



**National Aeronautics  
and Space Administration**

**Fiscal Year 2004  
Performance Plan Update**

## Introduction

This document is a revision of NASA's Fiscal Year 2004 (FY 2004) Performance Plan, originally published as part of the NASA Integrated Budget and Performance Document, titled *FY 2004 Budget Estimates*. NASA has made its performance measures more quantifiable and verifiable and presents these improvements in this *FY 2004 Performance Plan Update*.

## Background

NASA's *2003 Strategic Plan* marked a tremendous step forward in making the NASA performance planning system more measurable and accountable. It also made a commitment<sup>1</sup> to further improve the NASA performance planning system as part of the Administration's *President's Management Agenda*.

## NASA's Performance System

NASA's planning process starts with a long-term Vision and Mission and flows to more detailed multi-year outcomes and annual performance goals (APG).

NASA's Vision, Mission, goals, and objectives are documented in its *2003 Strategic Plan*. NASA presents the more detailed counterparts of its planning process (i.e., outcomes and APGs) in the Integrated Budget and Performance Document. Each Theme within NASA traces its performance planning measures from the Mission statements to the annual performance goals. Figure 1 in this section shows the flow of performance planning from NASA's Vision down to APGs.

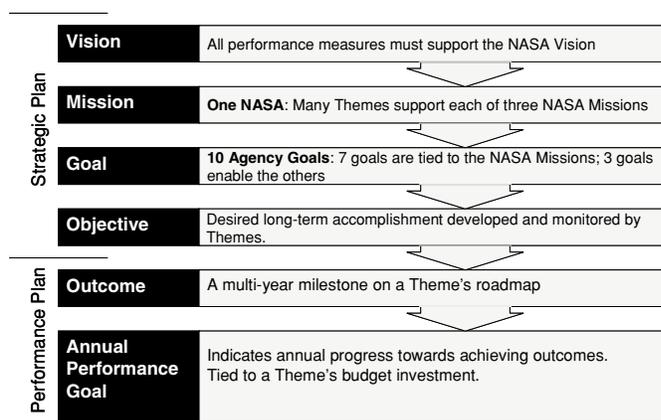
## Improvements

The improvements in this *FY2004 Performance Plan Update* provide a clearer description of what NASA expects to accomplish in its long-term outcomes. Outcomes are by far the most improved part of the plan. In response to the 2003 Strategic Plan, the Enterprises developed revised roadmaps that show how they will achieve the commitments in the Strategic Plan.

This additional planning effort is reflected in the quality of the new long-term outcomes.

The APGs have also been improved. NASA's new Theme-based budget system introduces an "investment" approach that integrates budgeting and performance planning. NASA has put significant effort into more clearly documenting the annual benefits of Theme investments through the APGs. This will enhance NASA's commitment to performance and will provide better tools to verify accountability.

Figure 1: Strategic and performance planning flow



<sup>1</sup> NASA 2003 Strategic Plan, pp. A-21

# Mission I: To Understand and Protect our Home Planet

## Goal 1: Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.

### Objective 1.1 Understand how the Earth is changing, better predict change and understand the consequences for life on Earth.

*Outcome 1.1.1 Enable prediction of polar and global stratospheric ozone recovery (amount and timing) to within 25% by 2014.*

*Outcome 1.1.2 Predict the global distribution of tropospheric ozone and the background concentration in continental near-surface air to within 25% by 2014.*

*Outcome 1.1.3 Enable extension of air quality forecasts for ozone and aerosols from 24 to 72 hours by 2010.*

APG 4ESS7 Atmospheric Composition - Integrate high latitude satellite, suborbital, and ground based observations, coupled with laboratory studies and model calculations to assess the potential for future ozone depletion in the arctic, and characterize the properties and distributions of various types of clouds and aerosols as they relate to the extinction of solar radiation in the atmosphere. Progress toward achieving outcomes will be validated by external review. (Outcome 1.1.1, 1.1.2, 1.1.3)

*Outcome 1.1.4 Use satellite data to help enable decreased hurricane landfall uncertainty from +/- 400 km to +/- 100 km in the three-day forecasts by 2010.*

*Outcome 1.1.5 Use satellite data to help extend more accurate regional weather forecasting from 3 days to 5 days by 2010.*

APG 4ESS8 Weather - Improve predictive capabilities of regional models using satellite-derived localized temperature and moisture profiles and ensemble modeling. Progress toward achieving outcomes will be validated by external review. (Outcome 1.1.4, 1.1.5)

*Outcome 1.1.6 Develop projections of future atmospheric concentrations of carbon dioxide and methane for 10-100 years into the future with improvements in confidence of >50% by 2014.*

*Outcome 1.1.7 By 2014, develop in partnership with other agencies, credible ecological forecasts that project the sensitivities of terrestrial and aquatic ecosystems to global environmental changes for resource management and policy-related decision-making.*

*Outcome 1.1.8 Report changes in global land cover, productivity, and carbon inventories with accuracies sufficient for use in the food industry, in evaluating resource management activities, and in verifying inventories of carbon emissions and storage.*

APG 4ESS9 Carbon Cycles, Ecosystems, and Biogeochemistry - Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Progress toward achieving outcomes will be validated by external review. (Outcome 1.1.6, 1.1.7, 1.1.8)

*Outcome 1.1.9 Enable development of seasonal precipitation forecasts with > 75% accuracy by 2014.*

*Outcome 1.1.10 Improve estimates of the global water and energy cycles by 2012 to enable balancing of the global and regional water and energy budgets to within 10%.*

APG 4ESS10 Water and Energy Cycle - Enhance land surface modeling efforts, which will lead to improved estimates of soil moisture and run-off. Progress toward achieving outcomes will be validated by external review. (Outcome 1.1.9, 1.1.10)

*Outcome 1.1.11 Reduce uncertainty in global sea level change projections by 50% by the year 2014, and include regional estimates of deviation from global mean.*

*Outcome 1.1.12 Enable 10-year or longer climate forecasts by the year 2014 with a national climate modeling framework capable of supporting policy decision-making at regional levels.*

APG 4ESS11 Climate, Variability and Change - Assimilate satellite and in situ observations into a variety of ocean, atmosphere, and ice models for purposes of state estimation; provide experimental predictions on a variety of climatological timescales; and determine the plausibility of these predictions using validation strategies. Progress toward achieving outcomes will be validated by external review. (Outcome 1.1.11, 1.1.12)

*Outcome 1.1.13 Enable 30-day volcanic eruption forecasts with > 50% confidence by 2014.*

*Outcome 1.1.14 Enable estimation of earthquake likelihood in North American plate boundaries with > 50% confidence by 2014.*

APG 4ESS12 Earth Surface and Interior Structure - Advance understanding of surface change through improved geodetic reference frame, estimates of mass flux from satellite observations of Earth's gravitational and magnetic fields, and airborne and spaceborne observations of surface height and deformation. Progress toward achieving outcomes will be validated by external review. (Outcome 1.1.13, 1.1.14)

## **Objective 1.2 Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology.**

*Outcome 1.2.1 By 2012, benchmark the assimilation of observations (geophysical parameters, climate data records) provided from 20 of the 80 remote sensing systems deployed on the flotilla of 18-22 NASA Earth observation research satellites.*

*Outcome 1.2.2 By 2012, benchmark the assimilation of 5 specific types of predictions resulting from Earth Science Model Framework (ESMF) of 22 NASA Earth system science models.*

*Outcome 1.2.3 By 2012, benchmark the assimilation of observations and predictions resulting from NASA Earth Science research in 8-10 decision support systems serving national priorities and the missions of federal agencies.*

APG 4ESA1 National applications: Benchmark measurable enhancements to at least 2 national decision support systems using NASA results, including the use of optical depth derived from MODIS data into the Air Quality Index provided by EPA and the use of ocean height Derived from Topex and Jason missions into reservoir monitoring tools with USDA. (Outcome 1.2.1, 1.2.3)

APG 4ESA2 Cross Cutting Solutions: Expand DEVELOP (Digital Earth Virtual Environment and Learning Outreach Project) workforce development program to 2-4 additional states and benchmark the use of NASA research results for water and energy decision support tools. (Outcome 1.2.1, 1.2.2, 1.2.3)

APG 4ESA3 Cross Cutting Solutions: Competitively select at least 5 solutions projects for the Research, Education, Applications solutions Network (REASoN) program to serve national applications through projects that support agriculture, public health and water quality decision support tools. (Outcome 1.2.1, 1.2.2, 1.2.3)

APG 4ESA4 Cross Cut Solutions: Verify and validate at least two commercial remote sensing sources/products for Earth science research including DigitalGlobe Quicksat and OrbImage Overview-3 high resolutions optical imagery. (Outcome 1.2.1)

## **Objective 1.3 Understand the origins and societal impacts of variability in the Sun-Earth connection.**

*Outcome 1.3.1 Develop the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect the Earth.*

APG 4SEC8 Successfully demonstrate progress in developing the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect the Earth. Progress towards achieving outcomes will be validated by external review.

*Outcome 1.3.2 Specify and enable prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere.*

APG 4SEC9 Successfully demonstrate progress in specifying and enabling prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere. Progress towards achieving outcomes will be validated by external review.

*Outcome 1.3.3 Understand the role of solar variability in driving space climate and global change in the Earth's atmosphere.*

APG 4SEC10 Successfully demonstrate progress in understanding the role of solar variability in driving space climate and global change in the Earth's atmosphere. Progress towards achieving outcomes will be validated by external review.

#### **Objective 1.4 Catalog and understand potential impact hazards to Earth from space.**

*Outcome 1.4.1 By 2008, inventory at least 90 percent of asteroids and comets larger than 1 km in diameter that could come near Earth.*

APG 4SSE10 Successfully demonstrate progress in determining the inventory and dynamics of bodies that may pose an impact hazard to Earth. Progress towards achieving outcomes will be validated by external review.

*Outcome 1.4.2 Determine the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth.*

APG 4SSE11 Successfully demonstrate progress in determining the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth. Progress towards achieving outcomes will be validated by external review.

### **Goal 2: Enable a safer, more secure, efficient, and environmentally friendly air transportation system.**

#### **Objective 2.1 Decrease the aircraft fatal accident rate, reduce the vulnerability of the air transportation system to hostile threats, and mitigate the consequences of accidents and hostile acts.**

*Outcome 2.1.1 By 2005, research, develop, and transfer technologies that will enable the reduction of the aviation fatal accident rate by 50% from the FY 1991-1996 average.*

APG 4AT4 Utilizing results of component testing, simulations, and analyses, complete an integrated program assessment of the suite of aviation safety technologies to determine their synergistic effect on reducing the fatal accident rate.

APG 4AT5 Propulsion system malfunctions are cited in 25% of fatal accidents, with disk and/or fan blade component failures being attributed to about 15% of these malfunctions. In FY 2004 NASA will develop prototype disks and engine containment materials with inherent failure resistant characteristics that will be ready for full scale testing in FY 2005.

APG 4AT6 Controlled Flight into Terrain (CFIT) accounts for 30% of General Aviation fatal accidents. During FY 2004, NASA will complete the flight evaluation of a synthetic vision system that improves pilot situational awareness by providing a display of "out-the-window" information that is not effected by adverse metrological conditions. This system when fully implemented has the potential to eliminate 90% of CFIT accidents.

*Outcome 2.1.2 By 2009, research, develop & transfer technologies that will reduce the vulnerability exposure of the aircraft, and reduce the vulnerabilities of other components in the air transportation system.*

APG 4AT7 Complete a preliminary demonstration, in a realistic operational environment, of an automated system to provide real-time identification of flight path deviations and a means to alert authorities in a prompt and consistent manner.

#### **Objective 2.2 Protect local and global environmental quality by reducing aircraft noise and emissions.**

*Outcome 2.2.1 By 2007, develop, demonstrate and transfer technologies that enable a reduction by half, in community noise due to aircraft, based on the 1997 state of the art.*

APG 4AT8 Validate initial concepts for engine and airframe source noise reduction by 5dB (re: to CY 2001 SOA).

*Outcome 2.2.2 By 2007, develop, demonstrate and transfer technologies for reducing NOx emission by 70% from the 1996 ICAO standard, to reduce smog and lower atmospheric ozone.*

APG 4AT19 Complete detailed design of a low-emission combustor leading to a 2005 test of a full-annular combustor demonstrating a 70% reduction of nitrogen oxides.

*Outcome 2.2.3 By 2007, develop, demonstrate and transfer technologies for reducing the green-house gas, CO2, emissions by 25% based on the state of the art for airframe and engine component technologies in 2000.*

APG 4AT9 Experimentally demonstrate a 2-stage highly loaded compressor for increasing pressure rise per stage.

### **Objective 2.3 Enable more people and goods to travel faster and farther, with fewer delays.**

*Outcome 2.3.1 By 2004, develop, demonstrate and transfer technologies that enable a 35% increase in aviation system throughput in the terminal area and a 20% increase in aviation system throughput en route based on 1997 NAS capacities.*

APG 4AT10 Complete validation and assessment of the Advanced Air Transportation Technologies products (tools/concepts) through field and laboratory demonstrations, analyses, evaluations, and assessments on a tool-by-tool basis to demonstrate an increase in terminal throughput by 35 percent and an increase in en route throughput by 20 percent.

*Outcome 2.3.2 By 2005, develop, demonstrate and transfer key enabling capabilities for a small aircraft transportation system.*

APG 4AT12 Flight demonstrate the ability to double the operations rate at non-towered, non-radar airports in low-visibility conditions using self-separation and flight-path guidance technologies for general aviation aircraft.

*Outcome 2.3.3 By 2009, develop, demonstrate, and transfer technologies that enable a further 5% increase in throughput in the terminal area and a further 10% increase in en route throughput based on 1997 NAS capacity.*

APG 4AT11 Develop a non-real-time Virtual Airspace Simulation Technology environment that will model the National Airspace System and provide the capability to conduct trade-off analyses amongst concepts and technologies for the future air transportation system.

APG 4AT13 Based on research completed under AATT project and current work under VAMS project, provide preliminary analysis and assessment of distributed air/ground traffic management (DAG/TM) operational concept.

## **Goal 3: Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.**

### **Objective 3.1 Enhance the Nation's security through partnerships with DOD, DHS and other U.S. or international government agencies.**

*Outcome 3.1.1 In partnership with DoD, develop and demonstrate risk-reduction technologies by 2009 that will enable quick-response access to space.*

APG 4SLI17 The DoD responsive space lift requirements as defined by the Analysis of Alternatives process will be assessed to determine the potential and priorities for leveraged technology investments that support both NASA and DoD needs.

*Outcome 3.1.2 Enhance national security and the quality of life by developing and deploying transformational space infrastructures that enable greater than 200-meter aperture space systems by 2015.*

APG 4SFS1 Identify 2-3 innovative systems and infrastructure concepts (and associated technologies) that can support prospective requirements of future human/robotic space initiatives that contribute materially to security and the quality of life.

*Outcome 3.1.3* By 2012, in partnership with the Department of Homeland Security, the Department of Defense, and the Department of State, deliver 15 observations and 5 model predictions for climate change, weather prediction and natural hazards to national and global organizations and decision-makers to evaluate 5 scenarios and optimize the use of Earth resources (food, water, energy, etc.) for homeland security, environmental security and economic security.

APG 4ESA5 Benchmark improvements to at least two of the target national applications - air quality and agricultural competitiveness.

*Outcome 3.1.4* Demonstrate effective international collaboration on the International Space Station.

APG 4ISS1 In concert with the ISS International Partners, extend a continuous two-person (or greater) crew presence on the ISS through the end of FY04.

*Outcome 3.1.5* Transfer technology both to and from the Department of Defense.

APG 4AT14 Conduct and obtain flight test data of autonomous aerial refueling technologies in support of DoD UCAV Program.

### **Objective 3.2 Improve the Nation's economic strength and quality of life by facilitating innovative use of NASA technology.**

*Outcome 3.2.1* On an annual basis, develop 200 new technology transfer agreements with the Nation's industrial and entrepreneurial sectors.

APG 4ITTP1 Complete 200 transfers of NASA technologies, expertise or facility usage to the U.S. private sector, through hardware licenses, software usage agreements, or Space Act agreements.

*Outcome 3.2.2* By 2008, realign commercial product development to focus on NASA needs, while maintaining industrial partnerships.

APG 4RPFS1 Complete realignment plans of SPD.

APG 4RPFS2 Enable industry research in space that allows them to bring one commercial product under investigation to market by FY04.

*Outcome 3.2.3* By 2008, develop and test at least two design tools for advanced materials and in-space fabrication, and validate on ISS.

APG 4RPFS3 Complete preparations for launch of a new containerless processing facility for research on synthesis of advanced materials on ISS.

APG 4RPFS4 Continue synthesis of zeolite crystals on ISS.

*Outcome 3.2.4* By 2008, working with all OBPR research organizations and other NASA enterprises, identify at least three additional users of Research Partnership Center spaceflight hardware.

APG 4RPFS5 Develop a database of RPC spaceflight hardware showing potential outside users.

APG 4RPFS6 Develop a system for sharing RPC spaceflight hardware with outside users.

*Outcome 3.2.5* By 2008, increase by 30% (from the 2003 level) the utilization of NASA/OBPR-derived technologies by other agencies, private sector, and academia to advance basic and applied research goals of practical impact.

APG 4PSR1 Maintain an active research program in collaboration with other agencies in laser light scattering, bioreactor, and containerless technologies.

**Objective 3.3 Resolve scientific issues in the low gravity environment of space that enrich life on Earth by leading to better design tools in energy, materials, medical, and communication technologies.**

*Outcome 3.3.1 By 2008, analyze the impact of the results of the first phase of ISS and ground-based research in Biotechnology, fundamental science, and engineering to demonstrate the introduction of at least two new design tools and/or process improvements to existing technologies and industrial practices.*

APG 4PSR2 Demonstrate the productivity of the research program in Combustion, Fluids Physics, Biotechnology, and Materials science and accomplish the milestones of ISS research projects.

*Outcome 3.3.2 By 2008, quantitatively assess the impact of space and ground-based research on fire safety hazard prevention and containment and on energy conversion to demonstrate measurable risk reduction and increased efficiency.*

APG 4PSR3 Process and analyze existing STS-107 data on fire safety and microgravity combustion research and maintain a productive ground and flight-based research program.

*Outcome 3.3.3 By 2008, develop at least three new leveraged research partnerships with industry, academia, and other government agencies that improve NASA spacecraft safety.*

APG 4RPFS7 Develop at least one enabling technology to improve the safety of space transportation systems.

## Mission II: To Explore the Universe and Search for Life

### Goal 4: Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.

#### Objective 4.1 Determine how fundamental biological processes of life respond to gravity and space environments.

*Outcome 4.1.1 Use ground-based simulators and ISS to determine gravity responses for at least five model organisms by 2008.*

APG 4BSR1 Solicit ground-based research on two widely studied model organisms.

APG 4BSR2 Produce a road map and strategic goals for plant research ground-based studies and flight opportunities. Solicit flight-based research on at least one model plant species.

*Outcome 4.1.2 Develop predictive models of cellular, pathogenic, and ecological responses to space for at least two organisms by 2008.*

APG 4BSR3 Solicit ground-based research on responses of cells and pathogens to space environments.

APG 4BSR4 Select two model species to support the development of predictive models. Communicate with the research community in workshops and at national and international scientific meetings about the approach.

*Outcome 4.1.3 By 2008, structure the Fundamental Space Biology flight research program to emphasize at least five model organisms and teams of Principal Investigators.*

APG 4BSR5 In coordination with International partners, solicit flight research on two model organisms and establish at least two research teams.

APG 4BSR6 Review and reprioritize Fundamental Space Biology flight experiments with a focus on model specimens.

APG 4BSR7 Reevaluate flight hardware and habitats with respect to research goals and focus resources on select units.

#### Objective 4.2 Expand understanding of fundamental physical processes and insight into the laws of nature through space-based investigation.

*Outcome 4.2.1 By 2008, complete the first generation of ISS research in colloidal physics and soft condensed matter and demonstrate the ability to control the colloidal engineering of at least two different model structures.*

APG 4PSR4 Demonstrate the productivity of the colloidal physics and soft-condensed matter program and accomplish the planned ISS research projects milestones.

*Outcome 4.2.2 By 2008, complete the design and fabrication of the first ISS fundamental microgravity physics facility to allow the performance of two capstone investigations in dynamical critical phenomena.*

APG 4PSR5 Demonstrate the accomplishments of the ISS fundamental physics facility development milestones and maintain a productive ground and space-based research program in condensed matter physics.

*Outcome 4.2.3 By 2008, complete the design for the ISS laser-cooling laboratory and demonstrate the feasibility to deploy the most accurate atomic clock in space.*

APG 4PSR6 Demonstrate the accomplishments of the ISS laser cooling and atomic physics facility milestones and maintain an innovative and productive ground and space-based research program in atomic and gravitational physics.

*Outcome 4.2.4 By 2008, complete the first phase of the ISS biotechnology facility and demonstrate cellular biotechnology research throughput increase by a factor of two.*

APG 4PSR7 Demonstrate the accomplishments of the ISS Biotechnology research facility development milestones and maintain a productive and innovative ground and space-based research program in cellular biotechnology and tissue engineering.

## **Goal 5: Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.**

### **Objective 5.1 Learn how the solar system originated and evolved to its current diverse state.**

*Outcome 5.1.1 Understand the initial stages of planet and satellite formation.*

APG 4SSE12 Successfully demonstrate progress in understanding the initial stages of planet and satellite formation. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.1.2 Understand the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact.*

APG 4SSE13 Successfully demonstrate progress in studying the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.1.3 Understand why the terrestrial planets are so different from one another.*

APG 4SSE14 Successfully demonstrate progress in understanding why the terrestrial planets are so different from one another. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.1.4 Learn what our solar system can tell us about extra-solar planetary systems.*

APG 4SSE15 Successfully demonstrate progress in learning what our solar system can tell us about extra-solar planetary systems. Progress towards achieving outcomes will be validated by external review.

### **Objective 5.2 Understand how life begins and evolves and determine the characteristics of the solar system that led to the origin of life.**

*Outcome 5.2.1 Determine the nature, history, and distribution of volatile and organic compounds in the solar system.*

APG 4SSE16 Successfully demonstrate progress in determining the nature, history, and distribution of volatile and organic compounds in the solar system. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.2.2 Identify the habitable zones in the solar system.*

APG 4SSE17 Successfully demonstrate progress in identifying the habitable zones in the solar system. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.2.3 Identify the sources of simple chemicals that contribute to pre-biotic evolution and the emergence of life.*

APG 4SSE18 Successfully demonstrate progress in identifying the sources of simple chemicals that contribute to prebiotic evolution and the emergence of life. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.2.4 Study Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere.*

APG 4SSE19 Successfully demonstrate progress in studying Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere. Progress towards achieving outcomes will be validated by external review.

### **Objective 5.3 Understand the current state and evolution of the atmosphere, surface, and interior of Mars.**

*Outcome 5.3.1 Characterize the present climate of Mars and determine how it has evolved over time.*

APG 4MEP9 Successfully demonstrate progress in characterizing the present climate of Mars and determining how it has evolved over time. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.3.2 Understand the history and behavior of water and other volatiles on Mars.*

APG 4MEP10 Successfully demonstrate progress in investigating the history and behavior of water and other volatiles on Mars. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.3.3 Understand the chemistry, mineralogy, and chronology of Martian materials.*

APG 4MEP11 Successfully demonstrate progress in studying the chemistry, mineralogy, and chronology of Martian materials. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.3.4 Determine the characteristics and dynamics of the interior of Mars.*

APG 4MEP12 Successfully demonstrate progress in determining the characteristics and dynamics of the interior of Mars. Progress towards achieving outcomes will be validated by external review.

#### **Objective 5.4 Determine if life exists or has ever existed on Mars.**

*Outcome 5.4.1 Understand the character and extent of prebiotic chemistry on Mars.*

APG 4MEP13 Successfully demonstrate progress in investigating the character and extent of prebiotic chemistry on Mars. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.4.2 Search for chemical and biological signatures of past and present life on Mars.*

APG 4MEP14 Successfully demonstrate progress in searching for chemical and biological signatures of past and present life on Mars. Progress towards achieving outcomes will be validated by external review.

#### **Objective 5.5 Develop an understanding of Mars in support of possible future human exploration.**

*Outcome 5.5.1 Identify and understand the hazards that the Martian environment will present to human explorers.*

APG 4MEP15 Successfully demonstrate progress in identifying and studying the hazards that the Martian environment will present to human explorers. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.5.2 Inventory and characterize Martian resources of potential benefit to human exploration of Mars.*

APG 4MEP16 Successfully demonstrate progress in inventorying and characterizing Martian resources of potential benefit to human exploration of Mars. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.5.3 By 2016, identify the 2-3 optimal candidate approaches to future human/robotic Mars exploration that enable a safe, affordable, and effective campaign to be undertaken by 2025-2030.*

APG 4SFS2 Identify 4-6 innovative system and infrastructure concepts (and associated technologies) that can support the potential requirements of future human/robotic space science missions.

#### **Objective 5.6 Understand the changing flow of energy and matter throughout the Sun, heliosphere, and planetary environments.**

*Outcome 5.6.1 Understand the structure and dynamics of the Sun and solar wind and the origins of magnetic variability.*

APG 4SEC11 Successfully demonstrate progress in understanding the structure and dynamics of the Sun and solar wind and the origins of magnetic variability. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.6.2 Determine the evolution of the heliosphere and its interaction with the galaxy.*

APG 4SEC12 Successfully demonstrate progress in determining the evolution of the heliosphere and its interaction with the galaxy. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.6.3 Understand the response of magnetospheres and atmospheres to external and internal drivers.*

APG 4SEC13 Successfully demonstrate progress in understanding the response of magnetospheres and atmospheres to external and internal drivers. Progress towards achieving outcomes will be validated by external review.

## **Objective 5.7 Understand the fundamental physical processes of space plasma systems.**

*Outcome 5.7.1 Discover how magnetic fields are created and evolve and how charged particles are accelerated.*

APG 4SEC14 Successfully demonstrate progress in discovering how magnetic fields are created and evolve and how charged particles are accelerated. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.7.2 Understand coupling across multiple scale lengths and its generality in plasma systems.*

APG 4SEC15 Successfully demonstrate progress in understanding coupling across multiple scale lengths and its generality in plasma systems. Progress towards achieving outcomes will be validated by external review.

## **Objective 5.8 Learn how galaxies, stars, and planetary systems form and evolve.**

*Outcome 5.8.1 Learn how the cosmic web of matter organized into the first stars and galaxies and how these evolved into the stars and galaxies we see today.*

APG 4ASO9 Successfully demonstrate progress in learning how the cosmic web of matter organized into the first stars and galaxies and how these evolved into the stars and galaxies we see today. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.8.2 Understand how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life.*

APG 4ASO10 Successfully demonstrate progress in understanding how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.8.3 Learn how gas and dust become stars and planets.*

APG 4ASO11 Successfully demonstrate progress in learning how gas and dust become stars and planets. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.8.4 Observe planetary systems around other stars and compare their architectures and evolution with our own.*

APG 4ASO12 Successfully demonstrate progress in observing planetary systems around other stars and comparing their architectures and evolution with our own. Progress towards achieving outcomes will be validated by external review.

## **Objective 5.9 Understand the diversity of worlds beyond our solar system and search for those that might harbor life.**

*Outcome 5.9.1 Characterize the giant planets orbiting other stars.*

APG 4ASO13 Successfully demonstrate progress in characterizing the giant planets orbiting other stars. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.9.2 Find out how common Earth-like planets are and see if any might be habitable.*

APG 4ASO14 Successfully demonstrate progress in finding out how common Earth-like planets are and seeing if any might be habitable. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.9.3 Trace the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life.*

APG 4ASO15 Successfully demonstrate progress in tracing the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.9.4 Develop the tools and techniques to search for life on planets beyond our solar system.*

APG 4ASO16 Successfully demonstrate progress in developing the tools and techniques to search for life on planets beyond our solar system. Progress towards achieving outcomes will be validated by external review.

**Objective 5.10 Discover what powered the Big Bang and the nature of the mysterious dark energy that is pulling the Universe apart.**

*Outcome 5.10.1 Search for gravitational waves from the earliest moments of the Big Bang.*

APG 4SEU9 Successfully demonstrate progress in searching for gravitational waves from the earliest moments of the Big Bang. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.10.2 Determine the size, shape, and matter-energy content of the Universe.*

APG 4SEU10 Successfully demonstrate progress in determining the size, shape, and matter-energy content of the Universe. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.10.3 Measure the cosmic evolution of dark energy.*

APG 4SEU11 Successfully demonstrate progress in measuring the cosmic evolution of the dark energy that controls the destiny of the Universe. Progress towards achieving outcomes will be validated by external review.

**Objective 5.11 Learn what happens to space, time, and matter at the edge of a black hole.**

*Outcome 5.11.1 Determine how black holes are formed, where they are, and how they evolve.*

APG 4SEU12 Successfully demonstrate progress in determining how black holes are formed, where they are, and how they evolve. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.11.2 Test Einstein's theory of gravity and map space-time near event horizons of black holes.*

APG 4SEU13 Successfully demonstrate progress in testing Einstein's theory of gravity and mapping space-time near event horizons of black holes. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.11.3 Observe stars and other material plunging into black holes.*

APG 4SEU14 Successfully demonstrate progress in observing stars and other material plunging into black holes. Progress towards achieving outcomes will be validated by external review.

**Objective 5.12 Understand the development of structure and the cycles of matter and energy in the evolving Universe.**

*Outcome 5.12.1 Determine how, where, and when the chemical elements were made, and trace the flows of energy and magnetic fields that exchange them between stars, dust, and gas.*

APG 4SEU15 Successfully demonstrate progress in determining how, where, and when the chemical elements were made, and tracing the flows of energy and magnetic fields that exchange them between stars, dust, and gas. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.12.2 Explore the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays.*

APG 4SEU16 Successfully demonstrate progress in exploring the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays. Progress towards achieving outcomes will be validated by external review.

*Outcome 5.12.3 Discover how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies.*

APG 4SEU17 Successfully demonstrate progress in discovering how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies. Progress towards achieving outcomes will be validated by external review.

## Mission III: To Inspire the Next Generation of Explorers

### Goal 6: Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.

#### Objective 6.1 Increase the number of elementary and secondary students and teachers who are involved in NASA-related education opportunities.

*Outcome 6.1.1 By 2008, increase by 20%, student participation in NASA instructional and enrichment activities.*

APG 4ED1 Develop protocols to establish a baseline of NASA student participation.

APG 4ED2 Develop and implement at least one model program, based on best practices, that engages students in NASA science and technology (inclusive of the science and technical Enterprises).

*Outcome 6.1.2 By 2008, increase by 20%, the number of elementary and secondary educators effectively utilizing NASA content-based STEM materials and programs in the classroom.*

APG 4ED3 Develop protocols to establish a baseline of NASA teacher participation.

APG 4ED4 Develop and implement a model program, based on best practices, that engages teachers in NASA science and technology (inclusive of the science and technical Enterprises).

*Outcome 6.1.3 By 2008, increase by 20%, family involvement in NASA-sponsored elementary and secondary education programs.*

APG 4ED5 Establish a baseline of existing NASA sponsored family involvement activities and existing and potential partners.

APG 4ED6 Using an established best-practices model, implement one NASA-sponsored family involvement component/program at each Center.

*Outcome 6.1.4 By 2008, 90% of NASA elementary and secondary programs are aligned with state or local STEM educational objectives.*

APG 4ED7 Establish a baseline to determine the number of states in which NASA state-based programs are being implemented.

#### Objective 6.2 Support higher education research capability and opportunities that attract and prepare increasing numbers of students and faculty for NASA-related careers.

*Outcome 6.2.1 By 2008, attain a statistically significant increase in the number and diversity of NASA-supported students graduating in NASA-related fields.*

APG 4ED8 Establish a NASA-wide baseline of the number and diversity of NASA-supported students.

*Outcome 6.2.2 By 2008, attain a statistically significant increase in the number of faculty in higher education institutions who are first-time proposers in NASA research and development opportunities.*

APG 4ED9 Develop an inventory identifying the number of first-time proposers and the universe of faculty in higher education institutions involved with NASA research and development opportunities.

*Outcome 6.2.3 By 2008, increase by 20% the number of higher education institutions that align their NASA research and development activities with STEM teacher preparation departments to improve STEM teacher quality.*

APG 4ED10 Develop a model to demonstrate how NASA's investment in higher education institutions can influence the quality of pre-service education in STEM fields.

*Outcome 6.2.4 By 2008, increase by 10% the number and diversity of students conducting NASA-relevant research.*

APG 4ED11 Develop an infrastructure and funding plan that provides Education sponsored flight research opportunities (including STS, ISS, ELV, balloons, and sounding rockets) for graduate, undergraduate, and selected high school students.

**Objective 6.3 Increase the number and diversity of students, teachers, faculty and researchers from underrepresented and underserved communities in NASA related STEM fields.**

*Outcome 6.3.1 By 2008, increase by 20%, underrepresented/underserved NASA-sponsored students who pursue academic degrees in NASA-related STEM disciplines.*

APG 4ED12 Develop protocols to establish a baseline of NASA underrepresented/underserved student participation.

APG 4ED13 Develop a model undergraduate program, based on best practices, bridging current programs, that engages underrepresented/underserved students.

*Outcome 6.3.2 By 2008, increase by 20%, the number and diversity of teachers and faculty from underrepresented/underserved communities and institutions who participate in NASA-related STEM programs.*

APG 4ED14 Develop protocols to establish a baseline of NASA underrepresented/underserved teacher/faculty participation in NASA STEM related learning environments.

*Outcome 6.3.3 By 2008, increase by 20% the number of underrepresented/underserved researchers and minority serving institutions that compete for NASA research and development opportunities.*

APG 4ED15 Establish a baseline of the numbers of underserved/underrepresented researchers and minority serving institutions competing for NASA research announcements.

APG 4ED16 Conduct 3 technical assistance workshops.

*Outcome 6.3.4 By 2008, increase family involvement in underrepresented/underserved NASA-sponsored student programs.*

APG 4ED17 Using an established best-practices model, pilot a NASA-sponsored family involvement component in one underrepresented/underserved NASA sponsored student program.

**Objective 6.4 Increase student, teacher, and public access to NASA education resources via the establishment of e-Education as a principal learning support system.**

*Outcome 6.4.1 By 2008, identify and implement 4 new advanced technology applications that will positively impact learning.*

APG 4ED18 Benchmark advanced technology tools/applications under development to determine the 4-6 with the most impact potential for NASA e-learning.

*Outcome 6.4.2 By 2008, demonstrate the effectiveness of NASA digital content materials in targeted learning environments.*

APG 4ED19 Assess at least 25 of the NASA explorer schools, utilizing the School Technology and Readiness (STaR) tool.

*Outcome 6.4.3 By 2008, establish a technology infrastructure that meets citizen demand for NASA learning services.*

APG 4ED20 Perform a NASA learning services technology infrastructure needs assessment.

**Goal 7: Engage the public in shaping and sharing the experience of exploration and discovery.**

**Objective 7.1 Improve public understanding and appreciation of science and technology, including NASA aerospace technology, research, and exploration missions.**

*Outcome 7.1.1 By 2008, establish a national program to engage the informal education community with NASA Science and Technology.*

APG 4ED23 Conduct an opinion survey to baseline public attitudes and knowledge of NASA research and exploration.

*Outcome 7.1.2 By 2008 provide instructional materials derived from NASA research and scientific activities that meet the needs of NASA's informal education partners.*

APG 4ED21 Compile an inventory of existing programs and partnerships to establish a baseline to assess and prioritize high-leverage and critical informal education programs and educational family involvement activities.

*Outcome 7.1.3 By 2008 provide professional development for NASA's informal education partners.*

APG 4ED22 Inventory and assess current NASA professional development programs for relevance to the targeted informal learning environments.

*Outcome 7.1.4 Engage the public in NASA missions, discoveries and technology through public programs, community outreach, mass media, and the Internet.*

APG 4SSE20 Through partnerships with major science museums or planetariums, put on display or on tour major exhibitions or planetarium shows based on Theme content.

APG 4SSE21 Provide materials and technical expertise to support the development of exhibits and programs at science museums and planetariums.

APG 4SSE22 Seek out and capitalize on special events and particularly promising opportunities in the Theme science program to bring space science to and involve the public in the process of scientific discovery.

APG 4ESA6 Provide in public venues at least 50 stories on the scientific discoveries, practical benefits, or new technologies sponsored by the Earth Science Enterprise.

APG 4ESS13 Post the most exciting imagery and explanations about Earth science on the Earth observations/ESE website.

APG 4SFS3 Ensure participation of all space flight programs and Centers in increasing by 10% venues that provide "hands-on" opportunities for the public to experience and become more knowledgeable of space flight benefits and contributions, particularly ISS.

APG 4RPFS8 Increase distribution of the Space Research newsletter by 5,000 over FY03 circulation in order to further educate the general public, industry, and academia on space-based research.

APG 4RPFS9 Through collaboration with PAO, establish and sustain a series of media briefings highlighting OBPR research.

APG 4RPFS10 Expand outreach activities that reach minority and under-represented sectors of the public, through increased participation in conferences and community events that reflect cultural awareness and outreach. Each fiscal year, increase the previous year baseline by supporting at least one new venue that focuses on these public sectors.

APG 4AT16 Partner with external organizations to celebrate the centennial of powered flight highlighting NASA's accomplishments & activities in the advancement of flight.

APG 4AT17 Partner with museums & other cultural organizations and institutions to promote NASA achievements to non-traditional audiences, develop and implement a series of traveling exhibitions highlighting NASA activities, develop and distribute informational material related to accomplishments and plans.

APG 4MSM15 Maintain publicly-available websites at the Program and Project levels. Publish at least 10 articles or papers on key innovations. Support at least 2 conferences or exhibits highlighting research in Aerospace Technology. (CICT, RMCS & ECT)

APG 4SLI18 Space transportation technical exhibits will be sponsored for at least five events reaching over 50,000 participants to improve public appreciation of the ongoing activities and benefits of NASA's space transportation research and technology development efforts.

APG 4ITTP2 Publish and distribute program specific publications (Aerospace Innovations, NASA Tech Briefs, Spinoff) including 1 industry targeted edition, in a sector where NASA can promote its technologies available for commercialization.

APG 4ITTP3 Provide public and industry access to the TechTracS database, which features approximately 18,000 updated and evolving new technologies, as well as technical briefs, diagrams, and illustrations.

# Space Flight Capabilities

## **Goal 8: Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.**

### **Objective 8.1 Assure safe, affordable, and reliable U.S.-based crew access and return from the International Space Station.**

*Outcome 8.1.1 Develop and deliver an Orbital Space Plane that provides safe, affordable and reliable transportation capability for no fewer than four crew, to and from the International Space Station as soon as practical, but no later than 2012.*

APG 4SLI4 The OSP Program Plan will be approved and the OSP Level 2 Requirements will be established and approved.

APG 4SLI5 A conceptual design of the Orbital Space Plane will be completed with sufficient cost, schedule, technical, and risk definition to enable a full-scale development decision.

APG 4SLI6 The X-37 Approach and Landing Test Vehicle will be certified for flight demonstration, establishing it as a test platform for technology demonstrations supporting the OSP.

APG 4SLI7 The Demonstration of Autonomous Rendezvous Technology flight article will be certified for flight demonstration, establishing it as a test platform for demonstrating key technologies required to enable an autonomous (no pilot in the loop) approach of an OSP to the International Space Station.

### **Objective 8.2 Improve the safety, affordability and reliability of future space transportation systems.**

*Outcome 8.2.1 Develop and demonstrate risk-reduction technologies by 2009 that will enable decisions for development of a lower-cost, higher reliability space transportation system.*

APG 4SLI8 The Next Generation Launch Technology (NGLT) Program Plan will be approved, aligning the Program implementation approach with the Space Transportation strategic objectives.

APG 4SLI9 The preliminary design of a reusable hydrocarbon prototype rocket engine will be completed, demonstrating the design's applicability to a reusable launch vehicle.

APG 4SLI10 A LOx/LH2 full flow staged combustion engine cycle will be operationally demonstrated to determine its applicability to a reusable launch vehicle.

APG 4SLI11 The preliminary design of a Rocket Based Combined Cycle (RBCC) ground testbed will be completed, paving the way toward ground demonstration of a hypersonic air-breathing propulsion system.

APG 4SLI12 The preliminary design of a Mach 4 ground turbine testbed will be completed, leading to the development of the primary element of a turbine-based combined-cycle hypersonic air-breathing propulsion system.

APG 4SLI13 The fabrication of the X-43C Mach 5 Multi-Module Flowpath Propulsion Demonstrator will be completed, enabling the ground demonstration of a hydrocarbon dual-mode scramjet powered vehicle applicable for a reusable launch vehicle.

APG 4SLI14 The testing and analysis of a light weight ceramic composite cooled panel in a scramjet test article will be completed, demonstrating a critical propulsion technology needed for development of an air-breathing reusable launch vehicle.

APG 4SLI15 The design and fabrication of a Mach 15 hypersonic scramjet model platform will be completed, leading to the demonstration of a scramjet engine at high Mach number.

**Objective 8.3 Improve the accessibility of space to better meet research, Space Station assembly, and operations requirements.**

*Outcome 8.3.1 Assure public, flight crew, and workforce safety for all Space Shuttle operations and safely meet the manifest and flight rate commitment.*

APG 4SSP1 Implement necessary modifications to the Space Shuttle system for return-to-flight in FY04.

APG 4SSP2 Achieve zero Type-A (damage to property at least \$1M or death) or Type-B (damage to property at least \$250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY2004.

APG 4SSP3 Achieve 100% on-orbit mission success for all Shuttle missions launched in FY04. For this metric, mission success criteria are those provided to the prime contractor (SFOC) for purposes of determining successful accomplishment of the performance incentive fees in the contract.

*Outcome 8.3.2 Extend the operational life of the Space Shuttle.*

APG 4SSP4 In FY04 conduct a critical review of requirements, priorities, risks, and progress to effectively support Shuttle service life extension.

**Objective 8.4 Assure capabilities for world-class research on a laboratory in low Earth orbit.**

*Outcome 8.4.1 Provide a safe, reliable, and well-managed on-orbit research facility.*

APG 4ISS2 Achieve zero Type-A (damage to property at least \$1M or death) or Type-B (damage to property at least \$250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY2004.

APG 4ISS3 Based on the Space Shuttle return-to-flight plan, establish a revised baseline for ISS assembly (through International Core Complete) and research support.

APG 4ISS4 Provide at least 80% of up-mass, volume and crew-time for science as planned at the beginning of FY04.

*Outcome 8.4.2 Expand the ISS crew size to accommodate U.S. and International Partner research requirements.*

APG 4ISS5 Obtain agreement among the International Partners on the final ISS configuration.

**Objective 8.5 Provide services for space communications, rocket propulsion testing, and launch in support of NASA, other government agencies and industry.**

*Outcome 8.5.1 Provide safe, well-managed and 95% reliable space communications, rocket propulsion testing, and launch services to meet agency requirements.*

APG 4SFS4 Maintain NASA success rate at or above a running average of 95% for missions on the FY04 Expendable Launch Vehicle (ELV) manifest.

APG 4SFS5 Achieve at least 95% of planned data delivery for the International Space Station, each Space Shuttle mission, and low-Earth orbiting missions in FY04.

APG 4SFS6 Achieve zero Type-A (damage to property at least \$1M or death) or Type-B (damage to property at least \$250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY2004.

APG 4SFS7 Achieve positive feedback from a minimum of 95% of all rocket propulsion test customers.

APG 4SFS8 Establish the Agencywide baseline space communications architecture, including a framework for possible deep space and near Earth laser communications services.

**Objective 8.6 Create concepts, technologies and capabilities for space transportation that enable affordable future infrastructures.**

*Outcome 8.6.1* By 2009, provide final requirements for initial human and robotic exploration infrastructures and missions to enable key decisions on the preferred pathways for future space transportation systems to be deployed as soon as 2015.

APG 4SFS9 Define and provide space transportation requirements for future human and robotic exploration and development of space to all NASA and other government agency programs pursuing improvements in space transportation.

**Goal 9: Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.**

**Objective 9.1 Understand human physiological reactions to reduced gravity and develop countermeasures to assure survival of humans traveling far from Earth.**

*Outcome 9.1.1* By 2008, develop and test candidate countermeasures using ground-based analysis and space flight.

APG 4BSR8 Use ground-based and space-based research to lessen the risks related to long duration phenomena such as bone loss, physiological adaptation to isolation and confinement, and the biological effects of radiation as described in the Bioastronautics Critical Path Roadmap.

APG 4BSR9 Publish results of Bioastronautics experiments conducted during early ISS Increments (1 through 8) and preliminary results from Increments 9 and 10.

APG 4BSR10 Maintain productive peer-reviewed research program in Biomedical Research and Countermeasures including a National Space Biomedical Research Institute that will perform team-based focused countermeasure-development research.

APG 4SFS10 Certify the medical fitness of all crew members before launch.

*Outcome 9.1.2* By 2008, reduce uncertainties in estimating radiation risks by one-half.

APG 4BSR11 Expand the space radiation research science community to involve cutting edge researchers in related disciplines by soliciting, selecting, and funding high quality research.

APG 4BSR12 Complete two experimental campaigns ("runs") using recently completed National Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory (BNL) to measure survival, genetic mutation (mutagenesis), and chromosome aberrations in cells and tissues to improve understanding of the biological effects of the space radiation environment.

APG 4BSR13 Evaluate radiation risks to astronauts by continued and careful analysis of past radiation exposures, results of medical follow up, and comparison with appropriately chosen control population not exposed to similar levels of radiation. Make experimental data available for operational use on ISS and other space-related activities where appropriate.

*Outcome 9.1.3* Advance understanding of the role of gravity in biological processes to support biomedical research.

APG 4BSR14 Openly solicit ground-based research in appropriate Fundamental Biology disciplines to lay the ground work for advanced understanding of the role of gravity in biological processes associated with the human health risks of space flight.

APG 4BSR15 Plan for increased early utilization for basic biology research in 2005 to take advantage of evolving ISS capabilities.

APG 4BSR16 Maintain a competitive, productive peer-reviewed research program to advance understanding of the role of gravity in biological processes.

**Objective 9.2 Develop new human support systems and solutions to low gravity technological challenges to allow the next generation of explorers to go beyond low earth orbit.**

*Outcome 9.2.1 Identify & test technologies by 2010 to reduce total mass requirements by a factor of three for Life Support using current ISS mass requirement baseline.*

APG 4BSR17 Demonstrate, through vigorous research and technology development, a 50% reduction in the projected mass of a life support flight system compared to the system baselined for ISS.

APG 4MSM1 Demonstrate ground test of a Mobile Intelligent Vehicle Health Management (IVHM) system for internal spacecraft operations that will provide environmental sensing capabilities and knowledge management services. The Mobile IVHM will perform independent calibration checks for environmental sensors; autonomously replace or substitute for failed environmental sensors; hunt down and isolate gas leaks and temperature problems; and provide a range of crew personal data assistant functions.

*Outcome 9.2.2 By 2008, develop predictive models for prototype two-phase flow and phase change heat transfer systems for low- and fractional gravity with an efficiency improvement of at least a factor of two over 2003 ISS radiative systems, and prepare ISS experiments for validation.*

APG 4PSR8 Increase the current strategic ground research in microgravity heat exchange and advance the existing ISS investigations toward flight.

*Outcome 9.2.3 By 2008, develop predictive engineering model and prototype systems to demonstrate the feasibility of deploying enhanced space radiation-shielding multi-functional structures with at least a factor of two improvement in shielding efficiency and mass reduction, and prepare a space experiment for validation.*

APG 4PSR9 Extend the available database on radiation effects on materials properties using the newly commissioned NASA Space Radiation Laboratory at Brookhaven.

**Objective 9.3 Demonstrate the ability to support a permanent human presence in low Earth orbit as a stepping-stone to human presence beyond.**

*Outcome 9.3.1 Develop experience in working and living in space by continuously supporting a crew on-board the ISS through 2016.*

APG 4ISS6 Continuously sustain a crew to conduct research aboard the ISS.

**Objective 9.4 Develop innovative concepts for systems, infrastructures and missions to extend the duration and boundaries of human space flight.**

*Outcome 9.4.1 By 2009, identify the preferred approach for sustainable human and robotic exploration beyond low Earth orbit, beginning no earlier than 2015.*

APG 4SFS11 Identify 5-9 alternative human exploration concepts/mission options for ambitious future human activities beyond LEO.

APG 4MEP17 Develop advanced concepts for Mars missions where human intervention can significantly increase the scientific return, and develop a technology roadmap for critical technologies that can be demonstrated effectively in the core robotic program.

APG 4SLI16 Complete the systems assessment of the Next Generation Launch Technology needs, priorities, and technical performance metrics and provide an integrated roadmap for space launch technology investments.

## **Goal 10: Enable revolutionary capabilities through new technology.**

### **Objective 10.1 Improve the capability to assess and manage risk in the synthesis of complex engineering systems.**

*Outcome 10.1.1 By 2005 demonstrate 3 prototype systems that prove the feasibility of resilient systems to mitigate risks in key NASA mission domains. Feasibility will be demonstrated by reconfigurability of avionics, sensors, and system performance parameters.*

APG 4MSM2 Develop a Prototype Concept Design Risk Workstation that provides the capability to identify, track, and trade-off risk in the conceptual design phase of missions. The workstation will integrate databases, visualization modules, solicitation routines, system simulations, and analysis programs that support an interactive system design process.

*Outcome 10.1.2 By 2006 provide 5 decision support tools/methodologies to fill the current technology gaps in the following areas of risk management: organizational risk, engineering risk, and early lifecycle design risks. These tools will provide: verifiable completeness checks, relative risk exposure comparisons, repeatable and distributable quantifications of system risk analysis.*

### **Objective 10.2 Create system concepts and demonstrate technologies that will enable new science measurements and scientific missions.**

*Outcome 10.2.1 By 2007, perform 10 technology assessments to identify high-payoff mission enabling technologies for guiding program investment decisions.*

APG 4MSM3 Develop a process for assessing the system-level benefits of new technologies, and complete technology assessments on 3 representative mission classes selected by the Technology Executive Board. A mission class is a set of missions with similar scientific objectives, such as large space-based astronomical observatories. The technology assessment will be concluded when the mission enabling technologies have been identified, and system-level performance goals for these technologies have been established.

*Outcome 10.2.2 By 2007, develop advanced spacecraft propulsion technologies to reduce the trip time for planetary missions by 30%.*

APG 4MSM4 Demonstrate lightweight, sub-kilowatt ion engine for small spacecraft to reduce interplanetary trip time by 30%.

*Outcome 10.2.3 By 2007, develop six new science measurement capabilities.*

APG 4MSM5 Develop bio-molecular probe to detect specific biomarker signature in-vitro for disease detection and astronaut health monitoring. Demonstrate a molecular probe that detects at least one specific biomarker in cells.

APG 4MSM6 Demonstrate > 5% efficiency for 2-micron laser transmitter. State-of-the-art laser transmitters have about 3% efficiency. Higher efficiency will enable smaller, lighter space-based lidar instruments for active sensing of the Earth's atmosphere.

APG 4MSM7 Develop 1,000-element array of superconducting transition edge sensors to enable astronomical imaging in the unexplored submillimeter region of the spectrum.

APG 4MSM8 Develop miniature chromatography system for separation and detection of organic materials to enable the search for life on other planets.

*Outcome 10.2.4 By 2006, demonstrate 4 revolutionary spacecraft systems technologies to enable distributed science collection, exploration of extreme environments, and lower mission cost.*

APG 4MSM9 Demonstrate by simulation millimeter precision formation flying. The simulation will validate sensors and control algorithms needed to enable constellations of spacecraft for distributed science measurements.

APG 4MSM10 Develop microspacecraft ground testbed that incorporates micro navigation subsystem, micro thrusters, and multifunctional structure. By integrating miniaturized spacecraft subsystems, the testbed will demonstrate a factor of 2 to 3 reduction in spacecraft mass, which will result in lower mission costs.

*Outcome 10.2.5 By 2006, increase capabilities to acquire and return scientific data by a factor of 3.*

APG 4MSM11 Develop critical spacecraft networking technologies. Demonstrate spacecraft communications technologies achieving 1Gbps or greater for near Earth, and 1Mbps or greater for deep space applications. Develop related protocols and software for Internet-like space computing and communications. High bandwidth communications and networking technologies will increase scientific return.

APG 4MSM12 Demonstrate in a laboratory environment deployment and rigidization of a jointed inflatable truss to enable modular assembly of large apertures. In-space assembly will enable a factor of 10 increase in aperture size to increase scientific return.

*Outcome 10.2.6 By 2005, demonstrate 6 automated reasoning, intelligent data understanding, or human centered computing technologies for science exploration missions.*

APG 4MSM13 Complete simulated autonomous science exploration mission - Demonstrate a successful analogue science mission (terrestrial rover or simulated spacecraft) with key autonomy technologies in planning/scheduling, science data priority assignment, system executives, and diagnostic systems, enabling goal-directed systems for science exploration missions.

*Outcome 10.2.7 By 2005, demonstrate 3 distributed or collaborative applications to improve the design or operations of future missions.*

APG 4MSM14 Develop collaborative science and engineering technologies for integrated simulation and information management, enabling reductions in set-up and management times for aerospace engineering, science simulations, and mission status awareness of remote exploration missions. Demonstrate standardized protocols and specifications for interoperability of simulation components and heterogeneous data sources; provide visual assembly of workflow components and tools; provide applications-oriented process management; and demonstrate heterogeneous database access technology that can automatically access distributed, heterogeneous data sources.

### **Objective 10.3 Leverage partnerships between NASA Enterprises, U.S. industrial firms, and the venture capital community for innovative technology development.**

*Outcome 10.3.1 Promote and develop innovative technology partnerships between NASA, venture capital firms and U.S. industry for the benefit of all Enterprise mission needs, initiating three (3) partnerships per year.*

APG 4ITTP4 Establish 3 partnerships with U.S. industry and the investment community using the Enterprise Engine concept.

APG 4ITTP5 Develop 36 industry partnerships that will add value to NASA Enterprises.

*Outcome 10.3.2 Facilitate on an annual basis the award of venture capital funds or Phase III contracts to two (2) SBIR firms to further develop or produce their technology through industry or government agencies.*

APG 4ITTP6 Achieve through NASBO, the award of Phase III contracts or venture capital funds to 2 SBIR firms to further develop or produce their technology through industry or government agencies.

### **Objective 10.4 Create novel aerospace concepts and technology to support future sustainable human and robotic exploration and development of space.**

*Outcome 10.4.1 By 2009, complete flight demonstration (Technology Readiness Level 7) of novel systems concepts to enable decisions on full-scale developments for safe, affordable, and effective human and robotic exploration infrastructures to be deployed no earlier than 2015.*

APG 4SFS12 Define and provide requirements, technology maturation roadmaps, and an investment strategy for human and robotic exploration and development of space to all NASA and other Agency programs pursuing revolutionary improvements of space capabilities.

APG 4SFS13 Identify 8-10 innovative concepts for transformational space capabilities to expand research, discovery, and exploration, focusing on future human & robotic space outposts and infrastructure in areas including space assembly, maintenance and servicing space utilities and self-sufficient space systems.

**Objective 10.5 Create novel aeronautics concepts and technology to support science missions and terrestrial and space applications.**

*Outcome 10.5.1 Develop technologies that will enable solar powered vehicles to serve as sub-orbital satellites for science missions.*

APG 4AT18 Demonstrate the efficient performance of a flight-prototype regenerative energy storage system in an altitude chamber.

*Outcome 10.5.2 By 2008, develop and demonstrate technologies required for routine Unmanned Aerial Vehicle operations in the National Airspace System above 18,000 feet for High-Altitude, Long-Endurance (HALE) UAVs.*

APG 4AT15 Deliver a validated set of requirements for UAV access at and above FL400, and a preliminary set of requirements for access at and above FL180.

# Implementing Strategies to Conduct Well-Managed Programs

## Solar System Exploration

APG 4SSE1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4SSE2 Each research project will allocate 75% of its funding competitively during FY04.

APG 4SSE3 SSE will complete all of its missions within 10% of their baseline schedules.

*Accomplish key development activities in support of Solar System Exploration:*

APG 4SSE4 Successfully launch MESSENGER.

APG 4SSE5 Deliver the Deep Impact spacecraft for Environmental Testing.

APG 4SSE6 Successfully complete the New Horizons/Pluto Critical Design Review (CDR).

*Accomplish key technology activities in support of Solar System Exploration:*

APG 4SSE7 Define the Level One science goals for the Jupiter Icy Moons Orbiter (JIMO) Mission.

APG 4SSE8 Release an NRA for high capability instruments useful on the JIMO Mission and follow-on Project Prometheus payloads.

APG 4SSE9 Release an NRA for the next New Frontiers Mission.

## Mars Exploration Program

APG 4MEP1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4MEP2 Each research project will allocate 75% of its funding competitively during FY04.

APG 4MEP3 MEP will complete all of its missions within 10% of their baseline schedules.

*Accomplish key development activities in support of Mars Exploration:*

APG 4MEP4 Successfully land at least one of the two Mars Exploration Rovers.

APG 4MEP5 Successfully complete the Level One Requirements for the Mars Exploration Rover Mission.

APG 4MEP6 Successfully complete the 2005 Mars Reconnaissance Orbiter (MRO) Assembly, Test, and Launch Operations (ATLO) Readiness Review.

*Accomplish key technology activities in support of Mars Exploration:*

APG 4MEP7 Complete Laser Communication Demonstration Concept Review.

APG 4MEP8 Release Instrument Announcement of Opportunity (AO) for the 2009 Mars Science Laboratory (MSL).

## Astronomical Search for Origins

APG 4ASO1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4ASO2 Each research project will allocate 75% of its funding competitively during FY04.

APG 4ASO3 ASO will complete all of its missions within 10% of their baseline schedules.

*Accomplish key development activities in support of the Astronomical Search for Origins:*

APG 4ASO4 Successfully complete Hubble Space Telescope (HST) Cosmic Origins Spectrograph (COS) development.

APG 4ASO5 Successfully complete Stratospheric Observatory For Infrared Astronomy (SOFIA) Observatory Flight Test.

APG 4ASO6 Successfully complete Space Infrared Telescope Facility (SIRTF) In-Orbit Checkout (IOC) and Science Verification.

*Accomplish key technology activities in support of the Astronomical Search for Origins:*

APG 4ASO7 Establish and freeze James Webb Space Telescope (JWST) System-Level Requirements.

APG 4ASO8 Validate Microarcsecond Metrology (MAM-1) Testbed progress toward interferometer sensor performance for Space Interferometry Mission (SIM).

## Structure and Evolution of the Universe

APG 4SEU1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4SEU2 Each research project will allocate 75% of its funding competitively during FY04.

APG 4SEU3 SEU will complete all of its missions within 10% of their baseline schedules.

*Accomplish key development activities to advance understanding of the Structure and Evolution of the Universe:*

APG 4SEU4 Successfully complete the Gamma-ray Large Area Space Telescope (GLAST) Mission Confirmation Design Review (CDR)

APG 4SEU5 Successfully launch Swift.

APG 4SEU6 Successfully complete Pre-Ship Review of Astro-E2 instruments X-ray Spectrometer (XRS) and X-ray Telescope (XRT).

*Accomplish key technology activities to advance understanding of the Structure and Evolution of the Universe:*

APG 4SEU7 Begin Formulation/Phase A for the Laser Interferometer Space Antenna (LISA) Mission.

APG 4SEU8 Complete Constellation-X (Con-X) design and fabricate the 8x8 Transition Edge Sensor Array for the X-ray Microcalorimeter Spectrometer.

## Sun-Earth Connection

APG 4SEC1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4SEC2 Each research project will allocate 75% of its funding competitively during FY04.

APG 4SEC3 SEC will complete all of its missions within 10% of their baseline schedules.

*Accomplish key development activities to advance understanding of the Sun-Earth Connection:*

APG 4SEC4 Begin Solar Terrestrial Relations Observatory (STEREO) Integration & Testing (I&T).

APG 4SEC5 Begin Solar Dynamics Observatory (SDO) Implementation.

*Accomplish key technology activities to advance understanding of the Sun-Earth Connection:*

APG 4SEC6 Release Announcement of Opportunity (AO) for Geospace Missions.

APG 4SEC7 Make AO selections for Magnetospheric Multiscale Mission.

## **Earth System Science**

APG 4ESS1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4ESS2 Each research project will allocate 80% of its funding competitively during FY04.

APG 4ESS3 Each project will complete its mission within 10% of its baseline schedules.

APG 4ESS4 Successfully develop and infuse technologies that will enable future science measurements by 1) advancing 25% of funded technology developments one Technology Readiness Level, and 2) maturing 2-3 technologies to the point where they can be demonstrated in space or in an operational environment.

APG 4ESS5 At least 90% of all on-orbit instruments will be operational during their design lifetimes.

APG 4ESS6 Disseminate data that are easy to access to science focus area customers.

## **Earth Science Applications**

APG 4ESA7 Deliver at least 90% of operating hours for all operations and research facilities.

APG 4ESA8 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

## **Biological Sciences Research**

APG 4BSR18 Complete all development projects within 110% of the cost and schedule baseline.

APG 4BSR19 Deliver at least 90% of operating hours for all operations and research facilities.

APG 4BSR20 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

## **Physical Sciences Research**

APG 4PSR10 Complete all development projects within 110% of the cost and schedule baseline.

APG 4PSR11 Deliver at least 90% of operating hours for all operations and research facilities.

APG 4PSR12 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

## **Research Partnerships and Flight Support**

APG 4RPFS11 Deliver at least 90% of operating hours for all operations and research facilities.

## **Aeronautics Technology**

APG 4AT1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4AT2 The Theme will allocate 75% of its procurement funding competitively during FY04.

APG 4AT3 The Theme will complete 90% of the major milestones planned for FY04.

## **Education**

APG 4EDU24 At least 80%, by budget, of research projects will be peer reviewed and competitively awarded.

## **International Space Station**

APG 4ISS7 Complete all development projects within 110% of the cost and schedule baseline.

APG 4ISS8 The ISS Program will complete all of its missions within 10% of its baseline schedules.

## **Space Shuttle Program**

APG 4SSP5 Complete all development projects within 110% of the cost and schedule baseline.

APG 4SSP6 Space Shuttle Program will execute its program within 10% of its baseline schedules.

## **Space and Flight Support**

APG 4SFS14 Complete all development projects within 110% of the cost and schedule baseline.

APG 4SFS15 Space and Flight Support will execute its programs within 10% of its baseline schedules.

## **Space Launch Initiative**

APG 4SLI1 Complete all development projects within 110% of the cost and schedule baseline.

APG 4SLI2 The Theme will distribute at least 80% of its allocated procurement funding to competitively awarded contracts.

APG 4SLI3 The Theme will complete all of its milestones within 10% of its baseline schedules.

## **Mission and Science Measurement Technology**

APG 4MSM15 The Theme will conduct external peer reviews on 45% of its research tasks prior to award.

## **Innovative Technology Transfer Partnerships**

APG 4ITTP7 Complete all development projects within 110% of the cost and schedule baseline.

APG 4ITTP8 Distribute at least 80% of allocated procurement funding to competitively awarded contracts, including continuing and new contract activities.

APG 4ITTP9 Complete all milestones within 10% of baseline schedules.