SPACE TECHNOLOGY

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**456.3**	**573.7**	**699.0**	**699.0**	**699.0**	**699.0**	**699.0**
SBIR and STTR	164.7	166.7	**173.7**	181.9	187.2	195.3	206.0
Partnerships Dev & Strategic Integration	26.6	29.5	**29.5**	29.5	29.5	29.5	29.5
Crosscutting Space Tech Development	120.4	187.7	**293.8**	272.1	266.6	259.7	247.0
Exploration Technology Development	144.6	189.9	**202.0**	215.5	215.7	214.5	216.5

SPACE TECHNOLOGY OVERVIEW ..... TECH- 2

SBIR AND STTR ..... TECH- 8

PARTNERSHIPS AND STRATEGIC INTEGRATION ..... TECH- 16

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT ..... TECH- 22

EXPLORATION TECHNOLOGY DEVELOPMENT ..... TECH- 32

SPACE TECHNOLOGY

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**456.3**	**573.7**	**699.0**	**699.0**	**699.0**	**699.0**	**699.0**
SBIR and STTR	164.7	166.7	**173.7**	181.9	187.2	195.3	206.0
Partnerships Dev & Strategic Integration	26.6	29.5	**29.5**	29.5	29.5	29.5	29.5
Crosscutting Space Tech Development	120.4	187.7	**293.8**	272.1	266.6	259.7	247.0
Exploration Technology Development	144.6	189.9	**202.0**	215.5	215.7	214.5	216.5
Change From FY 2012 Estimate	--	--	**125.3**				
Percent Change From FY 2012 Estimate	--	--	**21.8%**				

Note: *The FY 2011 and FY 2012 figures are adjusted to reflect comparable Exploration Technology content from the Exploration Account, comparable Space Technology Program content from the Space Operation account, and the movement of the Innovative Partnerships Program from the Cross Agency Support account, within the Space Technology account.*

Robonaut 2 waving to Space Shuttle Discovery, while its twin is en route to the ISS. In 2011, Robonaut became the first humanoid robot in space.

A critical component to advancing our future in space is the rapid development and infusion of new space technologies that can enable new missions for NASA, benefit the overall aerospace industry and other government agencies. The recently released, National Research Council Report, *NASA Space Technology Roadmaps and Priorities* noted "Future U.S. leadership in space requires a foundation of sustained technology advances that can enable the development of more capable, reliable, and lower-cost spacecraft and launch vehicles to achieve space program goals. A strong advanced technology development foundation is needed also to enhance technology readiness of new missions, mitigate their technological risks, improve the quality of cost estimates, and thereby contribute to better overall mission cost management…"

Space Technology investments enable future human and scientific exploration of near-Earth asteroids, the Moon, and Mars, just as current and past mission successes were supported by previous technology investments. This budget request funds the development of pioneering technologies that will increase our nation's capability to operate in space and enable deep space exploration. Significant progress in technology areas such as space power systems, entry, descent, and landing systems, propulsion, radiation protection, and cryogenic fluid handling are essential for human exploration beyond low Earth orbit. By investing in high-payoff transformative technology, Space Technology will mature the capabilities required for NASA's future, provide new capabilities, and lower the cost for other government agencies and private industry. Developing these solutions will stimulate the growth of the Nation's innovation economy, creating high-tech jobs.

SPACE TECHNOLOGY

The Office of the Chief Technologist (OCT) coordinates the Agency's overall technology portfolio to identify development needs and reduce duplication. In managing Space Technology investments, NASA employs a portfolio approach that spans a range of discipline areas and technology readiness levels (TRL) from concept study to flight demonstration. By funding a mixture of early stage conceptual studies (TRL 1-3), ground-based and laboratory testing aimed at demonstrating technical feasibility (TRL 3-5), and relevant environment flight demonstrations (TRL 5-7), Space Technology helps NASA attain a balance between mission-driven technology investments and the long-range, transformational technology and capability investments that are required to meet our Nation's far-reaching goals. By coordinating technology programs within NASA, OCT facilitates integration of available and new technology into operational systems that support specific human-exploration missions, science missions, and aeronautics. OCT also engages the larger aerospace community including other Government agencies, and, where there are mutual interests, develops partnerships to efficiently develop breakthrough capabilities. OCT leads NASA's efforts in transferring and commercializing technology to a wide range of users to ensure that the full value of these development efforts is realized.

Space Technology development takes place within NASA Centers, in academia and industry, and through partnerships with other Government agencies and international partners. NASA also participates in national technology development initiatives such as the National Robotics Initiative to increase opportunities for collaborative technology development. Investments include both competitively awarded and strategically-guided activities to address long-term Agency technology priorities and technology gaps identified within the Agency's space technology roadmaps. This roadmapping effort, initiated in late 2010 and externally reviewed by the National Research Council (NRC), aids NASA in formulating a balanced, cross-agency, technology investment perspective by identifying technology needs and overlaps, which will better ensure infusion of technologies into future missions conducted by NASA, industry or other Government users. The NRC's final report, released in February 2012, provides guidance for future competitive and guided technology investments. NASA is investing, at some level, in all 16 high priority research technologies referenced in the report.

Investments in space technology stimulate the economy and contribute to the Nation's global competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs. Those same advanced technologies developed for space exploration and the aerospace industry also advance products and services available everyday to the public. Knowledge provided by weather and navigational spacecraft, efficiency improvements in ground and air transportation, supercomputers, solar- and wind-generated energy, battery and fuel cell energy storage, the cameras found in many of today's cell phones, improved biomedical applications including advanced medical imaging and even more nutritious infant formula, as well as the protective gear that keeps our military, firefighters and police safe, have all benefitted from our nation's investments in aerospace technology. According to the 2011 Aerospace Industries Association Year End Review, the U.S. aerospace industry experienced its eighth consecutive year of growth and maintained the largest trade surplus of any manufacturing industry. A technology-driven NASA will maintain the Nation's aerospace community as a global technological leader for many years to come. NASA innovation also serves as an inspiration for young people to pursue science, technology, engineering, and mathematics (STEM) education and career paths.

Reaching our future exploration objectives will require these advanced technology and innovation commitments by NASA and the Nation. American technological leadership is vital to our national security, our economic prosperity and our global standing. The U.S. is as strong as it is today because of the technological investments made in earlier decades, because of the engineers, scientists and elected

officials who had the wisdom and foresight to make the investments required for our country to emerge as a global technological leader. That commitment accelerated our economy with the creation of new industries, products and services that yielded lasting benefits.

For more on Space Technology go to http://www.nasa.gov/offices/oct/home/index.html

EXPLANATION OF MAJOR CHANGES FOR FY 2013

There are no major changes to this organization from the FY 2012 estimate. The Space Technology account budget sees an increase from FY 2012 to support current phasing profiles of on-going high-priority Space Technology development efforts, and to support the congressionally mandated increases in the Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs.

ACHIEVEMENTS IN FY 2011

In early 2011, the Space Shuttle *Discovery* delivered Robonaut to the ISS. Robonaut is the first humanoid robot in space. Its primary job is teaching engineers how dexterous robots behave in space, with the goal of venturing outside the station to improve the efficiency and effectiveness of our spacewalkers.

NASA entered into an innovative partnership with the Colorado Association of Manufacturing and Technology which led to the creation of a joint NASA-Colorado Technology Acceleration program to drive space technology commercialization and contribute to regional economic growth. Colorado has leveraged this partnership and is in the process of creating a regional innovation cluster in aerospace and clean energy to take full advantage of the similar technology requirements of space exploration and renewable energy.

Guided by the draft technical area roadmaps, NASA made significant progress maturing a focused set of technologies across the range of the portfolio, from advanced concept studies to flight demonstration missions. Through the competitive award process, Space Technology selected 80 Space Technology Graduate Fellows, 30 NASA Innovative Advanced Concepts, over five hundred SBIR and STTR projects, seven new Game Changing Development projects, and three new Technology Demonstration missions. In addition, NASA made 25 new awards for the Flight Opportunities payloads and entered agreements with seven sub-orbital, reusable flight service providers. The NASA Center Innovation Fund initiated 181 innovative research activities at the NASA Centers. The office has more than 1,000 project elements and activities underway that span key technical areas and all levels of technical maturity.

In its first year, Space Technology engaged thousands of technologists and innovators to develop and test cutting-edge technologies distributed across the country. While the NRC conducted its review of the technology roadmaps, OCT worked with mission architecture teams to identify key technology areas requiring immediate investment. Using these internal, cross-Agency working groups and open competition, NASA identified nine technologies to receive priority funding based on their criticality in extending human presence beyond low Earth orbit and their ability to dramatically further scientific exploration of the solar system. These projects are: Laser Communications Relay Demonstration, Cryogenic Propellant Storage and Transfer, Low Density Supersonic Decelerators, Composite Cryogenic

SPACE TECHNOLOGY

Propellant Tanks, Robotic Satellite Servicing, Hypersonic Inflatable Aerodynamic Decelerators, Deep Space Atomic Clock, Large-Scale Solar Sail, and Human Exploration Telerobotics/Human-Robotic Systems.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

Space Technology will move forward with the nine high-priority investments initiated in FY 2011. Each of these projects has major testing, demonstration, and/or launch milestones in FY 2013. Designed to deliver data rates that will enable new class of deep-space exploration missions, the Laser Communications Relay Demonstration project will begin ground validation activities of advanced laser communication systems. Enabling precise landing of higher-mass payloads to the surface of planets, the Low Density Supersonic Decelerators effort will complete three critical full-scale tests to demonstrate parachute and inflatable decelerator performance required prior to supersonic-speed flight demonstration. The Composite Cryogenic Propellant Tank project will design and build a five meter diameter composite cryogenic propellant tank that will yield lower mass and lower cost rocket propellant tanks. The Cryogenic Propellant Storage and Transfer demonstration mission will conduct ground tests of the critical technologies required to enable long-term storage and handling of cryogenic fluids in space in preparation for a flight demonstration. While these projects will make visible individual steps, they are part of a broader portfolio of activities Space Technology will pursue in order to generate new technologies for use by NASA, other government agencies, and U.S. industry.

BUDGET EXPLANATION

The FY 2013 request is $699 million. This represents a $124 million increase from the FY 2012 estimate ($575 million). The FY 2013 request includes:

- $173.7 million for SBIR and STTR programs, which encourage small business owners to provide technical innovations;
- $29.5 million for Partnership Development and Strategic Integration to support technology transfer and commercialization, extending NASA's development efforts toward meeting other national needs, and setting and overseeing short- and long-term technology strategies and approaches for the Agency;
- $293.8 million for Crosscutting Space Technology Development (CSTD), which funds a diversified technology development portfolio that spans the TRL spectrum from concept study to flight demonstration, enabling revolutionary space capabilities; and
- $202.0 million for Exploration Technology Development (ETD), which funds development of high priority technologies required for human exploration beyond low Earth orbit, prior to their integration into specific mission systems.

SPACE TECHNOLOGY

Programs

SMALL BUSINESS INNOVATIVE RESEARCH (SBIR) AND SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)

SBIR and STTR continue to support early-stage research and development performed by small businesses through competitively awarded contracts. These programs produce innovations for both Government and commercial applications. SBIR and STTR provide the high-technology small business sector with an opportunity to develop technology for NASA, and commercialize that technology in order to provide goods and services that address other national needs based on the products of NASA innovation.

PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

Partnership Development and Strategic Integration comprise key Agency responsibilities managed by OCT: technology partnerships, technology transfer and commercialization, and the coordination of NASA's technology investments across the Agency through technology portfolio tracking and technology roadmapping. By providing coordination between Mission Directorates and Centers, and identifying collaboration opportunities with other government agencies and performing technology transfer, NASA can deliver forward-reaching technology solutions for future science and exploration missions, and help address significant national needs.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

CSTD activities enable NASA to develop transformational, broadly applicable technologies and capabilities that are necessary for NASA's future science and exploration missions and supportive of the space needs of other government agencies and the commercial space enterprise. NASA's CSTD activities span from early-stage conceptual studies to flight demonstration and use a mix of competitive and strategically guided projects to attract a broad array of participants. CSTD employs different innovation and technology maturation strategies, including grants, broad area announcements, announcement of opportunities, and prize opportunities, to achieve its goals. CSTD includes Space Technology Research Grants, NASA Innovative Advanced Concepts, Centennial Challenges, Flight Opportunities, and Edison and non-exploration specific Game Changing Development and Technology Demonstration missions.

EXPLORATION TECHNOLOGY DEVELOPMENT (ETD)

ETD advances technologies required for humans to explore beyond low Earth orbit. The program leverages the existing technical strength of the NASA Centers and addresses known needs in support of future human exploration activities. Example projects include Composite Cryogenic Propellant Tanks, Solar Electric Propulsion, Cryogenic Propellant Storage and Transfer, Human-Robotic Systems, and Human Exploration Telerobotics. NASA will continue space power generation and storage and in-space propulsion technology development efforts required to reduce risk for a future planned Solar Electric Propulsion Demonstration mission identified by HEOMD as a high-priority need. ETD technologies are higher risk investments that complement architecture and systems development efforts within Exploration by maturing breakthrough technology prior to systems integration. A modest level of competitive ETD

projects augment and complement the guided efforts, providing the opportunity to develop the best ideas, innovations, approaches and processes for the future human space exploration efforts.

SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)

FY 2013 BUDGET

	Actual	Estimate		Notional			
Budget Authority (in $ millions)	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**164.7**	**166.7**	**173.7**	**181.9**	**187.2**	**195.3**	**206.0**
Change From FY 2012 Estimate	--	--	**7.0**				
Percent Change From FY 2012 Estimate	--	--	**4.2%**				

As an example of a successful technology transfer, GATR (Ground Antenna Transmit and Receive) Technologies, of Huntsville, AL, licensed technology developed under a NASA SBIR (intended for an inflatable solar concentrator for power generation) from SRS Technologies and has provided additional product refinements leading to a ground-based satellite communications system. The company's efforts were enhanced by a U.S. DoD award to mature the ground-based antenna system.

NASA's SBIR and STTR programs fulfill a Congressional requirement to support early-stage research and development. They provide the small business sector with an opportunity to compete for funding to develop technology for NASA, and to commercialize that technology to spur economic growth. Research and technologies funded by competitively-awarded SBIR and STTR contracts have made important contributions to numerous NASA programs and projects. The Agency is actively working to increase the number of NASA-funded SBIR and STTR technologies used in NASA's missions and projects. Some of NASA's high-profile programs benefiting directly from SBIR technologies include the Next Generation Air Transportation System; smart sensors that assess launch vehicle structural health, three dimensional flash lidar technologies to assist with collision avoidance and navigation for space applications, and end-of-arm tooling on Mars surface rovers and landers.

NASA issues annual program solicitations for the SBIR and STTR programs that set forth a substantial number of topic areas. Both the list and description of topics are sufficiently comprehensive to provide a wide range of opportunities for small business concerns to participate in NASA's research and development programs.

Phase I awards give small businesses the opportunity to establish the scientific, technical and commercial merit, and feasibility of the proposed innovation in fulfillment of NASA needs. Phase II awards focus on the development, demonstration, and delivery of the proposed innovation. The most promising Phase I projects are awarded Phase II contracts through a competitive selection based on scientific and technical merit, expected value to NASA, and commercial potential. Phase II Enhancement (II-E) is an incentive for cost share to extend the research and development efforts of the current Phase II contract. Phase III is the commercialization of innovative technologies, products and services resulting from a Phase II

contract. This includes further development of technologies for transition into NASA programs, other Government agencies, or the private sector. Phase III contracts are funded from sources other than the SBIR and STTR programs and may be awarded without further competition.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

Congress reauthorized the SBIR and STTR programs in December 2011, increasing the required rate of investment for each program relative to Agency R&D beginning in FY 2012. Funding requirements have been implemented for FY 2012, and will be adjusted annually consistent with the schedule outlined in the law. NASA will be incorporating all other programmatic requirements within the next solicitation cycle.

BUDGET EXPLANATION

The FY 2013 request is $173.7 million. This represents a $6.9 million increase from the FY 2012 estimate ($166.8 million). The FY 2013 request includes:

- $149.6 million for SBIR, to provide technology development and infusion opportunities for small businesses;
- $19.4 million for STTR, to support research and development collaborations between small businesses and non-profit research institutions, such as universities; and
- $4.7 million for SBIR and STTR program support.

Projects

SBIR

The SBIR program was established by Congress in 1982 and reauthorized in 2011 to increase research and development opportunities for small business concerns. The program stimulates U.S. technological innovation, employs small businesses to meet Federal research and development needs, increases private sector commercialization of innovations derived from Federal research and development, and encourages and facilitates participation by socially disadvantaged businesses.

In FY 2013, the SBIR program is supported at a level of 2.7 percent of NASA’s extramural research and development budget. In FY 2013, the maximum value for an SBIR Phase I contract allowed by the recent reauthorization has been consistent to $150,000 for a period of performance of six months. For Phase II, the maximum total value of an SBIR award allowed by the recent reauthorization is $1,000,000 over a 24 month period of performance. The number and size of awards are based on the quality of proposals received.

SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)

Achievements in FY 2011

In FY 2011, the SBIR program awarded 450 Phase I and 215 Phase II contracts to small business firms. In addition, Phase IIE options were executed with 24 firms who have validated non-SBIR matching funds. One promising technology in the FY 2011 selection is quantifying and treating osteoporosis without using ionizing radiation. Another is the world's largest deformable mirror that, once installed on Mt. Palomar's 200 inch telescope, will be capable of generating images that are twice as sharp as those available from the Hubble Space Telescope. Yet another is a quiet jet engine airbrake that will reduce noise along the flight path (on the ground) on approach for various airplane architectures.

Key Achievements Planned for FY 2013

In FY 2013, SBIR will continue with a solicitation with topics addressing the identified needs of NASA's mission directorates, the Space Technology roadmaps, and the National Aeronautics Research and Development Plan. The SBIR budget will support awards associated with the solicitation released in summer 2012.

STTR

The STTR program, established by Congress in 1992, awards contracts to small business concerns for cooperative research and development with a non-profit research institution, like a university. NASA's STTR program facilitates transfer of technology developed by a research institution through the entrepreneurship of a small business, resulting in technology to meet NASA's core competency needs in support of its mission programs. Modeled after the SBIR program, STTR is funded separately with funding set at 0.35 percent of the NASA extramural research and development budget. In FY 2013, the maximum value for an STTR Phase I contract allowed by the recent reauthorization has been increased to $150,000 for a period of performance of twelve months. For Phase II, the maximum total value of an STTR award allowed by the recent reauthorization has been increased to $1,000,000 over a 24 month period of performance. The number and size of awards are based on the quality of proposals received.

Achievements in FY 2011

In FY 2011, STTR awarded 45 Phase I contracts and 27 Phase II contracts. Promising technologies in this year's selection include: advances in autonomous robot navigation in unstructured terrain; small probe entry descent and landing systems; and use of magnesium as the propellant for a Hall Effect thruster as an innovative approach to develop a high specific impulse, high efficiency propulsion system.

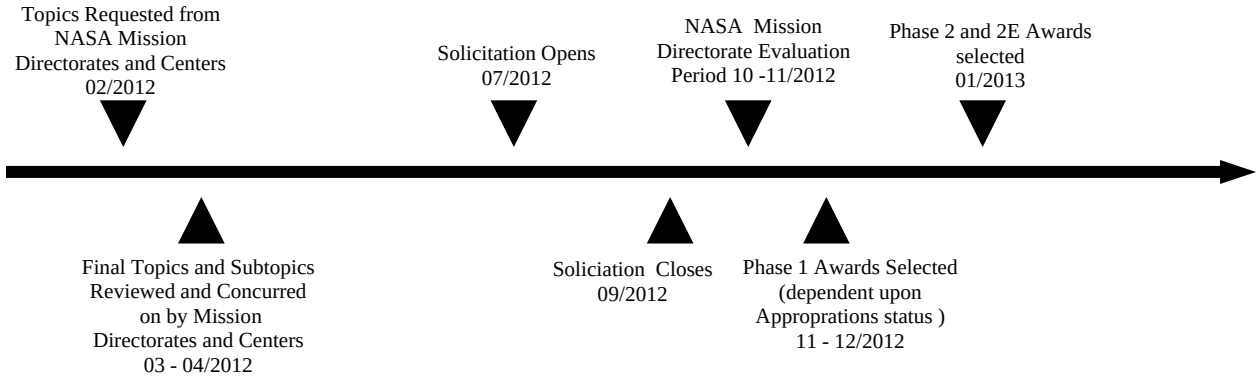
SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)

Key Achievements Planned for FY 2013

In FY 2013, the STTR program will continue addressing NASA's core competencies through a solicitation that is aligned with Space Technology roadmaps and the National Aeronautics Research and Development Plan. The STTR budget will support awards associated with the solicitation released in summer 2012.

Program Schedule

SBIR and STTR solicitation and award schedule is below.



Program Management & Commitments

The program executive for SBIR and STTR is located at NASA Headquarters and is responsible for the top-level programmatic oversight and management of SBIR and STTR. SBIR Phase II Enhancement (2-E) matches cost share funding with SBIR and STTR up to $250,000 of non-SBIR and non-STTR investment(s) from a NASA project, NASA contractor, or third party commercial investor to extend an existing Phase II project to perform additional research.

Project/Element	Provider
SBIR and STTR Program Management	Provider: N/A Project Management: NASA Headquarters NASA Center: ARC; All NASA Centers play a project management and implementing role. Cost Share: See explanation above

SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)

Acquisition Strategy

SBIR and STTR program management, in conjunction with NASA Center Chief Technologists and a mission directorate steering council, work collaboratively during the SBIR and STTR acquisition process (from topic development and proposal review and ranking) in support of final selection. Mission directorate and NASA Center personnel interact with SBIR and STTR award winners to maximize alignment and infusion of the SBIR and STTR products into NASA's future missions and systems. Topics and subtopics are written to address NASA's core competencies and are aligned with Space Technology roadmaps.

MAJOR CONTRACTS/AWARDS

SBIR Phase II Enhancement (2-E) matches cost share funding with SBIR and STTR funds up to $250,000 of non-SBIR and non-STTR investment(s) from a NASA project, NASA contractor, or third party commercial investor to extend an existing Phase II project to perform additional research. NASA selected 24 Phase IIE proposals that address critical research and technology needs for Agency programs and projects for final contract negotiations.

SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)

Element	Vendor/Provider	Location
SBIR Phase IIE	Emergent Space Technologies, Inc.	Greenbelt, MD
	Aries Design Automation, LLC	Chicago, IL
	Acellent Technologies, Inc.	Sunnyvale, CA
	Picometrix, LLC	Ann Arbor, MI
	Aspen Aerogels, Inc.	Northborough, MA
	Energy Plus Ltd.	Laguna Hills, CA
	Mechanical Solutions, Inc.	Whippany, NJ
	Lawrie Technology, Inc.	Girard, PA
	Composite Technology Development, Inc.	Lafayette, CO
	WEVOICE, Inc.	Bridgewater, NJ
	The DNA Medicine Institute	Cambridge, MA
	Intelligent Automation, Inc.	Cincinnati, OH
	Creare, Inc.	Hanover, NH
	Ashwin-Ushas Corp, Inc.	Holmdel, NJ
	Advanced Optical Systems, Inc.	Huntsville, AL
	Surface Optics Corporation	San Diego, CA
	Vista Photonics, Inc	Santa Fe ,NM
	Advanced Scientific Concepts, Inc.	Santa Barbara, CA
	Honeybee Robotics Ltd. (2 awards)	New York, NY
	Luna Innovations Incorporated	Blacksburg, VA
	Optical Scientific, Inc.	Gaithersburg, MD
	Plasma Processes, LLC.	Huntsville, AL

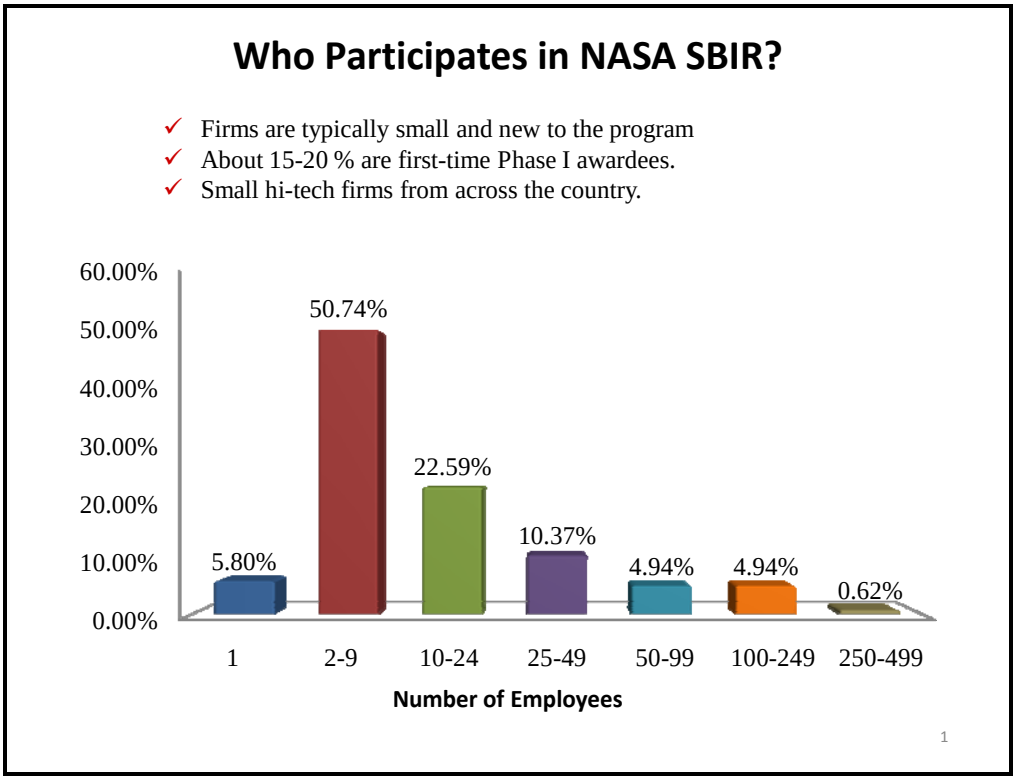
INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	National Academies	Jan-12	Assessment of the SBIR program. Review is currently in Phase II of a two-phase study. Phase II results are planned for completion in early FY 2012. Phase I results were published in FY 2009	TBD

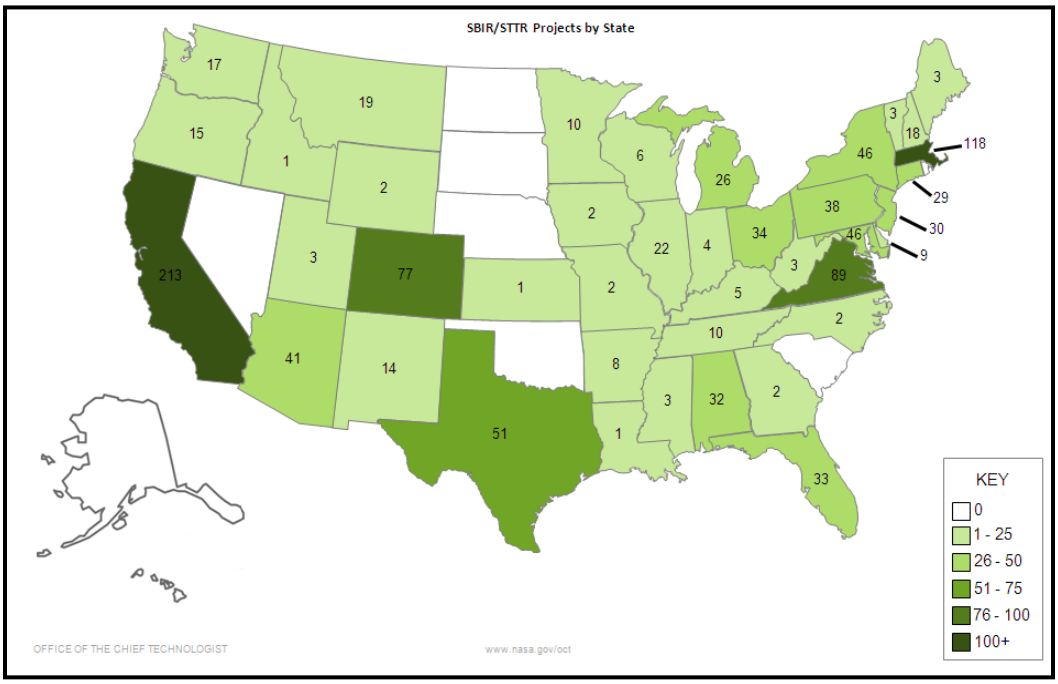
SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)

HISTORICAL PERFORMANCE

FY 2011 selections represented by size of company and geographic location.



SMALL BUSINESS INNOVATIVE RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER (SBIR AND STTR)



PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**26.6**	**29.5**	**29.5**	**29.5**	**29.5**	**29.5**	**29.5**
Change From FY 2012 Estimate	--	--	**0.0**				
Percent Change From FY 2012 Estimate	--	--	**0.0%**				

A team of engineers at the Space Telescope Science Institute developed software to manage time-consuming tasks for the Hubble Space Telescope, launched in 1990. The scheduling technology is now used in software that helps hospitals reclaim unused capacity.

The Chief Technologist serves as the NASA Administrator's principal advisor on matters concerning Agency-wide technology policy and programs. In this role, OCT helps NASA achieve a dual mandate: to foster technology transfer, including infusion of technologies into NASA missions, as well as commercialization of technologies emerging from NASA R&D; and to implement short- and long-term technology strategies for the Agency. Partnership Development and Strategic Integration acts on behalf of the NASA Chief Technologist to coordinate NASA internal (Mission Directorates and NASA Centers) and NASA external (industry, academia, other Government agencies, international) technology transfer and strategic planning for technology development.

Partnership Development leads technology transfer and commercialization activities across the Agency. This office also works to demonstrate and communicate opportunities made possible through NASA technology investments. To achieve these objectives, NASA technology transfer professionals work closely with NASA scientists, engineers, and software developers to foster commercial application of NASA's research and technology, including but not limited to: life sciences, robotics, materials, communication, propulsion, sensor technology, and optical imaging. This includes interagency coordination and joint activities, intellectual property management, and partnership opportunities with other Government agencies, academia, commercial industry, and International partners. Additional activities influence Agency innovation-related policies and programs and ensure that the Agency's technology investments stimulate partnerships and the exchange of knowledge and ideas both within NASA and throughout the U.S.

Strategic Integration coordinates and tracks technology investments across the Agency, and works to infuse technologies into future NASA missions. Strategic Integration includes Agency technology strategic planning activities including management of the NASA Technology Executive Council (NTEC), the Center Technology Council and documenting and evaluating the Agency technology portfolio to facilitate coordination and understanding of all Agency technology investments. SI works with internal and external stakeholders to develop and manage NASA's Space Technology Roadmaps, and fosters a culture of creativity and innovation at NASA Centers, particularly in regard to workforce development.

PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

BUDGET EXPLANATION

The FY 2013 request is $29.5 million. This is the same as the FY 2012 estimate ($29.5 million).

The activities supported by this account include:

- Conducting the Agency's technology transfer and commercialization efforts, and facilitating these activities within the Mission Directorates and Centers; and
- Strategic planning and coordination of Agency technology investments within and outside the Agency.

Projects

PARTNERSHIP DEVELOPMENT

Partnership Development provides strategic leadership for the Agency's partnership and commercialization activities and increases the exchange of ideas with innovative external organizations. Through Partnership Development, NASA meets, and seeks to exceed, legislative requirements for technology transfer. Program offices at each NASA Center seek secondary applications for the technologies originally created for NASA mission use and utilize partners to transfer the technologies from the laboratory to the marketplace. NASA's technology developments often benefit the aerospace industry by using fundamental discoveries to expand the Nation's capabilities. In addition, NASA technologies have often find application in non-aerospace industries, which fuels economic growth and the competitiveness of U.S. industry.

NASA also facilitates access and identifies ways to leverage technology investments of other Government agencies. To ensure full utilization of NASA's unique assets, partnership development includes connecting with industry technologists to facilitate use of NASA facilities. These efforts expand NASA's relationships with state, local, and regional technology-based economic development agencies and are responsive to the Presidential Memorandum, "Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses."

Achievements in FY 2011

In FY 2011, NASA entered into 406 new Space Act Agreements, 647 software usage agreements, and executed 34 new patent licenses and 547 software copyright licenses, representing a total of over 1,500 partnerships with outside entities. In addition NASA filed 129 patent applications, and reported 1,257 new inventions. These measures are tracked in the NASA Technology Transfer System. All of these efforts are directly linked to the strategic goal of partnership development that can benefit NASA and the

Nation. NASA initiated technology collaboration with Defense Advanced Research Projects Agency (DARPA), Air Force Research Laboratory, NSF, other Government agencies, and received six national awards from the Federal Laboratories Consortium recognizing NASA's outstanding work in the process of transferring federally developed technology. The Agency also highlighted a selection of technology transfer successes in its annual *Spinoff* report.

Key Achievements Planned for FY 2013

In FY 2013, NASA will continue to increase the public access to NASA technology through its multiple traditional technology transfer efforts, as well as through new and innovative collaborative methods. One example is a pilot program for co-development of technologies to simultaneously address NASA mission needs while also offering broader societal benefits. By doing this development in parallel, the time-to-market and overall development cost should be reduced. NASA will continue to pursue a variety of partnership opportunities with state and regional enterprises like that established in FY 2011 with the Colorado Association for Manufacturing and Technology, and with larger non-government organizations such as the World Bank.

STRATEGIC INTEGRATION

Strategic Integration performs an Agency-level technology coordination role to assist NASA in meeting mission requirements while filling technology gaps, anticipating future needs, and avoiding duplication. At the Agency level, Strategic Integration performs strategic planning, develops policy and requirements and provides coordination relative to the Space Technology portfolio. Through the NASA Technology Executive Council, the Chief Technologist, NASA mission directorates and the Chief Engineer review NASA's technology projects, budgets and schedule adequacy, of the Agency's technology development activities to meet Agency strategic goals. In addition, the council will identify and assess the Agency-level technology gaps, overlaps and synergies between the Agency's technology programs and assess the balance and prioritization of the Agency's technology investment portfolio.

Strategic Integration also conducts focused technology studies and analyses and tracks technology metrics to inform Agency technology investment decisions. Strategic Integration looks to the NASA Strategic Plan, the Space Technology Grand Challenges, and a set of 14 Space Technology roadmaps for top-down strategic guidance of its technology prioritization activities. Strategic Integration works with the Mission Directorates and NASA Centers, other NASA support offices and other Government agencies, Agency partners, academia, and industry. These organizations provide input to the Agency's technology portfolio prioritization and investment decision processes, resulting in a set of technology development and infusion activities that are closely aligned with NASA missions and support national needs.

Achievements in FY 2011

In FY 2011, NASA developed the initial draft Space Technology roadmaps and engaged NRC to evaluate and refine the balance of near-term mission-focused technology and longer-term transformational technology. NRC provided an interim report in August 2011 following analysis and public comment. The final report was delivered February 1, 2012. NASA also designed the Space Technology Grand Challenges, a set of technically challenging, strategic, space-related goals that push the Nation's technology boundaries and provide a guide to a stronger future for the Nation in space. The Space

PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

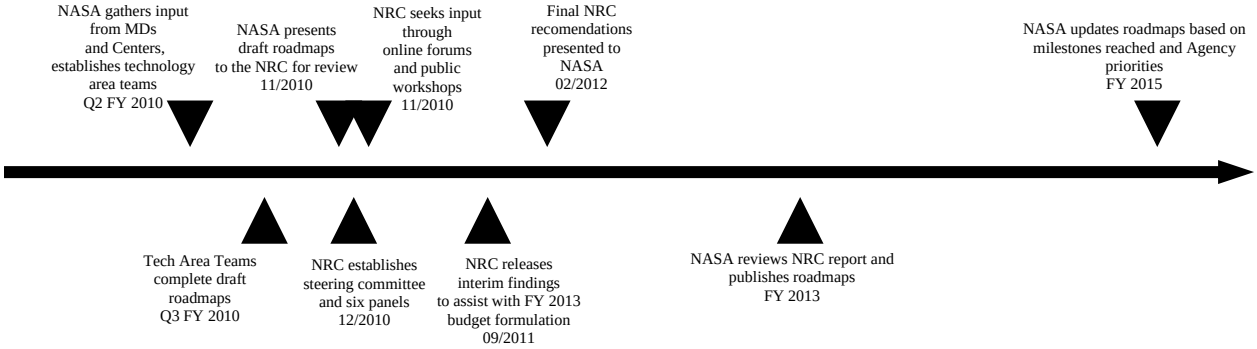
Technology Grand Challenges provide a framework for guiding technology awards across all Space Technology solicitations. NASA is also developing an Agency-level technology tracking system which will be used beginning in FY 2012 to track the Agency portfolio. Working internally, OCT developed and published policy and governance documents to initiate the Space Technology Program including the Space Technology Portfolio Plan, Portfolio Commitment Agreement, Organizational Conflict of Interest document, and ten individual program plans to provide management consistency across the Space Technology investment areas.

Key Achievements Planned for FY 2013

In FY 2013 and beyond, NASA will use the Space Technology roadmaps to guide investment in space technology across the Agency and within the Space Technology account. NASA uses the Space Technology Grand Challenges to engage the public through its program solicitations. OCT will continue to execute its program governance to manage the health of its programs, will implement the technology portfolio management system to increase the effectiveness of its investments and utilize its various councils, studies and public venues to reach out and engage the space technology stakeholders across a wide range of constituencies.

Program Schedule

The following diagram shows the Space Technology roadmaps development process.



PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

Program Management & Commitments

NASA Headquarters and the NASA Centers manage Partnership Development and Strategic Integration activities. Guidance is provided by the NASA mission directorates through the NASA Technology Executive Council and from the NASA Centers through the Center Chief Technologist.

Project/Element	Provider
Partnership Development	Provider: N/A Project Management: NASA Headquarters NASA Center: Each NASA Center has a technology transfer lead Cost Share: N/A
Strategic Integration	Provider: N/A Project Management: NASA Headquarters NASA Center: None Cost Share: N/A

Acquisition Strategy

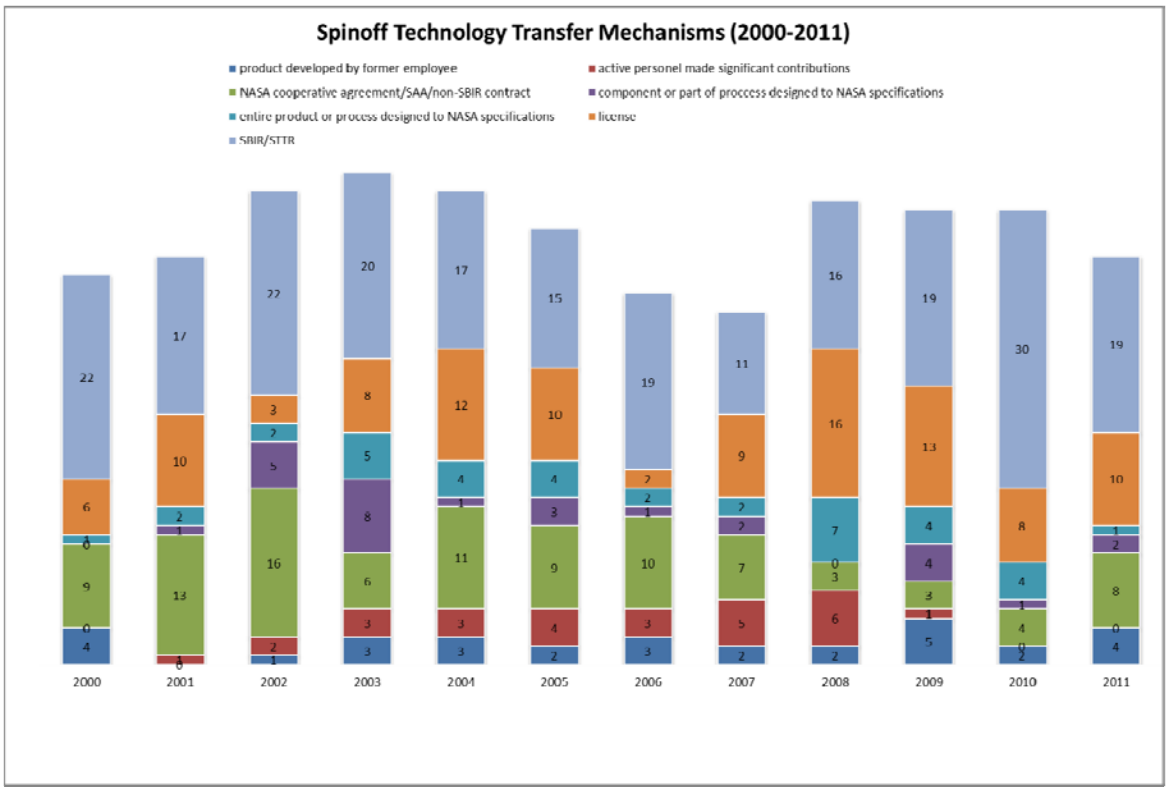
This organization does not participate in a substantial amount of procurement activity.

PARTNERSHIP DEVELOPMENT AND STRATEGIC INTEGRATION

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	NRC	Feb-12	The Aeronautics and Space Engineering Board of the NRC of the National Academies released final report on their review of NASA's draft Space Technology roadmaps. The steering committee provided specific guidance on how technology development funded by the Space Technology program can enhance the Agency's space science and exploration capabilities. The report identified key technologies that furthered development of space capabilities for the Nation's aerospace industry.	TBD

Historical Performance



CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

FY 2013 BUDGET

	Actual	Estimate		Notional			
Budget Authority (in $ millions)	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**120.4**	**187.7**	**293.8**	**272.1**	**266.6**	**259.7**	**247.0**
Change From FY 2012 Estimate	--	--	**106.1**				
Percent Change From FY 2012 Estimate	--	--	**56.5%**				

The Deep Space Atomic Clock project will develop a small, low-mass atomic clock, ten times more accurate than today's ground-based systems, which will enable precise, in-space navigation, improve stability for radio science, and enhance current satellite industry capabilities including the Nation's global positioning system.

CSTD invests in a diversified technology development and demonstration portfolio. CSTD activities enable revolutionary advances in broadly applicable technological capabilities for NASA's future science and exploration missions, while supporting other national needs.

CSTD selects and invests in technology across the TRL spectrum from conceptual studies to flight demonstrations. The program also supports training the next generation of inventors, scientists, and engineers, while creating a steady pipeline of technologies enabling NASA's future missions. These broadly applicable technologies are designed to enable entirely new capabilities and space missions. Through CSTD funded efforts, NASA engages a diverse set of participants, including the NASA Centers, other Government agencies, academia, and industry through both openly competed and strategically-guided processes.

CSTD focuses development in three technology maturation ranges: early stage (TRL 1-3), mid-level (TRL 4-5), and flight ready (TRL 6-7). NASA identified nine high priority space technology project elements in Space Technology's inception, five of which are funded within this program account: Laser Communications Relay Demonstration, Low Density Supersonic Decelerators, Solar Sail Demonstration, Deep Space Atomic Clock, and Robotic Satellite Servicing. In addition, Space Technology has more than 1,000 project elements and activities underway that range across many technology areas and levels of readiness. The NASA Mission Directorates, other Government agencies and private industry are the ultimate customers for CSTD innovations, technology developments and capability demonstrations.

NASA recognizes that maturing space technologies from idea and concept inception through demonstration in a relevant environment is a significant challenge, and comes with inherent technical risk.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

CSTD was developed to mitigate cost and schedule risk for NASA and the aerospace community by making available a continuous pipeline of technologies that will benefit NASA's future missions.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

An increase from FY 2012 estimate is required to support current phasing profiles and critical testing milestones, as further described within the Game Changing Development and Technology Capability Demonstration project elements.

BUDGET EXPLANATION

The FY 2013 request is $293.8 million. This represents a $105.1 million increase from the FY 2012 estimate ($188.7 million). The FY 2013 request supports:

- Development of a wide range of early stage advanced aerospace system concept and foundational technology development (TRL 1-3) efforts;
- Transformational game changing development across the critical mid-TRL (3-5) gap between early stage innovation and flight demonstration of a new technology; and
- Technology capability demonstrations that benefit multiple NASA missions, other Government agencies, or the space industry. This investment area matures technology to flight readiness status (TRL 6-7).

Projects

EARLY STAGE INNOVATION

NASA sponsors advanced aerospace system concept studies and foundational technology development efforts on a wide range of topics, including the following projects:

Space Technology Research Grants promotes research in technology fields through two competitive opportunities. First, provides award funds for competitive grants to University-based researchers conducting foundational research in space technology. Second, NASA competitively awards fellowships for graduate student research (Masters and Doctorate) that shows significant promise for future application toward NASA missions and strategic goals. Selected students perform research on their respective campuses and spend time at NASA Centers and/or not-for-profit research and development laboratories. In addition to a faculty advisor, each student will be matched with a researcher in the relevant field who will serve as the student’s professional advisor.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

NASA Innovative Advanced Concepts (NIAC) engages innovators to conduct aerospace system concept studies. NIAC funds the best early stage studies of visionary, long term concepts, aerospace architectures, systems, or missions submitted by researchers both within NASA and throughout the Nation.

Center Innovation Fund stimulates aerospace creativity and innovation at the NASA Centers. The activities are envisioned to fall within the scope of NASA space technology roadmaps or technology addressing a significant National need. The funds are distributed among the NASA Centers to allow them to support early stage innovative technology initiatives that leverage Center talent and capability.

Centennial Challenges uses partnerships to host prize purse competitions aimed at finding solutions to technical challenges that support NASA's missions in aeronautics and space. NASA provides the prize purse and partners with private, non-profit entities to manage the competitions at no cost to NASA. The program has been successful at engaging non-traditional participants such as independent inventors, non-government funded entities, and educational institutions in order to expand the pool of innovators available to achieve the Nation's challenging technology goals.

Achievements in FY 2011

In FY 2011, NASA selected 80 students for the inaugural class of Space Technology Research Fellows. NASA also announced 30 winners of Phase I NIAC awards. Winning proposals ranged from, "Space Debris Elimination" to "Economical Radioisotope Power," to "Printable Spacecraft" to "Ghost Imaging of Space Objects." NIAC awards were equally spread across applicants from academia, NASA and industry/national labs. Using FY 2011 Center Innovation Funds, NASA Centers selected and started approximately 180 tasks, comprising of a mix of special studies and exploratory efforts. All of these studies and exploratory efforts were aligned to the space technology roadmaps and the Grand Challenges.

The Green Flight Centennial Challenge to advance technologies in aircraft fuel efficiency and reduced emissions was conducted in September 2011. NASA awarded the largest prize in aviation history, created to inspire the development of more fuel-efficient aircraft and spark the start of a new electric airplane industry. The first place prize of $1.35 million was awarded to team Pipistrel-USA.com of State College, PA. The second place prize of $120,000 went to team eGenius, of Ramona, CA. The first and second place teams, which were both electric-powered, achieved twice the fuel efficiency requirement of the competition, meaning they flew 200 miles using just over a half-gallon of fuel equivalent per passenger.

Key Achievements Planned for FY 2013

In FY 2013, NASA will:

- Select 75 new space technology graduate fellows and 15 space technology research grants through an early career faculty initiative similar to the successful Department of Energy program;
- Initiate 15 new Phase I NIAC awards, further develop the most promising NIAC Phase I concepts from FY 2011 and FY 2012, and award five Phase II NIAC studies;

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

- Initiate at least two new Centennial Challenges, with topics to be decided based on the outcome of FY 2012 activities; and
- Using the Center Innovation Fund, Chief Technologists based at NASA Centers will select more than 50 additional awards for innovative technologies from their centers.

GAME CHANGING DEVELOPMENT

Within Game Changing Development, NASA focuses on maturing transformational technology across the critical gap between early stage innovation and flight demonstration of a new technology. These fixed duration, principal investigator-led investment areas have been identified as high priorities by NASA Mission Directorates:

Manufacturing Innovation includes innovation in rapid prototyping for low-cost manufacturing and algorithm and software development purposed for modeling and simulation to aid in streamlining manufacturing processes. This supports NASA's interface with the President's advanced manufacturing initiatives.

Robotic Satellite Servicing conducts demonstrations, such as the active Robotic Refueling mission on ISS, and formulates the architecture options and technology needs for future robotic servicing missions. The project element intends to spur the growth of a new commercial satellite-servicing industry. This is an important technology development effort for future Earth orbital and deep space exploration missions and is managed by the HEOMD.

Nanotechnology advances nanotechnology research and applications for space technology including nanomanufacturing, nanoelectronics, and nanoenhanced solar energy conversion. The project element also includes continued development of the nano-energetics propulsion effort. This effort is the primary NASA participant and interface with the National Nanotechnology Initiative.

Space Synthetic Biology leverages the efficiency of life in using its surrounding resources, turning those resources into habitats, materials and forms that perform a wide range of functions efficiently. This project element researches a range of genomics and synthetic biology approaches for the design of organisms to perform reliable functions for future human and robotic exploration activities.

FY 2011 Game Changing Broad Agency Announcement Selections is a follow-on to competitive selection of three projects that, if successful, will revolutionize existing systems: Woven Thermal Protection System project tests various flexible materials for application within woven thermal protection systems to identify materials that are easy to produce, customizable and apply to aeroshell surfaces, depending on particular atmospheric entry conditions; Electro-dynamic debris eliminator has potential applications in orbital debris capture, actively removing dangerous debris objects; and Amprius tests advanced battery cells that offer the promise of dramatic improvements in the energy density (energy/mass and energy/volume) and specific energy of lithium-ion batteries.

NASA will measure the success of the Game Changing Development investments as a whole, rather than expecting each project to produce homerun results. Over time, it can be expected that dramatic advances

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

in transformative space technology will enable entirely new NASA missions, and lead to solutions for a wide variety of society's grand technological challenges.

Achievements in FY 2011

In FY 2011, initial Space Technology solicitations were released and awards for Game Changing Development, resulting in the following project selections (also described above): woven thermal protection systems, electro-dynamic debris eliminator, Amprius, power beaming studies and materials optimization for a prototype battery for low temperature energy requirements.

Key Achievements Planned for FY 2013

In FY 2013, NASA will reach several important milestones in Game Changing Development.

- Demonstrate high-quality, space-worthy aerospace parts using additive manufacturing systems;
- Continue development and testing of advanced robotic systems and mission concepts for robotic satellite servicing; and
- Design and model a synthetic biology based flexible manufacturing system;
- Continue the FY 2011 Game Changing broad agency announcement selections as noted below:
  - Woven thermal protection systems develops and completes testing to identify suitable materials, and validates performance of carbon-based woven materials;
  - Electro-dynamic debris eliminator provides NASA with an advanced, subscale tether, and completes the manufacture and functional testing of this prototype for a tether-based in-space propulsion system; and
  - Amprius completes initial development and system testing of lithium-ion battery cells with dramatically improved power density needed for mission critical applications.

NASA will also initiate up to eight additional technologies, like those started in FY 2011, while further maturing those in development. As projects complete their life cycle, additional game changing technologies will be selected through broad agency announcements open to industry, academia, and the NASA Centers.

TECHNOLOGY CAPABILITY DEMONSTRATIONS

Within this investment area NASA demonstrates technologies that benefit multiple NASA missions, other Government agencies, and the space industry. This investment area matures new technology to flight readiness status via the projects described below:

Technology Demonstration Missions demonstrates crosscutting technologies in relevant environments. Project elements are listed below.

- Low Density Supersonic Decelerators demonstrates new technologies capable of safely landing high-mass payloads on planetary surfaces. This project element designs, develops and tests ring sail parachutes and supersonic inflatable braking systems.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

- Laser Communications Relay Demonstration flies and validates a reliable, capable, and cost-effective optical communications technology. Optical communications technology provides data rates up to 100-times higher than today's radio communication systems. These higher bandwidth capabilities will prove necessary for future human and robotic space missions. The technology is directly applicable to the next generation of NASA's space communications network. After the demonstration, the developed space and ground assets will be qualified for use by near-Earth and deep space missions requiring high bandwidth and a small ground station reception area.
- Deep Space Atomic Clock validates a miniaturized mercury-ion atomic clock that is ten times more accurate than today's ground based navigation systems. This project element will demonstrate ultra-precision timing in space and its benefits for one-way radio-based navigation. Precision timing and navigation is critical to the performance of a wide range of deep space missions and has the potential to improve the Nation's next generation GPS system.
- Solar Sail Demonstration deploys and operates a solar sail with an area seven times larger than ever flown in space. It is potentially applicable to a wide range of future space missions, including serving as an advanced space weather warning system to provide more timely and accurate notice of solar flare activity. This technology also could allow for propellant-less deep space exploration missions. NOAA is collaborating with NASA and L'Garde Inc. on the demonstration.

Edison Small Satellite Demonstration Missions develops and operates a series of small spacecraft demonstration missions, with the objective of accelerating the development of small spacecraft supporting technologies and capabilities for NASA, commercial, and other space sector users.

- Edison 1 EtherSat flies a constellation (swarm) of 12 to 20 small satellites (CubeSats) to perform an in-space demonstration of communications capabilities while also testing the applicability of such satellite constellations for future earth science and Department of Defense missions. The project element will explore affordable off-the shelf components (i.e. smart phone avionics) to support manufacturing, integration, launch and operations.

Flight Opportunities matures technologies by providing affordable access to space environments while also facilitating the development of the commercial reusable suborbital transportation industry. The project also procures commercial parabolic flights to test technologies in environments that simulate microgravity and the reduced gravity environments.

Achievements in FY 2011

In FY 2011, NASA selected three proposals as technology demonstration missions that will transform its space communications, deep space navigation, and in-space propulsion capabilities. The three Space Technology project elements will develop and fly a space solar sail, a deep space atomic clock, and a space-based optical communications system. Flight Opportunities selected seven companies to integrate and fly technology payloads on commercial suborbital reusable platforms that carry payloads near the boundary of space.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

Key Achievements Planned for FY 2013

In FY 2013, NASA will competitively select additional technology demonstration missions and increase funding for developing flight projects as they reach maturity and prepare for demonstration. Several important efforts include:

- Edison Small Satellite Demonstrations competitively selects at least one new small spacecraft mission, launching the Edison 1 EtherSat constellation and begin operational testing of communications and science demonstrations. Technology Demonstration Missions and Edison will likely utilize secondary or hosted payload excess capacity on government or commercial satellites, an effort which will facilitate lower cost access to space and ensure affordable demonstrations;
- Laser Communications Relay Demonstration begins ground validation activities for the optical space terminal and optical ground station designs;
- Low Density Supersonic Decelerators project will complete three critical full-scale test milestones (systems designs, initiate hardware fabrication and ground validation activities) required prior to final high-speed flight demonstrations;
- The Solar Sail and Deep Space Atomic Clock demonstration missions will hold key milestone reviews as they respectively prepare the largest solar sail ever flown that will lead to propellant-less deep space propulsion, and an atomic clock that will enable a level of spacecraft navigation precision and autonomous operations in deep space never before achieved;
- Low Density Supersonic Decelerators will begin three critical flight test campaigns involving verification testing of the largest NASA spacecraft entry parachute ever developed; system-level testing of NASA's first inflatable supersonic deceleration system; and high-speed high-altitude integrated testing of an entry system using the ring sail parachute and an inflatable decelerator; and
- Flight Opportunities plans to utilize all seven flight providers to host payloads supported by the Space Technology program on multiple flights.

Program Schedule

Specific timelines for deliverables and achievement major milestones vary from project to project, and are widely dependent on successful demonstration of experimental capabilities. See more in Historical Performance section below.

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

Program Management & Commitments

Management responsibility for project elements from CSTD and ETD are performed in an integrated manner.

Project/Element	Provider
Center Innovation Fund	Provider: NASA Centers Project Management: NASA Headquarters Program Executive NASA Center: Each Center competitively selects projects Cost Share: N/A
Centennial Challenges	Provider: Various Project Management: NASA Headquarters Program Executive NASA Center: MSFC Cost Share: External partners fund competition events; NASA supplies prize money.
NASA Innovative Advanced Concepts (NIAC)	Provider: Various Project Management: NASA HQ Program Executive NASA Center: N/A Cost Share: N/A
Space Technology Graduate Research Fellowships	Provider: Graduate students Project Management: Headquarters Program Executive NASA Center: GRC Cost Share: N/A
Game Changing Development	Provider: Various Project Management: HQ Program Executive NASA Center: LaRC Cost Share: N/A
Technology Demonstration Missions	Provider: Various Project Management: NASA Center: MSFC Cost Share: NASA HEOMD, NOAA

CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

Project Element	Provider
Franklin Small Satellite Subsystem Technologies	Provider: TBD Project Management: HQ Program Executive NASA Center: ARC Cost Share: N/A
Edison Small Satellite Demonstrations	Provider: Various Project Management: HQ Program Executive NASA Center: ARC Cost Share: N/A
Flight Opportunities	Provider: Various Project Management: HQ Program Executive NASA Center: DFRC Cost Share: N/A

Acquisition Strategy

CSTD is implemented through a blended acquisition approach, using both open competitive and strategically guided processes. All solicitations are open to the broad aerospace community to ensure engagement with the best sources of new and innovative technology. As such, CSTD efforts are performed by the Nation's highly skilled workforce in industry, academia, across all NASA Centers, and in collaboration with other government agencies through participation in technology panels and working groups, identifying development opportunities. Awards are made based on technical merit, cost, and impact to the Nation's future space activities. NASA uses acquisition mechanisms such as broad agency announcements, NASA research announcements, and prize competitions, with awards guided by priorities cited in the space technology roadmaps and NASA mission directorates.

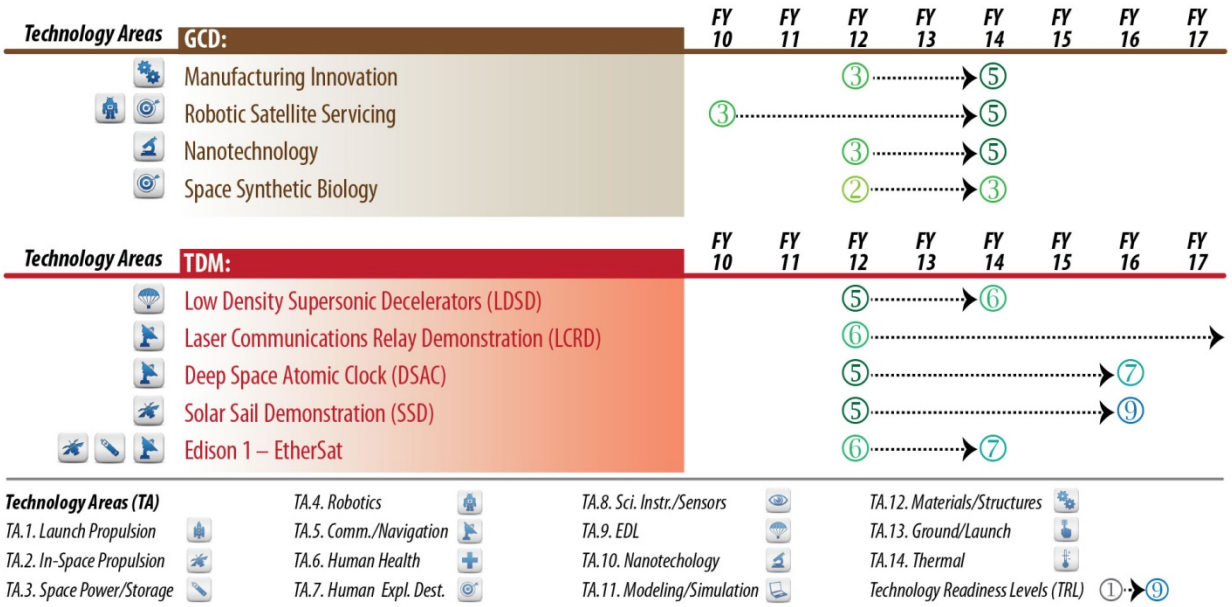
CROSSCUTTING SPACE TECHNOLOGY DEVELOPMENT (CSTD)

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Laser Communications Relay Demonstration	David Israel, Principal Investigator GSFC	Greenbelt, MD
Deep Space Atomic Clock	Todd Ely, Principal Investigator California Institute of Technology, JPL	Pasadena, CA
Solar Sail	Nathan Barnes, Principal Investigator L'Garde, Inc.	Tustin, CA
Low Density Supersonic Decelerator	Mark Adler, Project Manager, California Institute of Technology, JPL	Pasadena, CA

Historical Performance

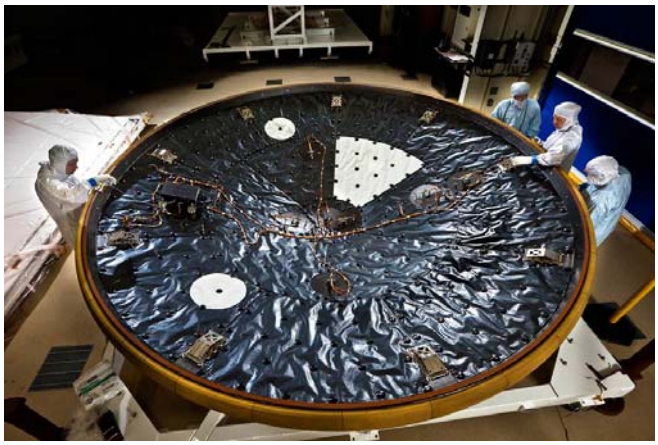
The following graphic is a technology investment overview identifying a subset of active Space Technology development efforts, most initiated in FY 2012, illustrating their core technology areas (aligned with the Space Technology roadmaps) and anticipated technology maturation through the life cycle of the project as awarded. Specific timelines for deliverables and achievement major milestones vary from project to project, and widely dependent on successful demonstration of experimental capabilities.



EXPLORATION TECHNOLOGY DEVELOPMENT (ETD)

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**144.6**	**189.9**	**202.0**	**215.5**	**215.7**	**214.5**	**216.5**
Change From FY 2012 Estimate	--	--	**12.1**				
Percent Change From FY 2012 Estimate	--	--	**6.4%**				



The MEDLI Mars Atmospheric Data System pressure sensors. These seven sensors are mounted on the interior of the heat shield and will collect data on pressure as the Mars Science Laboratory enters the Martian atmosphere.

ETD activities provide the long-range, critical technologies required to conduct future human exploration missions beyond low Earth orbit while reducing risk and life cycle cost. ETD develops and demonstrates the critical technologies that allow for future human exploration missions to destinations that include the Moon, Lagrange points, near Earth asteroids, and Mars. Through ETD, key exploration-specific capabilities are developed through ground-based and laboratory testing, and demonstrated in relevant environments including space flight demonstrations and testbeds such as ISS. After successful maturation of these critical technologies to an infusion point, human exploration program managers can baseline these proven capabilities for future human spaceflight systems and missions.

ETD focuses on the highest priority human spaceflight needs as identified in NASA's Space Technology roadmaps, and is guided by the technology prioritization studies performed by Exploration's human spaceflight architecture studies. ETD technology development is coordinated with the system capability demonstrations pursued within NASA Exploration, particularly with the Advanced Exploration Systems (AES) Program. In recent years, NASA initiated nine high priority space technology project elements, four of which are funded within this program account: Composite Cryogenic Propellant Tanks, Hypersonic Inflatable Aerodynamic Decelerators, Cryogenic Propellant Storage and Transfer, and Human-Robotics Systems/Human Exploration Telerobotics. Technology developed through ETD, once proven, is integrated into systems being developed in support of the architecture required by programs in the Space Operations and Exploration accounts.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

Starting in FY 2012, NASA moved the majority of the Exploration Technology Development and Demonstration activities from Exploration to Space Technology. This transfer improved the alignment and integration of NASA's space technology development portfolio by placing the management of these

space technology activities within an organization focused upon technology development, demonstration and infusion. In FY 2013, NASA is transferring the entry, descent, and landing development currently managed within Aeronautics to this account. These changes in FY 2012 and FY 2013 allow for leveraged synergy by conducting these projects alongside comparable space technology development efforts.

BUDGET EXPLANATION

The FY 2013 request is $202 million. This represents a $12 million increase from the FY 2012 estimate ($190 million).

The FY 2013 request supports exploration specific, game changing development, and technology demonstrations in support of NASA's human spaceflight endeavors.

Projects

EXPLORATION-SPECIFIC GAME CHANGING DEVELOPMENT

Within ETD, FY 2011 program activities and FY 2013 plans have been organized into several Exploration-specific Game Changing Development project elements.

In-Space Propulsion focuses on new chemical and electric propulsion component technologies necessary for efficient and affordable deep space exploration.

Space Power Generation and Storage invests in high efficiency solar cells and high-voltage power management and distribution systems as precursor to a solar electric propulsion demonstration; also develops advanced batteries and regenerative fuel cells.

Nuclear Systems tests power conversion and thermal management technologies for in-space nuclear power systems.

Lightweight Materials and Structures develops advanced materials and space structures technologies such as lightweight deployable solar arrays, to enable affordable high performance systems required for beyond LEO human exploration missions.

Human-Robotic Systems develops advanced robotics technology to amplify human productivity and reduce mission risks by improving human-robot interaction, robotic assistance, and providing in-space and surface servicing, manipulation and mobility systems. This effort also supports the Agency's role in the National Robotics initiative.

Autonomous Systems develops and demonstrates integrated autonomous systems capable of simplifying and managing complex ground and in-space operations to reduce workload and the dependence upon ground support staff and flight operations centers.

EXPLORATION TECHNOLOGY DEVELOPMENT (ETD)

Next-Generation Life Support develops next-generation life support systems technologies including water recovery, thermal control, and next-generation spacesuit component technologies.

Deployable Aeroshell Concepts and Flexible Thermal Protection System designs, analyzes, and tests component systems for flexible ablative thermal protection materials needed for high heat-flux planetary missions to enable greater atmospheric entry capability at Venus, Earth, Mars, Titan and the giant planets. This activity also develops concepts for very large mechanical, deployable aeroshells.

In-Situ Resource Utilization enables sustainable human exploration through use of exo-Earth (local planetary) resources. Concepts explore the production of fuel, oxygen, and water from the soil and atmosphere of celestial bodies.

Composite Cryogenic Propellant Tanks uses advanced composite materials to develop very large, lightweight propellant tanks applicable to future NASA human exploration architecture elements including the Space Launch System and its cryogenic propulsive stage.

Hypersonic Inflatable Aerodynamic Decelerator develops and demonstrates inflatable, aerodynamic braking systems for use at hypersonic velocities. This investment enables precise landing of large payloads on planetary surfaces including the ability to return payloads from ISS to Earth.

Advanced Radiation Protection assesses and matures transformative technologies to improve the radiation protection capabilities of future deep space exploration vehicles and habitats. This element focuses on radiation modeling and analysis as well as forecast modeling to complement AES work on radiation protection.

Achievements in FY 2011

In FY 2011, NASA selected six companies to study system concepts, define requirements, and estimate costs for a 30 kilowatt solar electric propulsion flight demonstration mission. These studies identified precursor technologies required to reach readiness for solar electric propulsion flight demonstration. In addition, tests were conducted for Hall electric propulsion thrusters at three different power levels. New long endurance fuel cells were tested and working fuel cells were supplied for the Desert RATS field demonstration. These technologies are being advanced through the Space Power Generation and Storage project element.

Key Achievements Planned for FY 2013

In FY 2013, NASA continues to mature exploration-specific technologies through development and field testing, including the following:

- Fabrication and testing of fuel cells for integration into the Advanced Exploration Systems Scarab Rover (Space Power Generation and Storage);
- Human-Robotic Systems completing next generation jet pack prototype for functional testing and complete grapple and dexterous arms for functional tests for the multi-mission space exploration vehicle;
- Lightweight Materials and Structures complete prototype design and testing of a complete multi-layer insulation material system critical for cryogenic fluid storage;

EXPLORATION TECHNOLOGY DEVELOPMENT (ETD)

- Deployable Aeroshell Concepts & Flexible Thermal Protection Systems completes an adaptable mechanically deployable aeroshell prototype design and down-select of advanced, high-heat flux thermal protection material;
- Complete water processor tests in preparation for delivery to the HEOMD-managed Advanced Exploration Systems;
- A five-meter, composite cryogenic propellant tank is built and delivered to MSFC in late FY 2013, to enter the testing phase planned for early FY 2014;
- Hypersonic Inflatable Aerodynamic Decelerator will perform risk reduction activities for a future demonstration from ISS; and NASA will release a broad agency announcement or a NASA Research Announcement open to industry, academia, and the NASA Centers for additional exploration-specific Game Changing Development activities.

EXPLORATION-SPECIFIC TECHNOLOGY DEMONSTRATIONS

NASA will continue development of exploration-specific Technology Demonstrations under the following project elements:

Human Exploration Telerobotics demonstrates continued and progressively challenging operations for Robonaut 2, as well as remote robotic operations using ISS, planetary rovers, and human robotic systems.

Cryogenic Propellant Storage and Transfer demonstrates the capability of in-space long term storage and the microgravity transfer of cryogenic propellants (liquid oxygen and hydrogen), essential for transportation on deep-space exploration missions. Cryogenic propellant storage and transfer is the most critical Space Technology demonstration for human exploration. Beyond the initial development of Space Launch System and the Orion Multi Purpose Crew Vehicle (Orion MPCV) currently underway within the Exploration account, the next essential architecture element to extend human presence beyond low Earth orbit is the development of a long duration cryogenic propulsion stage. The cryogenic propulsion stage must be capable of perform long term storage (greater than six months) and transferring cryogenic propellants such as liquid oxygen and liquid hydrogen. Creating this capability relies on the successful demonstration of the Cryogenic Propellant Storage and Transfer project element.

Materials International Space Station Experiment-X (MISSE-X) is an external platform on ISS allowing space environmental studies designed to advance the technology readiness of materials and devices critical for future space exploration. MISSE-X is a follow-on to the previous MISSE missions with improved sensing and monitoring of the ISS external environment, as well as active power accommodations and the expansion of the MISSE-X user community through incorporation of new, customer-desired capabilities.

NASA includes funds in this request for projects selected within the FY 2012 Technology Demonstration Missions broad agency announcement in addition to one to two new demonstrations selected in an FY 2013 technology demonstration mission broad agency announcement.

Achievements in FY 2011

In FY 2011, NASA launched Robonaut 2 to ISS and conducted successful power up and initial functional tests.

In the Cryogenic Propellant Storage and Transfer project element, NASA selected four companies to study system concepts, define requirements, and estimate costs for a cryogenic propellant storage and transfer flight demonstration mission. NASA also completed ground-based testing of liquid acquisition devices to drain liquid hydrogen from propellant tanks in microgravity.

In November 2011, Mars Science Laboratory (MSL) was launched to Mars with the MSL Entry, Decent and Landing Instrumentation (MEDLI) on board. MEDLI includes pressure, temperature, and thermal protection system recession sensors integrated into the MSL heat shield; functional tests were successfully completed for all components. The Autonomous Landing Hazard Avoidance Technology, or ALHAT, demonstrated operation of an integrated sensor suite in helicopter flight tests for constructing a three dimensional image of hazards in the landing zone.

Key Achievements Planned for FY 2013

Within Technology Demonstration Missions, NASA will:

- Conduct challenging human exploration telerobotics demonstrations by commanding and controlling Robonaut 2 while on ISS (both locally and from the ground).The humanoid robot will be tested in microgravity and subjected to the station's radiation and electromagnetic interference environments. The interior operations will provide performance data about how a robot may work side-by-side with astronauts. As development activities progress on the ground, ISS crews may be provided hardware and software to update Robonaut 2 to enable it to do new tasks;
- Complete the design and begin the fabrication and integration of the MISSE-X system; and
- Transition Cryogenic Propellant Storage and Transfer from formulation to implementation with development of the critical technologies and mission demonstration concepts required to enable long-term storage and handling of cryogenic fluids in deep-space. A demonstration mission targeted for early FY 2016.

NASA includes funds in this request for projects selected within the FY 2012 Technology Demonstration Missions broad agency announcement in addition to one to two new demonstrations selected in an FY 2013 Technology Demonstration Missions broad agency announcement.

Program Schedule

Specific timelines for deliverables and achievement major milestones vary from project to project, and are widely dependent on successful demonstration of experimental capabilities. See more in the Historical Performance section below.

EXPLORATION TECHNOLOGY DEVELOPMENT

Program Management & Commitments

NASA is implementing an integrated management approach to ETD and CSTD projects to capitalize on technical and management synergies. The two main projects under the ETD program, Exploration-specific Game Changing Development and Exploration-specific Technology Demonstration Missions, each have a Level 1 Headquarters program executive and Center managed Level 2 project office (shared with CSTD). A lead Center will manage each of the guided ETD project elements as a finite duration effort that will include both NASA in-house work and competitive procurements.

Project/Element	Provider
Exploration-specific Game Changing Development	Provider: Project Management: NASA HQ program executive NASA Center: LaRC Cost Share: N/A
Exploration-specific Technology Demonstration Missions	Provider: Project Management: NASA HQ program executive NASA Center: LaRC Cost Share: N/A

Acquisition Strategy

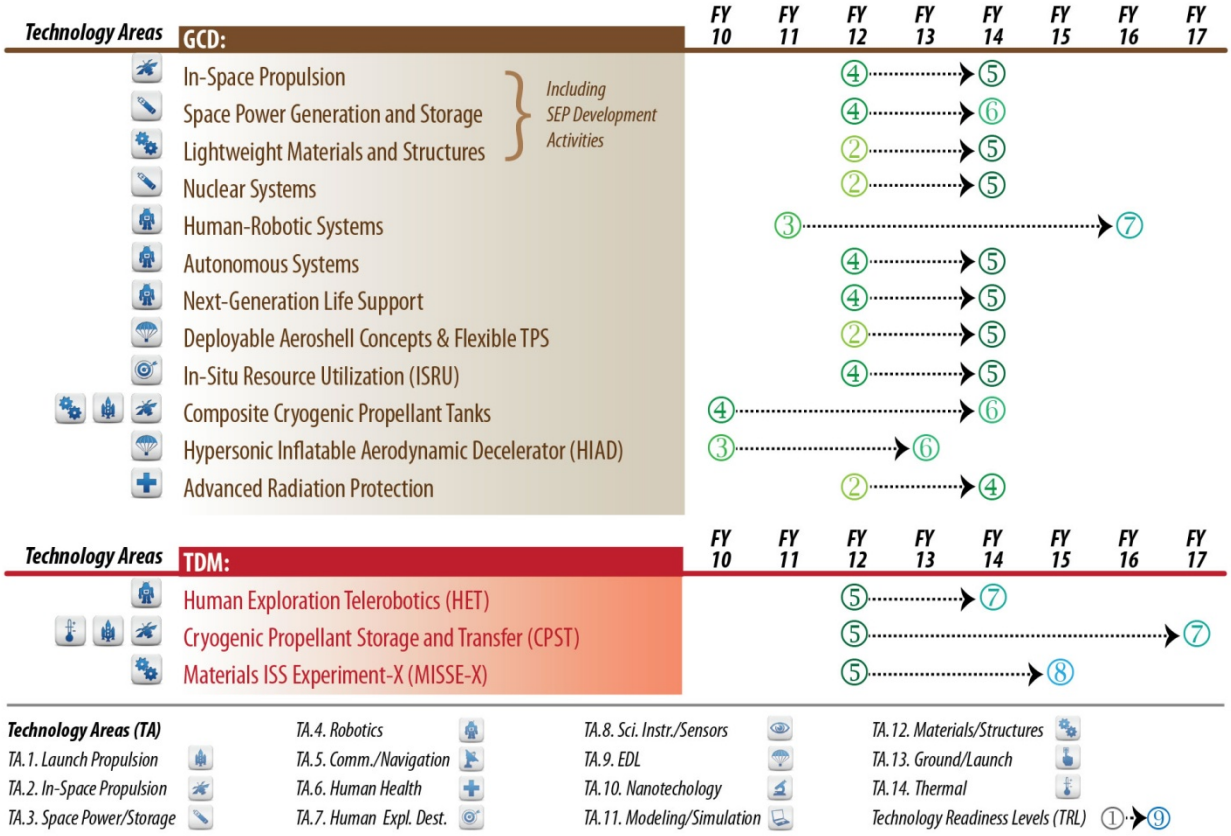
Additional competitively selected project elements will augment those created as guided activities in FY 2012. The focused technology areas for additional competitive project elements are determined by the priorities established by the Exploration program architecture studies as well as the NASA technology roadmapping. Drawing proposals from industry, academia, and the NASA Centers, exploration-specific Technology Demonstration Mission broad agency announcement offerors will perform high-value complementary or gap areas exploration technology demonstrations. Exploration-specific Technology Demonstration Missions proposers are strongly encouraged to partner and cost share with non-NASA entities.

EXPLORATION TECHNOLOGY DEVELOPMENT

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Human Robotic Systems	Rob Ambrose, Principal Investigator, JSC	Houston, TX
Composite Cryogenic Propellant Tank (MSFC)	Boeing	Huntington Beach, CA
Hypersonic Inflatable Aerodynamic Decelerator	Neil Cheatwood, Principal Investigator, LaRC	Hampton, VA
Composite Propellant Storage and Transfer	Sue Motil, Project Manager, GRC	Cleveland, OH
Human Exploration Telerobotics	Terry Fong, Project Manager, ARC	Moffett Field, CA

EXPLORATION TECHNOLOGY DEVELOPMENT

Historical Performance

The following technology investment overview identifies a subset of active Space Technology development efforts, illustrating their core technology areas (aligned with the Space Technology roadmaps) and anticipated technology maturation through the life cycle of the project as awarded. These efforts were primarily initiated in previous fiscal years by other NASA organizations and transferred to Space Technology.