National Aeronautics and Space Administration

FY 14 Space Technology Mission Directorate Briefing

Presented by:
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Space Technology Mission Directorate

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Importance of Federal R&D Investment

- Significant percentage of post-war economic growth is tied to technological innovation.
- While the U.S. spends more on R&D than any other nation, we now ranks 8th of OECD countries in R&D as share of GDP.
- It is estimated the effect of sequestration on R&D will cost the US economy's GDP about $200 billion by the year 2021 in lost intellectual property, technology development, and productivity.

"While R&D accounts for a small share of federal spending, it is disproportionately important in supporting long term economic growth." – MIT President Rafael Reif and former Intel CEO Craig Barrett in February *Financial Times*.

Why invest in Space Technology?

- Enables a **new class of NASA missions** beyond low Earth Orbit.
- **Delivers innovative solutions** that dramatically improve technological capabilities for NASA and the Nation.
- Develops technologies and capabilities that make NASA's missions **more affordable and more reliable.**
- Invests in the economy by **creating markets and spurring innovation** for traditional and emerging aerospace business.
- **Engages the brightest minds** from academia in solving NASA's tough technological challenges.

Value to NASA **Value to the Nation**

Addresses National Needs

A generation of studies and reports (40+ since 1980) document the need for regular investment in new, transformative space technologies.

Who:

The NASA Workforce
Academia
Industry & Small Businesses
Other Government Agencies
The Broader Aerospace Enterprise

Challenges for Deep Space Exploration

Communication

Environment Control & Life Supporting Systems

Power Generation & Storage

Logistics

Navigation

Manufacturing In Space & For Space

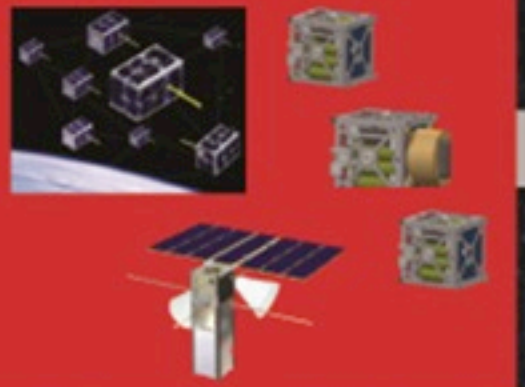
Entry, Descent & Landing

Radiation Mitigation

Propulsion

Trends in Space Technology

Small Spacecraft



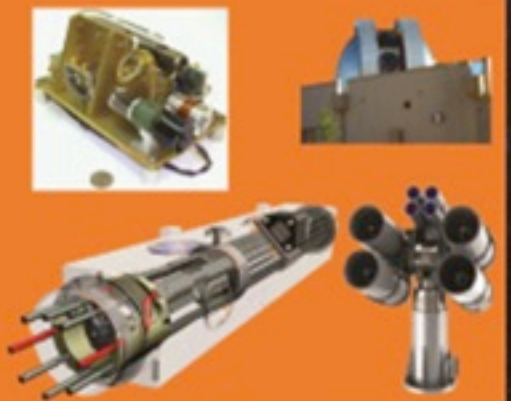
Entry, Descent & Landing

Propulsion

Robotics

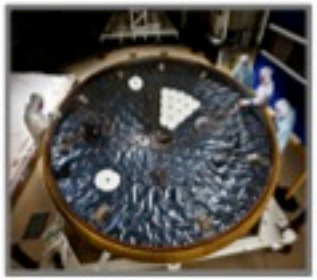
Manufacturing

Communications



Space Technology Highlights

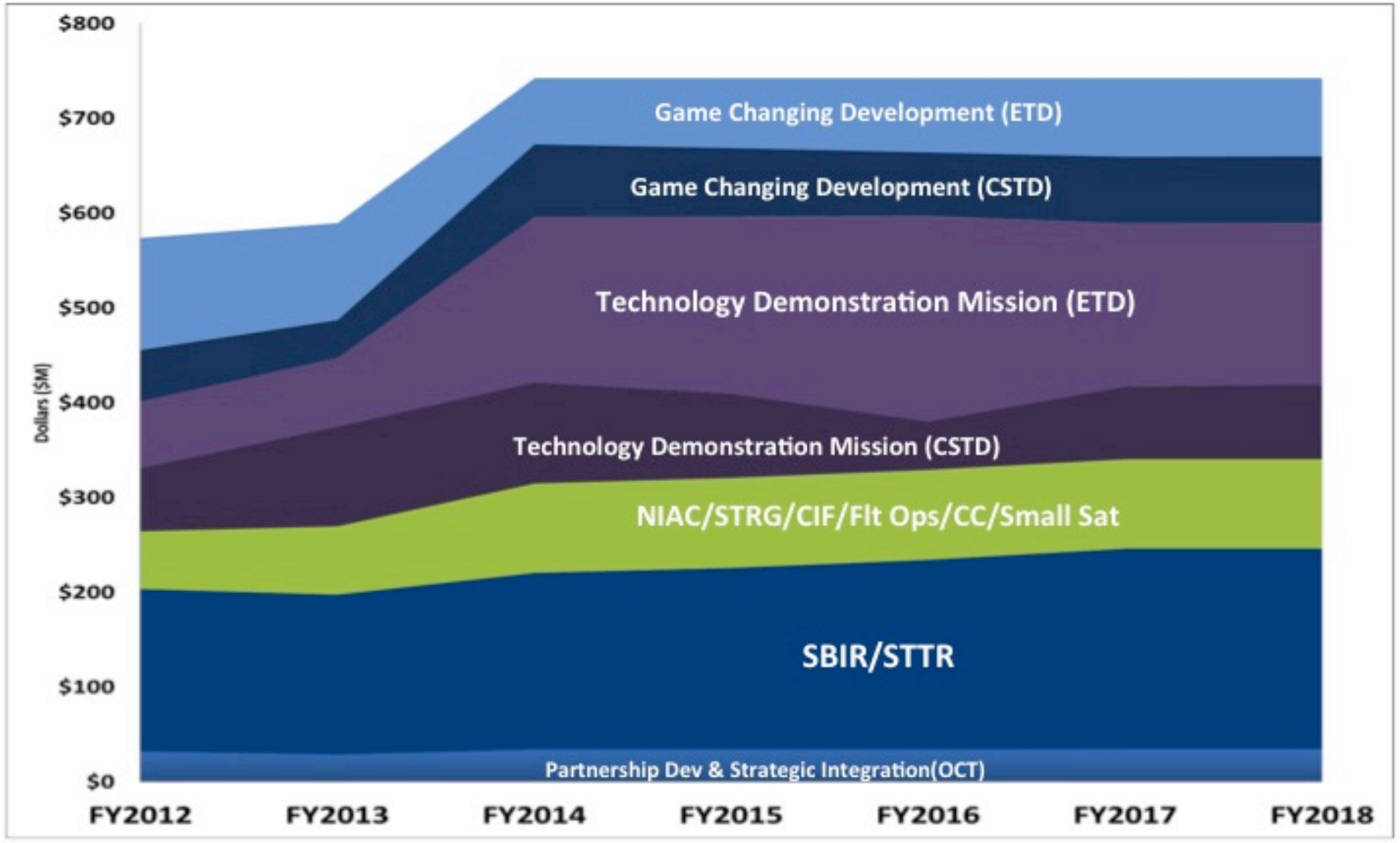
FY 2012-13 Accomplishments	Benefits
Successfully demonstrated feasibility of inflatable heat shields through launch of Inflatable Reentry Vehicle Experiment-3 (IRVE-3) from Wallops Flight Facility in Virginia.	Such heat shields offer the opportunity to significantly increase the landed mass and landing accuracy capabilities for future missions to other planets, such as Mars. It can also enable down mass from ISS.
Successfully fabricated a 2.4-meter cryogenic propellant tank in FY 2012, with testing to complete in FY 2013 (this summer). Follow on fabrication and testing a 5.5-meter diameter full scale tank in FY 2014. Out of autoclave processes were used.	Lower mass rocket propellant tanks will meet future Space Launch System needs, and improve upon costly aerospace manufacturing processes used for either metallic or composite manufacturing by reducing time required to manufacture very large aerospace structures – no large autoclaves or tooling.
Mars Science Laboratory Entry, Descent and Landing Instrument (MEDLI) suite was on board Curiosity, streaming real-time atmospheric and heating data from sensors imbedded within the vehicle's heat shield.	Data from MEDLI will help engineers design safer, more efficient entry systems for future missions. First time NASA collected data during Mars entry on heat shield performance and environmental data.
Technologies from 6 Small Business Innovation Research companies placed a role in enhancing Curiosity's primary mission. Other small businesses winning in open competitions – e.g. Deployable Space Systems, L'Garde, and Tyvak	NASA is not only investing in small businesses, but they contribute to our core Missions.



STMD FY 2014 President's Budget

	Budget Authority ($M)	FY 2014	Notional FY 2015	FY 2016	FY 2017	FY 2018
	FY 2014 President's Budget Request	**743**	**743**	**743**	**743**	**743**
OCT	Partnership Developments and Strategic Integration	**34**	**34**	**34**	**35**	**35**
Space Tech Mission Directorate	SBIR and STTR	**186**	**192**	**200**	**212**	**212**
	Crosscutting Space Tech Development	**278**	**256**	**213**	**241**	**244**
	Early Stage Innovation	62	62	62	62	62
	Flight Opportunities	15	15	15	15	15
	Small Spacecraft	17	17	17	17	17
	Game Changing Development	76	73	68	70	71
	Technology Demonstation Missions	107	89	51	77	79
	Exploration Technology Development	**244**	**260**	**295**	**255**	**252**
	Game Changing Development	70	74	79	83	83
	Technology Demonstation Missions	175	186	216	173	169

Funding Transitions



Space Technology's FY 2014 Strategy

- **Align the Space Technology Program with the Administration's Research and Development Priorities**
  - Prioritize areas based on Strategic Space Technology Investment Plan (SSTIP) and the NRC report on the NASA Space Technology Roadmaps
- **Aligns and supports proposed asteroid retrieval and redirect mission**
  - Accelerate high-powered Solar Electric Propulsion Demonstration Mission
- **Ensure Progress on Transformative and Crosscutting Technology Projects**
  - Continue a steady cadence of new solicitations
  - Key Projects: CPST, LCRD, Green Propellant, Small Spacecraft Technologies
  - In FY 2014, will conduct 3 major CDRs, 6 Ground or Flight Demos, and 1 Small Spacecraft Demo
- **Maintain a Sustainable Pipeline of Revolutionary Concepts and Develop the Workforce for the Future US Aerospace Enterprise**
  - Fellowships, University Grants, Center Innovation and Concept Studies
  - Programs: STRG, CIF and NIAC with yearly solicitations (CSTD)
- **Create New Space Markets and Explore Alternate Technology Approaches**
  - Small businesses, prize authority, sub-orbital flights
  - Programs: SBIR/STTR, Centennial Challenges, Flight Opportunities (CSTD)
- **Enhance Tech Transfer and Commercial Partnerships Opportunities** (PD/SI)

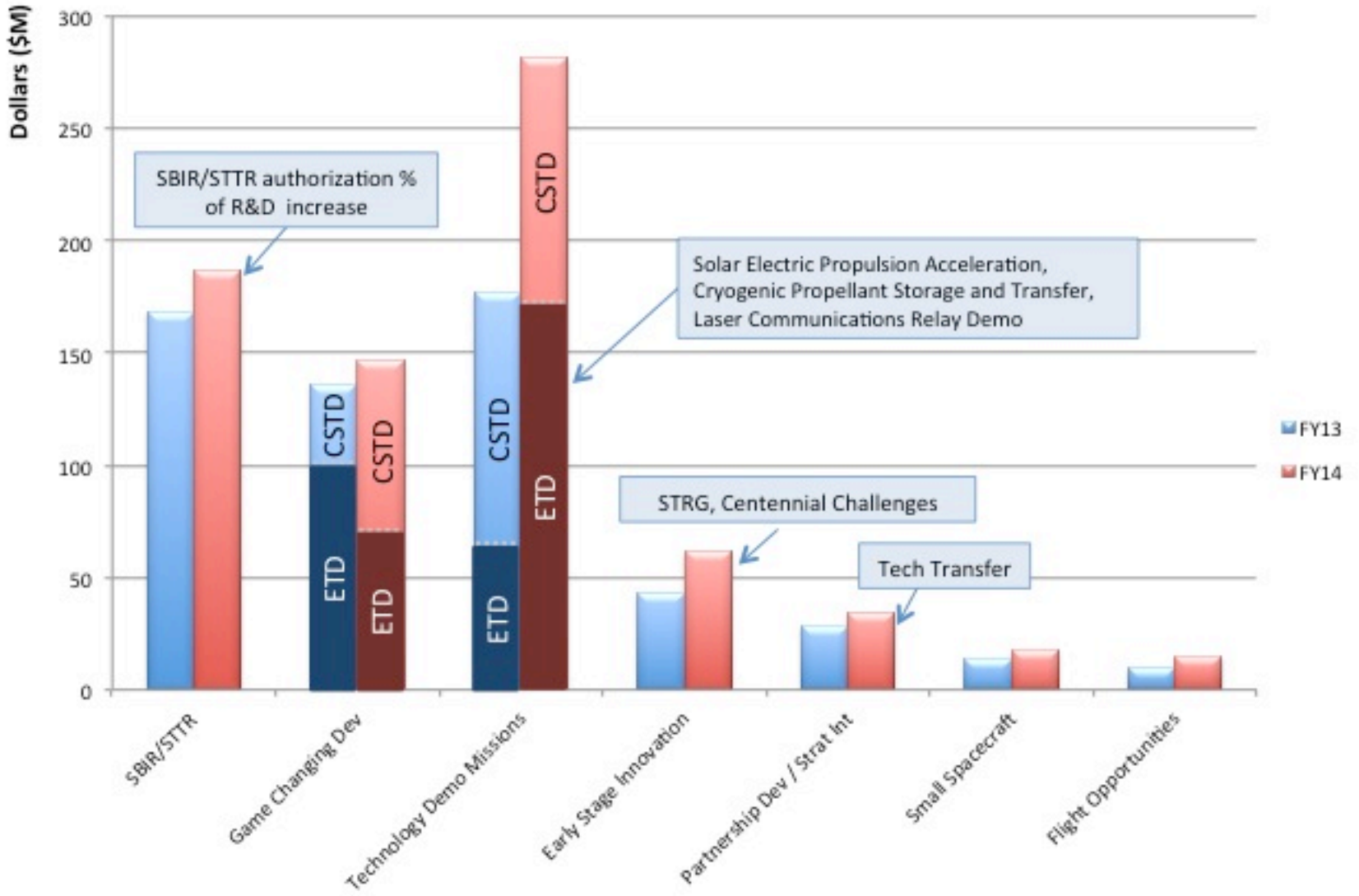
FY 2014 Key Budget Drivers

- The funding increase will support key Space Technology projects started in previous years, which in FY 2014 and early FY 2015 will build hardware or perform ground or spaceflight demonstrations.
  - STMD is managing multiple projects through key implementation phase milestones in FY14 – peak year for project funding.
  - STMD postponed FY13 milestones for some projects due to sequestration impacts - funding rephrased into FY14 to complete milestones

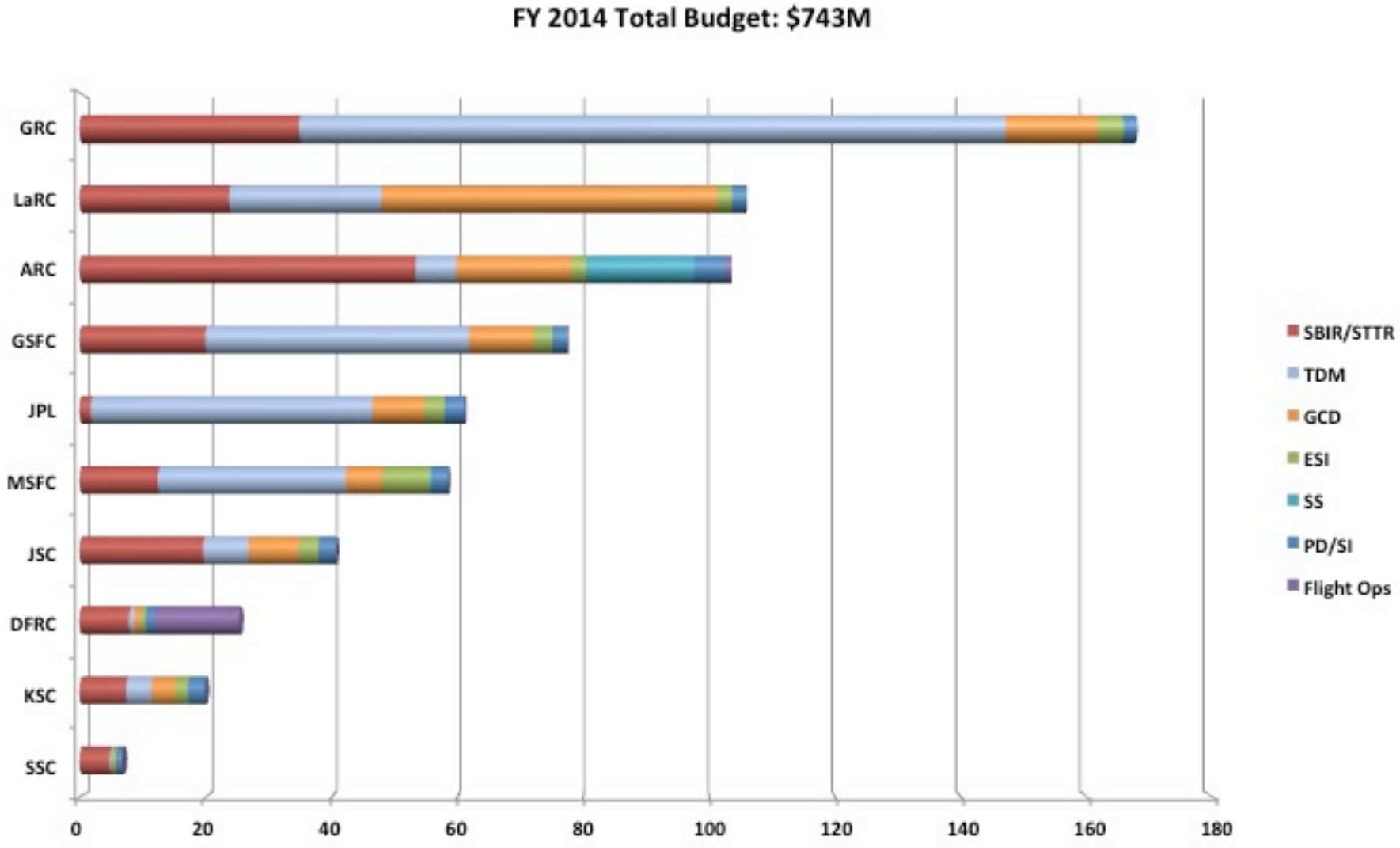
- The budget accelerates the development of a high-powered Solar Electric Propulsion (SEP) system that is enabling for the robotic segment, propulsion and detection of the asteroid retrieval mission

- Support of the Congressionally mandated increases in the Small Business Innovation Research and Small Business Technology Transfer Programs.

FY2013 to FY2014 Increases



FY2014 Budget Distribution

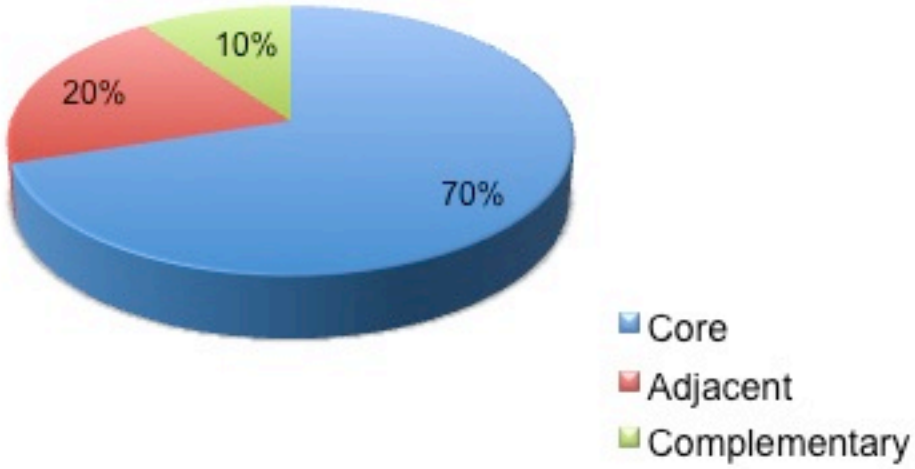


Strategic Investments in Technology

Evaluating current STMD investments as recommended by the Strategic Space Technology Investment Plan (SSTIP)

- Initial evaluation is consistent with the Core, Adjacent, and Complementary recommendations
- Approximately > 65% of investments are in Core areas
- STMD has investments in all 14 Technology Areas
- Approximately 10% of investments are low TRL (1-3) consistent with the recommendation by the National Research Council (NRC) Final Report on Space Technology Roadmaps and Priorities

Percentages of STMD Budget in each area



STMD investments are consistent with the Strategic Space Technology Investment Plan (SSTIP)

Space Technology Mission Directorate

With successful formulation and implementation of Space Technology program, NASA officially separates Office of the Chief Technologist (OCT) into two organizations: OCT and Space Technology Mission Directorate (STMD).

Space Technology Mission Directorate

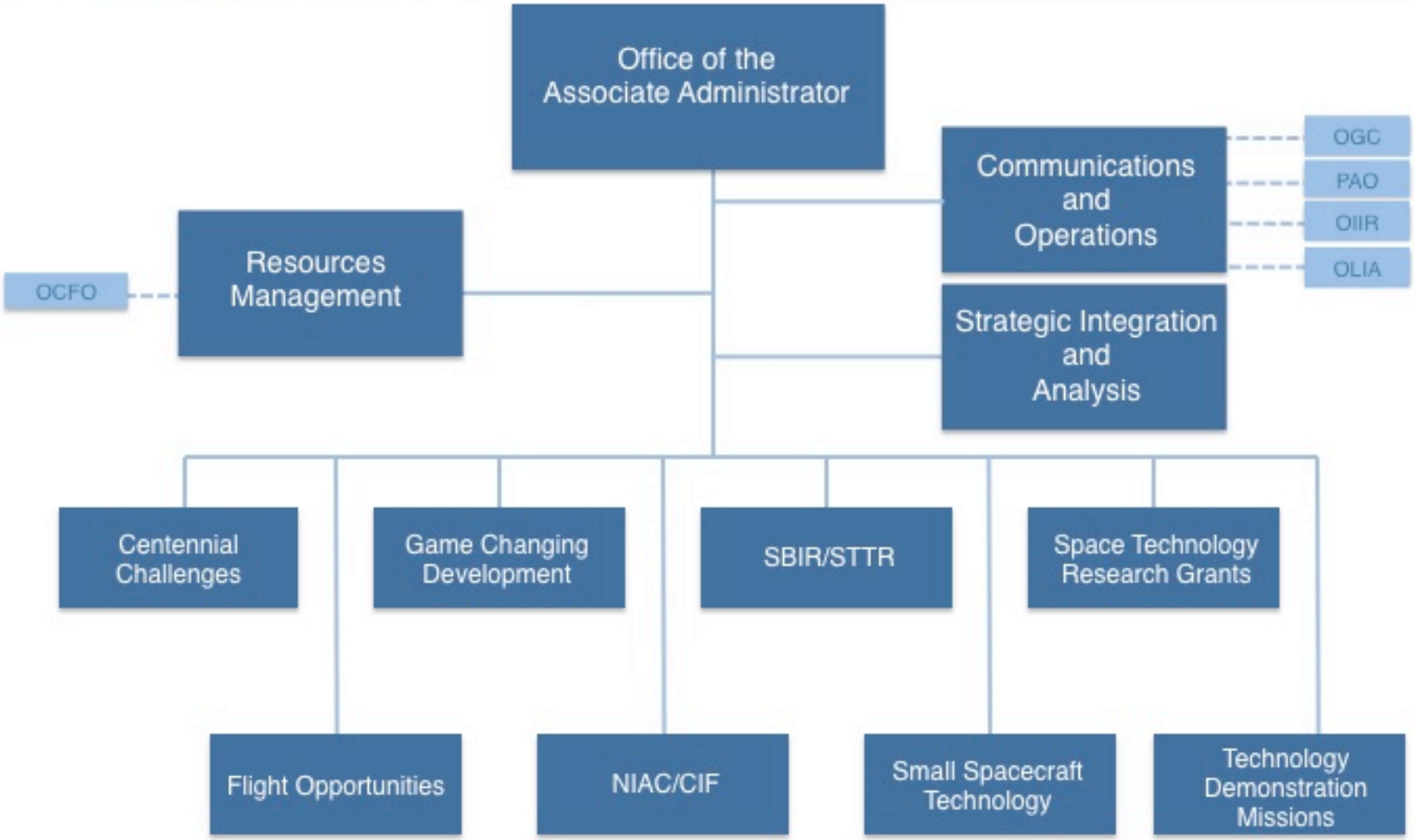
- Has direct management and budget authority of the Space Technology programs, which are performed by all 10 NASA Centers;
- Focuses on project execution and technology infusion into the Agency's exploration and science mission needs;
- Takes a customer driven approach, proving capabilities needed for future NASA missions and the national aerospace community; and
- Develops the Nation's innovation economy.

Office of the Chief Technologist

- Continues to serve as the Administrator's principal advisor and advocate on matters concerning Agency-wide technology policy and programs;
- Continues to lead NASA's technology transfer and commercialization efforts;
- Integrates, tracks, and coordinates all of NASA's technology investments; and
- Documents and communicates the societal impacts of the Agency's technology efforts.

Realignment will not affect the mission, content or budget authority of the Space Technology Programs.

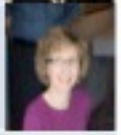
Space Technology Mission Directorate Organization



STMD Senior Leadership

Associate Administrator	**Michael Gazarik**	
Deputy Associate Administrator for Management	Dorothy Rasco	
Deputy Associate Administrator for Programs	James Reuther	
Director for Communications and Operations / Chief of Staff	G. Michael Green	
Director for Resource Management	Robert Carver	
Director for Strategic Integration and Analysis	Prasun Desai	
Senior Technical Officer	Harry Partridge	
Executive Officer	Natalie Simms	

Program Executives

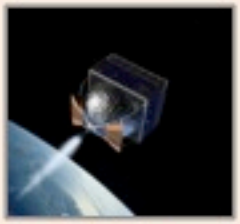
Program	Program Executive	
Center Innovation Fund & NIAC	Jay Falker	
Centennial Challenges	Larry Cooper	
Flight Opportunities	LK Kubendran	
Game Changing Development Program	Tibor Balint	
SBIR/STTR	Rich Leshner	
Small Spacecraft Technology Program	Andy Petro	
Space Technology Research Grants	Claudia Meyer	
Technology Demonstration Missions	Randy Lillard	

Space Technology Portfolio

Transformative & Crosscutting Technology Breakthroughs

Game Changing Development (ETD/CSTD)

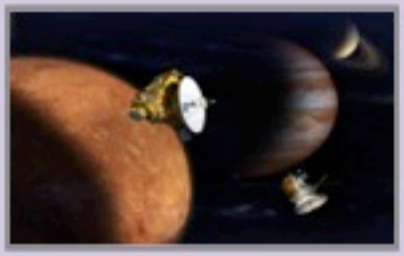
Technology Demonstration Missions (ETD/CSTD)



Small Spacecraft Technologies (CSTD)

Pioneering Concepts/ Developing Innovation Community

Space Technology Research Grant (CSTD)



NASA Innovative Advanced Concepts (NIAC) (CSTD)

Center Innovation Fund (CSTD)

Creating Markets & Growing Innovation Economy

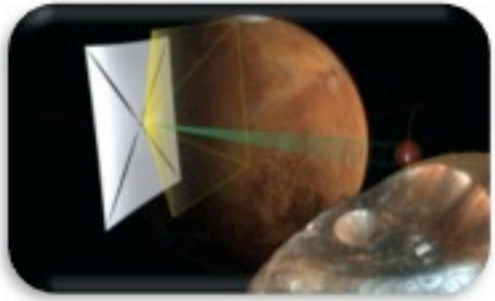
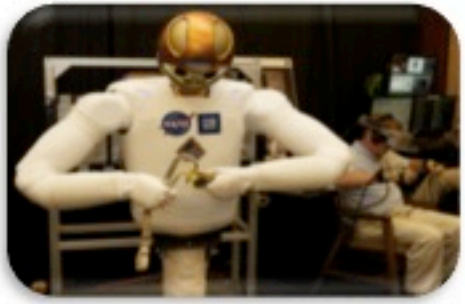
Centennial Challenges Prize (CSTD)

Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR)

Flight Opportunities Program (CSTD)

Space Technology Program Attributes

- **Adheres to a Stakeholder Based Investment Strategy:** NASA Strategic Plan, NASA Space Technology Roadmaps / NRC Report and Strategic Space Technology Investment Plan
- **Invests in a Comprehensive Portfolio:** Covers low to high TRL, student fellowships, grants, prize competitions, prototype developments, and technology demonstrations
- **Advances Transformative and Crosscutting Technologies:** Enabling or broadly applicable technologies with direct infusion into future missions
- **Merit Based Competition:** Research, innovation and technology maturation open to academia, industry, NASA centers and other government agencies
- **Executes with Structured Projects:** Clear start and end dates, defined budgets and schedules, established milestones, and project authority and accountability.
- **Informed Risk Taking:** Rapid cadence of technology maturation and infusion, informed risk tolerance to infuse as quickly as possible
- **Positions NASA at the cutting edge of technology:** Results in new inventions, enables new capabilities and creates a pipeline of innovators for National needs


Space Technology Technical Areas

TA01  • LAUNCH PROPULSION SYSTEMS

TA02  • IN-SPACE PROPULSION TECHNOLOGIES

TA03  • SPACE POWER & ENERGY STORAGE

TA04  • ROBOTICS, TELE-ROBOTICS & AUTONOMOUS SYSTEMS

TA05  • COMMUNICATION & NAVIGATION

TA06  • HUMAN HEALTH, LIFE SUPPORT & HABITATION SYSTEMS

TA07  • HUMAN EXPLORATION DESTINATION SYSTEMS

TA08  • SCIENCE INSTRUMENTS, OBSERVATORIES & SENSOR SYSTEMS

TA09  • ENTRY, DESCENT & LANDING SYSTEMS

TA10  • NANOTECHNOLOGY

TA11  • MODELING, SIMULATION, INFORMATION TECHNOLOGY & PROCESSING

TA12  • MATERIALS, STRUCTURES, MECHANICAL SYSTEMS & MANUFACTURING

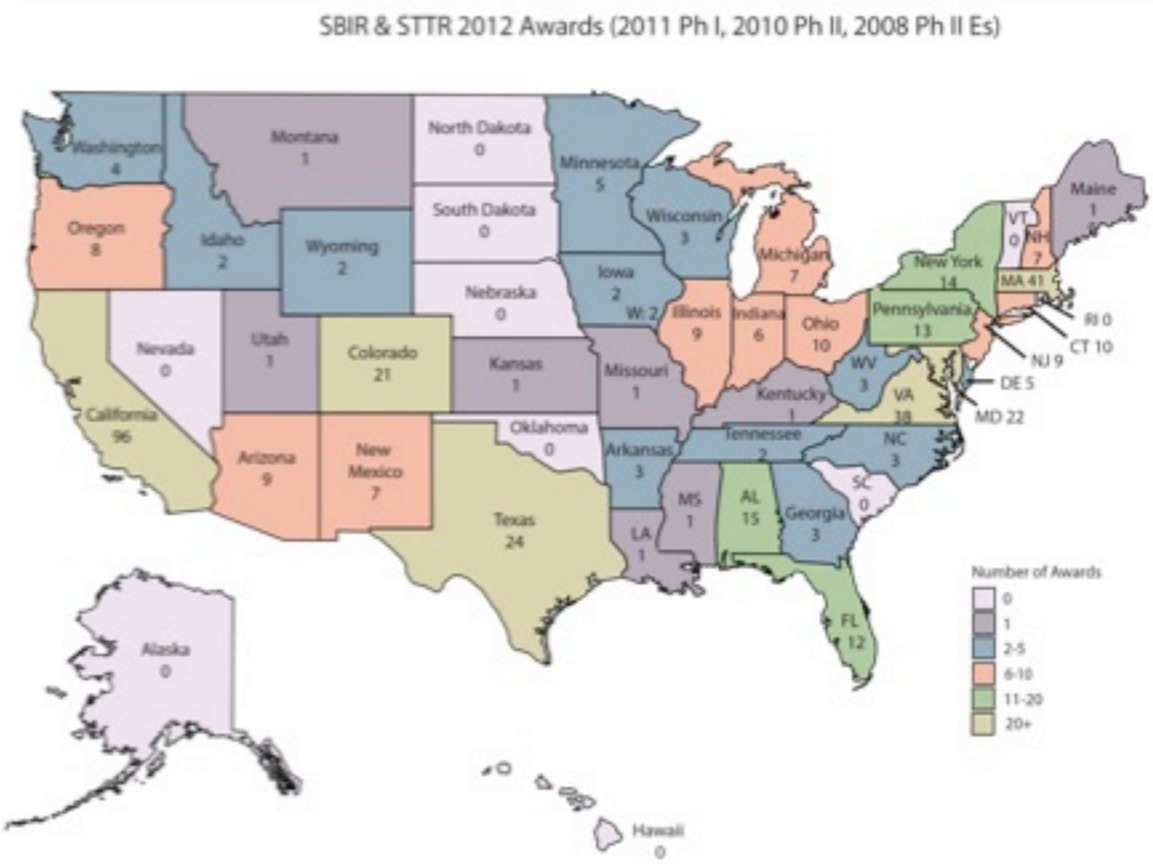
TA13  • GROUND & LAUNCH SYSTEMS PROCESSING

TA14  • THERMAL MANAGEMENT SYSTEMS

Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR)

Provides small business sector with opportunity to compete for funding to develop technology for NASA and commercialize that technology to spur economic growth.

- Annual Solicitations for Phase I awards
- Phase II proposed 9 months later
  - Phase II Enhancement (II-E): incentive for cost share to extend research and development efforts of current Phase II contract.
- Phase III-commercialization of Phase II projects.
  - Contract funded from sources other than the SBIR/STTR programs and may be awarded without further competition.

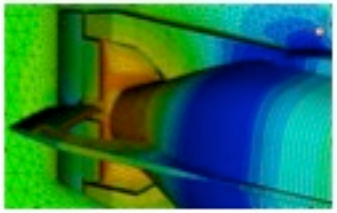


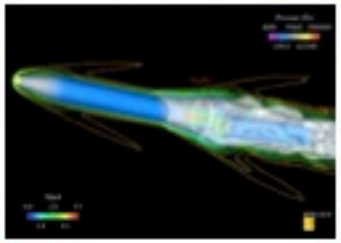
FY 2012 Awards: SBIR/STTR awarded 298 Phase I contracts, and 102 Phase II contracts in FY 2012.
FY 2013 Awards: SBIR/STTR selected 295 Phase I proposals from 216 US small businesses for negotiations; Additionally 38 SBIR Phase II proposals were awarded; Phase II selections still pending.
FY 2014 Plans: NASA increases the SBIR investment by 0.1 percent to 2.8 percent, and increase the STTR investment by 0.05 percent, to 0.40 percent of Agency R&D

SBIR and STTR Successes

NASA funded small businesses contributed to Mars Science Lab:

- GrammaTech, Inc.(Ithaca, NY) developed software for eliminating defects in mission-critical and embedded software applications directing rover operations. (image top right)
- Starsys Research, Inc. (Louisville, CO) developed planetary gearboxes for the articulated robotic arm and descent braking mechanism for controlling rate of descent to planetary surface.
- Creare, Inc.(Hanover, NY) developed space-qualified vacuum pump for Sample Analysis at Mars (SAM) instrument package.
- Yardney Technical Products, Inc. (Pawcatuk, CT) developed lithium ion batteries that enable power system to meet peak power demands or rover activities.
- Honeybee Robotics, Inc (New York, NY) created a dust removal tool used to remove the dust layer from rock surfaces and clean rover's observation tray, and designed the sample manipulation system for the Sample Analysis at Mars instrument package (image right).
- inXitu,Inc. (Mountain View, CA) had features of their automated sample handling system implemented in the Chemistry and Mineralogy experiment instrument.





Three SBIR/STTR Supporting the Space Launch System (SLS) modeling and simulation requirements:

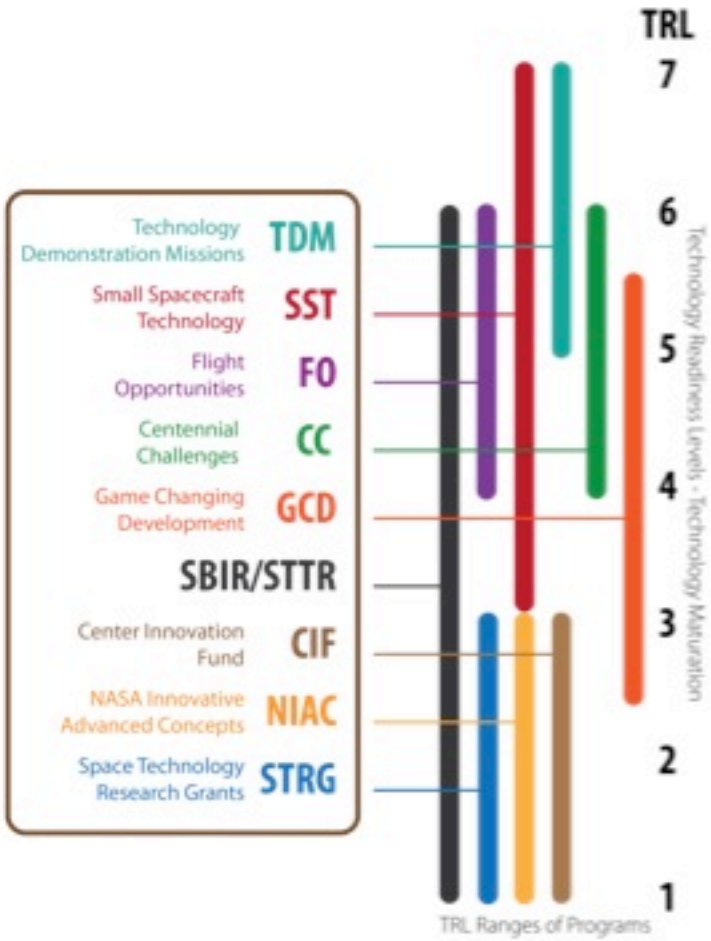
- Streamline Numerics, Inc. (Gainesville, FL) Fluid-flow design tool that can be used in design process by engineers to model full 3-D geometries with unsteady flow analysis. (image top left)
- AI Signal Research-(Huntsville, AL) high frequency data diagnostics tools to modify and validate PC-Signal software and expand analysis and environment prediction capabilities for current and future propulsion components.
- Tetra Research Corporation (West Princeton, IL) development of advanced flow analysis tools for solid rocket motor simulation to accurately simulate motor pressure and thrust as a function of time. (image bottom left)

Crosscutting Space Technology Development

Enables **revolutionary advances** in **broadly applicable technology** for NASA's future science and exploration missions, and addresses critical national needs.

- Advanced manufacturing capabilities
- Optical communications demonstration
- Supersonic decelerators – parachutes and inflatables
- Deep-space navigation development
- Small Spacecraft flight demos
- Flights on suborbital research platforms
- Early Stage research fellowships and development grants to academia, NASA researchers and private innovators
  - Including technology concept studies in asteroid detection, in situ resource utilization, autonomous robotics, and radiation mitigation
  - Utilizing prize competitions to spur innovation
  - Supporting Innovation at NASA Centers

Ensure NASA is receiving fresh ideas and contributing to the Nation's research engine



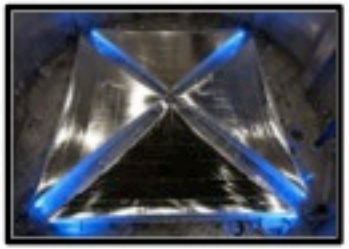
Crosscutting Space Technology Development

Low Density Supersonic Decelerators world's largest planetary entry parachute, world's first supersonic inflatable decelerators

- Conducts final sled tests for both the ring-sail parachute and supersonic inflatable decelerator test articles
- Conduct the first high-speed, high-altitude flight demonstration to simulate Mars atmospheric entry/ descent conditions

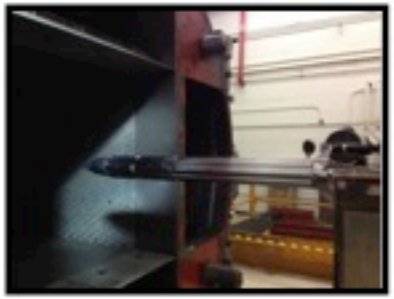
Sunjammer Solar Sail

- Entering final design and fabrication phase progressing toward system integration and flight readiness review; launch in late 2014



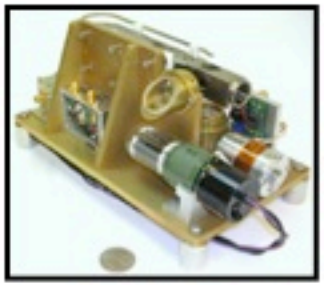
Soldier-Warfighter Operationally Responsive Deployer for Space (SWORDS) address the expanding demand for small payload (< 100kg), low cost, quickly available launch systems.

- Launch vehicle cost of approximately $1 million
- NASA Providing ground processing & avionics support
- Partnering with DARPA



Crosscutting Space Technology Development

Advanced Manufacturing Technologies Composite manufacturing processes, material mixtures, in situ resource construction techniques.



Deep Space Atomic Clock

- Complete Critical Design Review
- Fabricate the GPS equipment, clock ultra-stable oscillator
- Conduct final payload integration and testing prior to the flight

Edison Demonstration of Smallsat Networks

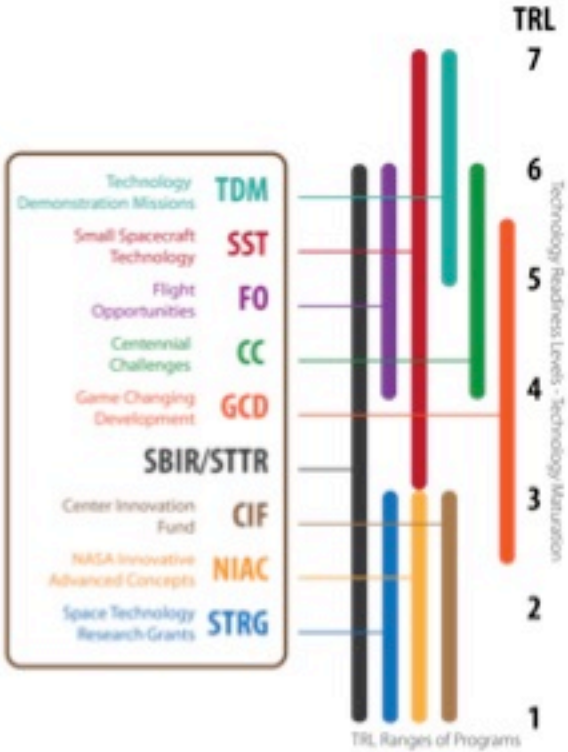
- Spacecraft cluster of eight cubesats; launch in late 2013
- Partnering with the Operationally Responsive Space Office for launch on the Super Strypi launch vehicle.

Flight Opportunities Commercial Access to Suborbital Space expects to use all providers for the first time in FY 2014, with approximately 30 flight campaigns based on payload demand

Exploration Technology Development

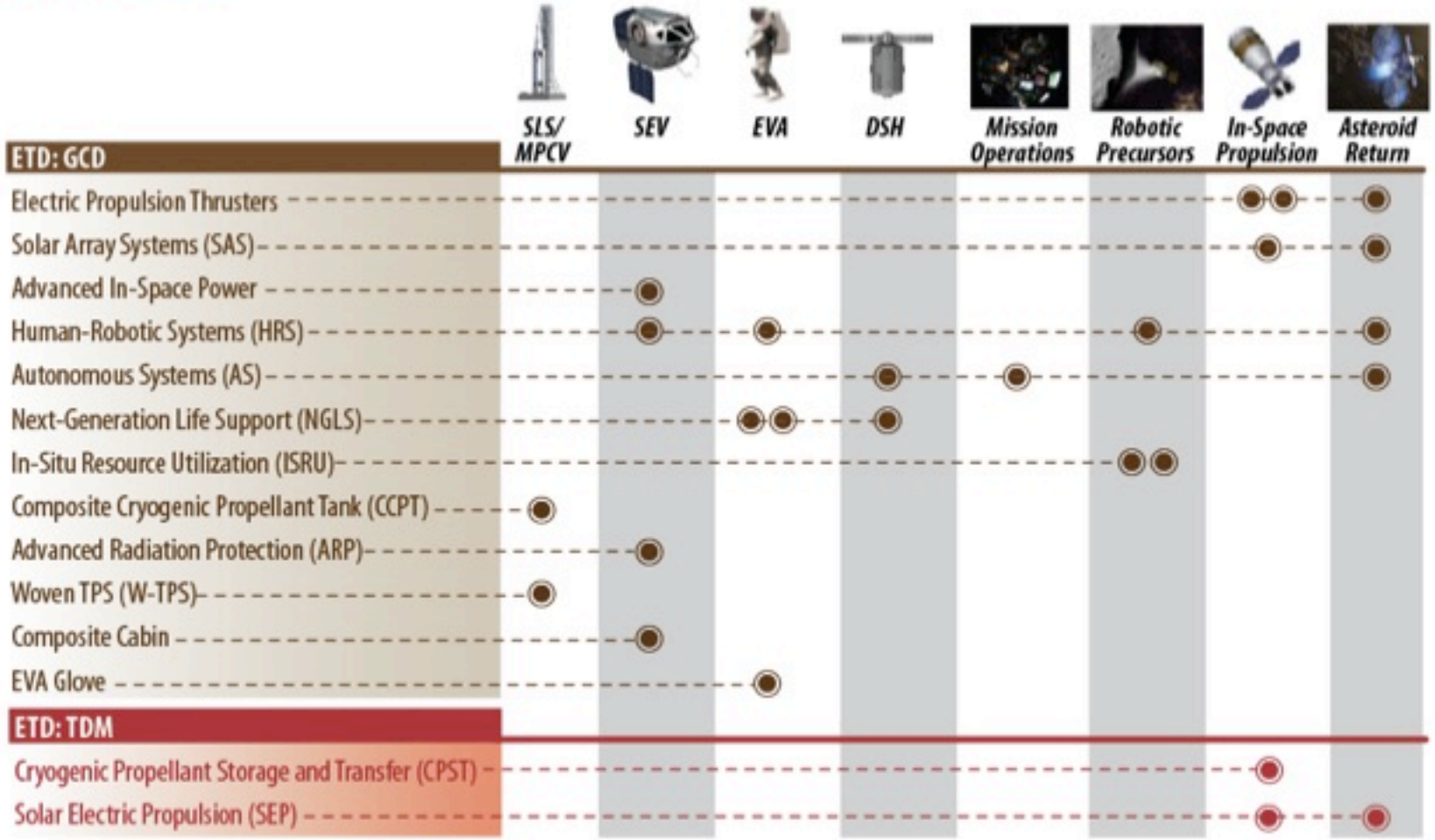
Develops technologies that **address breakthroughs** needed to achieve the Nation's human exploration goals.

- Works closely with NASA's Human Exploration and Operations Mission Directorate to reduce technological barriers, reduce mission risk and increase system efficiency.
- Supports acceleration of a high-powered Solar Electric Propulsion capability to power the robotic segment and propulsion of the proposed asteroid retrieval mission.
- Composite cryogenic propellant tank (5.5 meter)
- Cryogenic propellant storage and transfer demonstration
- Green propellant demonstration
- Life support system & space resource utilization components
- Batteries, fuel cells & in-space propulsion
- Entry, Descent and Landing systems
- Human-Robotic Systems and Human Exploration Telerobotics to assist humans work more efficiently and perform difficult and hazardous tasks



Exploration Technology Development

Infusion



FY2014 Big Nine

TDM
Laser Communications

Increases space-based broadband, delivering data rates 10-to-100 times faster than today's systems, addressing the demands of future missions.

TDM
Cryogenic Propellant Storage & Transfer

Better fuel handling technology will improve spacecraft fuel economy. Required for Cryogenic Propulsion Stage (Space Launch System - SLS - upper-stage).

TDM
Deep Space Atomic Clock

This tiny atomic clock is 10-times more accurate than today's ground-based navigation systems, enabling precise, in-space navigation.

TDM
Large-Scale Solar Sail

This solar sail has an area 7 times larger than ever flown in space, enabling propellant free propulsion and next generation space weather systems.

TDM
Low Density Supersonic Decelerators

Demonstrates new parachutes and inflatable braking systems at supersonic velocities enabling precise landing of large payloads on planetary surfaces.

TDM
Green Propellants

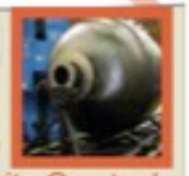
Develops and demonstrates green propellants, thus provides an alternative to highly corrosive and toxic hydrazine; consequently expanding the capabilities of small spacecraft systems.

TDM & GCD
Human Exploration Telerobotics & Human-Robotic Systems

Developing advanced systems capable of remotely operating robots to assist in future exploration; maturing new robots capable of assisting humans in routine and tedious work.

TDM & GCD
Solar Electric Propulsion

Develops large-scale solar array panels and deployment mechanisms. Critical step on the development path to a high-power solar electric propulsion system.



GCD
Composite Cryotank

Demonstrating large composite, light weight fuel tanks that can reduce the mass and cost of the next generation SLS.

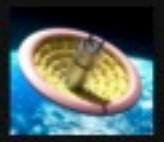
Human Missions

Science Missions

NASA Space Technology rolling big9 projects

Space Technology
Major Events & Milestones

2012



HIAD
IRVE 3

Telerobotics

MEDLI

2013

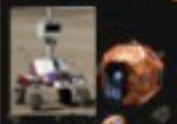
Telerobotics

PhoneSat

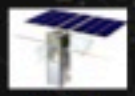
Edison Demo
SmallSat

2014

Solar
Sail



Telerobotics



ISARA

OCSD

Supersonic
Inflatable
Aerodynamic
Decelerator

2015

CPOD

Atomic
Clock

Green
Propellant

Supersonic
Inflatable
Aerodynamic
Decelerator

2016

2017

Cryogenic
Propellant

**SEP Demo
Mission**

2018

Laser
Communications

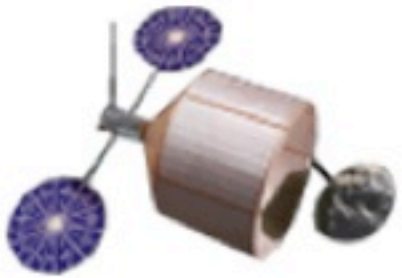
Future Planning

STMD: Asteroid Retrieval Mission

- NASA is planning a first-ever mission to capture and redirect an asteroid to earth-moon space. The effort aligns and leverages relevant portions of NASA's Science, Space Technology, and Human Exploration capabilities to achieve the President's challenge of sending astronauts to an asteroid by 2025.

- The overall mission is composed of three independently compelling elements:
  - Detection and characterization of candidate near earth asteroids
  - Robotic rendezvous, capture and redirection of an asteroid to earth-moon space
  - Crewed mission to explore and sample the captured asteroid using the Space Launch System (SLS) and the Orion crew capsule

- Space Technology will focus on high-powered Solar Electric Propulsion (SEP)
  - SEP is the primary propulsion for the robotic asteroid rendezvous and redirection
  - The retrieval mission is not possible without SEP
  - SEP is also enabling for deep space human exploration
  - SEP component technologies serve commercial needs
  - In FY14 STMD will accelerate SEP development



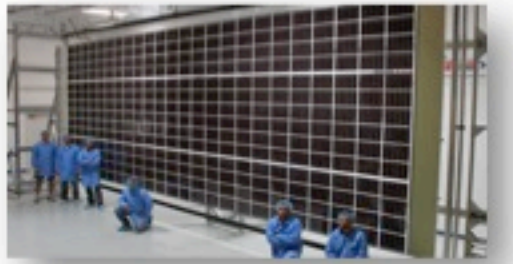
Space Tech Role in Agency Asteroid Strategy

Early Stage programs will foster innovation regarding:

- Asteroid detection, characterization and mitigation for planetary defense and asteroid retrieval mission target selection
- Asteroid proximity operations and resource utilization techniques

Game Changing will complete high power SEP tech development:

- Advanced solar array systems
- Advanced magnetic shielded Hall thrusters
- Power processing units (PPUs)



Technology Demonstration Missions will develop, test and demonstrate the SEP system as part of the retrieval mission:

- 30kW – 50 kW advanced solar arrays
- Magnetically shielded Hall thrusters & Power Processing
- Xenon propellant tanks

Additional Asteroid Retrieval funding in FY2014 will cover:

- Flight hardware solar array procurements
- Hall thruster engineering development units
- Design of Xenon propellant tanks

Alignment Strategy

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Asteroid Detection, Characterization & Selection Segment	SST	PS-2	Enhanced ground assets & Initial candidates	GEO-hosted payload detection; Final target selection						
Asteroid Redirection Segment	THIS SEGMENT TIMELINE NOTIONAL- SUBJECT TO CHANGE AS MISSION CONCEPT EVOLVES				Mission Launch & SEP Demo		Asteroid Rendezvous & Capture		Asteroid Maneuver to cis-lunar	
Orion & SLS Crewed Asteroid Exploration Segment		First flight of Orion			EM-1: Un-crewed Orion test beyond the Moon				EM-2: Crew on Orion to the asteroid	

Sensitive But Unclassified * PRE-DECISIONAL * Do Not Distribute

Partnership Development and Strategic Integration

Extending the benefits of NASA's technology investments to have a direct and measurable impact on daily life.

- Managed by NASA's Chief Technologist
- Provides the strategy, leadership, and coordination that guides NASA's technology and innovation activities.
- Documents and analyzes NASA's technology investments and tracks progress, aligning them with the Agency's plan.
- Technology transfer and technology commercialization activities.

Encourage partnerships, technology use, and commercialization; ensuring NASA technologies energize the commercial space sector, and provide the greatest benefit to the Nation.

Tangible Benefits

Companies featured in recent issues of NASA's *Spinoff* report have used NASA technology to:

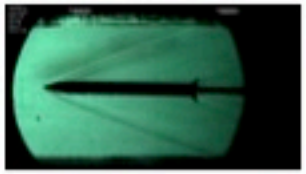
- Create more than 14,000 jobs
- Save more than 444,000 lives
- Generate more than $5 billion in revenue
- Save $6.2 billion in costs

Collaborations with Other Government Agencies

Currently, significant engagements include:

- Green Propellant Infusion Mission partnership with **Air Force Research Laboratory** propellant and rideshare with **DoD's Space Test Program (STP)**
- Solar Sail Demonstration partnership with **NOAA** and rideshare with **Air Force**
- Soldier-Warfighter Operationally Responsive Deployer for Space (SWORDS) low-cost nano-launch system with **Army**
- UAS Airspace Operations Prize Challenge coordinated with **FAA**
- Working with the **USAF Operationally Responsive Space Office (ORS)** for launch accommodations for the Edison Demonstration of Smallsat Networks (EDSN) mission.
- Partnership for Ohio's first hydrogen generating fueling station with **Greater Cleveland Regional Transit Authority** to power city bus
- Partnership with **DARPA** on "Next Generation Humanoid for Disaster Response"
- In discussion with **Department of Veteran Affairs** for a collaborative project with "Exoskeleton" from our Human Robotics Systems Program








NASA Space Technology: *Tapping into the future through student engineers and technologists across the Nation*

With over 350 activities in over 100 U.S. Academic Institutions, Space Technology is actively developing the Nation's technological leadership

Summary:
Space Technology Critical to our Future

- NASA's investments in Space Technology provide the transformative capabilities to enable new missions, stimulate the economy, contribute to the nation's global competitiveness and inspire the nation's next generation of scientists, engineers and explorers.

- The next great leaps in space exploration require significant and sustained investments in Space Technology

- Space Technology is delivering what we promised: hundreds of new technologies and capabilities – on time and within budget. FY14 demos for Small Spacecraft, Green Propellant, Composite Cryotank and LDSD.

- Space Technology will continue to engage U.S. universities and academic institutions to develop and demonstrate technologies with approximately 350 activities in FY12 including: fellowships, direct competitive awards of grants and contracts, and partnerships with NASA centers and commercial contractors.

- This budget request supports an accelerated development of a Solar Electric Propulsion (SEP) demonstration effort within Technology Demonstration Missions. SEP is critical and enabling for NASA's robotic mission to an asteroid. SEP technologies are also needed for future commercial satellites and essential for deep space human exploration missions.