


# Fiscal Year 2013 Budget Estimates





**NASA and the nation are embarking on an ambitious program of space exploration that will build on new technologies as well as proven capabilities as we expand our reach out into the solar system.**

**While reaching for new heights in space, we're creating new jobs right here on Earth – especially for the next generation of American scientists and engineers – by supporting cutting edge aeronautics and space technology innovations, research and development that will help fuel the Nation's economy for years to come.**

**Despite tough economic times, the FY13 budget continues to implement the science, aeronautics and space exploration program agreed to by the President and a bipartisan majority in Congress, laying the foundation for remarkable discoveries here on Earth and in deep space including new destinations such as an asteroid and Mars.**



# Overview

- We have made tough but sustainable choices to provide stability and continuity to existing programs and set an affordable pace for unfolding the next great chapter in exploration.
- We are making steady and tangible progress building the next-generation, deep space crew capsule and heavy-lift rocket; expanding use of the International Space Station to improve life on Earth and help make the next great leaps in scientific discovery and exploration; and partnering with American companies to create new transportation capabilities to reach low-Earth orbit, stimulate the economy and decrease our reliance on foreign launch providers.
- We are facilitating industry's innovation to develop access to low earth orbit, bringing work to American companies and supporting an economy built to last. This will allow NASA to focus on the big things that no one else can do and at the same time open an entirely new segment of the economy.
- We are driving advances in new aviation and space technologies like laser communications and zero-gravity propellant transfer, seeding innovation that will expand our capabilities in the skies and in space, support economic vitality, and help create new jobs and expanded opportunities for a skilled workforce.
- We are developing an integrated strategy to ensure that the next steps for the robotic Mars Exploration program will support science as well as long-term human exploration goals. The missions currently at Mars, the Mars Science Laboratory on its way, and MAVEN well into development, will help us understand the Red Planet and our needs in future years to meet the President's challenge to send humans to Mars in the mid-2030s.
- We are building and operating a balanced portfolio of innovative science missions that will reach farther into our solar system, reveal unknown aspects of our universe and provide critical data about our home planet.
- We are inspiring the next generation of scientists, technologists, engineers and astronauts.



# 2013 Highlights

➤ **The Budget accomplishes these goals by:**

- ✓ Developing a heavy-lift rocket and crew capsule, with an un-crewed test flight planned for as early as 2017 and a crewed flight as early as 2021.
- ✓ Continuing the commitment to fully using the International Space Station as a National Laboratory, as a unique platform to enable future exploration, and as a facility that brings nations together in a common pursuit of knowledge and experience.
- ✓ Embracing partnership with the U.S. commercial space industry to enable safe, reliable, and cost effective access to low Earth orbit for crew and cargo and to reduce American reliance on foreign services.
- ✓ Pursuing a portfolio of research and technology investments that will increase the nation's capability to operate in space and enable long-term deep space exploration. These investments, which will increase the capability and decrease the cost of NASA, commercial, and other government space activities, include numerous high payoff, high risk technology projects that industry cannot tackle today.



# 2013 Highlights, *continued*

- ✓ Continuing toward launch in 2018 of the James Webb Space Telescope which will again revolutionize our understanding of the universe.
- ✓ Pacing the development of our Mars science program to reflect an integrated strategy for long-term human and robotic exploration of the Red Planet.
- ✓ Taking care of Earth by providing critical long-term data that will help understand our planet's changes and enable more effective responses to natural disasters. We are committed to our work with other government agencies to track and address potential threats from near-Earth asteroids, solar flares, space weather, and other phenomena.
- ✓ Conducting cutting edge aeronautics research with an increased focus on enhancing aviation safety and efficiency of aircraft and the airspace, increasing performance and reducing environmental impacts.
- ✓ Developing and inspiring the next generation of explorers through STEM education activities throughout NASA's programs.
- ✓ Focusing on long-term affordability and efficiency through right-sizing and renewing NASA capabilities and infrastructure, and reducing administrative costs.



# Important Considerations

- **Out-year Funding Assumptions.** In this time of national fiscal austerity, NASA has accepted the challenge to manage to a flat out-year top-line budget. At this time, funding lines beyond FY13 should be considered notional. In general, NASA accounts are held at their FY 2013 request level, adjusted for the amounts transferred to the construction account in FY 2013.
- **Campaign to Promote Efficient and Effective Spending.** This budget continues NASA's efforts to improve operational efficiency and maintains reduced spending for service contracting, travel, supplies and materials, and printing and reproduction:
  - Consolidation of major IT contracts under the IT Infrastructure Integration Program (I3P)
  - Rationalization of facilities and infrastructure
  - Energy management improvements
  - Reductions in administrative expenses and service contracting
- **Aligning and Right-sizing the NASA Workforce**
  - Aligning human capital with the priority requirements of the Agency
  - Reduces the rate of re-hiring in FY2013 consistent with budget limitations
- **Presentation in full-cost, where all project costs are allocated to the project, including labor funding for the Agency's civil service workforce.**



# FY 2013 Budget Request

## Budget Authority (\$M) by Account, by Theme

FY14-17 outyears are notional

	Actual FY2011	FY2012 Est.	FY2013	FY2014	FY2015	FY2016	FY2017
<b>Science</b>	<b>4,919.7</b>	<b>5,073.7</b>	<b>4,911.2</b>	<b>4,914.4</b>	<b>4,914.4</b>	<b>4,914.4</b>	<b>4,914.4</b>
Earth Science	1,721.9	1,760.5	1,784.8	1,775.6	1,835.5	1,826.2	1,772.8
Planetary Science	1,450.8	1,501.4	1,192.3	1,133.7	1,102.0	1,119.4	1,198.8
Astrophysics	631.1	672.7	659.4	703.0	693.7	708.9	710.2
James Webb Space Telescope	476.8	518.6	627.6	659.1	646.6	621.6	571.1
Heliophysics	639.2	620.5	647.0	643.0	636.7	638.3	661.6
<b>Aeronautics</b>	<b>533.5</b>	<b>569.4</b>	<b>551.5</b>	<b>551.5</b>	<b>551.5</b>	<b>551.5</b>	<b>551.5</b>
<b>Space Technology</b>	<b>456.3</b>	<b>573.7</b>	<b>699.0</b>	<b>699.0</b>	<b>699.0</b>	<b>699.0</b>	<b>699.0</b>
<b>Exploration</b>	<b>3,821.2</b>	<b>3,712.8</b>	<b>3,932.8</b>	<b>4,076.5</b>	<b>4,076.5</b>	<b>4,076.5</b>	<b>4,076.5</b>
Exploration Systems and Development	2,982.1	3,007.1	2,769.4	2,913.1	2,913.1	2,913.1	2,913.1
Commercial Spaceflight	606.8	406.0	829.7	829.7	829.7	829.7	829.7
Exploration Research and Development	232.3	299.7	333.7	333.7	333.7	333.7	333.7
<b>Space Operations</b>	<b>5,146.3</b>	<b>4,187.0</b>	<b>4,013.2</b>	<b>4,035.1</b>	<b>4,035.1</b>	<b>4,035.1</b>	<b>4,035.1</b>
Space Shuttle	1,592.9	556.2	70.6	0.0	0.0	0.0	0.0
International Space Station	2,713.6	2,829.9	3,007.6	3,177.6	3,170.9	3,212.8	3,234.3
Space and Flight Support (SFS)	839.8	800.9	935.0	857.5	864.2	822.3	800.8
<b>Education</b>	<b>145.4</b>	<b>136.1</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
<b>Cross-Agency Support</b>	<b>2,956.4</b>	<b>2,993.9</b>	<b>2,847.5</b>	<b>2,847.5</b>	<b>2,847.5</b>	<b>2,847.5</b>	<b>2,847.5</b>
Center Management and Operations	2,189.0	2,204.1	2,093.3	2,093.3	2,093.3	2,093.3	2,093.3
Agency Management and Operations	767.4	789.8	754.2	754.2	754.2	754.2	754.2
<b>Construction &amp; Envrmtl Compl Restoration</b>	<b>432.9</b>	<b>486.0</b>	<b>619.2</b>	<b>450.4</b>	<b>450.4</b>	<b>450.4</b>	<b>450.4</b>
Construction of Facilities	373.3	441.2	552.8	359.5	362.9	360.0	360.0
Environmental Compliance and Restoration	59.6	44.8	66.4	90.9	87.5	90.4	90.4
<b>Inspector General</b>	<b>36.3</b>	<b>38.3</b>	<b>37.0</b>	<b>37.0</b>	<b>37.0</b>	<b>37.0</b>	<b>37.0</b>
<b>NASA FY 2013</b>	<b>18,448.0</b>	<b>17,770.0</b>	<b>17,711.4</b>	<b>17,711.4</b>	<b>17,711.4</b>	<b>17,711.4</b>	<b>17,711.4</b>

### Notes:

- FY 2011-2012 are consistent with submitted operating plans however, for comparability purposes, values for Space Technology in those years reflect the funding for Space Technology related activities executed in Exploration, Space Operations, and Cross Agency Support.
- FY 2012 Estimates include the impact to appropriation accounts of the \$30 million rescission included in the 2012 Appropriation Act, in addition to -\$1M from other prior appropriations included in the total.
- Funds associated with out-year estimates for programmatic construction remain in programmatic accounts.



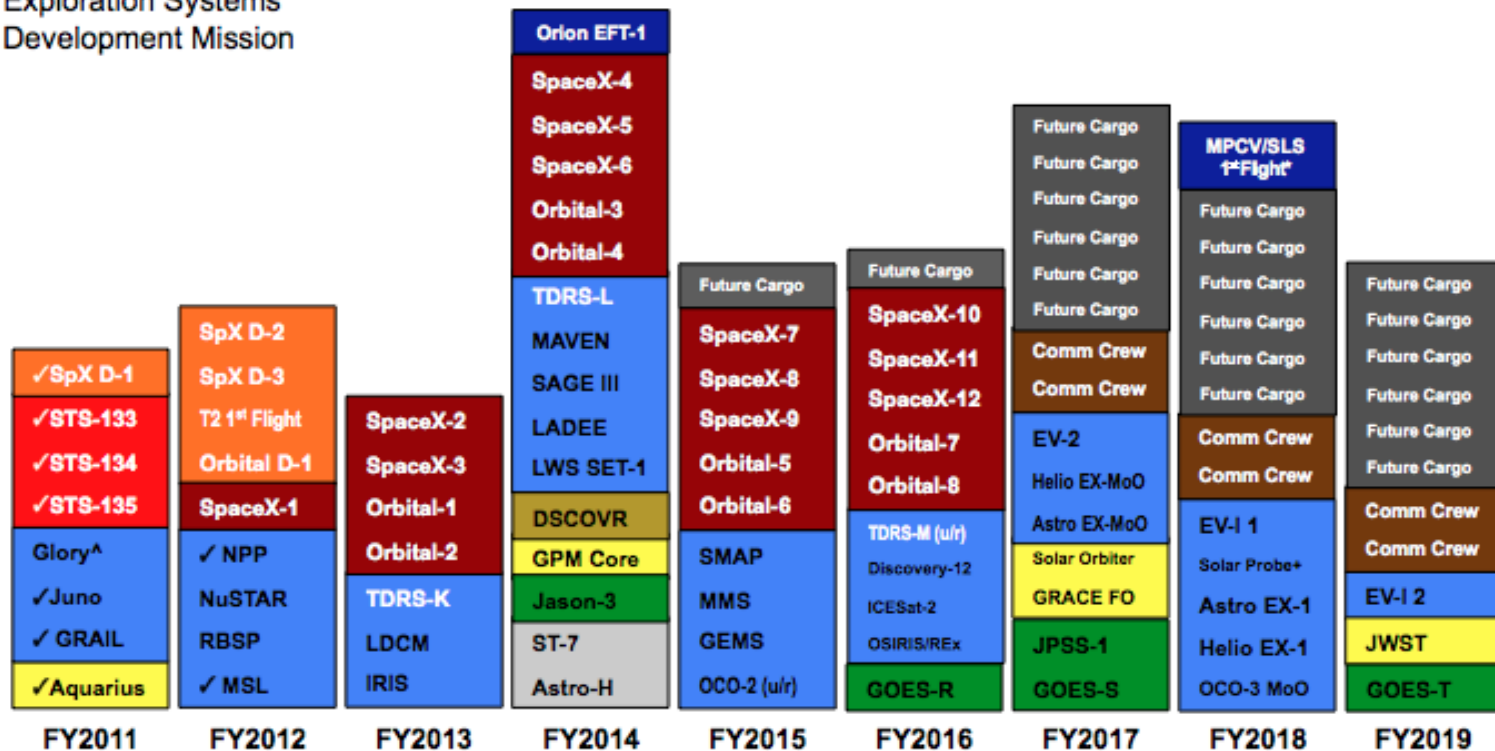
# NASA Mission Launches

(Fiscal Years 2011 - 2019)

- NASA Mission on US ELV
- Reimbursable for NOAA
- Joint NASA-NOAA- USAF Mission
- Joint NASA-International Partner Mission
- International Mission with NASA science instrument or contribution
- Exploration Systems Development Mission

- Space Shuttle Mission
- Commercial Orbital Transportation Services Missions
- ISS Commercial Resupply Services
- Future ISS Cargo Delivery Demand
- Commercial Crew Services

- ✓ Mission successfully launched
- ^ Mission launch failure
- SLS 1<sup>st</sup> Flight launch in CY2017.
- HEO missions denoted in white text.
- SMD missions denoted in black text.
- International launches not shown.
- Commercial flights notional, crew flights TBD.







# Earth Science

Outyears are notional

	2013	2014	2015	2016	2017
Earth Science	\$1,785	\$1,776	\$1,835	\$1,826	\$1,773



- Completes and launches the two remaining foundational missions: Landsat Data Continuity Mission (LDCM) and Global Precipitation Mission (GPM).
- Continues development of OCO-2 crucial to our understanding of the Earth's carbon cycle and its effect on the Earth's climate.
- Formulates and develops SMAP, ICESat-2, and continuity missions SAGE-III/ISS, GRACE-Follow on, and OCO-3 instrument.
- Maintains weather and climate change modeling capabilities to enhance forecast accuracy. Continues working with NOAA and OSTP to address approaches for providing sustained space-borne Earth observations.
- Operates 16 Earth-observing spacecraft.
- Maintains robust R&A, airborne science (including IceBridge), and technology development.

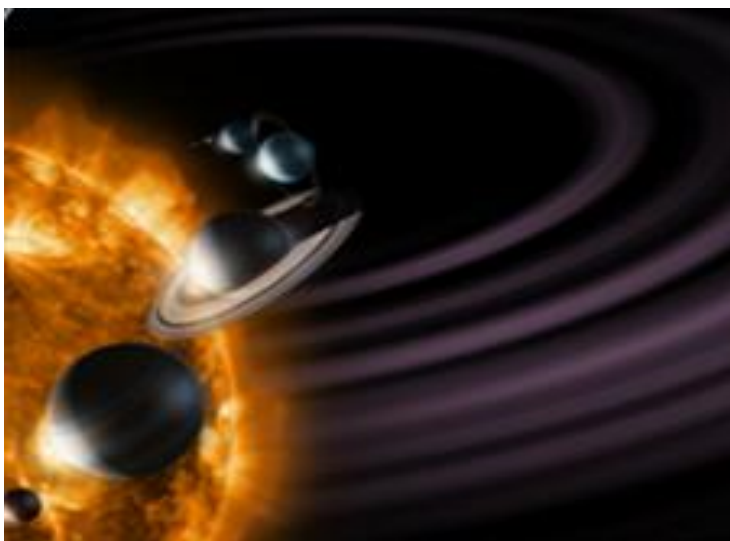


# Planetary Science

Outyears are notional

	2013	2014	2015	2016	2017
Planetary Science	\$1,192	\$1,134	\$1,102	\$1,119	\$1,199

- Continues work toward LADEE and MAVEN launches in CY2013.
- Follows the recent National Research Council's (NRC) *Decadal Survey* to the extent resources permit, and funds outer planet missions concept development.
- Supports ongoing Research and Technology, and Near Earth Object identification and study.
- Restructures future long-term Mars missions to better integrate our science and human Mars exploration efforts.



- Funds development of OSIRIS-REx for launch in 2016.
- Operates 16 Planetary missions, including JUNO and MSL.
- Continues flight development of the Advanced Stirling Radioisotope Generator for 2014/15 launch readiness.
- Continues restart activities for Plutonium-238 production.



# Astrophysics

Outyears are notional

	2013	2014	2015	2016	2017
Astrophysics	\$659	\$703	\$694	\$709	\$710

- Funds development of the Gravity & Extreme Magnetism (GEMS) mission, Stratospheric Observatory for Infrared Astronomy (SOFIA), and instruments for Japan's Astro-H mission.
- Funds the next Astrophysics Explorer mission, to be selected in 2013.
- Continues a robust R&A program.
- Operates 11 Astrophysics missions, including the Hubble Space Telescope, Chandra, Fermi and Kepler (subject to Senior Review).





# James Webb Space Telescope

Outyears are notional

	2013	2014	2015	2016	2017
JWST	\$628	\$659	\$647	\$622	\$571

- The James Webb Space Telescope (JWST) project has addressed the problems of the past and has moved forward with a new baseline for this vital project within the available resources.
- The new plan supports an October 2018 launch date that includes 13 months of budgeted schedule margin.
- The JWST plan was reviewed by NASA's independent Standing Review Board and responds to their findings and recommendations.

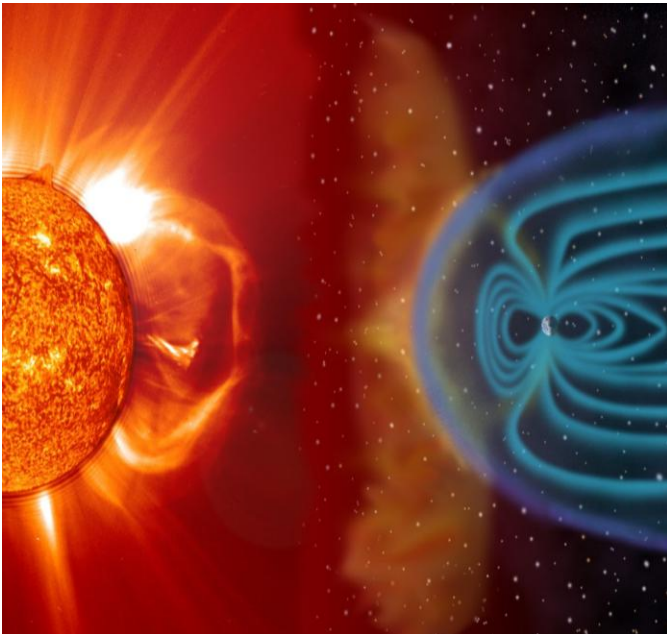




# Heliophysics

Outyears are notional

	2013	2014	2015	2016	2017
Heliophysics	\$647	\$643	\$637	\$638	\$662



- Works toward launch of the strategic MMS mission in 2015.
  - Launches the IRIS Small Explorer mission in 2013.
  - Funds the next Heliophysics Explorer mission selection planned for 2013.
  - Continues formulation of the highest priority “large” Heliophysics mission, Solar Probe Plus.
- 
- Completes the formulation and undertakes initial development of the Solar Orbiter Collaboration mission with the European Space Agency (ESA).
  - Operates 16 Heliophysics missions.



# Joint Agency Satellite Programs

In FY 2010, NASA established the Joint Agency Satellite Division (JASD) within the Science Mission Directorate at Headquarters to manage satellite development work for other agencies on a fully-reimbursable basis. JASD applies standard NASA project management processes to ensure mission success for our partners with a focus on efficiently managing operational satellite acquisitions.

During FY 2013, NASA expects to continue developing the following reimbursable missions for NOAA:

- Joint Polar Satellite System (JPSS): satellites, launch vehicles, ground system
- Geostationary Operational Environmental Satellite–R (GOES-R) series: satellites, launch vehicles
- Jason-3: instruments, launch vehicle
- Deep Space Climate Observatory (DSCOVR): satellite



# Aeronautics

Outyears are notional

	2013	2014	2015	2016	2017
Aeronautics	\$551	\$551	\$551	\$551	\$551

- Continues support for conducting cutting-edge research at the fundamental and integrated systems levels to advance U.S. leadership in aeronautics R&D and to address national aviation challenges.
- Maintains research focus in improving aviation safety, minimizing the environmental impact of aviation, developing innovative air traffic management technologies and revolutionary vehicle technologies for NextGen.
- Continues support for the integration of unmanned aircraft systems into the National Airspace System and the validation and verification of complex aviation systems.
- Continues support for maintaining and improving NASA's key aeronautics facilities.
- Combines hypersonic and supersonic research into a single project to focus on fundamental research for high-speed flight, and transfers responsibility for entry, descent and landing research to Space Technology to increase synergy with Agency's exploration and science missions.



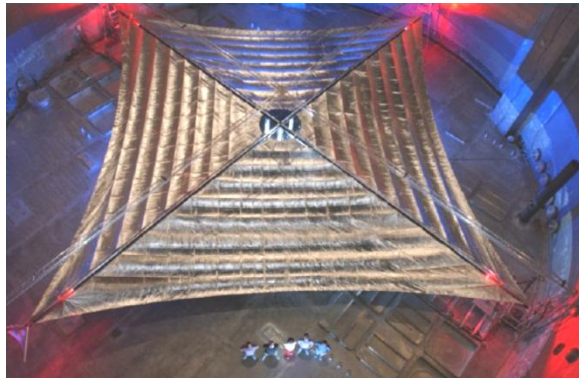


# Space Technology

Outyears are notional

	2013	2014	2015	2016	2017
Space Technology	\$699	\$699	\$699	\$699	\$699

- Develops and matures broadly applicable technology in areas such as: in-space propulsion, robotics, space power systems, deep-space communications, cryogenic fluid handling, and entry, descent, and landing, which are essential for exploration beyond low Earth orbit.
- Ensures a focus on both near-term mission-driven and long-range transformative technology required to meet our Nation's goals in space.



- Advances revolutionary concepts and capabilities, lowering development costs and reducing risk for the Nation's activities in space by engaging NASA Centers, small businesses, academia, industry, other Government agencies and international partners.
- Leads NASA's efforts in transferring and commercializing technology to a wide range of users to ensure the full economic value and societal benefit of these innovations is realized.





# Exploration Systems Development

Outyears are notional

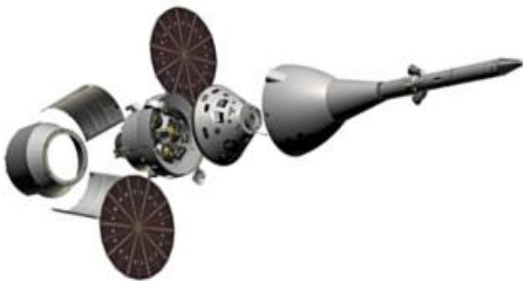
	2013	2014	2015	2016	2017
ESD	2,769	2,913	2,913	2,913	2,913

- By September 30, 2013, NASA will finalize cross-program requirements and system definition so that the first test flight of the Space Launch System (SLS) and Orion Multi-Purpose Crew Vehicle (MPCV) programs are successfully achieved at the end of 2017 in an efficient and cost effective way.
- Provides steady funding for SLS and Orion MPCV, along with associated Exploration Ground Systems (EGS).
- Exploration Systems Development (ESD) related funding is also in the Programmatic CoF (\$143.7 million) which is included in the CECR account.
- Prioritizes work on existing contracts to maintain progress and minimize workforce disruptions.



# Exploration Systems Development (cont)

- Develops the heavy-lift vehicle (\$1.88B in FY 13, including construction and exploration ground systems) that will be capable of launching the crew vehicle, other modules, and cargo for missions beyond low Earth orbit.
  - SLS selected architecture is an Ares/Shuttle-derived solution
- Corresponding modifications to the Kennedy Space Center launch range will be addressed by Exploration Ground Systems (EGS) program (\$0.4B in FY 2013, including construction).
  - NASA will modify Launch Complex 39 to support 2017 launch
- Develops the Orion Multi-Purpose Crew Vehicle (\$1.0B in FY13, including construction) that will carry crew to orbit, provide emergency abort capability on launch, sustain the crew while in space, and provide safe re-entry from deep space return velocities.
  - NASA designated the beyond-LEO version of Orion (“block 2”) as the MPCV selected architecture, and will pace funding so the vehicle will be available in tandem with SLS.
  - Supports Exploration Flight Test 1 (EFT-1) in FY 2014 to reduce crew vehicle program cost and schedule risks





# Commercial Spaceflight

Outyears are notional

	2013	2014	2015	2016	2017
Commercial Spaceflight	\$830	\$830	\$830	\$830	\$830

- Continues the development of U.S. commercial human spaceflight systems to reduce our dependence on Russian spaceflight capabilities for crew exchange.
- Facilitates the development of U.S. commercial crew space transportation capability with the goal of achieving safe, reliable, and cost effective access to and from low Earth orbit and the International Space Station.
- Builds off successful progress in the development of commercial cargo capabilities and the Commercial Crew Development (CCDev) activities.
- Supports award of multiple Space Act Agreements with the intent of having multiple partners progress in their integrated design and development efforts for a Crew Transportation System (CTS).
- Seeks to ensure that contracted services meet the Agency's crew transportation system certification requirements.



# Exploration Research and Development

Outyears are notional

	2013	2014	2015	2016	2017
ER and D	\$334	\$334	\$334	\$334	\$334

- Expands fundamental knowledge and develops advanced human spaceflight capabilities required to explore space in a more sustainable and affordable way.
- Comprises the Human Research Program (HRP) and the Advanced Exploration Systems (AES) program.
  - HRP conducts fundamental and applied research on the human system to provide countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human missions.
  - AES pioneers new approaches for rapidly developing prototype systems, demonstrates key capabilities, and validates operational concepts for future human missions beyond Earth orbit.
  - AES also supports a joint effort with the Science Mission Directorate to pursue robotic precursor activities that acquire strategic knowledge on potential destinations for future human missions.



# Space Shuttle

Outyears are notional

	2013	2014	2015	2016	2017
Space Shuttle	\$71	-	-	-	-

- Finalizes disposition for Space Shuttle property and capabilities no longer required.
- Completes final delivery of the shuttle orbiters
  - Discovery: reaches Smithsonian by April 2012.
  - Enterprise: moved to the Intrepid Air and Space Museum in April 2012.
  - Endeavour: arrives at the California Science Center in September 2012.
  - Atlantis: transported to the KSC Visitor's Complex in 2013.





# International Space Station

Outyears are notional

	2013	2014	2015	2016	2017
ISS	\$3,008	\$3,178	\$3,171	\$3,213	\$3,234

- In FY 2013, NASA plans for at least three flights delivering research and logistics hardware to the ISS by U.S. developed cargo delivery systems.
- The budget also supports:
  - Routine operation of the orbiting facility to support basic science and technology development.
  - Extension of ISS lifetime to 2020 or beyond in concert with our international partners.
  - Utilization of ISS research capabilities, including oversight of National Laboratory activities and research by a non-profit organization.
  - Acquisition of crew and cargo transportation to the ISS.





# Space and Flight Support

Outyears are notional

	2013	2014	2015	2016	2017
SFS	\$935	\$857	\$864	\$822	\$801

- Supports modernization plans for a 21<sup>st</sup> Century Space Launch Complex to improve capabilities and infrastructure for a low-cost multi-user space transportation facility at KSC in conjunction with Exploration Ground System efforts for SLS and Orion MPCV.
- Provides space communication and navigation capabilities to all missions through numerous networks.
  - Supports Space, Near Earth, Deep Space, and NASA Integrated Services Networks for all NASA missions
  - Extends life of spacecraft and ground systems with investments in communications networks, including exercising the option of an additional TDRS satellite.
- Ensures crew health and expertise for current and future missions by maintaining a sufficient number of astronauts with appropriate skills and experience.
- Provides safe, reliable, and cost effective launch services for NASA, Commercial and NASA-sponsored payloads using ELVs.
  - In FY 2013, includes 3 NASA launches, 4 commercial launches and support of DOD launches
  - Provides advisory support for the NASA COTS/CCDev demonstrations, exploration flight testing and science missions
  - Certifies new and emerging launch vehicles
- Supports government and commercial rocket propulsion testing at NASA test facilities.
  - Improves coordination with DoD through successful execution of the National Rocket Propulsion Test Alliance
  - Continues work on SSC's High Pressure Industrial Water System project



# Education

Outyears are notional

	2013	2014	2015	2016	2017
Education	\$100	\$100	\$100	\$100	\$100

- NASA will align the Education Portfolio (Office of Education, Mission Directorate and Center activities) with the priorities and strategies in the NSTC Co-STEM 5-Year Strategic Plan
- The budget will also focus on competitive opportunities for learners and educators; middle school pre- and in-service educator professional development; provide experiential opportunities, internships, and scholarships for high school and undergraduate students; and use NASA's unique missions, discoveries, and assets to inspire student achievement and educator teaching ability in STEM fields
- The Minority University Research and Education Project (MUREP) continues to support the nation's Historically Black Colleges and Universities, Hispanic Serving Institutions and Tribal Colleges through multi-year STEM grants to enhance their research capabilities and STEM curricula.
- The budget also encourages collaboration between government, academia, and industry to leverage NASA's investments in STEM to reach a greater number of students and educators.







# Cross-Agency Support and Construction

	2013	2014	2015	Outyears are notional	
	2013	2014	2015	2016	2017
Cross-Agency	\$2,847	\$2,847	\$2,847	\$2,847	\$2,847
Construction & ECR	\$619	\$450	\$450	\$450	\$450

## ➤ Cross-Agency Support

- Funds operations and maintenance of NASA’s 9 field centers, component facilities and headquarters to enable effective and efficient institutional support
- Provides agency-wide management functions, policy and oversight
- Conducts safety and reliability activities to assure safety and mission success
- Works to identify institutional efficiencies to drive down operational costs, including workforce sizing and the realignment of workforce skills and capabilities.

## ➤ Construction and Environmental Compliance and Restoration

- Reflects multi-decadal strategy to reduce and renew NASA’s infrastructure to be more efficient and sustainable
- Funds major repairs of NASA’s facilities, constructs new or modified facilities to conduct NASA’s program missions, and manages NASA’s environmental clean-up responsibilities

Questions?





# Acronyms

- **CRS: cargo resupply Services**
- **ELV: Expendable Launch Vehicle**
- **EPSCoR: Experimental Program to Stimulate Competitive Research**
- **ESA: European Space Agency**
- **GOES: Geostationary Operational Environmental Satellite**
- **GPM: Global Precipitation Mission**
- **GRACE: Gravity Recovery and Climate Experiment**
- **ICESat: Ice Cloud and Land Elevation Satellite**
- **IRIS: Interface Region Imaging Spectrograph**
- **ISS: International Space Station**
- **JPSS: Joint Polar Satellite System**
- **JUNO: Jupiter Uranus Neptune Outreach**
- **LADEE: Lunar Atmosphere Dust Environment Explorer**
- **LDCM: Landsat Data Continuity Mission**
- **MAVEN: Mars Atmosphere and Volatile Evolution**
- **MMS: Magnetospheric Multiscale Mission**
- **MSL: Mars Science Laboratory**
- **MPCV: Multi-Purpose Crew Vehicle**
- **MUREP: Minority University research and Education Program**
- **NOAA: National Oceanographic and Atmospheric Administration**
- **NPP: NPOESS Preparatory Project**
- **OCO: Orbiting Carbon Observatory**
- **OSIRIS-Rex: Origins Spectral Interpretation Resource Identification Security Regolith Explorer**
- **POES: Polar Operational Environmental Satellite**
- **RBSP: Radiation belt Storm Probes**
- **SAGE: Stratospheric Aerosol and Gas Experiment**
- **SLS: Space Launch System**
- **SMAP: Soil Moisture Active-Passive Mission**
- **STEM: Science, Technology, Engineering and Mathematics**
- **USGS: U.S. Geological Survey**