SCIENCE PROGRAM SUMMARY

The President's FY 2012 request for NASA includes $5,016.8 million for Science. NASA continues to expand humanity's understanding of our Earth, our Sun, the solar system, and the universe with 56 science missions in operation and 28 more in various stages of development. The Science budget funds these missions as well as over 3,000 competitively-selected research grants involving over 10,000 scientists, engineers, technologists, and their students across the Nation. The Agency selects competed missions and research proposals based on open competition and peer review. NASA's science efforts continue to advance a robust and scientifically productive program while making difficult choices commensurate with the Government-wide priority to constrain the Federal budget.

The challenges we face have been amplified by the failed launch of the Glory satellite on March 4th. This loss underscores the challenging nature of the space business. Reliable and affordable access to space is vital to NASA's science program.

Earth Science

The FY 2012 budget request includes $1,797.4 million for Earth Science. NASA's constellation of Earth observing satellites provides many of the global environmental observations used for climate research in the United States and abroad.

In early FY 2012, NASA plans to launch the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP), continuing selected climate data records and becoming an integral part of the Nation's operational meteorological satellite system for weather prediction. We also plan to select new Venture Class science instruments and small missions in FY 2012.

The Aquarius instrument on the Argentine Satélite de Aplicaciones Científicas (SAC)-D mission (launching later this year) will deliver the first global ocean salinity measurements to the science community in FY 2012. The Orbiting Carbon Observatory 2 (OCO-2), Landsat Data Continuity Mission (LDCM), and the Global Precipitation Measurement (GPM) missions will be in integration and testing in FY 2012. The first two NRC Decadal Survey missions, Soil Moisture Active/Passive (SMAP) and the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2), will both enter into development during FY 2012. This budget request also funds robust Research and Analysis, Applied Science, and Technology programs. In this climate of fiscal austerity there are some capabilities that will not be developed in order to keep the most important ones on track. Development of the second two Tier 1 Decadal Survey missions, the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI); and the Climate Absolute Radiance and Refractivity Observatory (CLARREO), has been deferred. NASA will continue pre-formulation work on the DESDynI and review international partner options. However, the FY 2012 request enables the Gravity Recovery And Climate Experiment Follow-on (GRACE-FO); the Pre-Aerosols-Clouds-Ecosystems (PACE); and the Tier 2

missions Surface Water and Ocean Topography (SWOT); and Active Sensing of CO2 Emissions Over Nights, Days, and Seasons (ASCENDS) to go forward as planned.

Planetary Science

The Science budget request includes $1,540.7 million for Planetary Science in FY 2012. NASA and its partners consider the period from October 2010 to August 2012 (the length of a Martian year) to be the "Year of the Solar System."

The Juno mission will launch in August 2011 and arrive at Jupiter in 2016. The Gravity Recovery And Interior Laboratory (GRAIL) mission, following launch in September 2011, will enter lunar orbit and help determine the structure of the lunar interior from crust to core; the mission will advance our understanding of the thermal evolution of the Moon by the end of its prime mission in FY 2012. A webcam is giving the public an opportunity to watch technicians assemble and test NASA's MSL "Curiosity," one of the most technologically advanced interplanetary missions ever designed. More than one million people have watched assembly and testing of Curiosity via a live webcam since it went on-line in October. Curiosity will launch in early FY 2012 and arrive at Mars in August 2012; it will be two times as large and three times as heavy as the Spirit and Opportunity rovers, and will focus on investigating whether conditions on Mars have been favorable for microbial life and for preserving clues in the rocks about possible past life. The MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) spacecraft will arrive at Mercury later this evening and will complete its first year in Mercury orbit in March 2012. MESSENGER's instruments will map nearly the entire planet in color, image the surface in high resolution, and measure the composition of the surface, atmosphere and nature of the magnetic field and magnetosphere. During its nearly decade-long mission, the Dawn mission will study the asteroid Vesta and dwarf planet Ceres -- celestial bodies believed to have accreted early in the history of the solar system. Dawn will enter into orbit around Vesta this summer and will depart in 2012 for its encounter with Ceres in 2015. NASA and the European Space Agency (ESA) have selected the five science instruments for the 2016 ExoMars Trace Gas Orbiter mission. The budget also supports robust Research and Analysis and Technology programs.

NASA recently received the new National Academy of Sciences Decadal Survey for Planetary Science, entitled *Vision and Voyages for Planetary Science in the Decade 2013—2022*. We are grateful to the Academy and to all the Survey participants for their hard work and thoughtful recommendations. NASA will use this Survey to prioritize ongoing programs and future mission opportunities.

Astrophysics

The FY 2012 budget request includes $682.7 million for Astrophysics (not including an additional $375 million for the James Webb Space Telescope [JWST] which is detailed below). This is a golden age of space-based Astrophysics, with 14 observatories in operation. Astrophysics research, technology investments, and missions aim to

understand how the universe works, how galaxies, stars and planets originated and developed over cosmic time, and whether Earth-like planets and life exist elsewhere in the cosmos.

The FY 2012 budget request reflects the scientific priorities of the new National Academy of Science Decadal Survey entitled, *New Worlds, New Horizons in Astronomy and Astrophysics*. The budget includes additional funding for the Explorer mission selection planned for 2012, sustains a vigorous flight rate of future astrophysics Explorer missions and missions of opportunity, and increases investments in recommended research and technology initiatives. Funding is also provided for pre-formulation investments in recommended large missions beyond JWST, while work on the Space Interferometry Mission (SIM) and Joint Dark Energy Mission (JDEM) has been brought to a close, consistent with the recommended Decadal Survey program. The Stratospheric Observatory for Infrared Astronomy (SOFIA) will complete its open door flight testing and conduct the first competed science observations in FY2012. The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will launch in early 2012. The NASA Astrophysics budget also supports continuing operations of the Hubble Space Telescope (HST), Chandra X-ray Observatory, and several other astrophysics observatories in space. The budget increases funding for the core Astrophysics research program, including sounding rocket and balloon suborbital payloads, theory, and laboratory astrophysics.

James Webb Space Telescope

The FY 2012 budget request includes $375 million for the James Webb Space Telescope (JWST). JWST is now budgeted as a separate theme, reflecting changes implemented in FY 2011 to improve management oversight and control over this critical project, as recommended by the Independent Comprehensive Review Panel's (ICRP) report in November 2010. The project, which was previously managed within the Science Mission Directorate's (SMD) Astrophysics Division within NASA Headquarters, and was part of the Cosmic Origins Program, is now managed via a separate program office at NASA Headquarters. The JWST Project Manager at Headquarters now reports directly to NASA's Associate Administrator and the Associate Administrator of SMD. The lead Center for JWST, Goddard Space Flight Center, has also implemented changes, with project management now reporting directly to the Center Director. JWST was the top priority large mission recommended in the previous NRC Decadal Survey and is considered a foundational element of the science strategy in the new Decadal Survey for Astronomy and Astrophysics. Cost growth and schedule issues identified during the Mission Critical Design Review led to the formation of the ICRP. The ICRP report concluded that the problems causing cost growth and schedule delays on the JWST project are associated with cost estimation and program management, not technical performance. The $375 million funding in 2012 gives the program a stable footing to continue progress while the Agency develops a revised program plan that includes a realistic assessment of schedule and lifecycle cost. The revised schedule and lifecycle cost will be reflected in the 2013 President's Budget Request.

Heliophysics

The FY 2012 budget request includes $622.3 million for Heliophysics. NASA's heliophysics satellites provide not only a steady stream of scientific data for NASA's research program, but also supply a significant fraction of critical space weather data used by other Government agencies for support of commercial and national security activities in space. Those agencies use the data to protect operating satellites, communications, aviation and navigation systems, as well as electrical power transmission grids. The spacecraft also provides images of the Sun with ten times greater resolution than high-definition television in a broad range of ultraviolet wavelengths. On February 6, 2011, the two Solar Terrestrial Relations (STEREO) spacecraft reached 180 degrees separation; when combined with the Solar Dynamics Observatory (SDO), these spacecraft will enable constant imaging of the full solar sphere for the next eight years, as the solar cycle peaks and begins to decline again. These three spacecraft working together and in combination with NASA's other solar observatories will give us unprecedented insight into the Sun and its dangerous solar storms that could threaten both satellites and humans in space as well as electric power systems on Earth. NASA has begun development of a mission, called Solar Probe Plus, that will visit and study the Sun from within its corona—a distance only 8.5 solar radii above its surface.

The FY 2012 budget will enable completion of the Radiation Belt Storm Probes (RBSP) mission for launch in FY 2012 as well as the completion of development of the Interface Region Imaging Spectrograph (IRIS) Explorer mission. In FY 2012, the Magnetospheric Multiscale (MMS) mission will enter its assembly and integration phase, the Solar Orbiter Collaboration with ESA will undergo Mission Confirmation Review, and the Solar Probe Plus mission will enter into the preliminary design phase. NASA has increased funding for the next Explorer mission selection planned for 2012 to enable selection of up to two full missions, as well as instruments that may fly on non-Explorer spacecraft. The budget also supports robust Research and Analysis and Sounding Rocket operations programs. The National Academy of Sciences has begun work on the next Decadal Survey for Heliophysics and we anticipate its release in the spring of 2012.

Life and Physical Sciences

The FY 2012 budget request includes $66.5 million to support research in the Life and Physical Sciences on the International Space Station (ISS), including a non-profit organization (NPO) to stimulate, develop and manage the U.S. national uses of the ISS National Lab. The ISS has transitioned from the construction era to that of operations and research, with a 6-person permanent crew, 3 major science labs, an operational lifetime through at least 2020, and a growing complement of cargo vehicles, including the European Automated Transfer Vehicle (ATV) and the Japanese H-II Transfer Vehicle (HTV). The FY 2012 budget request reflects the importance of this unparalleled research asset to America's human spaceflight program and will enable fundamental science advances in the areas of biology and physics in the little-understood space environment. These science investments will be informed by recommendations in the National

Academy of Science decadal survey for life and microgravity sciences, which will be released shortly.

Many avenues of research being conducted aboard the ISS may have terrestrial applications. For example, ISS research has shown that *Salmonella* bacteria become more virulent in microgravity (i.e., more aggressive in causing disease). Scientists have identified the gene responsible for this increased virulence and are developing a potential vaccine against *Salmonella*. AstroGenetix, Inc. has funded their own follow-on studies on ISS and is now pursuing approval of a vaccine as an Investigational New Drug with the Food and Drug Administration. They are now applying a similar development approach to methicillin-resistant *Staph aureus* (MRSA).

Microcapsules are tiny micro-balloons used in cancer treatment to deliver anti-cancer drugs directly to a tumor site. Microcapsules with improved cancer treatment properties developed on the ISS were reproduced on Earth and were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method are beginning.

Numerous plant growth experiments have investigated both the effects of microgravity, as well as the capability for growing regenerable food supplies for crew. Technology developed the for greenhouse flown on the ISS led to a new technology that is widely used on Earth, killing 98 percent of airborne pathogens (including Anthrax) for food preservation, doctors' offices, homes, and businesses.

Finally, as part of the ISS National Laboratory effort, the National Institutes of Health (NIH) are hosting three rounds of competition for the BioMed-ISS initiative. The first round of grants for the ground-based phase has been awarded to support the following important research topics:

- Studying bone-cells in a gravity-free environment in order to uncover new therapeutic targets for osteoporosis and related bone diseases.

- Applying lessons learned from studies of immune cells in the space environment, where the immune system is suppressed, to a new model for investigating the loss of immune response in older women and men.

- Using microgravity three-dimensional cell culture models to generate insights into how the barrier properties of the intestines, which inhibits the movement of toxins into the intestinal tract behave, and to explore how the absence of gravity affects alcohol's ability to compromise this barrier. The compromise of this barrier and the reduced resistance to toxin transport is major factor in alcohol-related disease, The microgravity environment is helping scientists understand the underlying mechanisms for this process.