's goals in aeronautics technology research and development. In 2010, the Administration updated the U.S. National Space Policy (National Space Policy), which recognizes the essential nature of space for our national and global well-being, including our roles in space science, exploration, and discovery. In the same year, Congress passed, and the President signed, the NASA Authorization Act providing the Agency important guidance in program content and conduct. We embrace the spirit, principles, and objectives of these key policies and legislation in our Vision, Mission, and core values.

The NASA Vision

To reach for new heights and reveal the unknown,
so that what we do and learn will benefit all humankind.

The NASA Mission

Drive advances in science, technology, and exploration
to enhance knowledge, education, innovation, economic vitality,
and stewardship of Earth.

An Expedition 24 crew member photographed a last quarter Moon setting behind the thin line of Earth's atmosphere as the International Space Station passed over central Asia on September 4, 2010. (Credit: NASA)

[1]NASA uses the term "mission" in two ways. When used as "Mission," it refers to NASA's core functions and responsibilities. When used as "mission," it refers to a special task given to an entity within NASA, such as a program or project, or a single flight of an aircraft or voyage of a spacecraft.

Core Values

Governance at NASA begins with shared core values guiding individual and organizational behavior as we execute our tasks. These core values are essential to our success.

- **Safety:** NASA's constant attention to safety is the cornerstone upon which we build mission success. We are committed, individually and as a team, to protecting the safety and health of the public, our team members, and those assets that the Nation entrusts to the Agency.
- **Integrity:** NASA is committed to maintaining an environment of trust, built upon honesty, ethical behavior, respect, and candor. Our leaders enable this environment by encouraging and rewarding a vigorous, open flow of communication on all issues, in all directions, and among all employees without fear of reprisal. Building trust through ethical conduct as individuals and as an organization is a necessary component of mission success.
- **Teamwork:** NASA's most powerful tool for achieving mission success is a multidisciplinary team of diverse, competent people across all NASA Centers. Our approach to teamwork is based on a philosophy that each team member brings unique experience and important expertise to project issues. Recognition of, and openness to, that insight improves the likelihood of identifying and resolving challenges to safety and mission success. We are committed to creating an environment that fosters teamwork and processes that support equal opportunity, collaboration, continuous learning, and openness to innovation and new ideas.
- **Excellence:** To achieve the highest standards in engineering, research, operations, and management in support of mission success, NASA is committed to nurturing an organizational culture in which individuals make full use of their time, talent, and opportunities in pursuit of excellence in both the ordinary and the extraordinary.

Mission success requires uncompromising commitment to Safety, Integrity, Teamwork, and Excellence.

Bobby Braun, NASA's Chief Technologist, talks with participants at a NASA town hall meeting, one of many forums he has used to renew interest in technology development. Later in the year, Braun participated in the TEDxNASA event. TEDx events bring together people from technology, engineering, and design (or TED) to exchange new ideas and discuss old ideas from a new perspective. In his talks, Braun emphasizes that the Nation needs to pursue big dreams, invest in technology, and seek innovative solutions to difficult challenges. At TEDx Braun stated, "Through a renewed focus on innovation and technology, I believe NASA can be an important catalyst for economic expansion in this Nation, increasing the societal impact of our space program." (Credit: NASA)

Overarching Strategies

The following overarching strategies govern the management and conduct of our aeronautics and space programs. These are standard practices that each organization within NASA employs in developing and executing their plans to achieve our strategic goals. They also provide a framework that guides our support for other areas of national and Administration policy: government transparency;[2] science, technology, engineering, and mathematics (STEM) education; energy and climate change; innovation; and increased citizen and partnership participation to help address the multitude of challenges faced by our Nation. The following overarching strategies help strengthen the Agency and support U.S. competitiveness on a global scale:

- **Investing in next-generation technologies** and approaches to spur innovation;
- **Inspiring students** to be our future scientists, engineers, explorers, and educators through interactions with NASA's people, missions, research, and facilities;
- **Expanding partnerships** with international, intergovernmental, academic, industrial, and entrepreneurial communities and recognizing their role as important contributors of skill and creativity to our missions and for the propagation of our results;
- **Committing to environmental stewardship** through Earth observation and science, and the development and use of green technologies and capabilities in NASA missions and facilities; and
- **Securing the public trust** through transparency and accountability in our programmatic and financial management, procurement, and reporting practices.

The Johnson Space Center's Life Support Systems and Environmental Control organization helps develop spacesuits for future human space flight. In one of the Center's laboratories, engineers test a suit's mobility during a basic task. (Credit: NASA)

[2]NASA uses the term "government" in two ways. When used as "Government," it refers to the Federal Government only. When used as "government," it includes Federal, state, and local governments.

Strategic Goals

2011 Through 2021 and Beyond

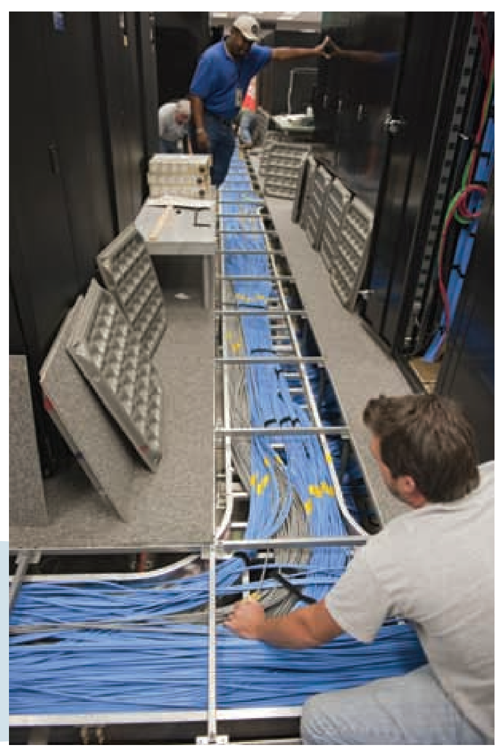
NASA has taken humans to the Moon, visited other planets in the solar system, gazed into the vast cosmos, and looked back to the earliest moments of the universe's beginnings. We have powered scramjet aircraft to 10 times the speed of sound, built the International Space Station (ISS), and launched satellites that study our ever changing Earth. These achievements were made possible by thorough planning set against ambitious but achievable goals. We look forward to continuing this tradition of achievement through our updated strategic goals for exploration, science, and technology development.

New in this 2011 Strategic Plan is a strategic goal that emphasizes the importance of supporting the underlying capabilities that enable NASA's missions. This addition ensures that our resource decisions directly address the balance of funding priorities between our missions and the requirements of institutional and program capabilities that enable our missions.

We actively focus our planning decisions by using a tiered set of statements that describe a desired state during a relative time frame. The following six strategic goals are long-term, spanning the next decade and beyond. For each strategic goal, we present an introduction that discusses why we are investing in this goal, followed by outcome statements that set targets for that goal over the next 10 years and beyond. We describe how each outcome contributes to the goal and include a highlight titled "Strategy@Work," which represents a current activity that embodies how we will achieve the outcome. Finally, we summarize potential challenges we are likely to encounter while pursuing each strategic goal and our current strategies for mitigating these challenges.

Our strategic goals and outcomes are the basis of our performance framework. They are in turn supported by objectives, performance goals, and annual performance goals. The objectives, included as an Appendix to this Strategic Plan, identify actions within a 10-year time frame that support progress toward their respective outcome. Additional performance goals, written to support the objectives, are published in NASA's budget request as our annual performance plan. They describe Agency activities that span the next five years and include a set of specific, measurable, annual performance goals that must align with our budget.

We depend on our valuable workforce to achieve the goals included in this Strategic Plan. Using our core values and overarching strategies as our guide, we empower and rely on our employees to innovate and excel in their efforts to achieve our goals and to deliver greater scientific and engineering return for the American people they are entrusted to serve.



At the Kennedy Space Center, electricians rewire the Launch Control Center's Young–Crippen Firing Room in preparation for launches of future human space flight vehicles. (Credit: NASA/K. Shiflett)

Strategic Goals and Outcomes

Strategic Goal 1: Extend and sustain human activities across the solar system.

1.1 Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.

1.2 Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.

1.3 Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.

Strategic Goal 2: Expand scientific understanding of the Earth and the universe in which we live.

2.1 Advance Earth system science to meet the challenges of climate and environmental change.

2.2 Understand the Sun and its interactions with Earth and the solar system.

2.3 Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

2.4 Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.

In January 2011, our Kepler mission, led by the Ames Research Center, confirmed the discovery of its first rocky planet, named Kepler-10b (shown in this artist's concept). Measuring 1.4 times the size of Earth, it is the smallest planet ever discovered outside our solar system. (Credit: NASA/Kepler Project/D. Berry)

Strategic Goal 3: Create the innovative new space technologies for our exploration, science, and economic future.

3.1 Sponsor early-stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.

3.2 Infuse game-changing and crosscutting technologies throughout the Nation's space enterprise to transform the Nation's space mission capabilities.

3.3 Develop and demonstrate the critical technologies that will make NASA's exploration, science, and discovery missions more affordable and more capable.

3.4 Facilitate the transfer of NASA technology and engage in partnerships with other government agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.

A research team from Purdue University go weightless aboard a Boeing 727 airplane during work conducted under our Facilitated Access to the Space Environment for Technology (FAST) Program. Sixteen research teams from small businesses, universities, and our Centers were selected competitively based on the value of their technology to NASA and the potential to increase the maturity of the technology through testing in reduced gravity conditions. During the 2010 FAST Flight Week, Purdue tested the a biochip as part of an advanced technology for fundamental space biology research. (Credit: NASA)

Strategic Goal 4: Advance aeronautics research for societal benefit.

4.1 Develop innovative solutions and advanced technologies through a balanced research portfolio to improve current and future air transportation.

4.2 Conduct systems-level research on innovative and promising aeronautics concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.

Strategic Goal 5: Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.

5.1 Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.

5.2 Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.

5.3 Ensure the availability to the Nation of NASA-owned, strategically important test capabilities.

5.4 Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.

5.5 Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success.

Strategic Goal 6: Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation, and contribute to a strong national economy.

6.1 Improve retention of students in STEM disciplines by providing opportunities and activities along the full length of the education pipeline.

6.2 Promote STEM literacy through strategic partnerships with formal and informal organizations.

6.3 Engage the public in NASA's missions by providing new pathways for participation.

6.4 Inform, engage, and inspire the public by sharing NASA's missions, challenges, and results.

Children learn while they play in an exhibit about the Sun at a Bring Our Children to Work Day at NASA. The Centers and Headquarters hold presentations and provide activities focusing on our Mission and the hosting location's primary capabilities. (Credit: NASA)

Strategic Goal 1

Extend and sustain human activities across the solar system.

Humanity's interest in the heavens has been universal and enduring. Humans are driven to explore the unknown, discover new worlds, push the boundaries of our scientific and technical limits, and then push further. NASA is tasked with developing the capabilities that will support our country's long-term human space flight and exploration efforts. We have learned much in the last 50 years, having embarked on a steady progression of activities and milestones with both domestic and international partners to prepare us for more difficult challenges to come. Our operations have increased in complexity, and crewed space journeys have increased in duration. The focus of these efforts is toward expanding permanent human presence beyond low Earth orbit.

We will pursue this goal through strategic investments and partnerships to drive advances in science and technology and deliver benefits to all humankind. To be successful, we will need equal and full participation from international partners and the commercial sector. We seek their partnership and mission-enabling contributions, as well as support capabilities and technologies. Additionally, we must develop a new space launch system and multi-purpose crew vehicle to support exploration activities.

We will continue to invest in research and development activities here on Earth, and we will make extensive use of our laboratory aboard ISS. With our international partners, we have sustained human presence in low Earth orbit for over a decade, transcending individual nationalism to live, work, and make discoveries in space that benefit us all. Mission by mission, these men and women are developing capabilities that will allow us to expand human space exploration across the solar system. In parallel, we will use the scientific data gathered by our robotic satellites and scouts to assess conditions in remote atmospheres and seek resources, like water- or oxygen-rich soil, that may be used by human explorers as we continue our human forays into the solar system.

To realize a robust space exploration program, we must use the intellectual and innovative wealth of the entire Nation, not just the scientists, engineers, technologists, and managers of NASA. We will enlist the research capacity of our colleges, universities, and aerospace partners to engage future generations of students. We also will encourage public contributions of innovation, and we will work with partners in the aerospace and other sectors to accelerate, develop, and implement capabilities and services that support all aspects of our missions.

NASA astronaut Tracy Caldwell Dyson, Expedition 24 flight engineer, looks through a window in the ISS Cupola at the blue and white of Earth. The Cupola is the largest window ever flown in space. Resembling a circular bay window, it allows the crew to monitor spacewalks and docking operations, as well as provides a spectacular view of Earth and other celestial objects. (Credit: NASA)

1.1 Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.

The ISS is a major stepping stone in achieving our exploration goals across the solar system. It provides a space-based research and development (R&D) laboratory to safely perform multidisciplinary, cutting-edge research. The international nature of ISS serves as a model for cooperation on future human space exploration missions beyond low Earth orbit. In collaboration with our international partners, we will extend the life-span of ISS to 2020 or beyond to maximize the potential of the Nation's newest National Laboratory. This continuously crewed laboratory enables the ongoing evolution of research and technology objectives and ensures that the benefits of this multinational investment in ISS can be realized.

This orbiting research laboratory allows us to develop, test, and validate the next generation of space technologies and operational processes needed to explore beyond low Earth orbit. It provides opportunities to address practical medical questions about astronaut health, including mitigating the effects of long journeys on space travelers, and supports a broad array of biological and physical sciences research to advance our knowledge and space flight capabilities. ISS also will host Earth and space observation instruments to expand our understanding of our home planet and the solar system and will support advanced engineering research and technology development for space exploration.

Under the auspices of an ISS National Laboratory non-profit management organization, we will continue to make the ISS available as a national resource, to promote opportunities for advancing basic and applied research in science and technology to other U.S. Government agencies, university-based scientists and engineers, and private firms. The National Laboratory management entity will be responsible for stimulating, developing, and managing a diversified R&D portfolio using the ISS to address U.S. needs.

ISS is transitioning from a focus on assembly to long-term operations and full utilization. A fully operational station allows us to pursue our mission-driven R&D goals, such as human biomedical research and spacecraft technology development, and support continued science and technology leadership. We look further forward, seeking to inspire the next generation of scientists and explorers by igniting a passion for STEM study and careers. ISS also provides a stable destination to facilitate the growth and evolution of new commercial opportunities, including crew and cargo transportation to low Earth orbit and beyond.

Strategy@Work

ISS is an unprecedented achievement in human endeavors to conceive, build, operate, and utilize a research platform in space. With our partners, we will use this permanently crewed laboratory in low Earth orbit to conduct multidisciplinary research and technology development and as a basis for human space exploration. Scientists from all over the world are already using ISS, putting their talents to work in many areas of science and technology and sharing their knowledge to improve life on Earth. We expect amazing discoveries from the activities aboard ISS.

Earth's horizon serves as a beautiful backdrop for ISS in this photo taken by an STS-131 crew member after Space Shuttle *Discovery* began to undock and separate from ISS. During its first decade in operations, over 200 explorers from 15 nations have visited the orbiting complex, and more than 600 experiments have been conducted aboard this amazing laboratory. (Credit: NASA)

1.2 Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.

To transform human space flight and develop other potential space markets, we must partner with U.S. industry to implement safe, reliable, and cost-effective access to and from low Earth orbit and ISS. Our programs are stimulating efforts within the private sector to enable a U.S. commercial space transportation capability. By providing expert advice, access to NASA facilities, and development funding, we foster entrepreneurial activity for developing and demonstrating commercial space transportation capabilities, which stimulates employment growth in engineering, analysis, design, and research. We will build on these valuable partnerships to support and promote commercial development as promising new markets arise.

A robust U.S. commercial space industry will reduce our reliance on non-U.S. human space flight systems and potentially lower the cost of access to space. Purchasing safe, reliable, and cost-effective crew and cargo transportation services will ensure that we satisfy our ISS obligations. This allows us to focus our resources on developing systems that can safely reach beyond low Earth orbit. In the future, we will seek to expand our partnerships for capabilities and services beyond low Earth orbit.

Strategy@Work

NASA's commercial crew initiative is designed to meet the objectives for our ISS crew transportation needs and enable the growth of a commercial human space flight industry for use by NASA and other customers. The commercial crew initiative represents a new way of doing business in human space flight and is based upon knowledge gained from prior NASA vehicle development programs.

SpaceX and Orbital Space Corporation are providing space transportation services to NASA. In the photo on the right, SpaceX launches their Falcon 9 rocket on its first flight to orbit from Cape Canaveral Air Force Station, next to the John F. Kennedy Space Center in Florida. In the photo below, Orbital's Taurus II stage one core structure arrives safely at the Wallops Flight Facility on December 3, 2010. The core is the first stage of the Taurus II vehicle. Orbital chose the Mid-Atlantic Regional Spaceport at Wallops (which is managed by the Goddard Space Flight Center) as the launch site for the Taurus II.

Credit: SpaceX

Credit: NASA

1.3 Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.

The first step in embarking on a long and challenging journey involves laying solid groundwork for a successful endeavor. Experienced personnel from across the Agency are building a set of "architectures," or mission frameworks, for multiple destinations in the solar system. These architectures include all aspects of mission performance—technologies, partnerships, safety, risk, schedule, and stakeholder priorities—that define the knowledge, capabilities, and infrastructure necessary to successfully support human space exploration. NASA, the President, and Congress will use these architectures to develop the roadmap for affordable and sustainable human space exploration. The core elements to a successful implementation are a space launch system and a multi-purpose crew vehicle to serve as our national capability to conduct advanced missions beyond low Earth orbit. Developing this combined system will enable us to reach cislunar space, near-Earth asteroids, Mars, and other celestial bodies.

Radiation exposure, behavioral health, and fitness challenges are important research program components for lowering risks of future extended-duration human space missions. As we continue to conduct research on human health and performance risks, we will be implementing an approach that has been endorsed by the National Academies' Institute of Medicine. This vital research, using data from our astronauts, will support and expand the knowledge base required for traveling at the frontiers of human space flight, allow us to develop effective countermeasures against the adverse effects of the space environment on the human body, and will spur technology development and innovation to protect crews.

Strategy@Work

A critical part of developing a plan for future human space exploration is finding reliable ways to mitigate the potential health risks. In September 2010, the ISS Expedition 24 crew installed the Muscle Atrophy Resistive Exercise System (MARES), a new facility available to support National Laboratory operations. Developed by the European Space Agency, MARES enables scientists to study the detailed effects of microgravity on the human muscle-skeletal system. It also provides a means to evaluate countermeasures for mitigating the negative effects of space flight, especially muscle atrophy.

Astronaut Shannon Walker, Expedition 24 flight engineer, works with MARES hardware during its installation in the Columbus Laboratory aboard ISS. (Credit: NASA)

Challenges

Advanced Technology Development. Innovative and affordable technologies are fundamental building blocks required to safely send humans beyond low Earth orbit and must be pursued over many years. These prioritized investments act as an economic stimulus across a broad spectrum of industries. Critical early components of this challenge include focused utilization, leveraged applications, and technology demonstrations aboard ISS.

Availability of Commercial Cargo and Crew Services. A key factor in sustaining and operating ISS is the ability to provide crew transportation and ensure cargo resupply following Shuttle retirement. We will continue to use the vehicles of our international partners for crew transportation, rescue, and cargo resupply until commercially provided capabilities are available.

Affordability and Sustainability. Exploration beyond low Earth orbit will span decades. While ideally, NASA's funding levels would be sufficient and sustainable to secure long-term stability of programs that will extend human presence into the solar system, that outcome is not guaranteed. We need to design an architecture that is affordable and sustainable over a long budget horizon. We will develop a program that can accommodate external changes by: employing innovative acquisition approaches; utilizing industry best practices; focusing on affordability, as well as performance factors; and continuing to work with interagency and international partners to ensure the safe execution of exploration missions beyond low Earth orbit.

Strategic Goal 2

Expand scientific understanding of the Earth and the universe in which we live.

NASA is expanding the scientific understanding of Earth and the universe by pursuing the answers to profound science questions that touch us all: How and why are Earth's climate and environment changing? How do planets and life originate? Are we alone? Using the priorities set by the Nation's best scientific minds through the National Academies' decadal surveys in Earth science, heliophysics, planetary science, and astronomy and astrophysics, we will develop, operate, and mine data from science missions that will have a global impact on humanity's understanding of our place in the universe and the sustainability of our home planet.

We are committed to appropriately balancing these four science areas to enable substantial progress on the priorities and objectives identified in their decadal surveys and on national mandates over a 10-year time frame. We manage a balanced portfolio of space missions and mission-enabling programs, including suborbital missions, technology development, research and analysis, and data archival and distribution to sustain progress toward these science goals. We will make investment choices based on scientific merit through open competition and peer review for both space mission development and research tasks.

We are operating more than 50 science missions and have more than 25 others in development. A key measure of our success is our progress toward achieving the science recommendations identified in each of the National Academies' decadal surveys. In 2005, an interim report by the decadal survey Committee on Earth Science and Applications from Space stated that the Nation's system of environmental satellites was "at risk of collapse," and their final report in 2007 noted that the situation had worsened. We are rectifying this and meeting national needs by accelerating pioneering research missions, initiating new climate continuity missions, and revitalizing interagency efforts. Through our interagency collaborations, we will lead the development and launch of the next generation of civil operational environmental satellites, including weather and climate satellites for the National Oceanic and Atmospheric Administration and successor Landsat satellites for the U.S. Geological Survey (USGS).

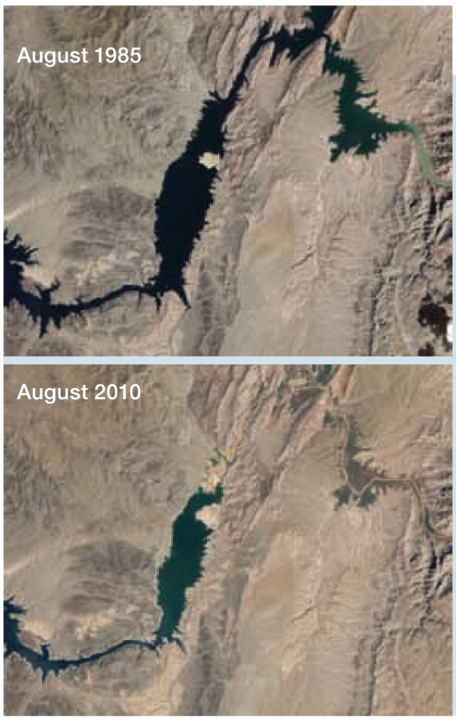
Ultimately, the pace of scientific progress is enhanced by rapid, open access to data from our science missions. We will establish and maintain effective international and interagency partnerships to leverage our resources and extend the reach of our science results. We also will share the adventure of our science missions, and the story of the science and research involved, with the public to engage them in scientific exploration and to improve STEM education nationwide.

This artist concept shows one of the Radiation Belt Storm Probes (RBSP) with its solar panels and booms deployed. We are developing RBSP to help us understand the Sun's influence on Earth and near-Earth space by studying our planet's radiation belts on various scales of space and time. It will explore fundamental processes that operate throughout the solar system, in particular those that generate hazardous space weather effects near Earth and phenomena that could affect solar system exploration. (Credit: NASA/JHU APL)

2.1 Advance Earth system science to meet the challenges of climate and environmental change.

NASA's pioneering work in Earth system science—the interdisciplinary view of Earth that explores the interaction among the atmosphere, oceans, ice sheets, land surface interior, and life itself—has enabled scientists to measure global and climate changes and to inform decisions by governments, organizations, and people in the United States and around the world. We make the data collected and results generated by our missions accessible to other agencies and organizations to improve the products and services they provide, including air quality indices, disaster management, agricultural yield projections, and aviation safety.

In addition to the missions in formulation at the time of the 2007 Earth science decadal survey release, we are now developing the first tier of missions the survey recommended, and we are conducting engineering studies and technology development for the second tier. Furthermore, we are planning implementation of a set of climate continuity missions to assure availability of key data sets needed for climate science and policy needs. These include a replacement for the Orbiting Carbon Observatory, planned for launch in 2013. We continue to play a major role in the U.S. Global Change Research Program, the U.S. Global Earth Observation working group, and their international affiliates to assure the mutual leveraging of interagency and international capabilities to meet our common goals.



The effect of drought and the increasing demand of a growing population are evident in these images taken by Landsat 5 of Lake Mead, the largest reservoir in the United States. The top image shows the Colorado River and the Gregg Basin (center) swollen with water. In the bottom image, the Colorado River is visible only as a brown line snaking up and off to the right. During 2010, Lake Mead reached its lowest level since 1956, holding just 37 percent of its potential capacity. Located east of Las Vegas and west of the Grand Canyon, Lake Mead provides power and water for Nevada, Arizona, southern California, and northern Mexico. (Credit: USGS)

Strategy@Work

Since the mid-1960s, the Goddard Space Flight Center and USGS have worked in concert to develop and maintain the Landsat series of satellites. Since the launch of Landsat 1 in 1972, the Landsat satellites have provided a continuous record of natural and human-induced landscape changes. The next Landsat satellite, the Landsat Data Continuity Mission (LDCM), scheduled to launch in 2013, will provide valuable data and imagery with broad applications in agriculture, education, business, science, and government. NASA and USGS are jointly planning the future of land imaging beyond LDCM.

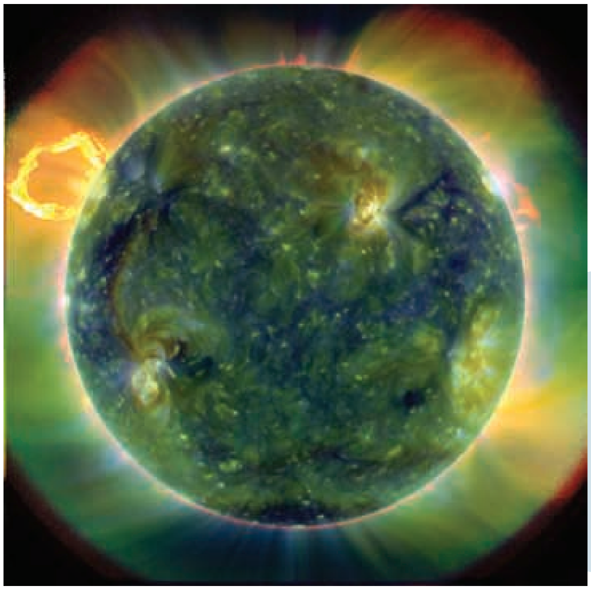
2.2 Understand the Sun and its interactions with Earth and the solar system.

Earth and the other planets of our solar system reside in the extended atmosphere of the Sun. This extended atmosphere, called the heliosphere, comprises a plasma "soup" of electrified and magnetized matter entwined with penetrating radiation and energetic particles. We experience space weather—disturbances in the plasma—from solar magnetic activity such as flares. Space weather effects range from awe-inspiring aurorae to widespread power and communication blackouts. Our heliophysics missions study the Sun, heliosphere, and planetary environments as elements of a single interconnected system. By analyzing the connections among the Sun, solar wind, and planetary space environments, we uncover fundamental physical processes that occur throughout the universe. Understanding the connections between the Sun and its planets allows us to predict the impacts of solar variability on human technological systems and to safeguard human and robotic space explorers outside the protective cocoon of Earth's atmosphere.

The Nation has never been so well prepared to monitor the onset of an upcoming solar cycle. NASA maintains a fleet of heliophysics spacecraft to monitor the Sun, geospace, and the space environment between the Sun and Earth, and we collaborate with other U.S. agencies and other nations' space agencies to enhance this capability. To advance space weather prediction capabilities, we make our vast research data sets and models available online to the public, industry, academia, and other civil and military interests. We also provide publicly available sites for citizen science and space situational awareness through various cell phone and e-tablet applications. Scientific priorities for future heliophysics missions are guided by decadal surveys produced by the National Academies. The next decadal survey for heliophysics will be completed in 2012.

Strategy@Work

The Solar Dynamics Observatory (SDO) provides nearly continuous observations of solar activity as part of a program to understand the causes of solar variability and its impacts on Earth. SDO employs three instruments to measure the Sun's magnetic field, the hot plasma of the solar corona, and the irradiance that creates the ionospheres of the planets. The observations enable researchers to predict the Sun's activity.



This SDO image of the Sun shows ultraviolet wavelengths, traces of hot plasma, and large eruptions on the Sun's corona. It is a composite of images taken on March 30, 2010, by SDO during a period called First Light, shortly after the instruments first opened their doors and began imaging the Sun. (Credit: NASA/Goddard Space Flight Center/SDO/Aerospace Industries Association)

2.3 Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

NASA's planetary science missions have revolutionized our understanding of the origin and history of the solar system. Our findings helped identify Pluto as one among many Kuiper Belt objects and led to new theories of the origins of the asteroid belt. Other missions indicated that Mars was once a watery world and have observed watery plumes and methane lakes on the moons of the giant planets. The launches of the New Horizons mission to Pluto and the Kuiper Belt, the Dawn mission to the asteroids Ceres and Vesta, and MESSENGER to explore Mercury's previously unseen hemisphere continue our initial reconnaissance of the major accessible bodies in the solar system.

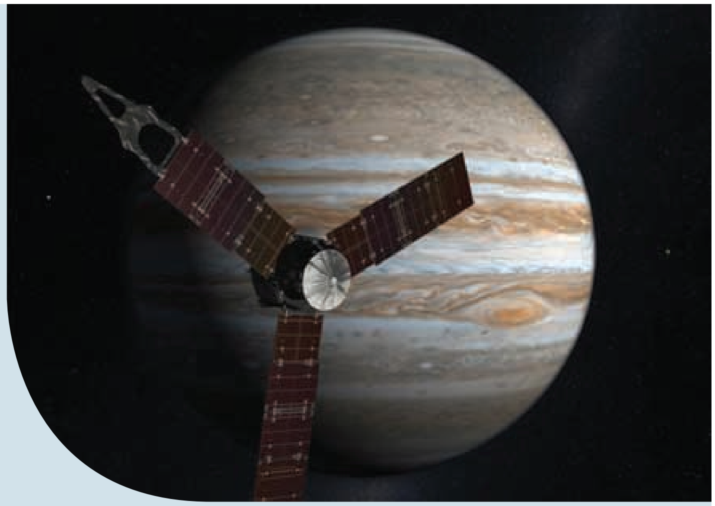
Closer to home, we are using ground-based assets in coordination with the National Science Foundation and the U.S. Air Force (USAF) to survey the volume of near-Earth space to detect, track, catalog, and characterize near-Earth objects that may either pose hazards to Earth or provide resources for future exploration. Mars, our closest planetary neighbor, is a near-term target for in-depth scientific exploration. The initial data we are gathering from our Mars rovers and orbiters is helping to inform planning and development of increasingly sophisticated Mars missions to assess present and past habitability of the red planet. We are planning and implementing an integrated Mars Exploration Program with the European Space Agency (ESA). Beyond Mars, New Horizons is on its way to the outer solar system, with Juno following in 2011, and we are jointly planning a flagship mission with ESA to the outer planets, targeting Jupiter's system of moons.

Building on decades of success, we intend to continue the use of robotic spacecraft to provide critical information to support safe, effective human space exploration beyond low Earth orbit. Our ongoing missions to the Moon and the inner solar system will generate knowledge to facilitate advanced robotic exploration and eventually prepare us for a sustained human presence outside of low Earth orbit. In parallel, we will continue to strengthen our coordinated implementation of international and interagency collaboration on robotic missions to meet the Agency's broadest objectives in science and exploration.

Scientific priorities for future planetary science missions are guided by decadal surveys produced by the National Academies. The next decadal survey for planetary science will be completed in 2011.

Strategy@Work

The Juno mission, scheduled to launch in 2011, will probe Jupiter's gravity, composition, and magnetic fields to search for the origin of planets. Arriving at Jupiter in 2016, Juno will determine how much water is in the planet's atmosphere. It will look deeply into the atmosphere to measure composition, temperature, cloud motions, and other properties. Juno's instruments also will map Jupiter's magnetic and gravity fields and magnetosphere. This evidence will help us understand planetary formation and how magnetic force fields affect the atmospheres.



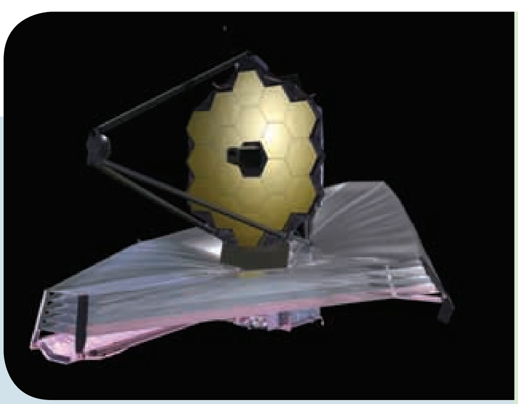
Juno approaches Jupiter in this artist's concept. The Jet Propulsion Laboratory manages the project. (Credit: NASA)

2.4 Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.

The 20th century marked a time of epic discoveries about the universe—the Big Bang theory, black holes, dark matter and dark energy, and the interrelated nature of space and time. NASA proudly leads the Nation and the world on the continual journey of scientific discovery to answer some of humanity's most profound questions about the solar system and universe: What are the origin and destiny of the universe? Does life exist elsewhere?

Having measured the age of the universe, we now seek to understand its birth, the edges of space and time near black holes, and the dark energy that fills the entire universe. We will explore the relationship between the smallest of subatomic particles and the vast expanse of the cosmos. Our missions will reveal the diversity of planets and planetary system architectures in our galaxy, pinpoint Earth-like, potentially life-supporting planets in other solar systems, and study stellar and planetary environments and what powers the most energetic galaxies. In conjunction with ground and airborne telescopes, our strategy is to design and launch space telescopes that exploit the full range of the electromagnetic spectrum to view the broad diversity of objects in the universe. Beyond the spectra of light waves, we also will seek to detect and measure gravity waves to understand the growth of galaxies and black holes.

The National Academies released its new astronomy and astrophysics decadal survey, *New Worlds, New Horizons in Astronomy and Astrophysics*, in summer 2010. In the decade ahead, we will work to implement the survey's recommendations and advance its science objectives.



This artist's concept of JWST shows its primary mirror, composed of 18 hexagonal beryllium mirror segments. Beneath the mirror is a five-layer sunshield, about the size of a tennis court, which protects the four extremely sensitive instruments that reside inside the telescope from the Sun's heat. (Credit: NASA)

Strategy@Work

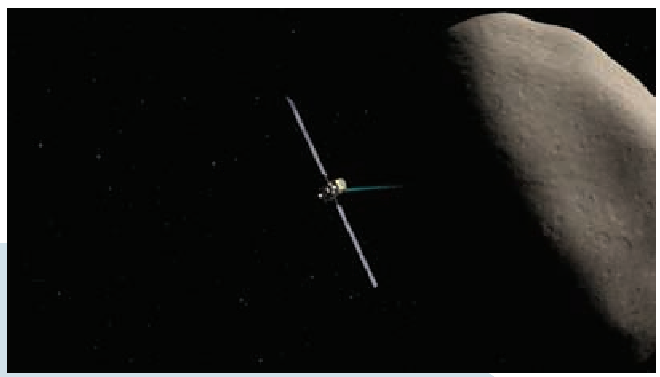
The James Webb Space Telescope (JWST) was the 2000 astronomy and astrophysics decadal survey top priority and the foundation upon which the 2010 decadal survey built its recommendations for future space astrophysics advances. Managed by the Goddard Space Flight Center, JWST will feature a 6.5-meter-diameter primary mirror and unprecedented sensitivity in the near- and mid-infrared wavelengths for both imaging and spectroscopy. As the next major general-user space facility, JWST will serve the worldwide science community and investigate areas such as the first stars and galaxies to form after the Big Bang, the formation of stars and planets in our galaxy, and the atmospheres of exoplanets.

Challenges

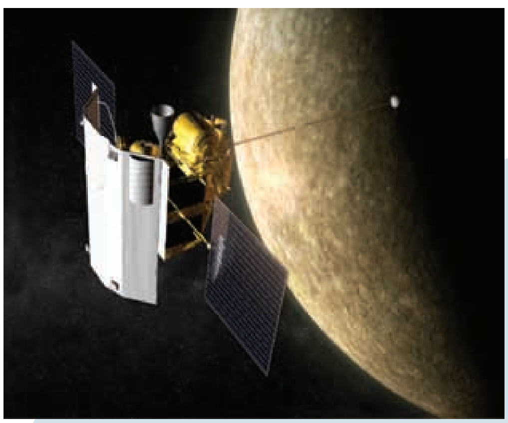
Access to Space. Science missions rely on expendable launch vehicles (ELVs) primarily acquired from commercial vendors. The pending retirement of the Delta II after 2011 leaves our science missions without a certified alternative vehicle in the medium ELV class. We are working with competitively selected vendors on new ELV offerings, but these are yet to be certified for our use. In the larger ELV class—those necessary for launch of nearly all our planetary science missions and many others—both increasing cost and limited availability are challenges. We are working with the USAF to assure availability at a manageable cost for this larger class.

Program Management. Over the last three years, we have fundamentally transformed how we manage our programs and projects, acquisition strategies, and procurements, particularly for our most complex science missions. We have strengthened program and project management, elevated acquisition decisions to our highest levels, instituted targeted enhancements to project management training, established more rigorous cost estimation practices, revamped the entire enterprise architecture for our acquisition systems, and revised procurement practices and systems. Nevertheless, significant management challenges remain as discussed, for example, in the report of the James Webb Space Telescope Independent Comprehensive Review Panel (released in November 2010). Many of the recommendations of that panel are being instituted Agency-wide. We also are working with the Government Accountability Office and others to further improve our program management capabilities.

Availability of Plutonium 238. Plutonium 238 activates and sustains the electrical power systems for spacecraft and planetary probes that cannot rely on solar energy, such as missions to the outer planets and large rovers on planetary surfaces. The total amount of Plutonium 238 available to NASA will be exhausted between 2017 and 2020. We are working with the Department of Energy in their effort to re-establish a domestic production capability.

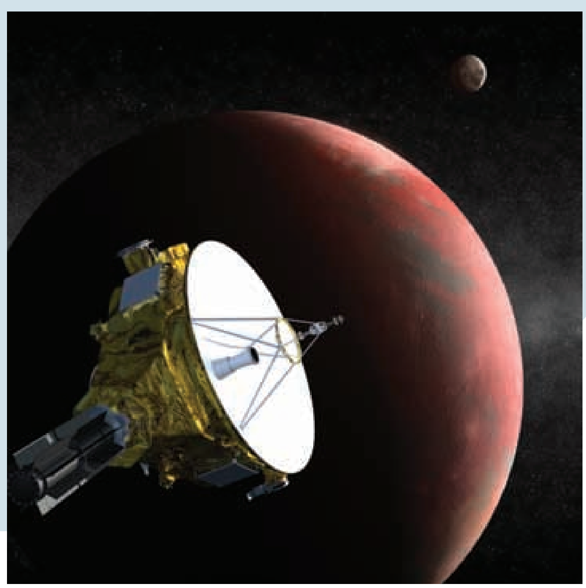


Credit: McREL



Credit: NASA/JHU–APL/CIW

Three planetary missions already launched by NASA are shown in these artist concepts. The MESSENGER spacecraft (upper left) will enter orbit around Mercury in March 2011. The Dawn spacecraft (upper right) will arrive at asteroid Vesta in July 2011 and then reach asteroid Ceres in February 2015. Finally, New Horizons (lower right) will arrive at Pluto in July 2015 and then will journey on to visit other Kuiper Belt objects beginning in 2016.



Credit: JHU–APL/SwR

Strategic Goal 3

Create the innovative new space technologies for our exploration, science, and economic future.

Our Nation's economic competitiveness is due in large part to decades of investment in technology and innovation. Since NASA's inception, we have used innovative technology development programs to generate new science, exploration, and aeronautics capabilities. Our innovations have enabled our missions, contributed to other government agencies' needs, cultivated commercial aerospace enterprises, and fostered a technology-based U.S. economy.

NASA will continue technology development programs that advance our missions' capabilities and effectiveness, and we will enable future scientific discovery and improved capabilities of other government agencies and the aerospace industry. Aggressive technology investments for our exploration and discovery missions will create a vibrant commercial space sector through the establishment of new markets in future technologies. We will transfer Agency-developed technologies, processes, discoveries, and knowledge to the commercial sector through various means including licenses, partnerships, and cooperative activities. These transferred technologies will be used to create products, services, cascading innovations, and other discoveries to fuel the Nation's economic engine and improve our quality of life.

Achieving our ambitious science and exploration objectives requires development of capabilities that do not yet exist or are currently too immature and too high-risk to use for current missions. The inclusion of an untried technology poses risks to planned budgets and schedules due to the unknown and unpredictable issues that may arise. To responsibly accelerate technologies for enabling future missions, we will create and sustain a portfolio that spans the technology readiness level (TRL) spectrum and balances mission-focused (pull) and transformational (push) technology investments. We will prioritize this portfolio using the Space Technology Grand Challenges, a set of important space-related problems that must be solved to efficiently and economically achieve our missions, and our Space Technology Roadmap, an integrated set of 14 technology area roadmaps. The National Academies is conducting a decadal-like survey based on our draft roadmap to identify and prioritize critical space technology investment areas.

This goal addresses three categories of technology investments that will expand the NASA portfolio across the TRL spectrum. The first set of technology investments focuses on fostering early-stage innovation in which a multitude of concept technologies are developed through a process of innovation, experimentation, idea generation, and investigation. We learn valuable lessons from these early-stage activities even when some of the technologies do not work as intended. Our technology efforts through student grants, fellowships, and other opportunities to inspire innovators will help grow a future workforce and stimulate greater creativity in our Nation.

The second category focuses on taking the best low-TRL technologies (those studied under the first category) and determining which of these "disruptive" innovations and technologies are viable through further technology development, prototyping, experimentation, testing, and demonstrations. The goal of these technology activities is to validate whether or not substantial improvements in affordability, capability, or reliability are truly achievable for missions.

The third type of technology investment supports technology development targeting near-term unique NASA mission needs. Through focused studies, dialogue, and development activities across NASA, as well as with academia, and industry, these technology activities will provide improved future technologies that are closely aligned with their associated missions.

Building a comprehensive portfolio with both near-term and long-term development streams will allow us to discover and advance high-payoff technologies that may fundamentally change the way we live and explore.

3.1 Sponsor early-stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.

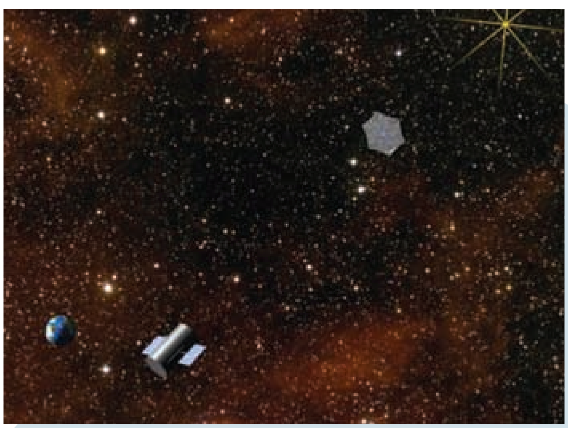
We consider early-stage innovation (low-TRL technology) to be the foundation of our development process. Investment in low-TRL technology increases knowledge and capabilities in response to new questions and requirements, and it stimulates creative new solutions to the challenges faced by NASA and the larger aerospace community. Investments in low-TRL projects, through partnerships with the public and private sectors, have historically benefited the Nation on a broad basis, generating new industries and spin-off applications and providing a cadre of new technology-savvy innovators to fuel the Nation's high-tech economy.

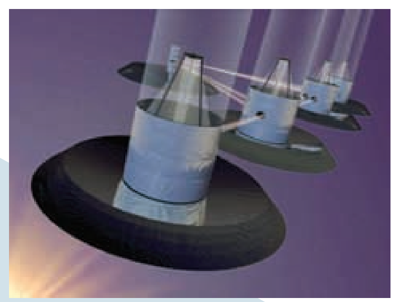
We will continue to engage the Nation's "citizen inventors" through prize-based challenges in areas such as satellite launch systems, advanced robotics, energy storage, green aviation, advanced materials, and wireless power transmission. We also will work to foster innovation within NASA, by providing Center R&D opportunities that capitalize on each Center's unique assets. To support studies and tests of visionary, long-term concepts, architectures, systems, and missions, we will continue to partner with other government agencies, academia, and the commercial sector.

Strategy@Work

The New Worlds Observer (NWO) is a large in-space instrument designed to block the light of nearby stars to observe their orbiting planets.

NWO started as a concept study in the NASA Innovative Advanced Concepts Program (formerly the NASA Institute for Advanced Concepts), part of the Office of the Chief Technologist at NASA Headquarters. This mission concept is one of several NASA has studied in recent years, including the Terrestrial Planet Finder, that have defined new possibilities for exoplanet detection and characterization. Findings from this futuristic concept have since informed the National Academies' astronomy and astrophysics decadal survey and have helped identify priorities and objectives for the next 10 years.





Left is an artist's concept of the New Worlds Observer. Above is an artist's concept of the Terrestrial Planet Finder. (Credit: NASA)

3.2 Infuse game-changing and crosscutting technologies throughout the Nation's space enterprise, to transform the Nation's space mission capabilities.

NASA requires a faster, more aggressive strategy for acquiring and applying new technologies if we are to create a sustainable set of affordable programs that achieve our longer-term goals. Without a robust effort that matures technologies and establishes their feasibility, the ideas and transformational concepts developed at a low TRL may not materialize into benefits for future NASA missions or our Nation's economy. We will bridge the gap between idea formulation and mission infusion to deliver improvements to our future missions. We will focus on maturing mid-TRL technologies and proving the feasibility of advanced space concepts and technologies that may lead to entirely new approaches to space system design and operations, exploration, and scientific research. Our technology development processes will provide tangible products capable of infusion into our missions, as well as into the commercial sector.

Through significant modeling, analysis, ground-based testing, and laboratory experimentation, we will mature technologies in preparation for potential system-level flight demonstrations within NASA or by other government agencies. Executing these challenging laboratory and space flight demonstrations requires: creating technology projects with well-defined milestones and schedules; developing facilities, laboratories, and flight test opportunities; fabricating materials, hardware, and software; developing and integrating technologies; and conducting demonstrations.

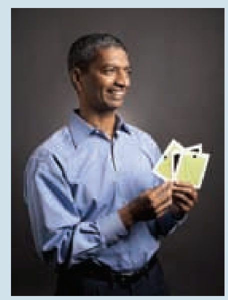
We will use an approach similar to the Defense Advanced Research Projects Agency (DARPA), the research and development agency for the U.S. Department of Defense (DOD). DARPA evaluates their technology investments annually for progress against baseline milestones and provides continued development support for promising investments. To ensure a collaborative environment and maximize our resources, we will work with other government agencies and share program management best practices. Recognizing the need to effectively leverage our workforce, we will use an optimized DARPA-like approach, in which we will rely on a combination of in-house and out-of-house workforce.

Strategy@Work

Bloom Energy can trace its roots to work performed at the Ames Research Center and the University of Arizona as part of our Mars space program. Originally, we charged a team with creating a technology that could sustain life on Mars. The team built a device capable of producing air and fuel from electricity and, conversely, electricity from air and fuel.

The technology quickly developed from concept, to prototype, to product. Bloom Energy has used the product to generate millions of kilowatts of electricity and eliminate millions of pounds of carbon dioxide, a greenhouse gas, from the environment.

The three layers of the Bloom Energy solid-oxide fuel cell combined steam and fossil or renewable fuel to create “reformed fuel.” Bloom Energy servers, shown left, are each the equivalent size of one parking spot. K.R. Sridhar (right) holds the fuel cell technology that is equivalent to 25 watts of power. A former researcher at the Ames Research Center, Sridhar now is the Chief Executive Officer of Bloom Energy. (Credit: Bloom Energy)



3.3 Develop and demonstrate the critical technologies that will make NASA’s exploration, science, and discovery missions more affordable and more capable.

Mission-driven technology development is intended to meet unique near-term mission needs within technical, cost, and schedule goals. We will use the Space Technology Grand Challenges, the Space Technology Roadmap, integrated architectures, and mission needs as resources to prioritize the desired set of future technologies that will offer the most synergies and advancement of mission capabilities. Using present approaches with this new strategy, we will enable advances and improved performance by furthering existing evolutionary technologies, as well as developing revolutionary new technologies. We will balance potential technology benefits with specific mission risks, to establish the appropriate time frame to infuse each emerging technology.

Across NASA, scientists and engineers will continue to collaborate on technology development, focusing on identifying technologies for future research and development, and testing promising concepts that will help achieve our mission objectives. We will draw from the creativity and innovation of our Nation’s scientists, engineers, and technologists while advancing U.S. technological leadership by partnering with industry, academia, other government agencies, and our international collaborators.

Strategy@Work

The Thermal Protection System (TPS), Advanced Development Project at the Ames Research Center developed ablative TPS options for the Orion crew capsule. The project advanced the mission planning options of our engineers by developing eight different TPS materials. The project re-invigorated an industry that was in danger of collapse and re-established a NASA TPS workforce. Mature heat shield technology and design options were transferred to the commercial space industry with implications for a wide variety of applications.

The team also discovered a potentially catastrophic heat shield problem with the Mars Science Laboratory and matured an alternate material—essentially avoiding mission cancellation.

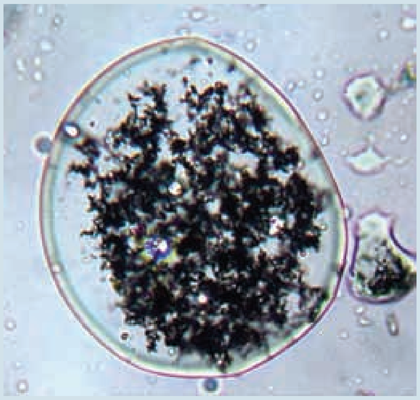
The Orion heat shield structure hovers above its layup mold during removal at the Lockheed Martin composite development facility. (Credit: Lockheed Martin)

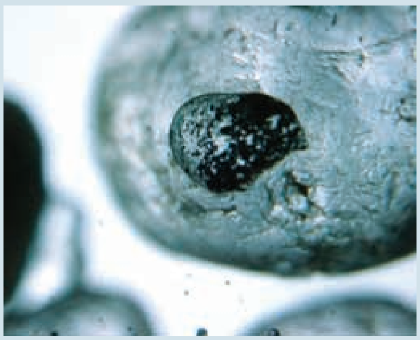
3.4 Facilitate the transfer of NASA technology and engage in partnerships with other government agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.

While technology and innovation are critical to successfully accomplishing our missions, an additional benefit is the positive impact on the Nation's economy. Recognizing a broader application of fundamental technology, we make a determined effort to transfer technologies outside of NASA and to develop technology partnerships. Our technology programs support our leadership in key research areas, fuel rapid improvements in mission capabilities, foster a robust industrial base, improve our competitive position in the international marketplace, enable new industries, and contribute to economic growth.

We seek partnerships and cooperative activities to develop technology that is applicable to our mission needs and contributes to the Nation's commercial competitiveness in global markets. Three key themes underscore our engagement with the emerging commercial space sector: considering the private sector as an investment partner, sharing the cost of developing a capability; purchasing services rather than hardware when possible; and fostering the creation of broader opportunities for innovation. Pursuing these partnership themes brings direct value to our current and future missions, advances the interests of the partners, and encourages additional commercial space development.

Beyond partnership strategies, we seek to transfer NASA technologies directly to other government agencies, the national aerospace industry, and the broader U.S. commercial sector. NASA-spurred advances in energy, communication, health, materials science, and other fields generate spinoff applications that benefit the Nation. We have established a core team at each NASA Center charged with technology transfer, licensing, and new partnership development, and we have tasked them to work closely with scientists and engineers to match our technologies with the needs of organizations external to NASA. We actively coordinate with state and local governments and regional economic development organizations to assess the market and develop strategies that will meet the emerging needs of NASA and our partners. We will continue to identify non-traditional strategies and approaches to engaging external partners, such as the use of auctions that highlight NASA patents available for licensing.





Strategy@Work

NASA's Kennedy Space Center collaborated with the University of Central Florida and GeoSyntec Consutants, Inc., to develop Emulsified Zero-Valent Iron (EZVI), a groundwater treatment system designed to eliminate chlorinated solvent pollution in impacted aquifers. EZVI encapsulates nano-scale or micro-scale iron particles in a water-in-oil emulsion. Both the water and iron particles react with the contaminants that naturally diffuse into the emulsion droplet's interior, rendering them non-toxic. EZVI was successfully developed, tested patented, and subsequently licensed for commercial use throughout the United States. To date, EZVI has been deployed in over 16 U.S. states and at one location in France and one in Japan. A U.S. industrial site was successfully removed from the U.S. Superfund National Priority List within one year after the application of EZVI due to successful removal of the contaminants.

The EZVI sample above shows micro-scale iron in the interior of a water-in-oil emulsion droplet, and the EZVI droplet left is on an individual sand grain. (Credit: above—R. DeVor, Univ. of Central Florida; left—NASA/J. Quinn)

Challenge

Implementation of a New Approach. Over the last decade, our technology development efforts have focused on incremental advances that enabled specific capabilities or missions. The increasing complexity and variety of challenges presented by our science, exploration, and aeronautics missions renders the incremental technology development model insufficient to meet our needs. Our emphasis on mission success requires a balance between accepting technology development risk to realize greater benefits and maintaining high mission success rates. The key strategy is to develop a diverse portfolio spanning the TRL spectrum, including near-term, mission-focused technologies and longer-term, high-payoff transformational technologies that solve difficult space-related problems. Through implementation of such a sustainable, strategic approach toward our technology development, we will address the immediate needs of NASA's missions, foster an innovative culture within the Agency to meet our long-term strategic goals, and contribute to the Nation's technological competitiveness.

A ground crewman unplugs electrical connections during pre-flight checks of NASA's Ikhana research aircraft at the Dryden Flight Research Center. From 2004 to 2006, we led a significant effort to assess the capabilities of Uncrewed Aerial Vehicles (UAVs) for civil use. Today, we use the Ikhana for Earth science research. We also are collaborating with the U.S. Department of Agriculture Forest Service to develop advanced fire surveillance technology. (Credit: NASA/T. Landis)

Strategic Goal 4

Advance aeronautics research for societal benefit.

A key enabler for American commerce and mobility, U.S. commercial aviation is vital to the Nation's economic well-being. NASA's aeronautics research contributes significantly to air travel innovation and aligns with the principles, goals, and objectives of the National Aeronautics Research and Development Policy and its related National Aeronautics Research and Development Plan. We explore early-stage concepts and ideas, develop new technologies and operational procedures through foundational research, and demonstrate the potential of promising new vehicles, operations, and safety technology in relevant environments. We are focused on the most appropriate cutting-edge research and technologies to overcome a wide range of aeronautics challenges for the Nation's current and future air transportation system.

NASA is addressing the research challenges that must be overcome to achieve the goals of the Next Generation Air Transportation System (NextGen) and to enable the design of vehicles that can support NextGen. Our goals are to expand airspace capacity, enable fuel-efficient flight planning, reduce the overall environmental footprint of airplanes today and in the future, diminish delays on the ground and in the sky, and improve the ability of aircraft to operate in all weather conditions while maintaining or exceeding exacting safety standards. Achieving NextGen's benefits will require contributions from all aeronautics research programs and continued collaboration with Government partners, academia, and industry.

As we look to future challenges in space exploration, we also are working to greatly advance fundamental understanding of the key aeronautics technologies that would make it possible to safely fly through any atmosphere of Earth or that of another planet. By expanding the boundaries of aeronautical knowledge for the benefit of all, our programs are helping to foster a collaborative research environment in which ideas and knowledge are readily shared and communicated.

We continue to work with our partners in other Government agencies, pursuing national goals while achieving our missions. Through the Joint Planning and Development Office (JPDO) we collaborate with the Departments of Commerce, Defense, Homeland Security, and Transportation, as well as the Federal Aviation Administration (FAA), and the White House Office of Science and Technology Policy. We work closely with JPDO agency partners to implement a multi-agency vision and plan that will resolve the serious challenges facing the U.S. air transportation system. We also participate in industry working groups and technical interchange meetings at the program and project level to solicit feedback from the broader community.

Through NASA Research Announcements, we support new and innovative ideas from industry and academia while providing support for STEM instruction and learning. We fund undergraduate and graduate scholarships, issue Innovation in Aeronautics Instruction grants to improve teaching programs at the university level, and sponsor student design competitions at undergraduate and graduate levels for both U.S. and international entrants. By directly connecting students with NASA researchers and our industrial partners, we become a stronger research organization while inspiring students to choose a career in the aerospace industry.

The Double Bubble D8 comes from a research team led by Massachusetts Institute of Technology, which participated in an 18-month NASA research effort to visualize the passenger airplanes of the future. Based on a modified tube and wing with a very wide fuselage to provide extra lift, the low sweep wing of the D8 reduces drag and weight and the embedded engines sit aft of the wings. The D8 series aircraft would be used for domestic flights and is designed to fly passengers in a coach cabin much roomier than that of current single-aisle aircraft. (Credit: NASA/MIT)

4.1 Develop innovative solutions and advanced technologies, through a balanced research portfolio, to improve current and future air transportation.

By 2025, air traffic within American airspace is projected to at least double its current rate. Future needs will exceed the limited solutions that aviation currently offers, requiring improvements in capacity, environmental compatibility, robustness, and freedom of mobility throughout the airspace while maintaining or increasing safety. From foundational research to integrated system capabilities, a broad portfolio is required to meet this challenge.

Our fundamental research programs take an integrated approach to address the critical long-term challenges of NextGen. These programs ensure a long-term focus on both traditional aeronautical disciplines and relevant emerging fields for integration into multidisciplinary system-level capabilities for broad application. This approach will enable revolutionary changes to both the airspace system and the aircraft that fly within it.

We continually seek to improve technology that can be integrated into today's state-of-the-art aircraft while enabling game-changing concepts for future generations of aircraft. Technologies for significant reductions in drag (thus improving fuel efficiency) and reduced fuel consumption compared to today's aircraft are key areas of research. We also are addressing the challenges to enable new rotorcraft and supersonic aircraft and conducting foundational research to realize sustained hypersonic flight. Research in the disciplines of materials and structures, propulsion systems, and airframe systems contribute to reducing fuel consumption, noise, and emissions for subsonic fixed wing aircraft and contribute to the development of revolutionary vehicle concepts and tools. Another key research goal is to characterize and understand the effects of synthetic and biological fuel alternatives on conventional jet aircraft systems using petroleum-based fuels and to develop technologies to enable fuel-flexible jet engines of tomorrow.

Our safety research spans aircraft operations, air traffic procedures, and environmental hazards. We aim to ensure that aircraft and operational procedures maintain the high level of safety that the American public has come to count on. The full realization of NextGen requires research to meet additional safety goals such as the capability for automated detection, diagnosis, and correction of adverse events that occur in flight and that crew workload and situational awareness are both safely optimized and adapted to the NextGen operational environment.

In the area of airspace systems, we conduct research in air traffic management concepts and technologies covering gate-to-gate operations on the airport surface, on runways, in the dense terminal area, and in the many en route sectors of the national airspace. As an example of its benefit, systems analysis results indicate that nearly 400 million gallons of fuel could be saved each year if aircraft could climb to and descend from their cruising altitude without interruption. To achieve this improvement, safe and efficient flight operation procedures first must be developed, validated, and certified for operational use. Our work will improve efficiency and reduce the environmental impact of aviation.

To stimulate new and innovative research in each of these areas and to ensure effective knowledge transfer from our work, we pursue strong teaming arrangements with other Federal agencies, large companies, small businesses, and universities.

This NASA DC-8 aircraft at the Dryden Flight Research Center is outfitted for alternative fuels emissions testing and measurement. (Credit: NASA)

Strategy@Work

NASA is conducting long-term fundamental research to understand the effects of various alternative fuels on aircraft engine emissions. Alternative fuels offer the potential for a significantly reduced carbon footprint over the entire life cycle, from fuel production to utilization. We have conducted ground tests using a NASA-owned DC-8 plane to study emissions from engines burning alternative fuel, which included two 100 percent synthetic fuels and blends of regular jet fuel with the synthetic fuels. The tests provided data that will improve understanding of the evolution of particulate emission and plume chemistry for engines burning alternative fuel. We conducted these tests in partnership with 11 other organizations including the FAA, U.S. Air Force Research Laboratory, Environmental Protection Agency, Boeing, GE Aviation, and Pratt & Whitney.

4.2 Conduct systems-level research on innovative and promising aeronautic concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.

NASA evaluates and selects the most promising concepts emerging from our fundamental research programs for integration at the systems level. We will test integrated systems in relevant environments to demonstrate that the combined benefits of these new concepts are in fact greater than the sum of their individual parts. By focusing on technologies that have already proven their merit at the fundamental level, we will help transition these technologies more quickly to the aviation community, as well as inform future fundamental research needs. We also will advance capabilities to design and integrate complex aviation systems. To date, the Integrated Systems Research Program (ISRP) has focused on the development of technologies and operational procedures to decrease the significant environmental impacts of the aviation system. We will focus on delivering validated data and technology that could enable routine operations for unmanned aircraft systems of all sizes and capabilities in the national airspace system and NextGen. In addition, we are integrating and evaluating new operational concepts through real-world tests and virtual simulations.

Our research approach will facilitate the transition of new capabilities to manufacturers, airlines, and the FAA for the ultimate benefit of the flying public. The integrated system-level research in this program will be coordinated with our ongoing long-term, fundamental research, as well as with the efforts of other Federal agencies.

Strategy@Work

The X-48B, an example of a blended wing body (BWB) configuration, is a remotely piloted aircraft with a hybrid shape that resembles a flying wing. The Integrated Systems Research Program develops and evaluates new integrated technologies and configurations such as the BWB aircraft to assess their potential to enable cleaner, quieter, and higher-performance air transportation. The X-48B was developed in partnership with USAF, Boeing, and Cranfield Aerospace Ltd.

The X-48B BWB subscale demonstrator banks over desert scrub at Edwards Air Force Base, near Dryden Flight Research Center, during a flight test. (Credit: NASA/C. Thomas)

Challenges

Inherent Risk. We pursue challenging, cutting-edge technology advances and aeronautics research goals that are inherently high risk. In accepting this risk, we gain valuable knowledge and advance the capabilities of the Agency, even when results fall short of expectations. By increasing our knowledge base and developing potential new solutions, we are able to make better-informed decisions regarding committing future research resources and pursuing promising high-return investments.

Partnership Influences. Our aeronautics partnerships provide many benefits, but they also introduce external dependencies that influence schedules and research output. We mitigate these risks through continual coordination with our partners. In doing so, we ensure we are moving forward on the right challenges and improving the transition of research results to users.

Strategic Goal 5

Enable program and institutional capabilities to conduct NASA's aeronautic and space activities.

NASA relies on program capabilities and institutional capabilities to accomplish our Mission. Our program capabilities, which are focused on meeting multiple complex programmatic objectives, encompass NASA-unique facilities, management of our scientific and engineering workforce, and the equipment, tools, and other required resources. Our institutional capabilities encompass a broad range of essential technical and non-technical corporate functions for the entire Agency. Engineering, systems engineering, and safety and mission assurance capabilities underpin the success for all our technical activities. Information, infrastructure, and security capabilities support the productivity of our scientists and engineers. Capabilities in human capital management, finance, procurement, occupational health and safety, equal employment opportunity (EEO) and diversity, and small business programs contribute to the strategic and operational planning and management that ensure resources are available when needed. Facilitating communications with the broad range of external communities important to our missions are capabilities in international and interagency relations, legislative and intergovernmental affairs, and strategic communications. These representative capabilities speak to the complexity of mission support, which in total consists of the program and institutional capabilities, resources, and related processes that support our mission requirements and Agency and Center operations.

Successful mission support requires integration of all elements across organizational and functional boundaries, and application of an Agency-wide view in making investment decisions. The linkage between our mission portfolio and our mission support elements must be understood through analyses to assess risks, opportunities and efficiencies, and then acted upon. Integration requires a strong governance structure to harmonize policies and business practices, mitigate conflicting requirements, and enforce the internal controls that oversee the effectiveness, efficiency, reliability, and compliance of our operations.

Our governance structure includes a decision-making process guided by short- and long-term considerations to create a balanced and integrated mission support portfolio. We use an approach that is requirements-oriented (aligned with missions and external requirements, e.g., legislation) to provide basic Center operations and an optimal mission support environment.

We also are addressing strategic themes such as affordability and sustainability for longer-term planning of our program and institutional capabilities. Components of these themes include green initiatives and energy efficiency, workforce alignment and readiness, diversity, improved acquisition, and eliminating Center duplication of capabilities. Our program and institutional capabilities must thus ensure, in the present and in the future, that core services and resources are ready and available Agency wide for performing our Mission.

Fire and steam signal a successful test firing of Orbital Sciences Corporation's Aerojet AJ26 rocket engine at the Stennis Space Center on December 17, 2010. Orbital will use AJ26 engines to power their Taurus II space vehicle on commercial cargo flights to the International Space Station. In addition to the Orbital partnership, Stennis also conducts testing on Pratt & Whitney Rocketdyne's RS-68 rocket engine. Stennis spent more than two years modifying the E-1 test stand in preparation for the testing. Through these kinds of modifications and upgrades, we ensure that our facilities meet our program and partner needs. (Credit: NASA)

5.1 Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.

We have a workforce that is skilled, competent, and dedicated to our missions. Our workforce also is passionate about their work, and they bring many dimensions of diversity, including ideas and approaches, to make their teams successful. To continue the successful conduct of our missions over the next 20 to 30 years, we must maintain and sustain our diverse workforce with the right balance of skills and talents. Our mission and institutional organizations work collaboratively to identify future needs and to identify gaps and potential shortfalls in skills. They also cooperatively plan Agency-level participation in new employee recruitment efforts.

We recruit talented people, seeking a workforce that is inclusive of all, regardless of race, color, national origin, sex, religion, age, disability, genetic information, sexual orientation, status as a parent, or gender identity. We work aggressively to identify and eliminate environmental factors that can diminish trust, impair teamwork, compromise safety, and ultimately undermine excellence. We conduct an annual self-evaluation as part of our Model EEO Plan, which is designed to identify and remove barriers to individual and team success. This evaluation helps us build a model workplace that promotes personal and professional growth, and respects and values the contributions of every member on our team. We also have established a Diversity and Inclusion Framework to increase the diversity of our workforce and the overall inclusiveness of our work environments. The framework takes us beyond a focus on EEO compliance to policies and practices designed to enhance innovation, creativity, and employee retention.

To align human resources with our mission, goals, and objectives, we conduct workforce analysis and planning. These systematic processes are used to identify and address the gaps between our current workforce and our future human capital needs. This enables us to determine the skill sets we need and identify which positions will require additional strategies to fulfill them. Our workforce development and training initiatives help redirect our employees in response to changing mission priorities. We provide leadership training and development programs to help mature the potential of our high-performing employees, making certain that we have readied our future leadership to pursue our long-range objectives. In conjunction with initiatives for our current workforce, we sponsor education programs to provide highly specialized research and engineering experiences to students with an interest in aeronautics and astronautics. By providing undergraduates and graduate students with hands-on opportunities to contribute to our current missions, we are effectively providing on-the-job training to the next-generation workforce.

NASA Mid-Level Leader Program participants gather for a photo during a meeting at the Johnson Space Center. The program provides significant leadership development opportunities for a diverse, Agency-wide group of individuals who have high potential for assuming greater leadership responsibilities throughout the Agency. As part of this program, participants learn to enhance their leadership skills and effectiveness in areas critical to our success, including communication, team building, trust building, influence, diversity and inclusion, decision making, and leading and managing change. (Credit: NASA)

Strategy@Work

As a learning organization, NASA provides robust leadership development programs and training for its employees. At the core is a continuum of development training and programs targeted to all levels ranging from GS–11 emerging leaders to senior executives. Change management is a key feature throughout the leadership curriculum, ensuring employees of today and tomorrow are prepared to lead as we evolve in a continually changing environment.

5.2 Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.

To safely and successfully conduct our many missions, we must ensure that we plan for, operate, and sustain the infrastructure that provides our program and projects with the facilities, capabilities, tools, and services they require. On an ongoing basis, we must ensure programmatic and institutional types of capabilities are available and effectively sized to support our current and future missions.

Toward that end, we perform periodic Agency-level integrated assessments of the supply of technical capabilities across all NASA Centers and integrated analyses of the demand for these capabilities across all NASA programs. This provides us with core information needed to balance institutional supply with program and project demand to ensure that capabilities are affordable and aligned with our long-term strategic goals.

In addition to periodic integrated assessments, we continuously work on planning, implementing, and evaluating our institutional and program mission support capabilities through master planning efforts. Active management in this arena helps us to assess institutional performance, identify and track resolution of identified issues, and coordinate resources across the Agency. This coordination improves resource planning, centralizing operations where appropriate, and balances cost, quality, and availability of our capabilities and assets to help minimize institutional risk to our missions. With this systemic view, we are able to incorporate best practices and standard processes and gain efficiencies by eliminating redundancies and assets that no longer benefit the Agency. Our integration of master planning guides actions such as consolidating and renewing needed capabilities, developing comprehensive energy and water conservation plans, planning budgets for repairs, and measuring progress and trends. Master planning also allows us to perform cross-Center assessments to examine further opportunities for consolidation of capabilities. As we update our mission plans and translate them into specific programs and projects, the use of master planning links mission support elements with projected funding to support our programs and their strategic objectives.

Strategy@Work

Our efforts to generate and use renewable energy sources include the ability to form and collaborate on effective public–private sector partnerships. At the Kennedy Space Center, we have teamed up with Florida Power & Light to provide new sources of green energy to both America's space program and Florida's residents. Continued collaboration on this joint venture also will help us meet our goals for use of power generated from renewable energy sources.

Through an "enhanced use lease" agreement, Florida Power & Light has built a 10 megawatt photovoltaic farm to generate power for the Kennedy Space Center grid. (Credit: NASA)

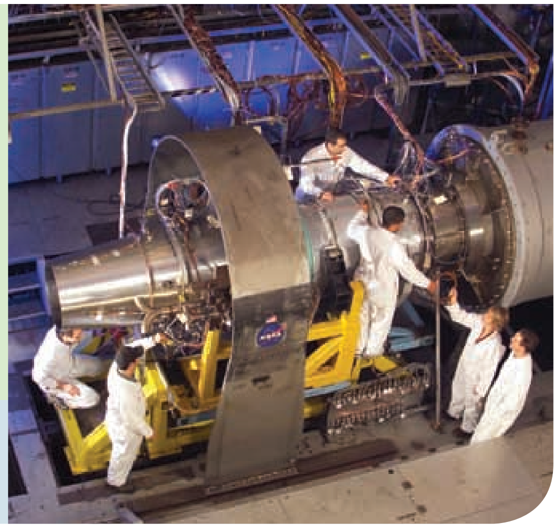
5.3 Ensure the availability to the Nation of NASA-owned strategically important test capabilities.

NASA has one of the largest, most versatile, and comprehensive sets of research and test facilities in the world. Our programs, other Federal agencies, and the private sector use the facilities to test and evaluate items to mitigate risk and optimize engineering designs. This work spans the engineering life cycle, from basic research to developing a discrete technology, to a full subsystem and system development. We manage our facilities and make strategic investments to ensure that ready access to comprehensive testing, with our flight research assets and in our state-of-the-art ground test facilities, is available for our missions and to the public and private sectors. We provide the vision and leadership for these nationally important assets and sustained support for their workforce, capability improvements, and new test technology development. By staying up to date on technological advances, industry demand, and issues that concern the public, we are able to make decisions on facility investments and divestments.

Additionally, we are responsible for building and maintaining a well-coordinated suite of national testing capabilities in collaboration with DOD through the National Partnership for Aeronautical Testing. Looking to the future, we will continue to develop and implement a facility investment and divestment plan that fully supports the current and long-term missions of NASA, DOD, and American industry.

Strategy@Work

The collaboration between our Aeronautics Test Program and Aviation Safety Program is providing a new testing capability in the Propulsion Systems Laboratory (PSL) for addressing the threat of high-altitude ice crystals to jet engine operability. The program recently demonstrated, for the first time, the ability to generate ice crystals at the very cold temperatures (–60 degrees Fahrenheit) encountered at the cruise altitudes of commercial aircraft. The PSL high-altitude ice crystal capability will become operational in FY 2011 and available to our Government partners and industry.



The Aeronautics Test Program used American Recovery and Reinvestment Act funds for the installation of its ice particle capability in PSL at the Glenn Research Center. (Credit: NASA)

5.4 Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.

An uninterrupted, reliable communications network is essential to receiving and transmitting the data that makes our space missions safe, efficient, and successful. This communications network is critical to space missions, providing the telemetry, tracking, and command activities required by each spacecraft. Communications capabilities enable us to transfer key data to ground systems, manage space operations, and maintain voice communications with crews on human space flight missions. As new spacecraft with different objectives and advanced technology are launched, communication needs change. In response, we modify and evolve our space communications capabilities to ensure our mission needs are fulfilled.

Our Space Communications and Navigation (SCaN) Program will continue its development of a unified space communication and navigation network capable of meeting robotic and human space exploration needs. We will use a new architecture definition document to guide the design of an integrated network architecture and the standards for the next generation of space communications. We also will continue to use competitive sourcing to acquire major modernization upgrades to the Space Network Ground Segment and to accomplish integration of the SCaN networks to a single, comprehensive network. Through close and ongoing cooperation with our international partners, we will work to develop cross-support network compatibility and interoperability for efficiency and effectiveness.

Assuring reliable and cost-effective access to space for payload missions also is critical to achieving our goals. Through our Launch Services Program (LSP), we are responsible for understanding the full range of civil space launch needs and working closely with other Government agencies and the launch industry to ensure that the safest, most reliable, on-time, and cost-effective commercial launch opportunities are available over a wide range of launch systems. LSP personnel work with customers from universities, industry, Government agencies, and international partners from the earliest phase of mission planning to purchase fixed-price launch services from domestic suppliers. LSP personnel also seek opportunities to share unused payload capacity aboard non-NASA launches to leverage launch funds. Most importantly, they provide oversight to ensure that our valuable, one-of-a-kind missions achieve their space flight objectives.

Strategy@Work

Our SCaN architecture is designed to provide a scalable, integrated, mission-enabling infrastructure that can readily evolve to accommodate new and changing technologies. SCaN enables our science, space operations, and exploration missions by providing comprehensive, robust, and cost-effective space communications services at exponentially-high data transmission rates.

The Goldstone Deep Space Communications Complex 70-meter antenna, glowing under an evening sky, serves as an integral part of the Deep Space Network. One of three main components of the SCaN communications infrastructure, the Deep Space Network communicates with our assets beyond low Earth orbit and throughout the solar system. The Jet Propulsion Laboratory manages our Deep Space Network. (Credit: NASA)

5.5 Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success.

Across the Agency, we seek and maintain strategic partnerships that leverage resources and increase the impact of our activities. Partnerships within the U.S. Government and with international, academic, and industrial organizations help us execute our missions more efficiently and effectively. We work cooperatively to identify common goals, develop new technologies and applications, and leverage technical expertise to minimize risk. Partnerships allow us to optimize the use of our research and testing facilities, our laboratories, and the talents and skills of our employees.

The National Space Policy includes direction to use inventive, nontraditional arrangements to acquire commercial space goods. We are exploring mechanisms such as building public–private partnerships, hosting Government capabilities on commercial spacecraft, and purchasing scientific or operational data products from commercial satellites. The ability to competitively procure technology or services when needed, rather than maintain a capability that cannot be fully used, will allow us to focus our resources for institutional and program capabilities in areas of evolving strategic importance. Greater varieties of partnerships within the Federal Government, and other innovations and collaborations for shared business services, also will allow us to focus on the activities essential for mission performance.

ISS Expedition 23 crewmembers from bottom left to right are: NASA astronaut Tracy Caldwell Dyson (flight engineer); Russian cosmonaut Alexander Skvortsov (flight engineer); and Japan Aerospace Exploration Agency astronaut Soichi Noguchi (flight engineer). In the center is Russian cosmonaut Oleg Kotov (commander). On the top row from left to right are: NASA astronaut T.J. Creamer (flight engineer) and Russian cosmonaut Mikhail Kornienko (flight engineer). (Credit: NASA)

Strategy@Work

The successes of ISS extend beyond purely science and technology. The human and global achievement cannot be measured in dollars, rubles, yen, or any other monetary unit. ISS construction and operation represents a model of unparalleled international cooperation and collaboration in planning, monitoring, and execution. This applies to ISS itself and the knowledge and human benefit it generates. The principal partnering space agencies for ISS are from Canada, Europe, Japan, Russia, and the United States.

Challenges

Meeting Changing Facilities Requirements. The challenges faced in managing the program and institutional capabilities and assets of NASA are as diverse as the operational functions we perform. A common challenge is managing current resources and capabilities and anticipating needs when new discoveries are being made and where technologies constantly are evolving. We maintain flexibility in our facilities management processes, supporting work that is critical to our programs, but allowing for changes in terms of size, number, type, or other requirements. An important subset of this is updating or replacing our aging or obsolete facilities. This is an area in which we are developing multi-year Center plans and one that we must manage aggressively to reduce facility costs and improve our overall capabilities. We seek optimal solutions in how we conduct our operations, often leveraging resources and opportunities offered by our partners or seeking products and services from commercial sources.

Achieving and Sustaining State-of-the-Art Technologies for Institutional Capabilities. To realize future cost, schedule, and quality improvements, we must stay current with technological progress. We actively monitor the R&D work of other Federal agencies, industry, academia, and other nations. We conduct studies and planning activities across the Agency to determine the potential mission applicability of emerging and maturing technologies. New tools, processes, and technologies improve our capabilities and scientific returns, but cannot be predicted in advance. Our institutional management processes must be sufficiently robust to maintain our research, testing, and operations capability, while allowing us to adopt and benefit from the latest technologies and innovations.

Managing a Distributed Infrastructure Base. Our program management is distributed across numerous mission areas and geographically separated Centers and facilities. This presents challenges in implementing a consistent and cost-effective set of processes, systems, and tools. Differences in local and state policies, zoning and environmental regulations, and even energy costs impact our ability to create and implement a consolidated approach. At every Center and facility, we take a proactive and cooperative approach in working with local, state, and Federal regulatory entities to mitigate possible negative impacts before policies or rules are finalized. By adhering to a common set of values and operating principles, but allowing for flexibility in implementation, we minimize risk to our missions and position the Agency for success in our future endeavors.

Researchers test the Boeing Aerodynamic Efficiency Improvement Joined Wing wind tunnel model in the Langley Research Center's Transonic Dynamics Tunnel. They are working with the Air Force Research Laboratory to develop technologies for future high-altitude, long-endurance uncrewed aircraft. The joined wing model "flew" in the wind tunnel so engineers could assess the surfaces and sensors that help control the aircraft. (Credit: NASA/S. Smith)

Strategic Goal 6

Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation, and contribute to a strong national economy.

At NASA, sharing information is a mandate within our founding legislation. Throughout our history, it has been a priority to make data from science missions, research, and other discoveries available for the benefit of the Nation. Our missions are a natural means of interacting with the public and supporting students and teachers. Through the excitement of missions and activities, we help stimulate student interest and achievement in science, technology, engineering, and mathematics (STEM) fields. STEM-focused teachers use their skills to motivate student achievement and spur creative and critical thinking both in and out of the classroom. In developing student interest and skills, future workers will be prepared to solve technical challenges that benefit our Nation and improve the quality of life on Earth. An American public that is knowledgeable and interested in science, aeronautics, and exploration will value the impact of advances in these fields that help maintain global competitiveness and a robust economy.

NASA offers structured programs for students and college faculty to engage in STEM learning activities such as competing in technical design challenges, launching student-built payloads, and participating in research and hands-on engineering experiences using real-world platforms, including high-altitude balloons, sounding rockets, aircraft, and space satellites. Undergraduate and graduate students can contribute directly to our missions by working with scientists and engineers on their research and technology development programs. Workshops, courses, and grant awards help teachers use NASA themes and materials to inspire their students in STEM topics.

As we continue our traditional means of outreach through print, television, and live events, we also have adopted emerging technologies and media that allow greater access and participation by the public, students, and teachers. Virtual events, live streaming video, online chats, and social media are some of the tools we use to broadly share our message and encourage active participation. Our online presence also has become an essential tool for fostering transparency in our operations and management practices, and we will continue to share information with the public on how we work.

Middle school students attending Hampton University's Young Doctor's Program work on the design of a robotic arm. The K-12 Programs Manager at the Langley Research Center chose them to participate in the challenge, held as part of our Summer of Innovation initiative to boost learning in science, technology, engineering, and mathematics. (Credit: NASA/S. Smith)

6.1 Attract and retain students in STEM disciplines along the full length of the education pipeline.

Education and industry experts have long warned our national leaders of an impending crisis in STEM education. Persistent calls to action warn us that failure to build a future workforce proficient in STEM will have adverse impacts on the economic growth and global competitiveness of the United States. International assessments consistently show that the performance of American students is lagging behind that of other nations. As part of the national imperative to encourage students to pursue STEM studies and the myriad career opportunities that could be open to them, we will continue our efforts to help inspire the passion and creative potential of our students.

We employ education specialists at each NASA Center to work with local and regional constituents, customers, and industry partners to best map resources and opportunities that meet the needs of the education community. This distributed management system allows us to be responsive to national priorities and initiatives, such as "Race to the Top" and "Educate to Innovate," while maintaining flexibility in delivering products and services to teachers and students. Our specialists work directly with elementary and secondary educators through local and national education organizations. In those interactions, elementary, secondary, and informal educators learn how to translate our current research and technology advances into meaningful education experiences that inspire their students.

At the elementary and secondary school levels, we actively encourage students to think positively about STEM as they develop their knowledge, skills, and long-term career interests. At the undergraduate and graduate levels, we work hand-in-hand with colleges and universities to provide student research and engineering experiences that contribute to our missions. To ensure that beneficiaries of our Agency-funded educational programs are afforded equal opportunities, regardless of race, ethnicity, gender, age, or disability, we conduct compliance reviews and offer support and strategies to improve access.

Strategy@Work

The Internet expands the reach of our education experiences to those who cannot easily access NASA Centers and facilities. New technologies and delivery media allow students and teachers to interact with our scientists and engineers, regardless of distance in terms of geography, time zones, or preferred communication styles. Experimenting with how we deliver our education programs and products keeps us current with the tools preferred by a new generation of Americans.

These students are applying real-time NASA satellite data to better understand concepts in their elementary mathematics lessons. Activities that incorporate NASA themes, like meteorology, oceanography, and technology, help to build analytical skills and spur interest in science, technology, engineering, and mathematics. (Credit: U.S. Satellite Laboratory)

6.2 Build strategic partnerships that promote STEM literacy through formal and informal means.

In the same way a complex mission takes millions of ideas, thousands of workers, and hundreds of companies working toward specific objectives to be successful, it will take the same type of effort to improve STEM literacy. The complexity of meeting formal and informal education needs and requirements demands a highly collaborative approach. Through strategic partnerships, we leverage the resources and expertise of our partners, scale our own investments to reach new audiences, and expand established networks. It is the magnitude of this effort and the need for fresh and constantly renewing sources of innovative solutions and non-traditional approaches that make strategic partnerships the key to supporting STEM education. Tapping into our partners' creativity and innovation will help disseminate our products and services in a broader and more systematic manner to reach new users more effectively than what we can do alone.

Partnerships for formal education, particularly with higher education institutions and aerospace companies, focus on engineering and research efforts under the supervision of practicing professionals. These partners are able to provide independent research projects for undergraduate and graduate students and multiply many times over what we can host at our own facilities. Hands-on experiences are unparalleled in their ability to develop a student's advanced STEM skills and prepare them for a career.

Partnerships with elementary and secondary schools help to meet the needs of students and educators in a resource-scarce environment. We work with local, state, and Federal organizations to ensure that our services and products provide information and opportunities that are appropriate, meet established needs, and support ongoing STEM initiatives. Our teacher training experiences meet continuing education standards, allowing teachers to gain necessary professional development credits. Students involved in NASA activities, including rocket launches and other competitions, benefit from local partnerships that provide technical support and, even more importantly, career role models.

NASA has only nine Centers and the Jet Propulsion Laboratory,[3] but every community in the Nation has a library, museum, science center, or other informal education venue that can help to share our story. Space exploration, robotics, and advanced technologies provide compelling storylines for television, Web, print, and film. Through partnerships with organizations that develop content that is appealing to students and the general public, careers in STEM can be portrayed as compelling and rich in diversity.

Each year, we release announcements of opportunity, requests for entrepreneurial offers, and other solicitations that encourage partners to collaborate with us. Through funded cooperative agreements or unfunded collaborations, we seek organizations with parallel goals and complementary skills to help us inspire, engage and educate the public, and attract students into STEM studies and careers.

Strategy@Work

The National Space Grant College and Fellowship Program comprises 52 consortia, representing all 50 states, the District of Columbia, and Puerto Rico. Each consortia includes academic institutions, industry groups, and educational organizations. Over 850 university affiliates provide research and engineering internships, mentoring for competitions, and formal NASA coursework. State-based consortia are responsive to specific needs of their regions, bringing NASA content and education support to K–12 school districts, and informal learning centers.

Our Student Launch Initiative offers annual competitions for middle school, high school, and university students to design, build, and launch a reusable rocket with a scientific or engineering payload to one mile above ground level. The students gain technical, as well as management, business, and communication skills through this rewarding experience. NASA staff, Space Grant faculty, and other partners provide guidance and expertise to help teams achieve success. Teams from around the country participate in the Student Launch Initiative, which is managed through the Marshall Space Flight Center in Alabama. (Credit: NASA)

6.3 Engage the public in NASA's missions by providing new pathways for participation.

Opening pathways for the public to actively participate in NASA's activities is a new focus consistent with the philosophy of government transparency. Participatory engagement seeks to include the general public in the adventure and excitement of our activities and tap into individual creativity and capabilities to enhance our work in science, discovery, and exploration.

[3]The Jet Propulsion Laboratory, a Federally Funded Research and Development Center operated under a contract with the California Institute of Technology.

Our participatory engagement activities span the communications spectrum ranging from passive activities—like watching online NASA videos—to highly interactive activities that use NASA-related social media tools or provide hands-on experiences. We also use these activities to collaborate with the public on interpretation of data and discoveries. We foster prize-based competitions, offering opportunities for organizations and private individuals to propose innovative solutions to specific challenges we have identified. By increasing the mechanisms through which the public can directly and specifically contribute to our missions, we can bring additional creativity and capability to some of our biggest challenges, and leverage our resources to accomplish even more toward our goals.

Active engagement by the public also reflects an increased relevancy of Agency activities to these individuals. What NASA does is exciting, and we want to encourage as many like-minded Americans as possible to join us in our ventures.

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We are finding new ways to include the public directly in our missions, including offering incentive prizes. Our Centennial Challenges are designed to generate novel solutions to problems of interest to NASA and the Nation. We are seeking innovations from diverse and non-traditional sources, including private companies, student teams, and independent inventors. The innovations that are generated may also offer potential solutions in other applications or benefit other national challenges.

Members of the LaserMotive team prepare their climber prior to launching on the climb that won them the Centennial Challenges 2009 Power Beaming competition held at the Dryden Flight Research Center. The Challenge was a demonstration of wireless power transmission in which teams build and demonstrate systems to beam energy from the ground to a robotic device that climbs a vertical cable. To be successful, the climber had to reach the top of the cable at a height of one kilometer (0.62 miles). (Credit: NASA)

6.4 Inform, engage, and inspire the public by sharing NASA's mission, challenges, and results.

The opportunities and means for sharing information have increased tremendously with the Internet and other new technologies. For scientific and programmatic announcements, we will continue traditional communications activities such as issuing press releases, hosting media events, and providing photographs and videos of our missions and events. We will continue to grow NASA Television and the www.nasa.gov Web site to offer a variety of formats, content, and activities to communicate with specific audiences. The popularity of social media and networking offers new means of reaching and communicating with diverse audiences. Interactive experiences with our astronauts, scientists, and engineers, through an online presence and other outreach events are well-suited for engaging the public and students.

We share the direct results of our missions by releasing our scientific data to researchers and other Government agencies. We contribute our data to online portals such as www.data.gov, allowing its use by anyone with the capability to access the data. NASA Web sites host a wealth of mission and program information, and we participate fully in Administration initiatives for transparency by providing specific program and project information through information-sharing portals.

We are continually exploring new tools, techniques, and capabilities to reach the public and ways in which to inform the media on the activities of the Agency. Our goal is to share the results and challenges of our missions with the public to inspire them and increase their knowledge and awareness of NASA's work.

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Each NASA program and project includes an outreach strategy in its mission planning. At a media event held in April 2010 at the Newseum in Washington, D.C., representatives from the Solar Dynamics Observatory (SDO) project introduced the satellite's first images. Events like this involve disseminating press releases, arranging for media and public interaction with the science team, creating mission information for our Web sites, and providing live coverage of the event on NASA Television.

Dean Pesnell (second from left), the SDO project scientist, from the Goddard Space Flight Center, presented new images from the SDO on Wednesday, April 21, 2010. (Credit: NASA)

Challenge

Attracting Students to STEM. Through STEM, students have the potential to change the world. With the myriad of opportunities that compete for the attention of students, our challenge is to ignite a passion for STEM education. Part of this challenge is in reaching students, and the people who most influence them, with products and services that will attract learners at all levels to STEM careers. We use the exciting content and results from our missions to develop products and services that support students, educators, and national STEM initiatives. With our resources we foster development of public–private partnerships—collaborations that build communities to support STEM education and provide stability through times of economic growth or decline. We work cooperatively with universities, professional education societies, national and state-based organizations, and states and school districts to ensure that our products and services continue to meet the evolving needs of formal and informal educators and students, both in and out of the classroom. We seek opportunities for early adoption of tools and techniques shown by research to positively impact teaching, learning, and interest in STEM topics.

Reaching New Audiences. We now have more channels for communication and public engagement than ever before. Understanding the character of newer generations, their preferred technologies, modes, and styles of communicating will determine how successful we are in communicating NASA's value. As an organization known for our research and technology, we embrace new tools and work to understand and keep pace with new technology. We must balance use of new media tools with traditional ones as we strive to communicate across all sections of the public.

Strategy for Success: A Performance Focus

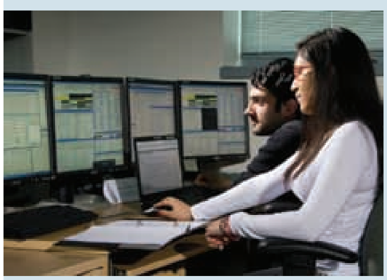
NASA is privileged to take on missions of extraordinary risk, complexity, public visibility, and national importance. To achieve the ambitious goals set forth in this Strategic Plan, we will continue to manage our missions and responsibilities with a strong dedication to our core values, overarching strategies, and the desire to push the frontiers of exploration, science, and aeronautics for the benefit of the Nation.

Our strategic goals and outcomes are the result of intense internal evaluation and external consultation with our stakeholders. Reaching out to our external stakeholders for their input ensures that we have the Nation's goals in mind as we set our own. The strategic goals and outcomes form the top tier of our performance framework from which more detailed measures are derived for the near-term goals articulated in our annual performance plans. (Please see the Appendix regarding NASA's performance framework.) We ensure our activities are conducted in accordance with all statutory, regulatory, and fiduciary responsibilities by performing regular internal surveys, audits, and reviews. We also work with independent and external entities for audits and studies that focus on the management of our institution and programs, as our continued success is reliant on a commitment to quality in everything we do.

Our strategic goals are challenging, but with a strong performance focus, we believe we will accomplish much toward this plan over the next decade. We embrace transparency and accountability and we commit ourselves to being leaders and identifying best practices for communicating our performance—both our successes and our setbacks—to our stakeholders and the public.

Credit: NASA

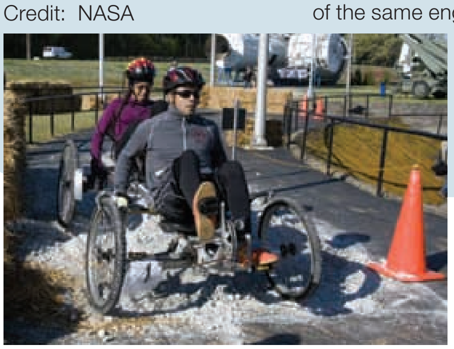
Credit: NASA/E. James



Credit: Capitol College

With help from NASA, future careers in science, technology, engineering, and mathematics are a reality for these students. Learning from real-world programs and projects, many also are contributing to the results that help us reach our goals. **Left:** Two students from the Space Operations Institute at Capitol College maintain the on-campus backup mission control center for the Tropical Rainforest Measurement Mission (TRMM). Many of the Institute's students transition from interns to Goddard Space Flight Center employees. **Upper left:** A NASA scientist shows middle school students that temperature and light are important factors for algae growth. They were participating in the Citizen Science Program at NASA Ames Research Center, where they could benefit from interacting with real scientists in a stimulating environment. **Upper right:** Santa Clara University students run mission operations for the Organism/Organic Exposure to Orbital Stresses (O/OREOS) nanosatellite at Ames Research Center. The students will run O/OREOS for several years for educational and engineering experiments. **Below right:** Errol Korn, lower left, explains the dropsonde experiment to a University of Maryland Baltimore County graduate student (seated) inside NASA's DC-8 airplane. The Genesis and Rapid Intensification Processes (GRIP) experiment being flown in the DC-8 was a NASA Earth science field experiment conducted in 2010 to better understand how tropical storms form and develop into major hurricanes. **Below left:** Racers from the University of Puerto Rico in Humacao won first place in the college division of NASA's 17th annual Great Moonbuggy Race, organized by the Marshall Space Flight Center. The race challenges teams to design, build, and race lightweight, human-powered buggies, tackling some of the same engineering challenges dealt with by NASA engineers past and present.

Credit: NASA



Credit: NASA/P.E. Alers

Appendix: NASA's Performance Framework

Strategic Goals, Outcomes, and Objectives

NASA's long-term planning is guided by the strategic goals and outcomes described in the body of this Strategic Plan. The next level of performance detail is defined by the objective statements included below. Objectives identify targets within a 10-year time frame and form the framework for our annual performance plan (APP). The APP outlines measureable performance goals for each objective in the next five years, with specific annual performance goals (APGs) aligned to the annual budget request.

NASA regularly collects and assesses performance information contributing to the APP measures and goals as the basis for programmatic and institutional decision-making processes within the Agency. NASA reports progress on the APP to Congress and the public in our annual Performance and Accountability Report, to support programmatic decision-making at a government-wide level. Our performance framework is thus an important tool for communicating with our stakeholders and the public. Through this framework we are held accountable for the Nation's investment in NASA's missions, reporting on achievements as well as shortfalls, and planning our performance goals for the next year.

Strategic Goal 1: Extend and sustain human activities across the solar system.

Outcome 1.1: Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.

Objective 1.1.1: Maintain resources (on-orbit and on the ground) to operate and utilize the ISS.

Objective 1.1.2: Advance engineering, technology, and research capabilities on the ISS.

Outcome 1.2: Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.

Objective 1.2.1: Enable the commercial sector to provide cargo and crew services to the International Space Station (ISS).

Outcome 1.3: Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.

Objective 1.3.1: Execute development of an integrated architecture to conduct human space exploration missions beyond low Earth orbit.

Objective 1.3.2: Develop a robust biomedical research portfolio to mitigate space human health risks.

Objective 1.3.3: Identify hazards, opportunities, and potential destinations, to support future safe and successful human space exploration missions.

Strategic Goal 2: Expand scientific understanding of the Earth and the universe in which we live.

Outcome 2.1: Advance Earth system science to meet the challenges of climate and environmental change.

Objective 2.1.1: Improve understanding of and improve the predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition.

Objective 2.1.2: Enable improved predictive capability for weather and extreme weather events.

Objective 2.1.3: Quantify, understand, and predict changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity.

Objective 2.1.4: Quantify the key reservoirs and fluxes in the global water cycle and assess water cycle change and water quality.

Objective 2.1.5: Improve understanding of the roles of the ocean, atmosphere, land and ice in the climate system and improve predictive capability for its future evolution.

Objective 2.1.6: Characterize the dynamics of Earth's surface and interior and form the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events.

Objective 2.1.7: Enable the broad use of Earth system science observations and results in decision-making activities for societal benefits.

Outcome 2.2: Understand the Sun and its interactions with Earth and the solar system.

Objective 2.2.1: Improve understanding of the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium.

Objective 2.2.2: Improve understanding of how human society, technological systems, and the habitability of planets are affected by solar variability interacting with planetary magnetic fields and atmospheres.

Objective 2.2.3: Maximize the safety and productivity of human and robotic explorers by developing the capability to predict extreme and dynamic conditions in space.

Outcome 2.3: Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

Objective 2.3.1: Inventory solar system objects and identify the processes active in and among them.

Objective 2.3.2: Improve understanding of how the Sun's family of planets, satellites, and minor bodies originated and evolved.

Objective 2.3.3: Improve understanding of the processes that determine the history and future of habitability of environments on Mars and other solar system bodies.

Objective 2.3.4: Improve understanding of the origin and evolution of Earth's life and biosphere to determine if there is or ever has been life elsewhere in the universe.

Objective 2.3.5: Identify and characterize small bodies and the properties of planetary environments that pose a threat to terrestrial life or exploration or provide potentially exploitable resources.

Outcome 2.4: Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.

Objective 2.4.1: Improve understanding of the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity.

Objective 2.4.2: Improve understanding of the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today.

Objective 2.4.3: Generate a census of extra-solar planets and measure their properties.

Strategic Goal 3: Create the innovative new space technologies for our exploration, science, and economic future.

Outcome 3.1: Sponsor early-stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.

Objective 3.1.1: Create a pipeline of new low Technology Readiness Levels (TRL) innovative concepts and technologies for future NASA missions and national needs.

Outcome 3.2: Infuse game-changing and crosscutting technologies throughout the Nation's space enterprise to transform the Nation's space mission capabilities.

Objective 3.2.1: Prove the technical feasibility of potentially disruptive new space technologies for future missions.

Objective 3.2.2: Spur the development of routine, low-cost access to space through small payloads and satellites.

Objective 3.2.3: Demonstrate new space technologies and infuse them into future science and exploration small satellite missions and/or commercial use.

Objective 3.2.4: Demonstrate new space technologies and infuse them into missions.

Objective 3.2.5: Provide flight opportunities and relevant environments to demonstrate new space technologies.

Outcome 3.3: Develop and demonstrate the critical technologies that will make NASA's exploration, science, and discovery missions more affordable and more capable.

Objective 3.3.1: Demonstrate in-space operations of robotic assistants working with crew.

Objective 3.3.2: Develop and demonstrate critical technologies for safe and affordable cargo and human space exploration missions beyond low Earth orbit.

Outcome 3.4: Facilitate the transfer of NASA technology and engage in partnerships with other government agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.

Objective 3.4.1: Promote and develop innovative technology partnerships among NASA, U.S. industry, and other sectors for the benefit of Agency programs and national interests.

Strategic Goal 4: Advance aeronautics research for societal benefit.

Outcome 4.1: Develop innovative solutions and advanced technologies through a balanced research portfolio to improve current and future air transportation.

Objective 4.1.1: Develop advanced technologies to improve the overall safety of the future air transportation system.

Objective 4.1.2: Develop innovative solutions and technologies to meet future capacity and mobility requirements of the Next Generation Air Transportation System (NextGen).

Objective 4.1.3: Develop tools, technologies, and knowledge that enable significantly improved performance and new capabilities for future air vehicles.

Outcome 4.2: Conduct systems-level research on innovative and promising aeronautics concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.

Objective 4.2.1: Develop advanced tools and technologies that reduce the technical risk associated with system-level integration of promising aeronautical concepts.

Strategic Goal 5: Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.

Outcome 5.1: Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.

Objective 5.1.1: Establish and maintain a workforce that possesses state-of-the-art technical and business management competencies.

Objective 5.1.2: Provide opportunities and support systems that recruit, retain, and develop undergraduate and graduate students in STEM-related disciplines.

Outcome 5.2: Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.

Objective 5.2.1: Achieve mission success by factoring safety, quality, risk, reliability, and maintainability as integral features of programs, projects, technologies, operations, and facilities.

Objective 5.2.2: Provide information technology that advances NASA space and research program results and promotes open dissemination through efficient, innovative, reliable, and responsive services that are appropriately secure and valued by stakeholders and the public.

Objective 5.2.3: Develop and implement long-range infrastructure plans that address institutional capabilities and critical assets, directly link to mission needs, ensure the leveraging of external capabilities, and provide a framework for Agency infrastructure decision-making.

Outcome 5.3: Ensure the availability to the Nation of NASA-owned, strategically important test capabilities.

Objective 5.3.1: Work with the National Rocket Propulsion Test Alliance to identify NASA, Department of Defense, and commercial capabilities and requirements.

Objective 5.3.2: Ensure that NASA's Aeronautics Test Program (ATP) facilities are available and capable of supporting research, development, test, and evaluation goals and objectives for NASA and national aerospace programs.

Outcome 5.4: Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.

Objective 5.4.1: Ensure reliable and cost-effective access to space for missions critical to achieving the National Space Policy of the United States of America.

Objective 5.4.2: Transform the Florida launch and range complex to provide a robust launch and range infrastructure for future users.

Objective 5.4.3: Build and maintain a scalable, integrated, mission support infrastructure that can readily evolve to accommodate new and changing technologies, while providing integrated, comprehensive, robust, and cost-effective space communications services at order-of-magnitude higher data rates to enable NASA's science and exploration missions.

Outcome 5.5: Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success.

Objective 5.5.1: Facilitate the use of the ISS as a National Laboratory for cooperative research, technology development, and education.

Objective 5.5.2: Enhance international and interagency partnerships through increased use of international and interagency coordination mechanisms.

Strategic Goal 6: Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation, and contribute to a strong national economy.

Outcome 6.1: Improve retention of students in STEM disciplines by providing opportunities and activities along the full length of the education pipeline.

Objective 6.1.1: Provide quality STEM curricular support resources and materials.

Objective 6.1.2: Provide NASA experiences that inspire student interest and achievement in STEM disciplines.

Objective 6.1.3: Assess grant recipient institutions throughout the education pipeline to ensure that grant recipients demonstrate a consistent commitment to civil rights compliance.

Outcome 6.2: Promote STEM literacy through strategic partnerships with formal and informal organizations.

Objective 6.2.1: Develop NASA's leadership role in national STEM improvement efforts, as demonstrated by provision of meaningful educator professional development and student experiences, adoption of education technologies, and contributions to STEM education policies and strategies.

Outcome 6.3: Engage the public in NASA's missions by providing new pathways for participation.

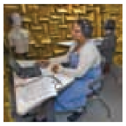
Objective 6.3.1: Extend the reach of participatory engagement across NASA.

Outcome 6.4: Inform, engage, and inspire the public by sharing NASA's missions, challenges, and results.

Objective 6.4.1: Use strategic partnerships with formal and informal educational organizations to provide NASA content to promote interest in STEM.

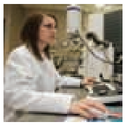
Objective 6.4.2: Provide clear, accurate, timely, and consistent information that is readily available and suitable for a diverse audience.

Objective 6.4.3: Provide the communications infrastructure to enable NASA's commitment to make government more open, transparent, and participatory.

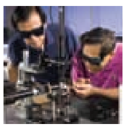


Gold-colored foam wedges shield test subjects from outside noises during an acoustics test at the Langley Research Center. Our researchers study people's perception of aircraft sounds, especially the role of rattle noises and vibration. The researchers use this information to help design quieter aircraft. (Credit: NASA/S. Smith)

The crew of STS-133 meet Robonaut 2, the latest generation of the Robonaut astronaut helpers, that will be launching with them to the International Space Station. It will be the first humanoid robot in space, and although its primary job for now is teaching engineers how dexterous robots behave in space, the hope is that through upgrades and advancements, it could one day venture outside the station to help spacewalkers make repairs or additions to the station or perform scientific work. (Credit: NASA)

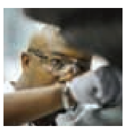


Goddard Space Flight Center technologist Stephanie Getty works on a platform, called ChemFET, that could be used to detect organic molecules that may indicate the presence of past or current life on Mars, Titan, and other solar system objects. She also is developing this technology to locate specific biomarkers linked to breast cancer. Some people have a greater chance of developing certain types of cancer if a mutation occurs in specific genes. The presence of such a change is sometimes called a risk marker, indicating that cancer is more likely to occur. ChemFET may provide a fully electronic and affordable method to identify risk markers and detect cancer early in its development. (Credit: C. Gunn)

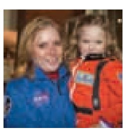


Dr. David Chao (left), Dr. Negli Zhang, and Dr. John Sankovic (not pictured) created the award-winning Multidimensional Contact Angle Measurement Device, a technology that helps engineers understand how liquids spread on different surfaces. Understanding this phenomenon is critical to producing many commonly used liquids, including paints, coatings, and lubricants. In space applications, it is important for determining the optimal performance of heat pipes and fuel tanks. The device can provide a 360-degree view of the liquid spreading process, rather than only the side view available with previous devices. It also costs up to 15 times less than current, less-capable commercial systems. (Credit: M. Smith, WYLE)

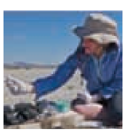
Students create paper rockets, which they will launch by jumping on empty two-liter soft drink bottles or using bicycle pumps, at the Jet Propulsion Laboratory's outdoor stomp rocket activity. Part of our Summer of Innovation, the activity helped teach the students about motion, force, and design. (Credit: NASA/JPL–Caltech)



A weld technician monitors as the Universal Weld System completes the final friction stir weld on the Orion crew vehicle in May 2010 at our Michoud Assembly Facility in New Orleans, Louisiana. Nondestructive evaluations validated the strength and integrity of the weld before the crew vehicle was prepped for ground testing in flight-like environments, including static vibration, acoustics, and water landing tests. (Credit: NASA)



Astronaut Anna Fisher holds a three year old, dressed in her commander's spacesuit, at Hampton, Virginia's, 2010 Holly Days Parade. Months earlier, the girl became frustrated when she could not take the Moon out of the sky and put it in her pocket. Her parents took her interest as their cue to expose her to all things space, including—but definitely not limited to—meeting an astronaut. Fisher told girl that if she wanted to be an astronaut, she would need to study hard and get good grades in school. (Credit: NASA/S. Smith)



Felisa Wolfe-Simon processes mud from Mono Lake, California, to inoculate media to grow microbes on arsenic. Researchers conducting tests in the harsh environment of Mono Lake have discovered the first known microorganism on Earth able to thrive and reproduce using the toxic chemical arsenic. The microorganism substitutes arsenic for phosphorus in its cell components. This finding of an alternative biochemistry makeup will alter biology textbooks and expand the scope of the search for life beyond Earth. (Credit: H. Bortman)

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Mission success requires uncompromising commitment to Safety, Integrity, Teamwork, and Excellence.

National Aeronautics and Space Administration

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