FY 2016 NASA Budget Comparison

Update 2

This document provides an overview of the **President's FY 2016 NASA Budget request** in comparison with the **House Committee on Science, Space and Technology (HSST) passed NASA Authorization Bill**, the **House passed Commerce, Justice, Science Appropriations Bill**, and the **Senate Appropriations Committee (SAC) passed Commerce, Justice, Science Appropriations Bill**. The HSST provided two authorization budgets – an "aspirational" one – in the event that the Budget Control Act caps were repealed and a "constrained" one in the event that the caps remain in place. The first section provides a comparison of funding levels provided by each top-line item. The analysis then looks in detail at the proposal within Science, Exploration, Space Operations, and Space Technology.

NASA Budget Proposals Overview – FY 2016 Funding

Budget Authority, $ in millions	Consolidated Approps, 2015 (P.L. 112-235)	President's FY 2016 NASA Base Budget Request	HSST NASA Authorization Act Aspirational (H.R. 2039)	HSST NASA Authorization Act Constrained (H.R. 2039)	House Passed Commerce, Justice, Science Approps Bill (H.R. 2578)	Senate Approps Committee (SAC) Passed Commerce, Justice, Science Approps Bill (H.R. 2578)
Science	5,244.700	5,288.6	4,951.7	4,678.6	5,237.5	5,295
Aeronautics Research	651.000	571.4	571.4	571.4	600	527.4
Space Technology	596.000	724.8	596	500	625	600
Exploration	4,356.700	4,505.9	4,953.1	4,845.4	4,759.3	3,831.2
Space Operations	3,827.800	4,003.7	3,992.5	3,950.4	3,957.3	4,756.4
Education	119.000	88.9	119	119	119	108
Safety, Security, and Mission Services (formerly						

Cross-Agency Support)	2,758.900	2,843.1	2,843.1	2,843.1	2,768.6	2,784
Construction and Environmental Compliance and Restoration	419.100	465.3	465.3	465.3	425	352.8
Inspector General	37.0005	37.4	37	37	37.4	37.4
Total	**18,010.2005**	**18,529.1**	**18,529.1**	**18,010.2**	**18,529.1**	**18,292.2**

Science

Budget Authority, $ in millions	Consolidated Approps, 2015 (P.L. 112-235)	President's FY 2016 NASA Budget Request	HSST NASA Authorization Act Aspirational (H.R. 2039)	HSST NASA Authorization Act Constrained (H.R. 2039)	House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)	SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)
Earth Science	1,772.5	1,947.3	1,450	1,198.5	1,682.9	1,931.6
Planetary Science	1,437.8	1,361.2	1,500	1,500	1,557	1,321
Astrophysics	684.8	709.1	730.7	709.1	735.6	730.6
James Webb Space Telescope	645.4	620	620	620	620	620
Heliophysics	662.2	651	651	651	642	649.8
Education	42	--	--	--	--	42
Total	**5,244.7**	**5,288.5**	**4,951.7**	**4,678.6**	**5,237.5**	**5,295**

President's FY 2016 Budget Request for Overall Science Portfolio

In FY 2016, the President's base budget requested $5,288.5 million for Science missions, $43.8 million above the funds appropriated for Science missions in FY 2015.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $4,951.7 million for Science (aspirational) or $4,678.6 million (constrained), $336.8 (aspirational) or $609.9 (constrained) million below the President's FY 2016 request.
- The HSST passed FY 2016 NASA Authorization Act would affirm under section 802 that it is the sense of Congress "that a balanced and adequately funded set of activities, consisting of research and analysis grants programs, technology development, small, medium, and large space missions, and suborbital research activities, contributes to a robust and productive science program and serves as a catalyst for innovation and discovery.'' Further, "In proposing the funding of programs and activities for the Administration for each fiscal year, the Administrator shall, to the greatest extent practicable, follow guidance provided in the current decadal surveys from the National Academies' Space Studies Board."
- Section 302 states that "it is the sense of Congress that conducting deep space exploration requires radioisotope power systems, and establishing continuity in the production of the material needed to power these systems is paramount to the success of these future deep space missions. It is further the sense of Congress that Federal agencies supporting the Administration through the production of such material should do so in a cost effective manner so as not to impose excessive reimbursement requirements on the Administration."
- Accordingly, "The Director of the Office of Science and Technology Policy and the Administrator, in consultation with other Federal agencies, shall conduct an analysis of:

- (1) the requirements of the Administration for radioisotope power system material that is needed to carry out planned, high priority robotic missions in the solar system and other surface exploration activities beyond low-Earth orbit; and
- (2) the risks to missions of the Administration in meeting those requirements, or any additional requirements, due to a lack of adequate radioisotope power system material."

- The above-described analysis would be required to:
  - (1) detail the Administration's current projected mission requirements and associated timeframes for radioisotope power system material;
  - (2) explain the assumptions used to determine 16 the Administration's requirements for the material, including—
    - (A) the planned use of advanced thermal conversion technology such as advanced thermocouples and Stirling generators and converters; and
    - (B) the risks and implications of, and contingencies for, any delays or unanticipated technical challenges affecting or related to the Administration's mission plans for the anticipated 2 use of advanced thermal conversion technology;
  - (3) assess the risk to the Administration's programs of any potential delays in achieving the schedule and milestones for planned domestic production of radioisotope power system material;
  - (4) outline a process for meeting any additional Administration requirements for the material;
  - (5) estimate the incremental costs required to increase the amount of material produced each year, if such an increase is needed to support additional Administration requirements for the material;
  - (6) detail how the Administration and other Federal agencies will manage, operate, and fund production facilities and the design and development of all radioisotope power systems used by the Administration and other Federal agencies as necessary;
  - (7) specify the steps the Administration will take, in consultation with the Department of Energy, to preserve the infrastructure and workforce necessary for production of radioisotope power systems and ensure that its reimbursements to the Department of Energy associated with such preservation are equitable and justified; and
  - (8) detail how the Administration has implemented or rejected the recommendations from the National Research Council's 2009 report titled ''Radioisotope Power Systems: An Imperative for Maintaining U.S. Leadership in Space Exploration''
- Finally, "the Administrator shall transmit the results of the analysis to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate" within 180 days after the date of enactment.
- Section 303 states that "the direction of the unique competence of the Administration to the search for life's origin, evolution, distribution, and future in the Universe. In carrying out this objective, the Administration may use any practicable ground-based, airborne, or space-based technical means and spectra of electro-magnetic radiation.''
- Section 304 states that "it is the sense of Congress that principal investigator-led small orbital science missions, including CubeSat class, University Explorer (UNEX) class, Small Explorer (SMEX) class, and Venture class, offer valuable opportunities to advance science at low cost, train the next generation of scientists and engineers, and enable participants in the program to acquire skills in systems engineering and systems integration that are critical to maintaining the Nation's leadership in space and to enhancing the United States innovation and competitiveness abroad." The NASA Administrator should undertake a review of these science missions, to include:
  - (1) the status, capability, and availability of existing small orbital science mission programs and the extent to which each program enables the participation of university scientists and students;
  - (2) the opportunities such mission programs provide for scientific research;
  - (3) the opportunities such mission programs provide for training and education, including scientific and engineering workforce development, including for the Administration's scientific and engineering workforce; and

    - (4) the extent to which commercial applications such as hosted payloads, free flyers, and data buys could provide measurable benefits for such mission programs, while preserving the principle of independent peer review as the basis for mission selection.
- Finally, within 270 days after the date of enactment, "the Administrator shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report on the review and recommendations from the review.
- Section 30504 states that "the Administrator shall carry out biennial reviews within each of the Science divisions to assess the cost and benefits of extending the date termination of data collection for those missions that exceed their planned missions' lifetime. The assessment shall take into consideration how extending missions impacts the start of future missions." In addition, "the Administrator shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate, at the same time as the submission to Congress of the Administration's annual budget request for each fiscal year, a report detailing any assessment required by" the above section during the previous year.
- Lastly, "when deciding whether to extend a mission that has an operational component, the Administrator shall consult with any affected Federal agency and shall take into account the potential benefits of instruments on missions that are beyond their planned mission lifetime."

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $5,237.5 million for Science, $51 million below the President's FY 2016 request.

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $5,295 million for Science, $6.5 million above the President's FY 2016 request.

Earth Science

About

From space, NASA satellites can view Earth as a planet and enable the study of it as a complex, dynamic system with diverse components: the oceans, atmosphere, continents, ice sheets, and life. The Nation's scientific community can thereby observe and track global-scale changes, connecting causes to effects. Through partnerships with agencies that maintain forecasting and decision support systems, NASA improves national capabilities to predict climate, weather, and natural hazards, manage resources, and support the development of environmental policy.

- President's FY 2016 Earth Science Missions:
    - $348.4 million for Earth Science Research and Analysis;
    - $136.9 million for Computing and Management;
    - $127.4 million for Ice, Cloud, and land Elevation Satellite-2;
    - $15.9 million for Soil Moisture Active and Passive;
    - $66.3 million GRACE Follow-On;
    - $78.3 million for Surface Water and Ocean Topagraphy
    - $607.4 million for Other Missions and Data Analysis within Earth Systematic Missions;
    - $185.2 million for Venture Class Missions;
    - $825 million for Other Missions and Data Analysis within Earth Systems Science Pathfinder Missions;
    - $190.7 million for Earth Science Multi-Mission Operations;
    - $60.7 million for Earth Science Technology;
    - $47.6 million for Applied Sciences;
- "Building on NASA's successful launch of the NASA/USGS Landsat Data Continuity Mission (LDCM)/Landsat-8 mission in February 2013, the Administration's new Sustainable Land Imaging (SLI) program will provide US users with high-quality, global, land imaging measurements that are compatible with the existing 42-year record. The proposed program will address near- and longer-term issues of

continuity risk; and will evolve flexibly and responsibly through investment in, and introduction of, new sensor and system technologies."

- The new SLI system is multi-decadal in nature and "involves three NASA mission/development activities, including initiation of Landsat 9 immediately in FY 2015, along with a fourth activity combining technology investments and detailed system engineering to design and build a full-capability Landsat 10 satellite."
- NASA and NOAA Earth-observing satellite responsibilities are rearranged in the FY2016 budget request "to leverage NASA Earth Science's expertise in developing Earth-observing satellites while allowing NOAA to focus its development efforts on its weather satellites and weather forecasting mission."
- Accordingly, "NOAA will be responsible only for satellite missions that contribute directly to NOAA's ability to issue weather and space weather forecasts and warnings to protect life and property," While "NASA will be responsible for other nondefense Earth-observing satellite missions."
    - Beginning in FY16, responsibility for "TSIS-1 and future ocean altimetry missions (following Jason-3, which remains a NOAA mission)" will be transferred to NASA, while "geostationary and polar-orbiting weather satellites, radio occultation satellites, and space weather satellites" will remain NOAA's responsibility.

FY 2016 Congressional Action

<u>HSST Passed NASA Authorization Act (H.R. 2039)</u>

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $1,450 million for Earth Science (aspirational) or $1,198.5 million (constrained), $493.7 (aspirational) or $748.8 (constrained) million below the President's FY 2016 request.
- Section 341 states that "it is the sense of Congress that the Administration is being asked to undertake important Earth science activities in an environment of increasingly constrained fiscal resources, and that any transfer of additional responsibilities to the Administration, such as climate instrument development and measurements that are currently part of the portfolio of the National Oceanic and Atmospheric Administration, should be accompanied by the provision of additional resources to allow the Administration to carry out the increased responsibilities without adversely impacting its implementation of its existing Earth science programs and priorities."
- Section 341 goes on to state that "the administrator shall continue to carry out a balanced Earth science program that includes Earth science research, Earth systematic missions, competitive Venture class missions, other missions and data analysis, mission operations, technology development, and applied sciences, consistent with the recommendations and priorities established in the National Academies' Earth Science Decadal Survey" and that "the Administrator shall collaborate with other Federal agencies, including the National Oceanic and Atmospheric Administration, non-government entities, and international partners, as appropriate, in carrying out the Administration's Earth science program. The Administration shall continue to develop first-of-a-kind instruments that, once proved, can be transitioned to other agencies for operations."
- Accordingly, "whenever responsibilities for the development of sensors or for measurements are transferred to the Administration from another agency, the Administration shall seek, to the extent possible, to be reimbursed for the assumption of such responsibilities."
- Section 342 addresses decadal cadence, stating that "the Administrator shall seek to ensure to the extent practicable a steady cadence of large, medium, and small Earth science missions."
- Regarding Venture Class missions, Section 343 maintains that "it is the sense of Congress that the Administration's Venture class missions provide opportunities for innovation in the Earth science program, offer low-cost approaches for high-quality competitive science investigations, enable frequent flight opportunities to engage the Earth science and applications community, and serve as a training ground for students and young scientists. It is further the sense of Congress that the Administration should seek to increase the number of Venture class projects to the extent practicable as part of a balanced Earth science program."
- Section 344 mandates that "the Administrator shall carry out a scientific assessment of the Administration's Earth science global datasets for the purpose of identifying those datasets that are

useful for understanding regional changes and variability, and for informing applied science research. The Administrator shall complete and transmit the assessment to Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate not later than 180 days after the date of enactment of this Act."

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $1,682.9 million for Earth Science, $264.1 million below the President's FY 2016 request.
- The committee report states that the reduced budget still "maintains most programs at the fiscal year 2015 operating level and adopts reductions proposed in the budget request for the Soil Moisture Active and Passive satellite; the Global Precipitation Measurement Project; and GRACE follow-on activities."
- Funds were not authorized for the Thermal-Infrared Free-Flyer, in lieu of authorizing to appropriate $32.9 million for Landsat-9, " in accordance with direction on the Landsat program provided in the statement accompanying Public Law 113—235." Accordingly, the committee report orders NASA to "provide a report no later than 90 days after enactment of this Act regarding cost, schedule, and milestones toward achieving a launch of Landsat-9 no later than 2023."
- Finally, "NASA shall ensure that the Earth Science portfolio is focused on the science priorities as outlined in the 2007 Earth Science decadal survey."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $1,931.6 million for Earth Science, $15.4 million below the President's FY 2016 request.
- The SAC bill includes $100 million "to continue formulation and development of Landsat-9 as a copy of Landsat-8" and directs NASA "to maintain a target launch date for Landsat-9 of 2020 so that the risk of losing the 16-day revisit cycle is minimized by having Landsat-9 on orbit before Landsat-7 fails."
- However, "the Committee has not provided funding for an additional free flying thermal infrared instrument ahead of Landsat-9. "
- The committee's recommendation additionally includes $75 million "for the Pre-Aerosol, Clouds, and Ocean Eco- system [PACE] mission. The Committee expects NASA to clarify the proposed cost baseline for PACE, including the treatment of science operations and the science definition team's instrument recommendations."

Planetary Science

About

To answer questions about the solar system and the origins of life, NASA sends robotic space probes to the Moon, other planets and their moons, asteroids and comets, and the icy bodies beyond Neptune.

- President's FY 2016 Planetary Science Missions:
  - $162.5 million for Planetary Science Research and Analysis;
  - $7.1 million for Directorate Management;
  - $50.0 million for Near Earth Object Observations;
  - $56.7 million for Other Missions and Data Analysis within Planetary Science Research;
  - $92.1 million for InSight;
  - $64.0 million for Other Missions and Data Analysis within Discovery;
  - $189.7 million for Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer;
  - $69.3 million for Other Missions and Data Analysis within New Frontiers;
  - $411.9 million for Mars Exploration;
  - $116.2 million for Outer Planets;
  - $141.7 million for Technology;
- NASA's "two highest priority flagships" are the Mars 2020 Rover and the initiation of a Europa mission.
- The President's FY16 budget request includes $228 million for Mars Rover 2020. In 2015, "The Mars Rover 2020 mission will complete Phase A/Formulation with the SRR/Mission Definition Review and begin Phase B/Formulation."

- The President's FY16 budget request includes $30 million for Europa exploration, marking the first time that the President's budget "supports the formulation and development of a Europa Mission" and "allowing NASA to begin project formulation, Phase A."

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $1,500 million for Planetary Science (aspirational and constrained), $138.8 million above the President's FY 2016 request.
- Section 321 addresses decadal cadence, stating that "the Administrator shall seek to ensure, to the greatest extent practicable, that the Administration carries out a balanced set of planetary science programs in accordance with the priorities established in the most recent decadal survey for planetary science. Such programs shall include, at a minimum—
    - (1) a Discovery-class mission at least once every 24 months;
    - (2) a New Frontiers-class mission at least once every 60 months; and
    - (3) at least one Flagship-class mission per decadal survey period, including a Europa mission with a goal of launching by 2021.
- Section 322 addresses Near-Earth objects. In that section, Congress finds that:
    - "(1) Near-Earth objects pose a serious and credible threat to humankind, as many scientists believe that a major asteroid or comet was responsible for the mass extinction of the majority of the Earth's species, including the dinosaurs, approximately 65 million years ago.
    - (2) Similar objects have struck the Earth or passed through the Earth's atmosphere several times in the Earth's history and pose a similar threat in the future.
    - (3) Several such near-Earth objects have only 15 been discovered within days of the objects' closest approach to Earth, and recent discoveries of such large objects indicate that many large near-Earth objects remain to be discovered.
    - (4) The efforts undertaken by the Administration for detecting and characterizing the hazards of near-Earth objects should continue to seek to fully determine the threat posed by such objects to cause widespread destruction and loss of life."
- Section 322 also directs the Administrator to "continue to detect, track, catalogue, and characterize the physical characteristics of near-Earth objects equal to or greater than 140 meters in diameter in order to assess the threat of such near-Earth objects to the Earth, pursuant to the George E. Brown, Jr. Near-Earth Object Survey Act (42 U.S.C. 16691). It shall be the goal of the Survey program to achieve 90 percent completion of its near-Earth object catalogue (based on statistically predicted populations of near-Earth objects) by 2020.
- Also in Section 322, Congress "reaffirms the policy set forth in section 20102(g) of title 51, United States Code (relating to detecting, tracking, cataloguing, and characterizing asteroids and comets)" and directs the Director of the Office of Science and Technology Policy and the Administrator to "transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate, not later than 1 year after the date of enactment of this Act, an initial report that provides—
    - (1) recommendations for carrying out the Survey program and an associated proposed budget;
    - (2) analysis of possible options that the Administration could employ to divert an object on a likely collision course with Earth; and
    - (3) a description of the status of efforts to coordinate and cooperate with other countries to discover hazardous asteroids and comets, plan a mitigation strategy, and implement that strategy in the event of the discovery of an object on a likely collision course with Earth."
- Following the report's issuance, "the Administrator shall annually transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report that provides—
    - (1) a summary of all activities carried out pursuant to subsection (c) since the date of enactment of this Act, including the progress toward achieving 90 percent completion of the survey described in subsection (c); and

    - (2) a summary of expenditures for all activities carried out pursuant to subsection (c) since the date of enactment of this Act."
- The Administrator, in collaboration with other relevant Federal agencies, "shall carry out a technical and scientific assessment of the capabilities and resources to—
    - (1) accelerate the survey described in subsection 6 (c); and
    - (2) expand the Administration's Near-Earth Object Program to include the detection, tracking, cataloguing, and characterization of potentially hazardous near-Earth objects less than 140 meters in diameter.
    - (h) TRANSMITTAL.—Not later than 270 days after the date of enactment of this Act, the Administrator shall transmit the results of the assessment carried out under subsection (g) to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate."
- Section 323 addresses public-private partnerships for Near-Earth objects. The section states that "it is the sense of Congress that the Administration should seek to leverage the capabilities of the private sector and philanthropic organizations to the maximum extent practicable in carrying out the Near-Earth Object Survey program in order to meet the goal of the Survey program."
- Section 323 mandates that within 180 days of the Act becoming law, "the Administrator shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report describing how the Administration can expand collaborative partnerships to detect, track, catalogue, and categorize near-Earth objects."
- Section 324 addresses potential tsunami affects from Near-Earth object impact, stating that "the Administrator, in collaboration with the Administrator of the National Oceanic and Atmospheric Administration and other relevant agencies, shall prepare a report identifying and describing existing research activities and further research objectives that would increase our understanding of the nature of the effects of potential tsunamis that could occur if a near-Earth object were to impact an ocean of Earth" and shall provide the report to the committees of relevance within 180 days of the Act becoming law.
- Section 325 develops a national astrobiology strategy, stating that "the Administrator shall enter into an arrangement with the National Academies to develop a science strategy for astrobiology that would outline key scientific questions, identify the most promising research in the field, and indicate the extent to which the mission priorities in existing decadal surveys address the search for life's origin, evolution, distribution, and future in the Universe. The strategy shall include recommendations for coordination with international partners."
- The strategy developed under section 325 shall be used by the Administrator "in planning and funding research and other activities and initiatives in the field of astrobiology." Within 18 months of enactment, "the National Academies shall transmit a report to the Administrator, and to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate, containing the strategy developed."
- Section 326 requires that "no later than 180 days after the date of enactment of this Act, the Administrator shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report describing how the Administration can expand collaborative partnerships to study life's origin, evolution, distribution, and future in the Universe."
- Section 327 addresses assessment of Mars architecture and lays out that "the Administrator shall enter into an arrangement with the National Academies to assess—
    - (1) the Administration's revised post-2016 Mars exploration architecture and its responsiveness to the strategies, priorities, and guidelines put forward by the National Academies' planetary science decadal surveys and other relevant National Academies Mars-related reports;
    - (2) the long-term goals of the Administration's Mars Exploration Program and such program's ability to optimize the science return, given the current fiscal posture of the program;

    - (3) the Mars architecture's relationship to Mars-related activities to be undertaken by agencies and organizations outside of the United States; and
    - (4) the extent to which the Mars architecture represents a reasonably balanced mission portfolio."
- Finally, "not later than 18 months after the date of enactment of this Act, the Administrator shall transmit the results of the assessment to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate."

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $1,557 million for Planetary Science, $195.8 million more than the President's FY16 request.
- The committee report states that "NASA's request for Planetary Science once again proposes a decrease below appropriated levels and would have a negative impact on both planned and existing mission"
- The committee also specifies that $50 million is to be spent for near earth object observations, and $175 million is "for Discovery, including restoration of $19 million for the Lunar Reconnaissance Orbiter program."
- The report also authorizes to appropriate $448 million for Mars Exploration, of which "not less than $250 million is for a Mars Rover 2020 mission that meets scientific objectives from the most recent Planetary Science decadal survey." Further, "the Committee is convinced that additional early funding for the Mars 2020 mission will enable overall economies to be achieved by procuring elements identical to the Curiosity Rover successfully operating on Mars." Accordingly, "the recommendation also restores $13.700 million for the Mars Opportunity Rover which the budget proposed to eliminate."
- The committee report directs NASA to "create an Ocean World Exploration Program whose primary goal is to discover extant life on another world using a mix of Discovery, New Frontiers and flagship class missions consistent with the recommendations of current and future Planetary Decadal surveys."
- The bill also authorizes to appropriate $226 million, "of which not less than $140 million is for the Jupiter Europa Clipper, or comparable mission, to support the process of finalizing the mission design concept that meets the scientific objectives described in the most recent Planetary Science decadal survey."
- "To support sustained momentum" in the Ocean Worlds program, "NASA shall ensure that future funding requests are consistent with achieving a launch no later than 2022, with the goal of launching on a Space Launch System platform..."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $1,321 million for Planetary Science, $40.2 million below the President's FY 2016 request.
- The SAC bill includes $228 million for the Mars 2020 Rover, $50 million for Near Earth Object Observations within Planetary Science Research, and $189.7 million for the Origins Spectral Interpretation Resource Identification and Security Regolith Explorer – all funded at the President's FY 16 request.
- Additionally, the SAC bill provides $7 million for New Frontiers Future Missions, $5 million above the President's FY 16 request, "to enable NASA to accelerate the next New Frontiers Announcement of Opportunity to a date before February 1, 2016."
- In addition, "the Committee welcomes the rendezvous of New Horizons with Pluto scheduled for July 14, 2015, and encourages NASA to continue the momentum generated by this mission to carry over for future research on the outer planets, including Uranus."
- Finally, "the Committee supports Advanced Sterling Radioisotope Generator research and development to enable planetary and other science research."
- The committee report emphasizes that "a mission to Europa represents one of the highest large mission priorities of the Planetary Science Decadal Survey," and describes the May 2015 announcement by NASA of nine scientific instruments for the mission. In order for NASA "to capitalize on investments it has made in producing a heavy lift launch vehicle capability… the Committee directs NASA, in setting the

baseline Europa mission highlighted in the decadal survey, to use the Space Launch System as the launch vehicle. "

Astrophysics

About

Having measured the age of the universe, the scientific community now seeks to explore its ultimate extremes: its birth, the edges of space and time near black holes, and the mysterious dark energy filling the entire universe. Scientists have recently developed astronomical instrumentation sensitive enough to detect planets around other stars.

- President's FY 2016 Astrophysics Missions:
  - $72.3 million for Astrophysics Research and Analysis;
  - $34.2 million for Balloon Project;
  - $81.1 million for Other Missions and Data Analysis within Astrophysics Research;
  - $97.1 million for Hubble Space Telescope;
  - $85.2 million for Stratopheric Observatory for Infrared Astronomy;
  - $17 million for Other Missions and Data Analysis within Cosmic Origins;
  - $107.6 million for Physics of the Cosmos;
  - $64.2 million Exoplanet Exploration;
  - $88 million for Transiting Exoplanet Survey Satellite;
  - $62.4 million for Other Missions and Data Analysis within Astrophysics Explorer;
- The President's FY16 Budget Request "restores funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) mission," and notes that "the 2016 Senior Review panel will evaluate SOFIA's scientific productivity."

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $730.7 million for Astrophysics (aspirational) or $709.1 million (constrained), $21.6 million more (aspirational) or exactly the amount requested from the President's FY 2016 request.
- Section 311 would direct the NASA Administrator to "seek to ensure to the extent practicable a steady cadence of large, medium, and small astrophysics missions."
- Section 312 states that the administrator "shall enter into an arrangement with the National Academies to develop science strategy for the study and exploration of extrasolar planets, including the use of the Transiting Exoplanet Survey Satellite, the James Webb Space Telescope, a potential Wide-Field Infrared Survey Telescope mission, or any other telescope, spacecraft, or instrument as appropriate. Such strategy shall—
  - (1) outline key scientific questions;
  - (2) identify the most promising research in the field;
  - (3) indicate the extent to which the mission priorities in existing decadal surveys address the key extrasolar planet research goals;
  - (4) identify opportunities for coordination with international partners, commercial partners, and other not-for-profit partners; and
  - (5) make recommendations on the above as appropriate.
- Within 18 months of the date of enactment, "the National Academies shall transmit a report to the Administrator, and to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate, containing the strategy developed," which the Administrator will use to "inform roadmaps, strategic plans, and other activities of the Administration as they relate to extrasolar planet research and exploration; and provide a foundation for future activities and initiatives.

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $735.6 million for astrophysics, $26.5 million above the President's FY 2016 request.
- As a result of the Kepler Mission's revelation that "the Milky Way Galaxy is teeming with exoplanets," the Committee "recommends that NASA accelerate its exoplanet program goals to discover, characterize, and eventually identify exoplanet candidates that could harbor life." Accordingly, "an increase of $35,800,000 is recommended to develop capabilities within the Exoplanet Exploration program to directly image exoplanets on the Wide-Field Infrared Survey Telescope (WFIRST) mission with a coronagraph and to develop technology for future potential missions, consistent with the priorities in the Astrophysics Decadal Survey for WFIRST and exoplanet technology."
- The committee report includes $85.2 million to fully fund SOFIA at the President's FY16 request.
- According to the committee report, "NASA is planning to conduct a Senior Review of Operating Missions for SOFIA in early 2016." The committed also "understands that as determined by policy established in the NASA authorization Act, NASA conducts such senior reviews of programs that have exceeded planned operational life; completed the mission/operational activities designed to meet its initial, approved science objectives and requirements; are beyond prime mission; or will not still be in its prime mission when the subsequent review occurs two years hence."
- SOFIA began its prime mission in 2014 and has a designed operational life of up to 20 years. Accordingly, "NASA shall not commence a review of SOFIA until it meets the requirements for such senior reviews as outlined above.
- *Regarding Education and Public Outreach (EPO), "t*he recommended level for the Astrophysics Division includes $32,000,000 for Science Mission Directorate (SMD)-wide EPO activities. NASA shall, in the fiscal year 2016 spending plan, proportionally reallocate these funds among the SMD divisions, resulting in a dedicated budget line for each division's own EPO activities. This approach will still permit competition among projects for the best use of funds and focus that competition among projects that are more easily compared to one another and provide better stability for the educational communities in each major SMD discipline."

<u>SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The SAC passed FY 2016 CJS bill would appropriate $730.6 million for Planetary Science, $21.5 million above the President's FY 2016 request.
- The SAC bill provides $98.3 million for the Hubble Space Telescope, $1.2 million than the President's FY 2016 request; $85.2 to fully-fund the Stratospheric Observatory for Infrared Astronomy (SOFIA) at the President's FY 2016 request, and $90 million for the Wide-Field Infrared Survey Telescope (WFIRST).
- Regarding SOFIA, "the Committee includes the full budget request for SOFIA, a program that had been previously proposed for cancellation in fiscal year 2015 after operations began in May 2014. The Committee understands NASA is now proposing a Senior Review panel evaluation of the program's scientific productivity in 2016, 3 years ahead of schedule. Typically, a NASA program is given 4 to 5 years to prove the merit of its science before undergoing a Senior Review. Therefore, the Committee directs that any early Senior Review of SOFIA shall only be for the purposes of allowing SOFIA to undergo such a review in preparation for future evaluation and that the results of this review shall not be used to justify early cancellation."
- In addition, "the Committee has provided funding for completion of pre-formulation and initiation of formulation of the WFIRST mission using the Astrophysics Focused Telescope Assets, with the goal of completing Key Decision Point-A no later than January 15, 2016. The Committee has accelerated this key mission recommended by the decadal survey and expects it to achieve overlap and scientific synergy with Hubble and the James Webb Space Telescope, including linking science operations and the science archive."
- Regarding Explorers, "small- and medium-sized Explorer missions have been recognized by decadal surveys as missions that meet multiple goals of providing frequent flight opportunities; allowing students and Principal Investigators to gain hands on flight experience; responding rapidly to new developments in science; providing path- finders for larger missions; and providing value when comparing science productivity to cost. The Committee continues its strong support of Astrophysics and Heliophysics Explorers and expects NASA to provide adequate resources within the amount provided to

increase frequency of Explorer Announcements of Opportunity [AO]. Explorer AOs should occur at least every 3 years, and NASA's goal should be to increase the frequency to every 2 years."

- Within Astrophysics, the request includes $20 million for education funding within the Science Mission Directorate [SMD]. For FY16, "the Committee provides no less than $42 million for education as reflected in a more transparent single line within the SMD funding chart. This includes the $20 million education funding included in the budget submission within the Astrophysics program. However, the Committee supports the recommendation that the Astrophysics program administer this SMD-wide education funding. The Committee encourages NASA to prioritize funding for on-going education efforts linked directly to its science missions and to encourage SMD-funded investigators to be directly involved in outreach and education efforts. The Committee notes that the $42 million is well below the authorized mandate that 1 percent of all NASA science funds are allocated to education-related efforts. Thus, this amount does not rep- resent a cumulative total of all on-going and longstanding education activities that will be conducted throughout SMD in fiscal year 2016."

James Webb Space Telescope

About

The James Webb Space Telescope (JWST) is a large, space-based astronomical observatory. The mission is a logical successor to the Hubble Space Telescope, extending beyond Hubble's discoveries by looking into the infrared spectrum, where the highly red-shifted early universe must be observed, where relatively cool objects like protostars and protoplanetary disks emit infrared light strongly, and where dust obscures shorter wavelengths.

President's FY 2016 James Webb Space Telescope:

- $620 million for James Webb Space Telescope

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $620 million for the James Webb Space Telescope (aspirational and constrained), the exact amount requested from the President's FY 2016 request.
- Section 313 states that "it is the sense of Congress that:
    - (1) the James Webb Space Telescope will revolutionize our understanding of star and planet formation and how galaxies evolved, and advance the search for the origins of the universe;
    - (2) the James Webb Space Telescope will enable American scientists to maintain their leadership in astrophysics and other disciplines;
    - (3) the James Webb Space Telescope program is making steady progress towards a launch in 2018;
    - (4) the on-time and on-budget delivery of the James Webb Space Telescope is a high congressional priority; and
    - (5) maintaining this progress will require the Administrator to ensure that integrated testing is appropriately timed and sufficiently comprehensive to enable potential issues to be identified and addressed early enough to be handled within the James Webb Space Telescope's development schedule prior to launch."

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $620 million for JWST to fully fund the President's FY 2016 request.
- The committee report notes that "According to the most recent GAO report, JWST officials note that the project remains within its cost cap and is maintaining its 2018 launch date, but that the program is entering the critical integration stage and issues persist that may impact the overall schedule."
- The report requires NASA to continue providing the committee with "quarterly briefings on JWST's technical status and achievement of program milestones, and budget and schedule performance."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $620 million for JWST to fully fund the President's FY 2016 request.
- The committee report expresses the committee's appreciation for "GAO's continuing work to monitor JWST progress, costs, and schedule," and states that since "JWST has reached a level of development where 100 percent of the telescope's mass is now beyond Key Decision Point-C, a milestone that indicates that significant progress has been made towards its 2018 launch date,"the bill maintains an "overall development cost ceiling for JWST at $8 billion," which "the Committee intends to hold NASA and its contractors to."The Committee additionally "expects to be kept fully informed on issues relating to program and risk management, achievement of cost and schedule goals, and the program's technical status."

Heliophysics

About

Using a fleet of sensors on various spacecraft in Earth orbit and throughout the solar system, NASA seeks to understand how and why the Sun varies, how Earth responds to the Sun, and how human activities are affected. The science of heliophysics enables the predictions necessary to safeguard life and society on Earth and outward journeys of human and robotic explorers.

- President's FY 2016 Heliophysics Missions:
  - $34 million for Heliophysics Research and Analysis;
  - $48.3 million for Sounding Rockets;
  - $21.6 million for Research Range;
  - $54.6 million for Other Missions and Data Analysis within Heliophysics Research;
  - $230.4 million for Solar Probe Plus;
  - $62.9 million for Solar Orbiter Collaboration;
  - $49.7 million for Other Missions and Data Analysis within Living with a Star;
  - $30.1 million for Magnetospheric Multiscale;
  - $20.4million Other Missions and Data Analysis within Solar Terrestrial Probes;
  - $49.8 million for ICON;
  - $49.2 million for Other Missions and Data Analysis within Heliophysics Explorer Program;
- The President's FY16 budget request "supports a gradual increase with a goal of fully implementing [the] DRIVE [Diversify, Realize, Integrate, Venture, Educate initiative] by the end of the decade.
- "The Heliophysics Explorer Program provides frequent flight opportunities for world-class scientific investigations on focused and timely science topics." NASA selects participants through a competitively-selected announcements of opportunity process. "Based on available funding, there is an expected three-year cadence. "Based on current funding projections, NASA can release the next Explorers AO no earlier than FY 2016."
  - Under the Heliophysics Explorer Program, the President's FY16 Budget Request supports continued development of ICON for launch in 2017.
- The President's FY16 budget request includes $230.4 to continue development of Solar Probe Plus, part of the Living with a Star program. The Solar Probe Plus will be ready for launch by 2018.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $651 million (both aspirational and constrained) to fully fund Heliophysics at the President's FY 2016 request.
- Section 331 emphasizes the importance of decadal cadence, stating that "the Administrator shall seek to ensure to the extent practicable a steady cadence of large, medium, and small heliophysics missions."
- Section 332 addresses space weather and states directs that "the Director of the Office of Science and Technology Policy, in consultation with the Administrator, the Administrator of the National Oceanic and Atmospheric Administration, the Director of the National Science Foundation, and heads of other

relevant Federal agencies, shall enter into an arrangement with the National Academies to provide a comprehensive study that reviews current and planned ground-based and space-based space weather monitoring requirements and capabilities, identifies gaps, and identifies options for a robust and resilient capability. The study shall inform the process of identifying national needs for future space weather monitoring, forecasts, and mitigation. The National Academies shall give consideration to international and private sector efforts and collaboration that could potentially contribute to national space weather needs. The study shall also review the current state of research capabilities in observing, modeling, and prediction and provide recommendations to ensure future advancement of predictive capability."

- Further, within 14 months of the date of enactment of this Act, "the National Academies shall transmit a report containing the results of the study to the Director of the Office of Science and Technology Policy, and to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on 17 Commerce, Science, and Transportation of the Senate."

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $642 million for Heliophysics, $9 million below the President's FY 2016 request.

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $649.8 million to fund Heliophysics, $1.2 million below the President's FY 2016 request.
- The Committee also provides $230.4 million "for the Solar Probe Plus mission, the same as the budget request. The Committee strongly affirms its multiyear commitment to a 2018 launch for the solar probe plus mission and fully expects that all future NASA budget submissions will adhere to a funding profile that guarantees a 2018 launch."

Exploration

Budget Authority, $ in millions	Consolidated Approps, 2015 (P.L. 112-235)	President's FY 2016 NASA Budget Request	HSST NASA Authorization Act Aspirational (H.R. 2039)	HSST NASA Authorization Act Constrained (H.R. 2039)	House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)	SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)
Exploration Research and Development	306.4	399.2	399.2	399.2	350	321.2
Commercial Crew	805.0	1,243.8	1,243.8	1,136.1	1,000	--
Orion Multipurpose Crew Vehicle(s)	1,194.0	1,096.3	1,200	1,200	1,096.3	1,200
Space Launch System	1,700.0	1,356.5	1,700	1,700	1,850	1,900
SLS Integration	--	--	--	--	53	--
Exploration Ground Systems	351.3	410.1	410	410	410	410
Total	**4,356.7**	**4,505.9**	**4,953**	**4,845.3**	**4,759.3**	**3,831.2**

President's FY 2016 Budget Request for Overall Exploration Portfolio

In FY 2016 the President base budget requested $4,505.9 million for Exploration missions, $149.2 million above the funds appropriated for Exploration missions in FY 2015.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $4,953 million for Exploration (aspirational) or $4,845.5 (constrained), respectively $447.1 million and $339.4 above the President's FY 2016 request.
- Section 201 asserts that "human exploration deeper into the Solar System shall be a core mission of the Administration. It is the policy of the United States that the goal of the Administration's exploration program shall be to successfully conduct a crewed mission to the surface of Mars to begin human exploration of that planet. The use of the surface of the Moon, cis-lunar space, near-Earth asteroids, Lagrangian points, and Martian moons may be pursued provided they are properly incorporated into the Human Exploration Roadmap described in section 70504 of title 51, United States Code."
- A stated key objective of exploration is "to accelerate the development of capabilities to enable a human exploration mission to the surface of Mars and beyond through the prioritization of those technologies and capabilities best suited for such a mission in accordance with the Human Exploration Roadmap under section 70504 of title 51, United States Code.''
- NASA is prohibited from obtaining non-U.S. human space flight capabilities "unless no domestic

commercial or public-private partnership provider that the Administrator has determined to meet safety and affordability requirements established by NASA for the transport of its astronauts is available to provide such capabilities."

- Section 202 lays out the "stepping stone approach to exploration," stating, "in order to maximize the cost effectiveness of the long-term space exploration and utilization activities of the United States, the Administrator shall direct the Human Exploration and Operations Mission Directorate, or its successor division, to develop a Human Exploration Roadmap to define the specific capabilities and technologies necessary to extend human presence to the surface of Mars and the sets and sequences of missions required to demonstrate such capabilities and technologies."
- In developing the human exploration roadmap, the NASA Administrator shall:
    - "(1) Include the specific set of capabilities and technologies that contribute to extending human presence to the surface of Mars and the sets and sequences of missions necessary to demonstrate the proficiency of these capabilities and technologies with an emphasis on using or not using the International Space Station, lunar landings, cis-lunar space, trans-lunar space, Lagrangian points, and the natural satellites of Mars, Phobos and Deimos, as testbeds, as necessary, and shall include the most appropriate process for developing such capabilities and technologies;
    - (2) include information on the phasing of planned intermediate destinations, Mars mission risk areas and potential risk mitigation approaches, technology requirements and phasing of required technology development activities, the management strategy to be followed, related International Space Station activities, and planned international collaborative activities, potential commercial contributions, and other activities relevant to the achievement of the goal established in section 201(a) of the National Aeronautics and Space Administration Authorization Act for 2016 and 2017;
    - (3) describe those technologies already under development across the Federal Government or by nongovernment entities which meet or exceed the needs described in paragraph (1);
    - (4) provide a specific process for the evolution of the capabilities of the fully integrated Orion crew vehicle with the Space Launch System and how these systems demonstrate the capabilities and technologies described in paragraph (1);
    - (5) provide a description of the capabilities and technologies that need to be demonstrated or re- search data that could be gained through the utilization of the International Space Station and the status of the development of such capabilities and technologies;
    - (6) describe a framework for international co- operation in the development of all technologies and capabilities required in this section, as well as an assessment of the risks posed by relying on inter- national partners for capabilities and technologies on the critical path of development;
    - (7) describe a process for utilizing nongovernmental entities for future human exploration beyond lunar landings and cis-lunar space and specify what, if any, synergy could be gained from—
        - (A) partnerships using Space Act Agreements (as defined in section 2 of the National Aeronautics and Space Administration Authorization Act for 2016 and 2017); or
        - (B) other acquisition instruments;''
    - (8) include in the Human Exploration Roadmap an addendum from the National Aeronautics and Space Administration Advisory Council, and an addendum from the Aerospace Safety Advisory Panel, each with a statement of review of the Human Exploration Roadmap that shall include –
        - (A) subjects of agreement;
        - (B) areas of concern; and
        - (C) recommendations; and
    - (9) include in the Human Exploration Roadmap an examination of the benefits of utilizing current Administration launch facilities for trans-lunar missions."
- The section also provides that "the Administrator shall update such Human Exploration Roadmap as needed but no less frequently than every 2 years and include it in the budget for that fiscal year transmitted to Congress under section 1105(a) of title 31, and describe—

    - (1) the achievements and goals reached in the process of developing such capabilities and technologies during the 2-year period prior to the sub-mission of the update to Congress; and
    - (2) the expected goals and achievements in the following 2-year period.
- In addition, within 180 days of the date of enactment of this Act, "the Administrator shall transmit a copy of the Human Exploration Roadmap developed under section 70504 of title 51, United States Code, to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate."
- Also, "the Administrator shall transmit a copy of each updated Human Exploration Roadmap to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate not later than 7 days after such Human Exploration Roadmap is updated.
- Section 202 further addresses international participation, stating that "The President should invite the United States partners in the International Space Station program and other nations, as appropriate, to participate in an international initiative under the leadership of the United States to achieve the goal of successfully conducting a crewed mission to the surface of Mars."
- In addition, "not later than 180 days after the date of enactment of this Act and concluding not later than 1 year after such date of enactment, the Administrator shall conduct a well-publicized competition among students in elementary and secondary schools to name the elements of the Administration's exploration program, including—
    - (1) a name for the deep space human exploration program as a whole, which includes the Space Launch System, the Orion crew vehicle, and future missions; and
    - (2) a name for the Space Launch System"

<u>House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The House passed FY 2016 CJS bill would appropriate $4,759.3 million to fund Exploration $253.4 million above the President's FY 2016 request.
- Because "the goals of the program beyond EM–2 are not well-defined," the committee directs that "within one year of enactment of this Act, NASA shall provide the Committee with a comprehensive, multi-year plan outlining long-term exploration goals beyond EM–2, using the 130 metric ton SLS or a comparable launch vehicle."
- The above-described plan "shall assess and propose alternative payloads, mission capabilities, necessary propulsion, crewed and uncrewed options and alternative destinations, such as Mars or Europa."
- Further, "this plan shall include yearly funding estimates and define quarterly milestones by mission directorate that will be necessary to achieve a range of possible missions, which will enable a more frequent SLS launch tempo than currently projected by NASA."
- Finally, "this plan shall also incorporate funding estimates and milestones necessary to complete the EUS for EM–2 and additional missions beyond EM–2."

<u>SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The SAC passed FY 2016 CJS bill would appropriate $3,831.2 million to fund Exploration, $674.7 million below the President's FY 2016 request. However, "for fiscal year 2016, the Exploration account does not include funds for Commercial Crew, which are now located under ISS Crew and Cargo transportation in the Space Operations account."
- The committee report states, "Space Launch System [SLS], Orion multi-purpose crew vehicle [Orion], and Exploration ground systems are all critical to the timely and successful initial launch of Exploration Mission-1 [EM– 1]. To date, both SLS and Exploration ground systems have completed Key Decision Point-C reviews, and Orion is expected to complete its review in the third quarter of 2015. Once that point is reached, NASA intends to develop an integrated schedule by the end of calendar year 2015 that will solidify the schedule for EM– 1, and provide the necessary guidance to ensure EM–1 is launched as early in 2018 as possible."
- The committee is disappointed, however, "that the funding requested by NASA for SLS and Orion once again bears little relation to necessary funding levels or to amounts provided in previous years. The lack of support for these programs indicates that NASA is allowing an artificially low development funding profile and inefficient decision processes to create unnecessary risks to the EM–1 schedule. The

Committee has repeatedly been compelled to provide appropriate funding to keep the human exploration program from incurring costly setbacks and to maintain development schedules. Continued insufficient funding proposals from NASA for all aspects of related to EM–1 and its crewed follow on test flight will only lead to cost escalation and unnecessary schedule delays that will then have to be addressed in future budget years."

Space Launch System

About

The NASA Authorization Act of 2010 directed NASA to develop an evolvable heavy-lift rocket that will allow human exploration beyond low Earth orbit.

- President's FY 2016 Space Launch System (SLS):
- NASA FY 2016 budget justification documents note that "The vehicle's capabilities will evolve using a block upgrade approach, driven by near- and long-term exploration mission requirements."
  - First, "SLS will carry over 70 metric tons to low Earth orbit and nearly 30 metric tons to the exploration proving ground near the Moon."
  - Next, "follow-on upgrades, including an advanced Exploration Upper Stage (EUS) will improve vehicle lift performance to 105 metric tons to low Earth orbit and 40 metric tons to the lunar proving ground, significantly increasing mission capability."
  - Finally, "SLS will evolve to carry over 130 metric tons to low Earth orbit, necessary to launch the large elements needed for human exploration of Mars."
- EUS "leverages technology investments made by the STMD in areas such as cryogenic fluid management and advanced composites." NASA has already begun leveraging "this close coordination demonstrated between STMD and HEOMD" to serve as the basis for "future exploration technologies and capabilities needed to explore Mars in the 2030s."
- The President's FY16 request for SLS funding keeps the SLS EM-1 on track for launch capability readiness in November 2018.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $1,700 million for SLS (aspirational and constrained), $343.5 million more than the President's FY 2016 request.
- It is the finding of Congress that SLS is "the most practical approach to reaching the Moon, Mars, and beyond, and Congress reaffirms the policy and minimum capability requirements for the Space Launch System contained in section 302 of the National Aeronautics and Space Administration Authorization Act of 2010."
- In order "to promote safety and reduce programmatic risk," the Administrator is directed to "budget for and undertake a robust ground test and uncrewed and crewed flight test and demonstration program for the Space Launch System and the Orion crew vehicle and shall budget for an operational flight sufficient to maintain safety and operational readiness."
- Section 203 also includes a section regarding the GAO report. "Not later than 270 days after the date of enactment of this Act, the Comptroller General shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report on the Administration's acquisition of ground systems in support of the Space Launch System. The report shall assess the extent to which ground systems acquired in support of the Space Launch System are focused on the direct support of the Space Launch System and shall identify any ground support projects or activities that the Administration is undertaking that do not solely or primarily support the Space Launch System."
- A utilization report is mentioned," as well, in which the NASA Administrator, Secretary of Defense and Director of National Intelligence address "the effort and budget required to enable and utilize a cargo variant of the 130-ton Space Launch System configuration described in section 302(c) of the National Aeronautics and Space Administration Authorization Act of 2010 (42 U.S.C. 18322(c))." The report is to

"include consideration of the technical requirements of the scientific and national security communities related to such Space Launch System and shall directly assess the utility and estimated cost savings obtained by using such Space Launch System for national security and space science missions. The Administrator shall transmit such report to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate not later than 180 days after the date of enactment of this Act."

- The committee report discusses an advanced booster competition, and specifies that "not later than 90 days after the date of enactment of this Act, the Associate Administrator of the Administration shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report that—
    - (A) describes the estimated total development cost of an advanced booster for the Space Launch System;
    - (B) details any reductions or increases to the development cost of the Space Launch Sys- tem which may result from conducting a com- petition for an advanced booster; and
    - (C) outlines any potential schedule delay to the Space Launch System 2018 Exploration Mission–1 launch as a result of increased costs associated with conducting a competition for an advanced booster.
- Accordingly, "if the Associate Administrator reports reductions pursuant to paragraph (1)(B), and no adverse schedule impact pursuant to paragraph (1)(C), then the Administration shall conduct a full and open competition for an advanced booster for the Space Launch System to meet the requirements described in section 302(c) of the National Aeronautics and Space Administration Authorization Act of 2010 (42 U.S.C. 18322(c)), to begin as soon as practicable after the development of the upper stage has been initiated."

<u>House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The House passed FY 2016 CJS bill would appropriate $1,850 million for SLS, $493.5 million above the President's FY 2016 request.
- Of that SLS funds, no less than $50 million is to be used for "continued enhanced upper stage (EUS) development."
- The report directs NASA to provide the committee with a report "no later than 120 days after enactment of this Act describing investments to date on the EUS and a spend plan with milestones for the funds provided in fiscal year 2016."
- NASA also is instructed to continue providing quarterly reports on SLS by major program element, "as first required in the statement accompanying Public Law 112–55."
- Last, the committee directs NASA "to the maximum extent possible," to "ensure that all vehicle development funding leverages existing investments; promotes efficiency through commonality of design and simultaneous development; and minimizes the need for redesigns or other costly changes affecting future SLS vehicle configurations."

<u>SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The SAC passed FY 2016 CJS bill would appropriate $1,900 million for SLS, $543.5 million below the President's FY 2016 request.
- The Committee "reiterates its unwavering support of the Space Launch System [SLS] and the ability for SLS to open the human exploration of space to a wide range of missions," stating that "SLS has successfully passed its Key Decision Point-C [KDP–C] milestone and the program is diligently working towards its first flight in 2018. While KDP–C defines a readiness date of November 2018, the current progress of SLS will result in the vehicle being delivered ahead of its planned schedule."
- The Committee also finds that "the budgetary resources provided for SLS in the fiscal year 2016 budget request are insufficient and do not take into account the current management schedule for flight readiness, nor does the funding level present a path forward beyond EM–1. In February 2015, the U.S. Government Accountability Office [GAO] reported that NASA's cost estimates for both SLS and Orion do not extend beyond the first flight of the combined system. GAO further reported that NASA's budget estimates do not include the development costs for upper-stage development for SLS or production costs for the second test flight scheduled for 2021. GAO also stated that NASA's funding requests do not

meet SLS program requirements. While the Committee has chosen to correct the funding shortfalls in fiscal year 2016, NASA is directed to address these issues identified by GAO in future budget submissions."

- The Committee is also concerned "that NASA will attempt to take the Interim Cryogenic Propulsion Stage [ICPS] that will be used for EM–1 and create a human rated variant. In doing so, NASA would spend $150,000,000 to develop a human rated engine that would be used only once, before being replaced by the Exploration Upper Stage [EUS]. Such planning wastes valuable time and funding resources that should be used for developing the EUS from the beginning so that it will be available for all crewed SLS missions."
- Toward a goal "to ensure proper funding," the Committee provides that "no less than $100,000,000 provided for the direct development of the EUS to be used for EM–2. This funding level is necessary in order for the SLS to continue its progress towards a successful EM–1 launch as early as possible in 2018, to facilitate development of essential EUS propulsion hardware, and to begin the procurement process of long lead items for a crewed launch in 2021."

Orion Multi-Purpose Crew Vehicle

About

NASA's FY 2016 budget justification documents states that Orion MPCV will be capable of carrying "a crew of four astronauts beyond Earth orbit and provide habitation and life support for up to 21 days." The spacecraft has three components: a crew module, service module, and launch abort system, with a separate adapter to connect the crew and launch vehicles.

- The crew module is described as a "familiar capsule shape on the outside, but inside it contains state of the art crew systems." During a mission the Orion MPCV will "house the crew, providing a safe environment within which to live and work." In addition, "Its advanced heat shield will protect the crew from the reentry heating during a high-speed return from beyond Earth orbit."
- The service module "is comprised of a crew module adapter and an ESA-designed and developed service module section, and together they provide in-space power, propulsion, and other life support systems."
- The launch abort system sits "atop the crew module," and "in the event of an emergency during launch or climb to orbit, will activate within milliseconds to propel the crew module away from the launch vehicle to safety." Further, the launch abort system "provides a protective shell that shields the crew module from dangerous atmospheric loads and heating during descent." The spacecraft will jettison the system "once Orion is out of the atmosphere and safely on its way to orbit."
- A successful EFT-1 Flight Test of the Orion Capsule was conducted in December 2014, the data from which "will help NASA to understand better many of the top risks to astronauts who will fly on Exploration Mission (EM)-2 and future missions."
- Next, "Orion will continue design, development, and testing, focusing on EM-1 and EM-2," while "NASA continues working toward a capability to launch EM-1, which includes launching an uncrewed vehicle to demonstrate the performance of an integrated SLS rocket and uncrewed Orion vehicle prior to EM-2, a crewed flight…. An integrated EM-1 launch date will be determined once the SLS, EGS, and Orion have completed their respective Critical Design Reviews."

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $1,200 million for Orion (aspirational and constrained), $103.7 million more than the President's FY 2016 request.
- In Section 204, the relevant committee report states that "the Orion crew vehicle shall meet the needs and the minimum capability requirements described in section 303 of the National Aeronautics and Space Administration Authorization Act of 2010 (42 U.S.C. 18323)."
- Accordingly, within 60 days after the date of enactment of this Act, the Administrator shall transmit a report to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate—
  - (1) detailing those components and systems of the Orion crew vehicle that ensure it is in compliance

with section 303(b) of such Act (42 U.S.C. 18323(b));
    - (2) detailing the expected date that the Orion crew vehicle will be available to transport crew and cargo to the International Space Station; and
    - (3) certifying that the requirements of section 303(b)(3) of such Act (42 U.S.C. 18323(b)(3)) will be met by the Administration.

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $1,096.3 million for Orion to fully fund the President's FY 2016 request.
- In addition, NASA is directed to "provide quarterly briefings to the Committee on efforts to address parachute issues that arose during the December 2014 test flight and to address heat shield issues that NASA has been working to resolve since 2013. These updates shall include the overall status of Orion and its ability to ride on SLS for Exploration Mission (EM)–1."
- The committee also states its concern that that "NASA's current schedule does not provide adequate time to fully test all systems necessary to support humans prior to EM–2." Accordingly, "NASA shall provide the Committee with an assessment, no later than the second quarter of fiscal year 2016, of its ability to test all human-rated systems on EM–1."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $1,200 million for Orion, $103.7 million above the President's FY 2016 request.
- The committee states that "Orion is an essential component of NASA's human exploration goals that extend beyond low-Earth orbit. However, in the same report by GAO that cited issues with funding levels for SLS, GAO also concluded that NASA is not budgeting for the production, operations, and sustainment costs associated with Orion beyond this first successful test flight. GAO has found that technical risks and budgetary uncertainty threaten Orion's future success. Moreover, current NASA plans lack sufficient requests for funding needed to build and test systems essential for crew such as environmental control, life support, and critical displays. The Committee looks forward to a successful result for Orion's KDP–C review."

Integrated Launch Readiness

The President's FY16 request did not include a portion called Integrated Launch Readiness.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- No relevant language

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $53 million for Integrated Launch Readiness, which did not exist in the President's FY 2016 request.
- The committee report states that the funds are to address coordination issues among Orion, SLS, and ground systems "and ensure that they are progressing in tandem toward EM-1 and future missions."
- The committee also directs NASA to notify the committee no later than 10 days after the decision regarding the date for the EM-1 mission. That decision should be made by December 2015.
- Further, "to provide the Committee with a greater understanding of the complete costs of an integrated SLS/Orion program, NASA shall submit a comprehensive plan, with yearly budgets by component including various ground facilities and quarterly milestones, to achieve an integrated launch readiness dates for EM–1 and EM–2. This report shall also provide an analysis of various capabilities that will be provided with 70, 105, and 130 metric ton capabilities, to include the yearly costs necessary to proceed with this incremental approach."
- The committee also stresses safety, noting that that it "understands that various risks need to be retired in the integrated program prior to safely transporting humans. Nothing in this report or accompanying Act directs NASA to proceed with any human spaceflight programs until all of the risks have been retired."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- "To ensure that NASA follows its own guidance and does not require SLS and Orion to incur a higher risk profile than other major missions, the bill directs NASA to formulate a reliable and realistic Joint Confidence Level. In doing so, NASA shall provide the Committee with an annual budget profile based upon NASA's own 70 percent JCL standard which is to be submitted concurrently with the annual budget submission. Any JCL that is less than 70 percent shall be justified and documented, and NASA shall still provide the Committee with the full cost estimates that would be needed to achieve a 70 percent JCL."

Commercial Crew

About

With an eye to the future of human spaceflight, NASA is looking to the U.S. private sector to develop and operate safe, reliable, and affordable crew transportation to low Earth orbit, including to the International Space Station (ISS).

- In 2016, "commercial crew industry CCtCap teams will accomplish significant milestones under their contracts, such as Boeing's Integrated Parachute System Drop Tests and service module hot fire launch abort test and SpaceX's plans for uncrewed flight to ISS and Launch Site Operational Readiness Review."

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $1,243.8 million (aspirational) or $1,136.1 million (constrained), to fully fund or fund $107.7 million below the President's FY 2016 request, respectfully.
- It is the sense of Congress "that once developed and certified to meet the Administration's safety and reliability requirements, United States commercially provided crew transportation systems offer the potential of serving as the primary means of transporting American astronauts and international partner astronauts to and from the International Space Station and serving as International Space Station emergency crew rescue vehicles. At the same time, the budgetary assumptions used by the Administration in its planning for the Commercial Crew Program have consistently assumed significantly higher funding levels than have been authorized and appropriated by Congress.
- It is further the sense of Congress "that credibility in the Administration's budgetary estimates for the Commercial Crew Program can be enhanced by an independently developed cost estimate. Such credibility in budgetary estimates is an important factor in understanding program risk."
- The stated objective of the Commercial Crew program is "to assist the development of at least one crew transportation system to carry Administration astronauts safely, reliably, and affordably to and from the International Space Station and to serve as an emergency crew rescue vehicle as soon as practicable within the funding levels authorized. The Administration shall not use any considerations beyond this objective in the overall acquisition strategy."
- Regarding safety, "Consistent with the findings and recommendations of the Columbia Accident Investigation Board, the Administration shall ensure that safety and the minimization of the probability of loss of crew are the highest priorities of the commercial crew transportation program."
- Minimizing cost is emphasized: "The Administrator shall strive through the competitive selection process to minimize the life cycle cost to the Administration through the planned period of commercially provided crew transportation services."
- Transparency is also important. "Transparency is the cornerstone of ensuring a safe and reliable commercial crew transportation service to the International Space Station. The Administrator shall, to the greatest extent practicable, ensure that every commercial crew transportation services provider has provided evidence-based support for their costs and schedule."
- The NASA Administrator is directed to conduct an independent cost and schedule estimate is ordered within 60 days after the date of enactment, which shall include:
    - (A) all activities associated with the development, test, demonstration, and certification of commercial crew transportation systems;
    - (B) transportation and rescue services required by the Administration for International Space

Station operations through calendar year 2020 or later if Administration requirements so dictate; and (C) the estimated date of operational readiness for the program.

- Within 180 days after the estimate is initiated, the Administrator shall transmit the results to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate.

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $1,000 million for Commercial Crew, $244 million below the President's FY 2016 request.
- The Committee report shares the concerns of the committee that "some project milestones have slipped for a variety of reasons" and directs NASA to "continue submitting quarterly reports on the status of the Commercial Crew Integrated Capability and Commercial Crew Transportation Capability con- tracts. NASA also shall provide an assessment within 90 days of enactment of this Act on the need to reserve flights on the Soyuz capsule in tandem with the Commercial Crew program in 2017 and 2018."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- For purposes of the 2016 budget, the Senate version of the appropriations bill For fiscal year 2016, "the Exploration account does not include funds for Commercial Crew, which are now located under ISS Crew and Cargo transportation in the Space Operations account."

Space Operations

Budget Authority, $ in millions	Consolidated Approps, 2015 (P.L. 112-235)	President's FY 2016 NASA Budget Request	HSST NASA Authorization Act Aspirational (H.R. 2039)	HSST NASA Authorization Act Constrained (H.R. 2039)	House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)	SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)
International Space Station	-	3,105.6	Not specified	Not specified	3,075.6	3,951.6
Space and Flight Support	-	898.1	Not specified	Not specified	881.7	Not specified, but logic dictates 804.8
Total	**3,827.8****	**4,003.7**	**3,992.5**	**3,950.4**	**3,957.3**	**4,756.4**

** The ISS and Space and Flight Support sub-numbers are not broken out for this account.

President's FY 2016 Budget Request for Overall Space Operations Portfolio

In FY 2016 the President base budget requested $4,003.7 million for Space Operations missions, $175.9 million above the funds appropriated for Space Operations missions in FY 2015.

- President's FY 2016 Space Operations:
  - $1.1061 billion for ISS Systems Operations and Maintenance;
  - $394 million for ISS Research
  - $1.6055 for ISS Crew and Cargo Transportation
  - $23.3 million for 21st Century Space Launch Complex
  - $539.7 million for Space Communications Networks
  - $92.7 million for Space Communications Support
  - $108.5 million for Human Space Flight Operations
  - $86.7 million for Launch Services
  - $47.2 for Rocket Propulsion Test

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $3,992.5 million for Space Operations (aspirational) or $3,950.4 (constrained), respectively $11.2 million and $53.3 million below the President's FY 2016 request.

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $3.957.3 million to fund Space Operations, $46.4 million below the President's FY 2016 request.

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill would appropriate $4,756.4 million for Space Operations, $751.2 million above the President's FY 2016 request.
- New for FY16, "the Committee has chosen to fund all activities related to the ISS within the same account to consolidate funding required for the supply and operation of this national asset and to allow the ISS to be managed as a whole program, within the budgetary resources provided. This realignment and unification of ISS activities will allow NASA's programs associated with operating the ISS, developing

crew capabilities, and supporting human activity in low-Earth orbit, to be analyzed and evaluated in its entirety. This budgetary adjustment will only affect the structure of ISS-related funding and will not alter the many aspects of the ISS program, or its management structures that are currently in place within Human Exploration and Operations."

International Space Station

About

As the world's only space-based multinational research and technology testbed, ISS is critical to the future of human space activities. The facility enables scientists to identify and quantify risks to human health and performance and to develop and test countermeasures and technologies to protect astronauts during extended human space exploration. In addition, ISS offers unique opportunities for research and development, allowing scientists to investigate biological and physical processes in an environment very different from that on Earth.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act does not specify how much the committee would authorize to appropriate for the ISS sub-account.
- Section 211 states that it is the finding of Congress that:
    - (1) The International Space Station is an ideal testbed for future exploration systems development, including long-duration space travel.
    - (2) The use of the private market to provide cargo and crew transportation services is currently the most expeditious process to restore domestic access to the International Space Station and low- Earth orbit.
    - (3) Government access to low-Earth orbit is paramount to the continued success of the International Space Station and National Laboratory.
- The section also lays out that it is the policy of the United States that:
    - (1) The United States International Space Station program shall have two primary objectives: supporting achievement of the goal established in section 201 of this Act [editor's note: to land a crewed mission on Mars] and pursuing a research program that advances knowledge and provides benefits to the Nation. It shall continue to be the policy of the United States to, in consultation with its international partners in the International Space Station program, support full and complete utilization of the International Space Station.
    - (2) The International Space Station shall be utilized to the maximum extent practicable for the development of capabilities and technologies needed for the future of human exploration beyond low-Earth orbit and shall be considered in the development of the Human Exploration Roadmap developed under section 70504 of title 51, United States Code.
    - (3) The Administrator shall, in consultation with the International Space Station partners—
        - (A) take all necessary measures to support the operation and full utilization of the International Space Station; and
        - (B) seek to minimize, to the extent practicable, the operating costs of the International Space Station.
    - (4) Reliance on foreign carriers for crew transfer is unacceptable, and the Nation's human space flight program must acquire the capability to launch United States astronauts on United States rockets from United States soil as soon as is safe and practically possible, whether on Government-owned and operated space transportation systems or privately owned systems that have been certified for flight by the appropriate Federal agencies.
- Congress also uses this section to reaffirm:
    - (1) its commitment to the development of a commercially developed launch and delivery system to the International Space Station for crew missions as expressed in the National Aeronautics and Space Administration Authorization Act of 2008 (Public Law 110–422), and the National Aeronautics and Space Administration Authorization Act of 2010 (Public Law 111–267);

- (2) that the Administration shall make use of United States commercially provided International Space Station crew transfer and crew rescue services to the maximum extent practicable;
- (3) that the Orion crew vehicle shall provide an alternative means of delivery of crew and cargo to the International Space Station, in the event other vehicles, whether commercial vehicles or partner-supplied vehicles, are unable to perform that function; and
- (4) the policy stated in section 501(b) of the 18 National Aeronautics and Space Administration Authorization Act of 2010 (42 U.S.C. 18351(b)) that the Administration shall pursue international, commercial, and intragovernmental means to maximize International Space Station logistics supply, maintenance, and operational capabilities, reduce risks to International Space Station systems sustainability, and offset and minimize United States operations costs relating to the International Space Station.

- The section goes on to address assured access to LEO, stating "Section 70501(a) of title 51, United States Code, is amended to read as follows: 'It is the policy of the United States to maintain an uninterrupted capability for human space flight and operations in low-Earth orbit, and beyond, as an essential instrument of national security and the capability to ensure continued United States participation and leadership in the exploration and utilization of space.''
- On the topic of extension criteria, the Administrator should submit a report within a year of enactment to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate "a report on the feasibility of extending the operation of the International Space Station that includes—
  - (1) criteria for defining the International Space Station as a research success;
  - (2) any necessary contributions to enabling execution of the Human Exploration Roadmap devel14oped under section 70504 of title 51, United States Code;
  - (3) cost estimates for operating the International Space Station to achieve the criteria required under paragraph (1);
  - (4) cost estimates for extending operations to 2024 and 2030;
  - (5) an assessment of how the defined criteria under paragraph (1) respond to the National Academies Decadal Survey on Biological and Physical Sciences in Space; and
  - (6) an identification of the actions and cost estimate needed to deorbit the International Space Station once a decision is made to deorbit the laboratory.

<u>House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The House passed FY 2016 CJS bill would appropriate $3,075.6 million for ISS, $30 million below the President's FY 2016 request.
- The Committee states that it is concerned, "particularly in light of NASA's proposal to ex- tend the life of the Station through 2024, that annual ISS operations costs are increasing."
- The report directs NASA to "continue to implement cost savings measures with the goal of slowing and reducing the ISS operations budget while maximizing research opportunities."
- In addition, "all reductions from the request level shall be implemented in the operations budget rather than ISS research or crew and cargo transportation."
- The committee is also of the belief that "NASA's budget request continues to allocate insufficient funding and effort to ISS research," and "that this imbalance must be addressed by directing a greater share of research funding to actual physical and biological science research."
- Accordingly, NASA is directed "to provide a strategy for accomplishing this goal over the next five fiscal years, which shall be provided "no later than 120 days after the enactment of this Act.

<u>SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The SAC passed FY 2016 CJS bill would appropriate $3,951.6 million for ISS, $846 million above the President's FY 2016 request to fund ISS Operations, Research, Crew, and Cargo Services.
- The committee report states that "the committee has consistently supported the construction and operation of the ISS on the premise that it would support world- class science conducted by the United States, as well as our inter- national partners. The Committee encourages NASA to work with its international partners to support the ISS through 2024, to maintain a high level of safety, and maximize the return of scientific research. In addition, the Committee considers astronaut safety its highest

priority and NASA must ensure that safety standards for transportation are not compromised as NASA begins to replace its reliance on existing Russian capabilities with purchasing services from domestic crew transportation providers."

- This version of the bill moves ISS Crew and Cargo Transportation from the Exploration account to the Space Operations account, where "the Committee recommends $2,505.5 million to fund ISS cargo resupply and crew transportation, including $900 million for development milestone payments to U.S.-based ISS Crew providers."
- The Committee emphasizes that "that the initial rounds of development funding for ISS Crew capabilities represented a $1,90 million investment prior to awarding another $6,800 million in potential payments for two ISS Crew providers to finish development of their vehicles and conduct initial flights. At the end of this final round of vehicle development and testing of this capability, NASA will have paid a total of $8,700 million to conduct a competition between several companies. This substantial investment from the Federal Government comes prior to NASA purchasing future crew services for the ISS from these domestic providers."
- "Given the significant sums being invested by NASA," the committee says that "it is incumbent that these funds are regularly reviewed." "To date, milestones intended to show progress in the development of the ISS Crew capability have already begun to be delayed. More technically challenging milestone completion dates are about to be reached or may be potentially postponed further. It is the intent of the Committee to continue to closely monitor and review progress of the ISS Crew capability through the quarterly reports that are provided by NASA."
- The committee expresses serious concern regarding a Notice of Intent issued by NASA on February 6, 2015, "to purchase another six seats from the Russians during the 2018–2019 time period. While NASA appears to be protecting its access to ISS, the Committee notes NASA has consistently stated that domestically launched crew transportation capabilities will be ready during this time period so that the United States can end our reliance on such vehicles. Particularly concerning is that the notice of intent specifically states that 'NASA needs to secure crew transportation with a known reliable provider to ensure a continued U.S. presence aboard the ISS.' Such statements are deeply concerning and indicate that even NASA, which has continual insight and oversight of the ISS crew program, does not have confidence that even with significant financial and technical support, the availability of a reliable domestic ISS crew capability by 2017 is guaranteed."
- Finally, the Committee states that it "has provided the requested amount for ISS Cargo in anticipation that during fiscal year 2016, the companies contracted to provide cargo services will be capable of delivering cargo to, and returning it from, the ISS, consistent with current agreements."

Space and Flight Support

About

Space and Flight Support consists of multiple programs providing Agency-level capabilities critical to the success of NASA missions and goals.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act does not specify how much the committee would authorize to appropriate for the space and flight support sub-account.

House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The House passed FY 2016 CJS bill would appropriate $881.7 million for Space and Flight Support, $16.4 million below the President's FY 2016 request.
- The committee's recommendation includes the requested $23.2 million for the 21st Century Space Launch Complex program, which is "designed to modernize and upgrade both Wallops Flight Facility and Kennedy Space Center launch and range complexes."
- NASA is directed to "provide periodic updates to the Committee regarding status of the Wallops Flight Facility and its ability to resume commercial launches."
- The Committee "supports maintaining launch sites serving the International Space Station at both the

Kennedy Space Center and the Wallops Flight Facility to ensure uninterrupted domestic cargo access to the Station."

- When launch failures occur in the commercial cargo program, "NASA shall submit a report within 180 days of enactment of this Act on all anomalies and losses in the commercial cargo program and how any such anomalies have been corrected."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The SAC passed FY 2016 CJS bill does not specify how much the committee would authorize to appropriate for the space and flight support sub-account; however, because it does specify the total Space Operations budget and does specify the ISS sub-account, logic dictates that the committee would appropriate $804.8 million for Space and Flight Support, $93 million below the President's FY 2016 request.
- This version of the bill provides $30.3 million for the 21st Century Space Launch Complex, $7 million above the President's FY16 request. The Committee "is concerned about the ability of commercial space launch providers to plan for the future, given the preponderance of funding that is dedicated from the 21st Century Space Launch Complex to the facilities at Kennedy Space Center. The program's authorized purposes include projects at all NASA-owned launch facilities. The Committee directs that any new Commercial Space Flight infrastructure investment proposals for the 21st Century Space Launch Complex program take into account the cargo mission needs also demonstrated at the Wallops Flight Facility [WFF], which is expected to complete repairs on the launch pad and return to flight in fiscal year 2016. There are now growing capacity issues at WFF that, if not resolved, could soon prevent the center from taking on small and large missions due to limitations associated with facilities related to spacecraft processing and fueling. Therefore, the Committee provides the increased funding to fill maintenance gaps at the WFF launch complex, and further directs NASA to take into consideration the full potential of all NASA-owned launch complexes."
- The Committee also "recognizes and appreciates the complexities involved in sustaining NASA's Near Earth, Space, and Deep Space communications networks and infrastructure that support NASA's scientific and exploration activities," and therefore "directs NASA to develop a plan, budget, and timeline for sustainment of the existing network and infrastructure up-grades within 180 days of enactment of this act."

Space Technology

Budget Authority, $ in millions	Consolidated Approps, 2015 (P.L. 112-235)	President's FY 2016 NASA Budget Request	HSST NASA Authorization Act Aspirational (H.R. 2039)	HSST NASA Authorization Act Constrained (H.R. 2039)	House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)	SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)
Space Technology Research and Development (formerly, the separate Crosscutting Space Technology and Exploration Technology Development)	-	491.0	Not specified	Not specified	Not specified	Not specified
Agency Technology and Innovation	-	33.0	Not specified	Not specified	Not specified	Not specified
SBIR and STTR	-	200.9	Not specified	Not specified	Not specified	Not specified
Total	**596.0**	**724.9**	**596**	**500**	**625**	**600**

President's FY 2016 Budget Request for Overall Space Technology Portfolio

In FY 2016, the President's base budget requested $724.9 million for Space Technology missions, $128.9 million above the funds appropriated for Space Technology missions in FY 2015.

FY 2016 Congressional Action

HSST Passed NASA Authorization Act (H.R. 2039)

- The HSST passed FY 2016 NASA Authorization Act would authorize to appropriate $596 million for Space Technology (aspirational) or $500 million (constrained), respectively $128.9 million and $224.9 million below the President's FY 2016 request.
- It is the sense of Congress "that space technology is critical to—
  - (1) enabling a new class of Administration missions beyond low-Earth orbit;
  - (2) developing technologies and capabilities that will make the Administration's missions more afford- able and more reliable; and
  - (3) improving technological capabilities and promoting innovation for the Administration and the Nation.
- Section 70507 of title 51, U.S. Code, will be amended to authorize the NASA Administrator to "establish a Space Technology Program to pursue the research and development of advanced space technologies that have the potential of delivering innovative solutions and to support human exploration of the

solar system or advanced space science. The program established by the Administrator shall take into consideration the recommendations of the National Academies' review of the Administration's Space Technology roadmaps and priorities, as well as applicable enabling aspects of the Human Exploration Roadmap specified in section 70504. In conducting the space technology program established under this section, the Administrator shall—

  - (1) to the maximum extent practicable, use a competitive process to select projects to be supported as part of the program;
  - (2) make use of small satellites and the Ad- ministration's suborbital and ground-based plat- forms, to the extent practicable and appropriate, to demonstrate space technology concepts and developments; and
  - '(3) undertake partnerships with other Federal agencies, universities, private industry, and other spacefaring nations, as appropriate."

- Regarding small business programs, "The Administrator shall organize and manage the Administration's Small Business Innovation Research program and Small Business Technology Transfer Program within the Space Technology Program.
- To ensure nonduplication, "The Administrator shall include in the budget for each fiscal year, as transmitted to Congress under section 1105(a) of title 31, a certification that no project, program, or mission undertaken by the Space Technology Program is duplicative of any other project, program, or mission conducted by another office or directorate of the Administration.''
- In addition, "the Administrator shall ensure that the Administration's projects, programs, and activities in support of technology research and development of advanced space technologies are fully coordinated and aligned and thatresults from such work are shared and leveraged within the Administration. Projects, programs, and activities being conducted by the Human Exploration and Operations Mission Directorate in support of research and development of advanced space technologies and systems focusing on human space exploration should continue in that Directorate. The Administrator shall ensure that organizational responsibility for research and development activities in support of human space exploration not initiated as of the date of enactment of this Act is established on the basis of a sound rationale. The Administrator shall provide the rationale in the report specified in [the annual report]"
- This section also requires the NASA Administrator to provide a report to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate, which will compare "the Administration's space technology investments with the high-priority technology areas identified by the National Academies in the National Research Council's report on the Administration's Space Technology Roadmaps. The Administrator shall identify how the Administration will address any gaps between the agency's investments and the recommended technology areas, in a projection of funding requirements."
- In addition, "the Administrator shall include in the Administration's annual budget request for each fiscal year the rationale for assigning organizational responsibility for, in the year prior to the budget fiscal year, each initiated project, program, and mission focused on research and development of advanced technologies for human space exploration."
- Finally, "The Administrator shall utilize the International Space Station and commercial services for space technology demonstration missions in low-Earth orbit whenever it is practical and cost effective to do so."

<u>House Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)</u>

- The Committee recommends $625 million for Space Technology, which is $99.9 million below the President's FY16 request.
- The committee recommendation "includes no less than $25 million for icy satellite surface technology and test-bed activities."
- The committee recommendation also "includes no less than $20 million for nuclear propulsion technologies for space transportation and exploration" and directs that within 180 days of enactment, "NASA shall provide a report on ongoing nuclear propulsion re- search and how NASA intends to employ this technology to support various exploration programs."

SAC Passed Commerce, Justice, Science Appropriations Bill (H.R. 2578)

- The Committee recommends $600 million for Space Technology, which is $124.9 million below the President's FY16 request.
- Included in the Space Technology budget, the Committee recommends $150 million "for satellite servicing to continue the pathfinder mission [RESTORE–L] to refuel Landsat-7 or another U.S. Government-owned satellite in low-Earth orbit no later than 2019." since "Pathfinder technologies were funded and proven on the International Space Station. The Committee recommendation includes funding for a full-scale, stand- alone demonstration which will benefit multiple NASA mission directorates and, therefore, is more appropriately funded within Space Technology. The mission shall be co-managed and led by the Science Mission Directorate."
- The committee report notes that "in allocating funding for RESTORE–L, NASA shall not include amounts carried over from previous fiscal years. The Committee has also included bill language for this initiative so it continues in a timely fashion and to avoid lingering drains on satellite servicing funds that have been diverted to other purposes in earlier years. Celebrations of the 25th anniversary of the Hubble Space Telescope demonstrated the value of repair, upgrades, and life extension for productive but expensive Government-owned space assets. Given constraints imposed by the Budget Control Act, satellite servicing offers a unique and valuable means to stagger the capital requirements for new satellites by significantly extending the useful life of existing ones. The funds set aside for the RESTORE–L Path- finder mission should lead to the immediate funding of efforts to formulate a rapid mission, done in partnership with and overseen by NASA's existing satellite servicing expertise. The Administrator shall furnish the Committee with a written schedule to accomplish the execution of RESTORE–L not later than 30 days after the enactment of this act."
- Space Technology also encompasses the Small Business Innovation Research (SBIR) program, which has had "previous success in commercialization of results from federally funded research and development projects. The SBIR program encourages domestic small businesses to engage in Federal research and development, and creates jobs. The Committee therefore directs NASA to place an increased focus on awarding SBIR awards to firms with fewer than 50 employees."
- Finally, "within the funds provided for Cross- cutting Space Technology Development, the Committee provides $20 million for Flight Opportunities. The Committee notes that NASA initiated a program during fiscal year 2015 to promote the development of nano-launch orbital capabilities within Flight Opportunities, and directs NASA to further pursue the design and development of an affordable system that can carry nanosatellites to low-Earth orbit from within the funds provided."

About the Space Foundation

Founded in 1983, the Space Foundation is the foremost advocate for all ssectors of space, and is a global, nonprofit leader in space awareness activities, educational programs and major industry events, including the annual Space Symposium, in support of its mission "to advance space-related endeavors to inspire, enable and propel humanity." Space Foundation World Headquarters in Colorado Springs, Colo., USA, has a public Discovery Center, including El Pomar Space Gallery, Northrop Grumman Science Center featuring Science On a Sphere® and the Lockheed Martin Space Education Center. The Space Foundation has a field office in Houston and conducts government affairs from its Washington, D.C., office. It annually publishes *The Space Report: The Authoritative Guide to Global Space Activity*, and through its Space Certification™ and Space Technology Hall of Fame® programs, recognizes space-based innovations that have been adapted to improve life on Earth. Visit www.SpaceFoundation.org, follow us on Facebook, Instagram,LinkedIn, Pinterest, Twitter and YouTube, and read our e-newsletter *Space Watch*.

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