



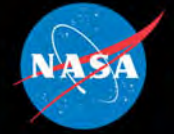
Importance of Federal R&D Investment



- 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.

Addresses National Needs

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



Value to NASA

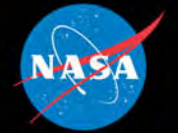
Value to the Nation



Who:

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

Challenges for Deep Space Exploration



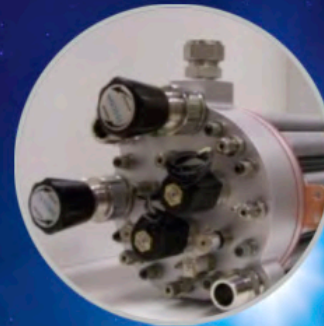
Communication



Environment
Control &
Life Supporting
Systems



Logistics



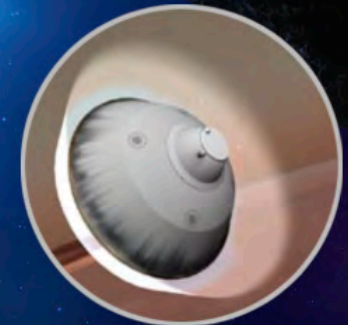
Power
Generation
& Storage



Navigation



Manufacturing
In Space &
For Space



Entry,
Descent
& Landing



Radiation
Mitigation



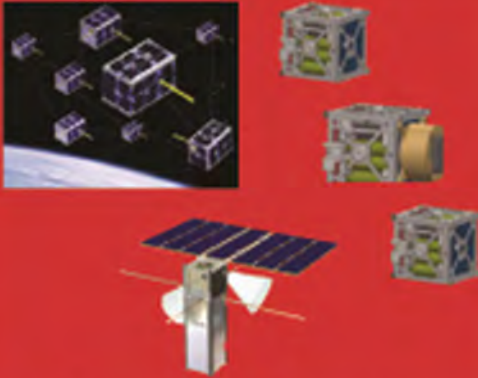
Propulsion



Trends in Space Technology



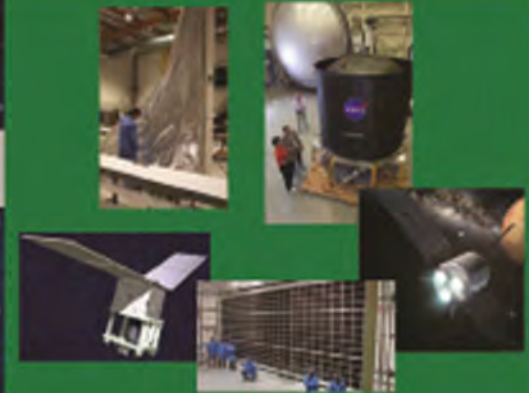
Small Spacecraft



Entry, Descent & Landing



Propulsion



Robotics



Manufacturing



Communications

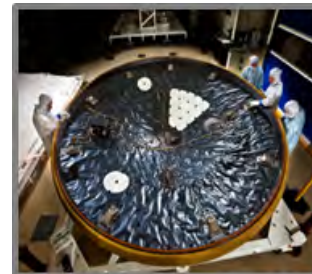




Space Technology Highlights



FY 2012-13 Accomplishments	Benefits
<p>Successfully demonstrated feasibility of inflatable heat shields through launch of Inflatable Reentry Vehicle Experiment-3 (IRVE-3) from Wallops Flight Facility in Virginia.</p>	<p>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.</p>
<p>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.</p>	<p>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.</p>
<p>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.</p>	<p>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.</p>
<p>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</p>	<p>NASA is not only investing in small businesses, but they contribute to our core Missions.</p>





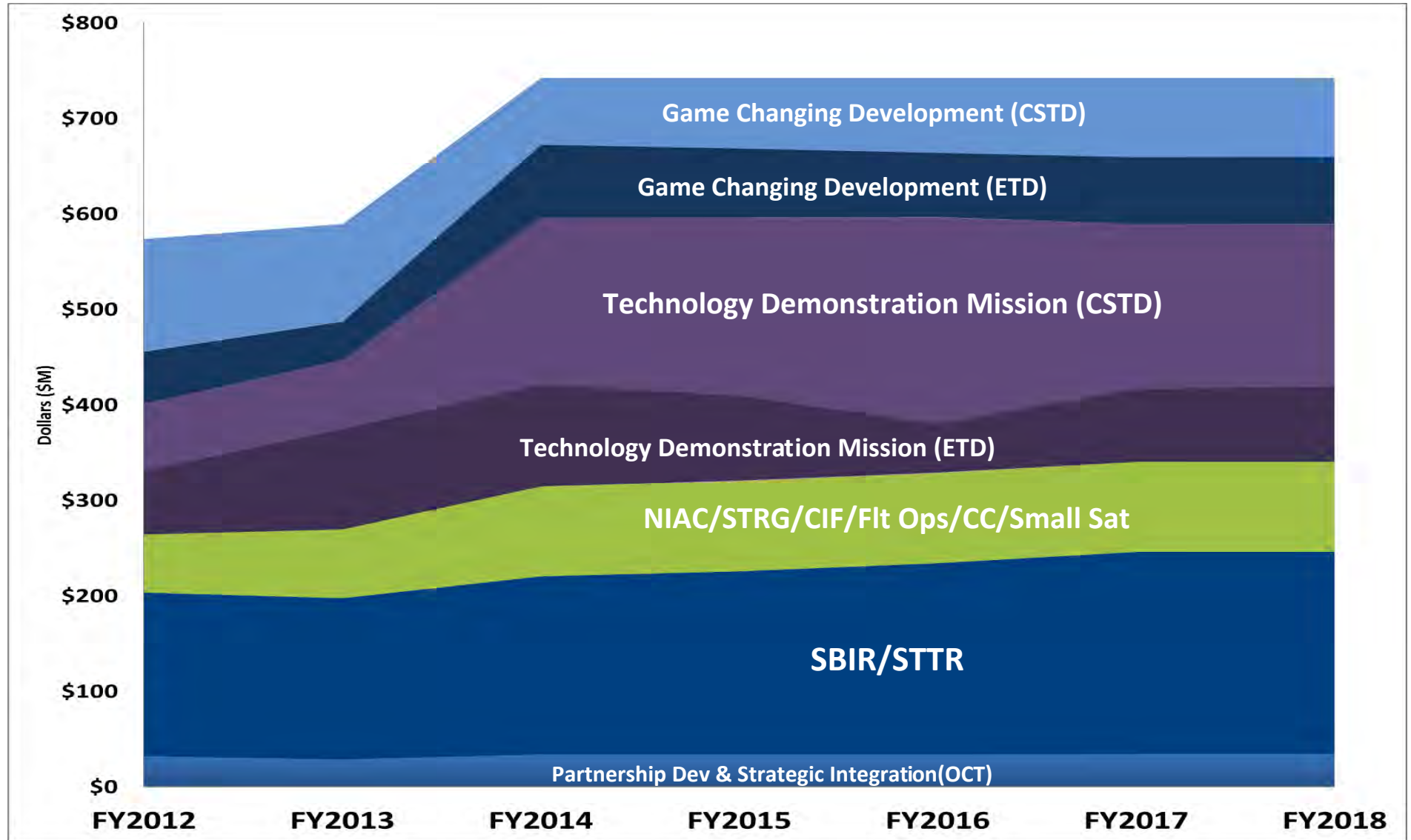
STMD FY 2014 President's Budget



		FY 2014	Notional			
		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
FY 2014 President's Budget Request		743	743	743	743	743
OCT	<u>Partnership Developments and Strategic Integration</u>	34	34	34	35	35
Space Tech Mission Directorate	<u>SBIR and STTR</u>	186	192	200	212	212
	<u>Crosscutting Space Tech Development</u>	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 Demonstration Missions	107	89	51	77	79
	<u>Exploration Technology Development</u>	244	260	295	255	252
	Game Changing Development	70	74	79	83	83



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)**



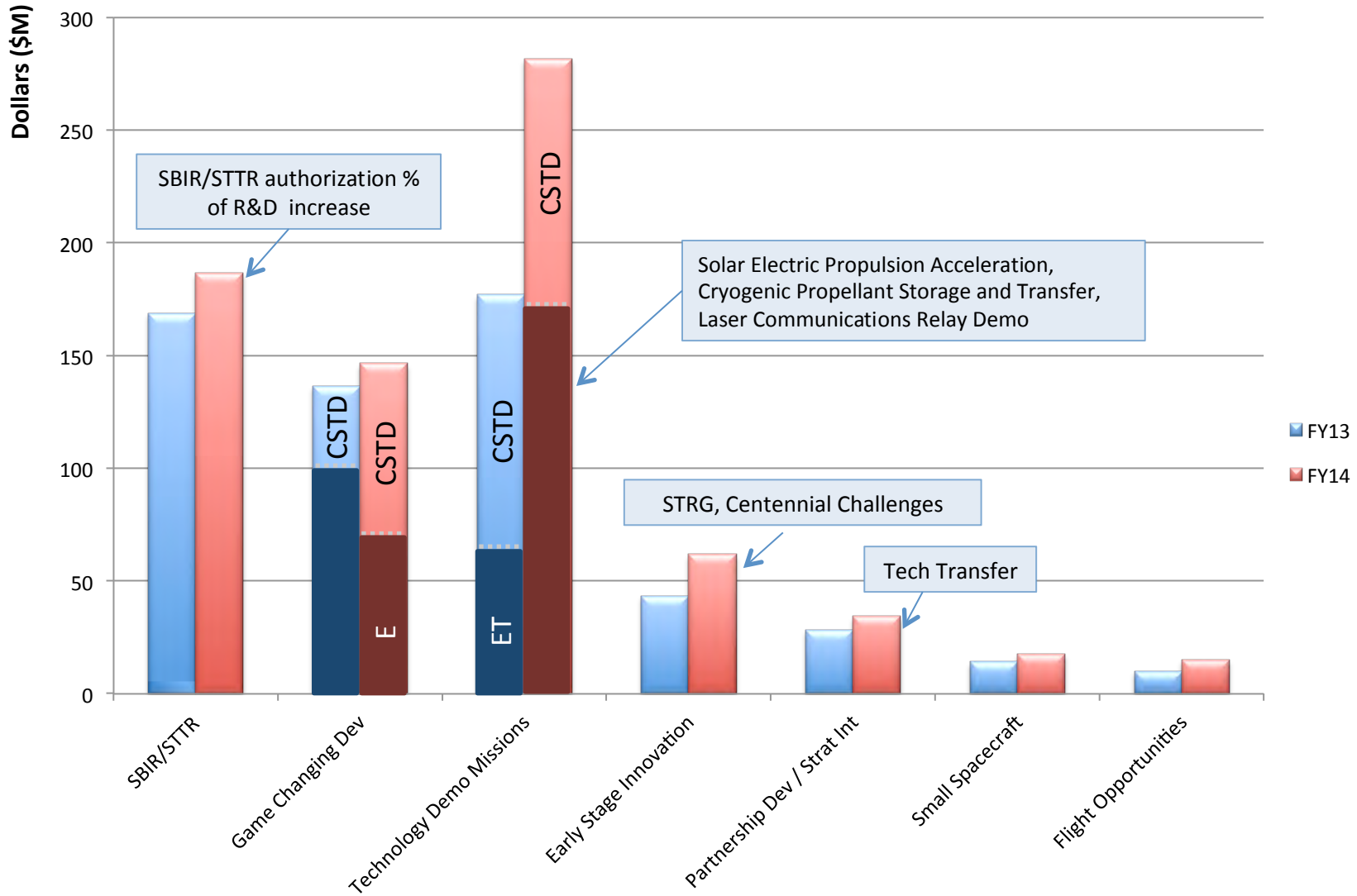
FY 2014 Key Budget Drivers



- 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

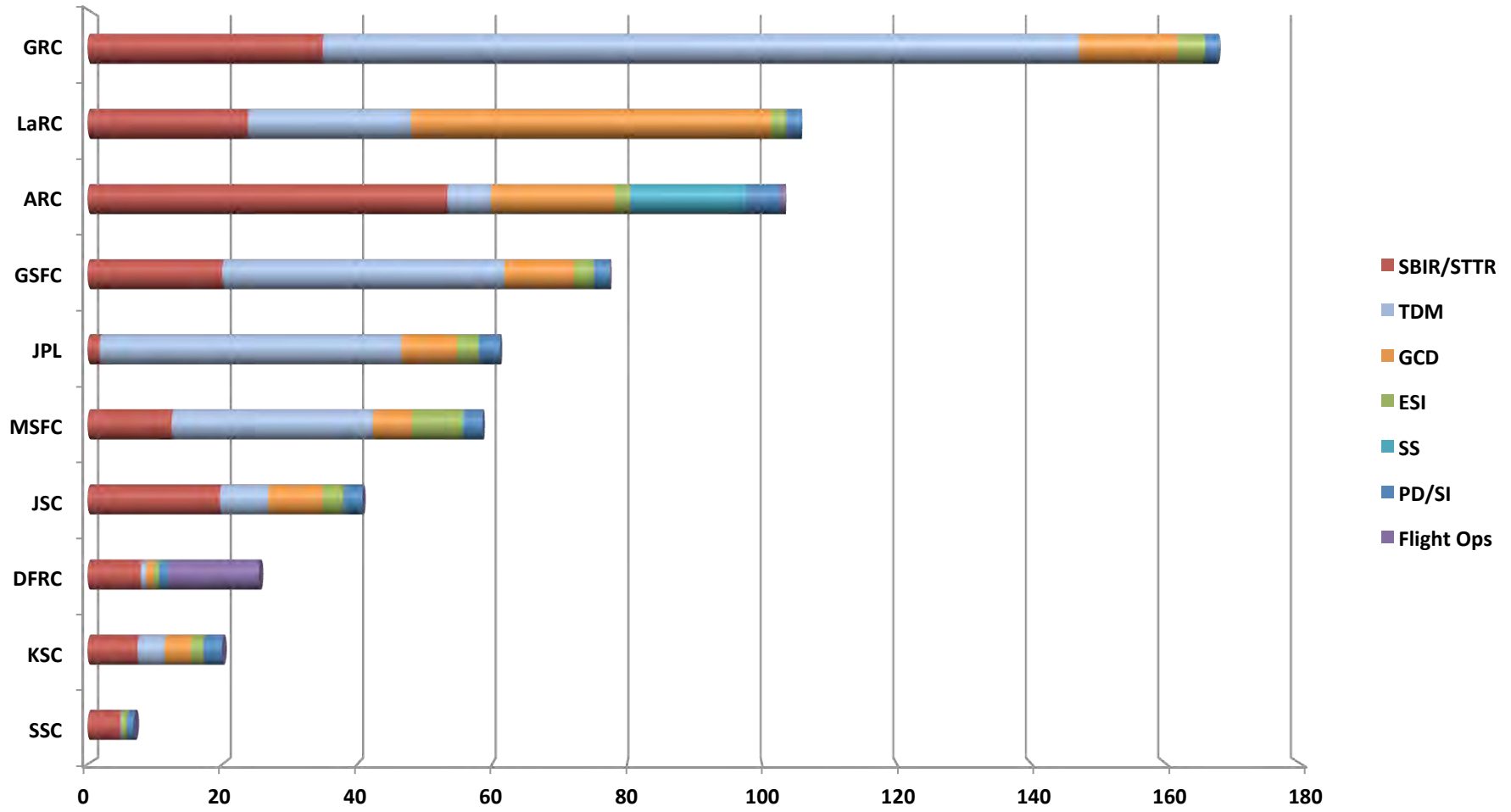




FY2014 Budget Distribution

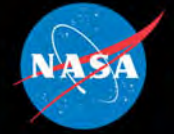


FY 2014 Total Budget: \$743M





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.

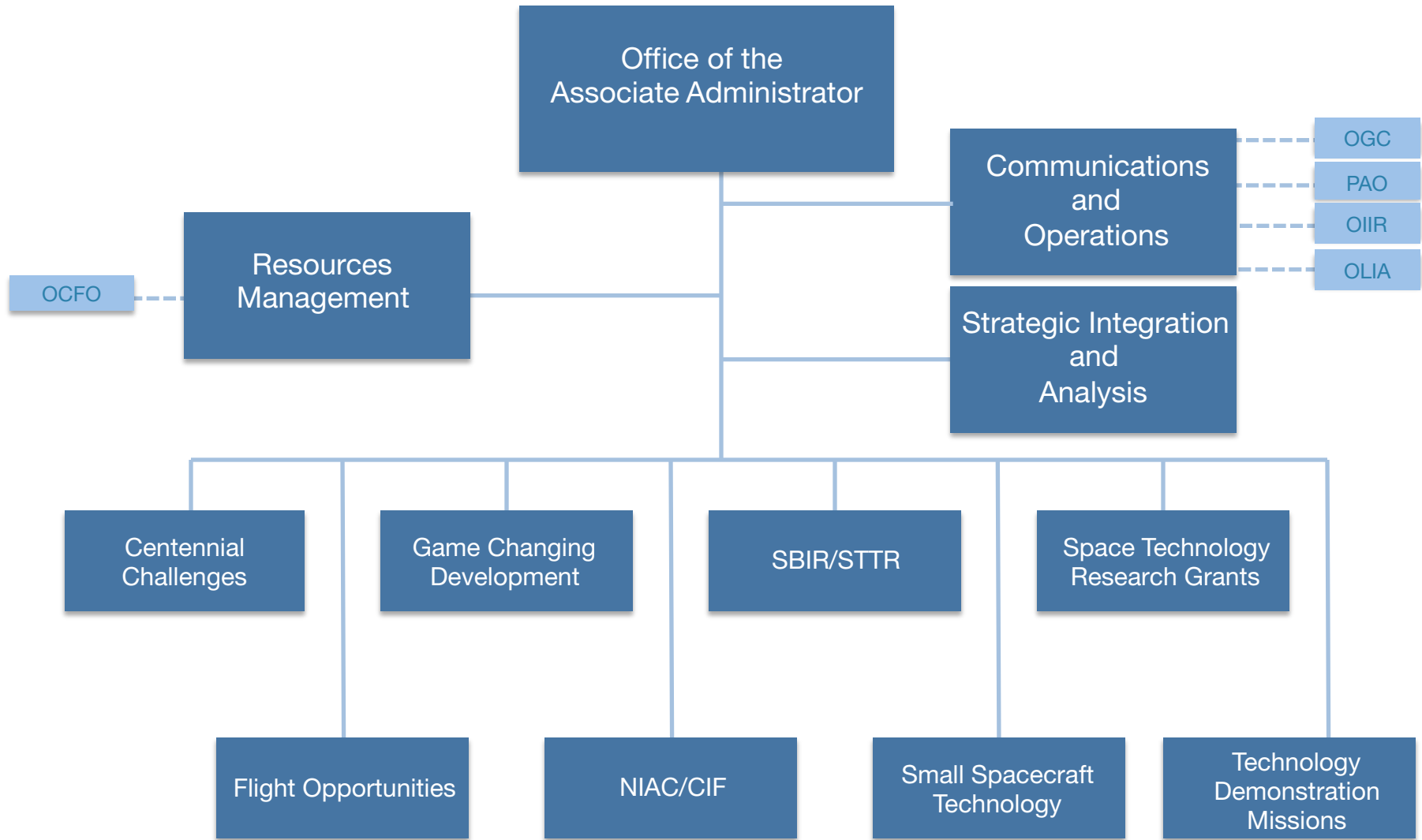
Office of the Chief Technologist

- 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



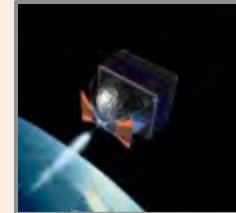
Transformative & Crosscutting Technology Break throughs



Game Changing Development (ETD/CSTD)



Technology Demonstration Missions (ETD/CSTD)

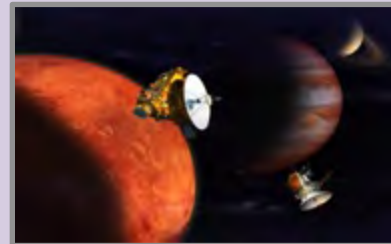


Small Spacecraft Technologies (CSTD)

Pioneering Concepts/ Developing Innovation Community



Space Technology Research Grant (CSTD)



NASA Innovative Advanced Concepts (NIAC) (CSTD)



Center Innovation Fund (CSTD)

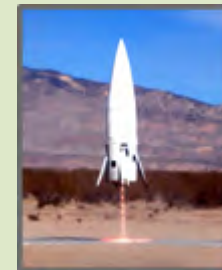
Creating Markets & Growing Innovation Economy



Centennial Challenges Prize (CSTD)



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



Flight Opportunities Program (CSTD)

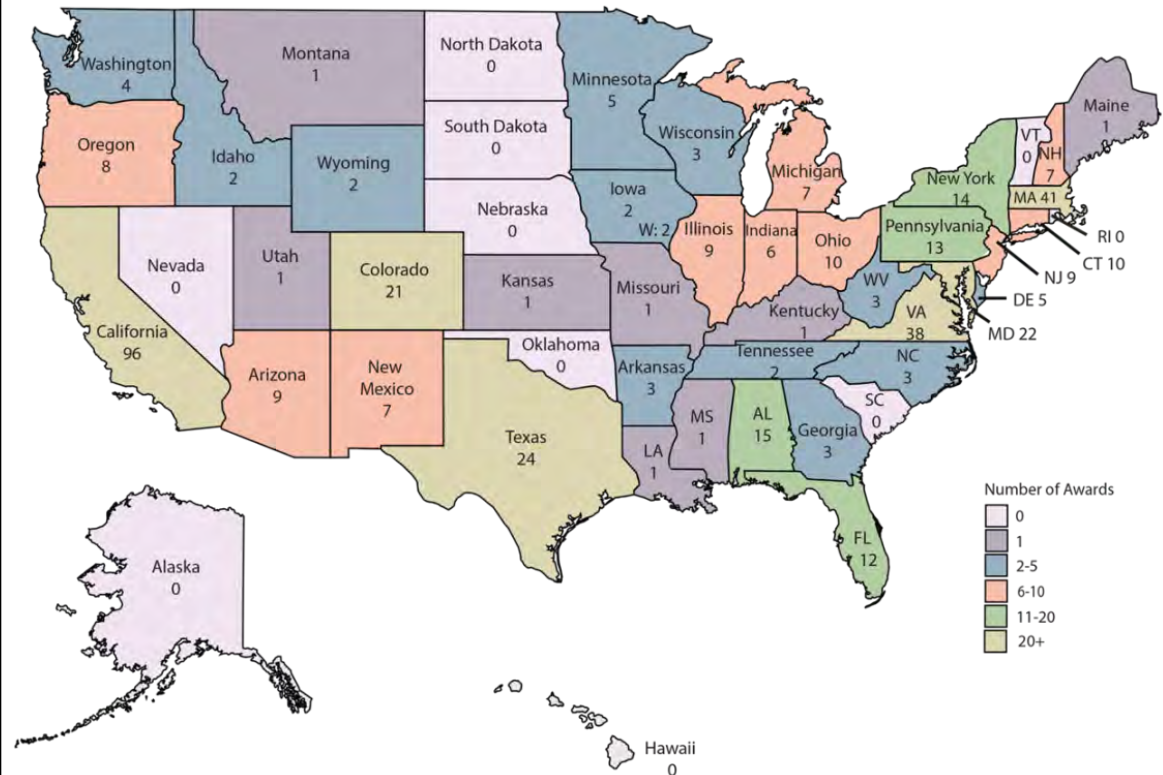
Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR)



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.

SBIR & STTR 2012 Awards (2011 Ph I, 2010 Ph II, 2008 Ph II Es)



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

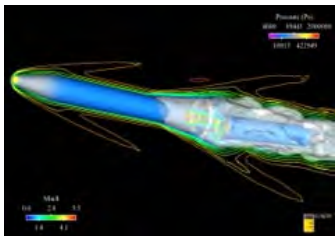
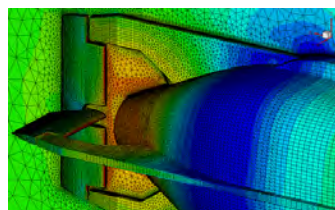


SBIR and STTR Successes



NASA funded small businesses contributed to Mars Science Lab:

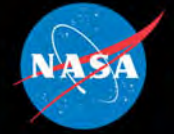
- GrammaTech, Inc.(Ithaca, NY) developed software for eliminating defects in mission-critical and embedded software applications directing rover operations. (image top right)
- Starsys Research, Inc. (Louisville, CO) developed planetary gearboxes for the articulated robotic arm and descent braking mechanism for controlling rate of descent to planetary surface.
- Create, 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)

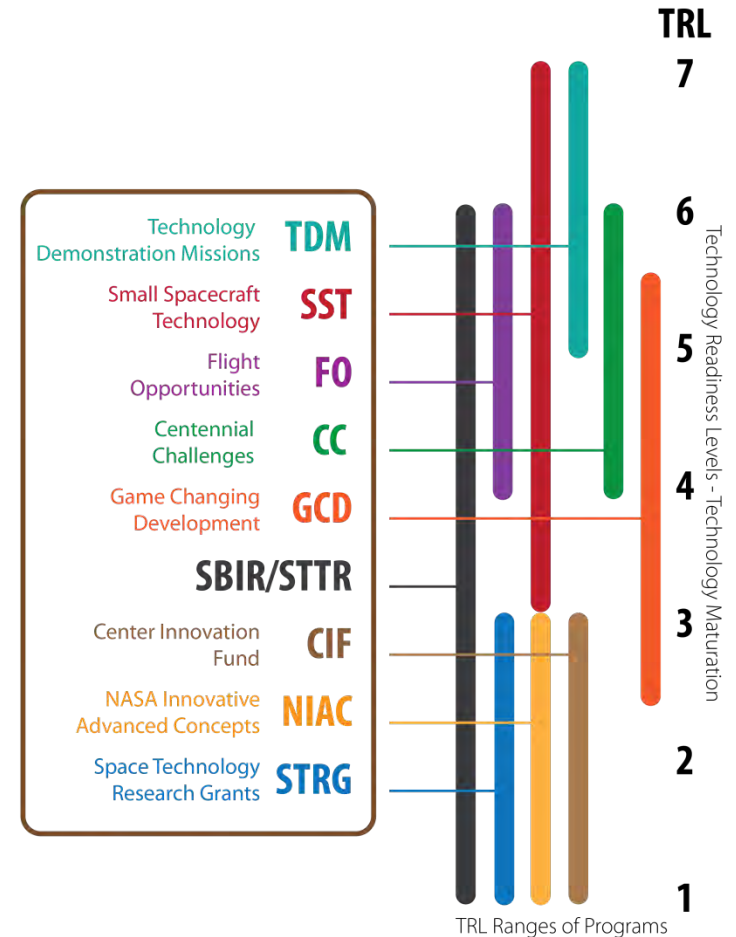
Crosscutting Space Technology Development



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



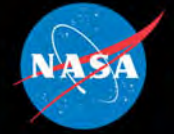
Edison Demonstration of Smallsat Networks

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



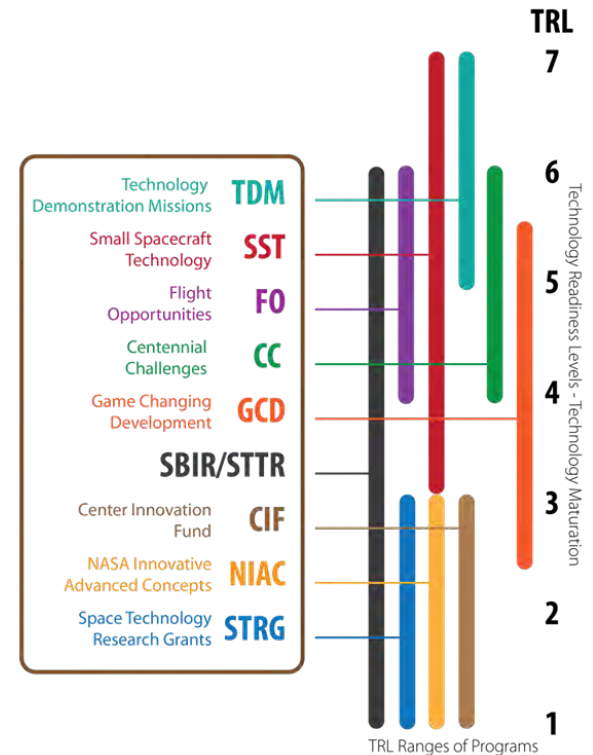
Flight Opportunities Commercial Access to Suborbital Space expects to use all providers for the first time in FY 2014, with approximately 30 flight campaigns based on payload demand

Exploration Technology Development



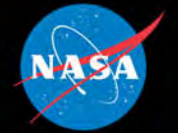
Develops technologies that **address breakthroughs** needed to achieve the Nation's human exploration goals.

- 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

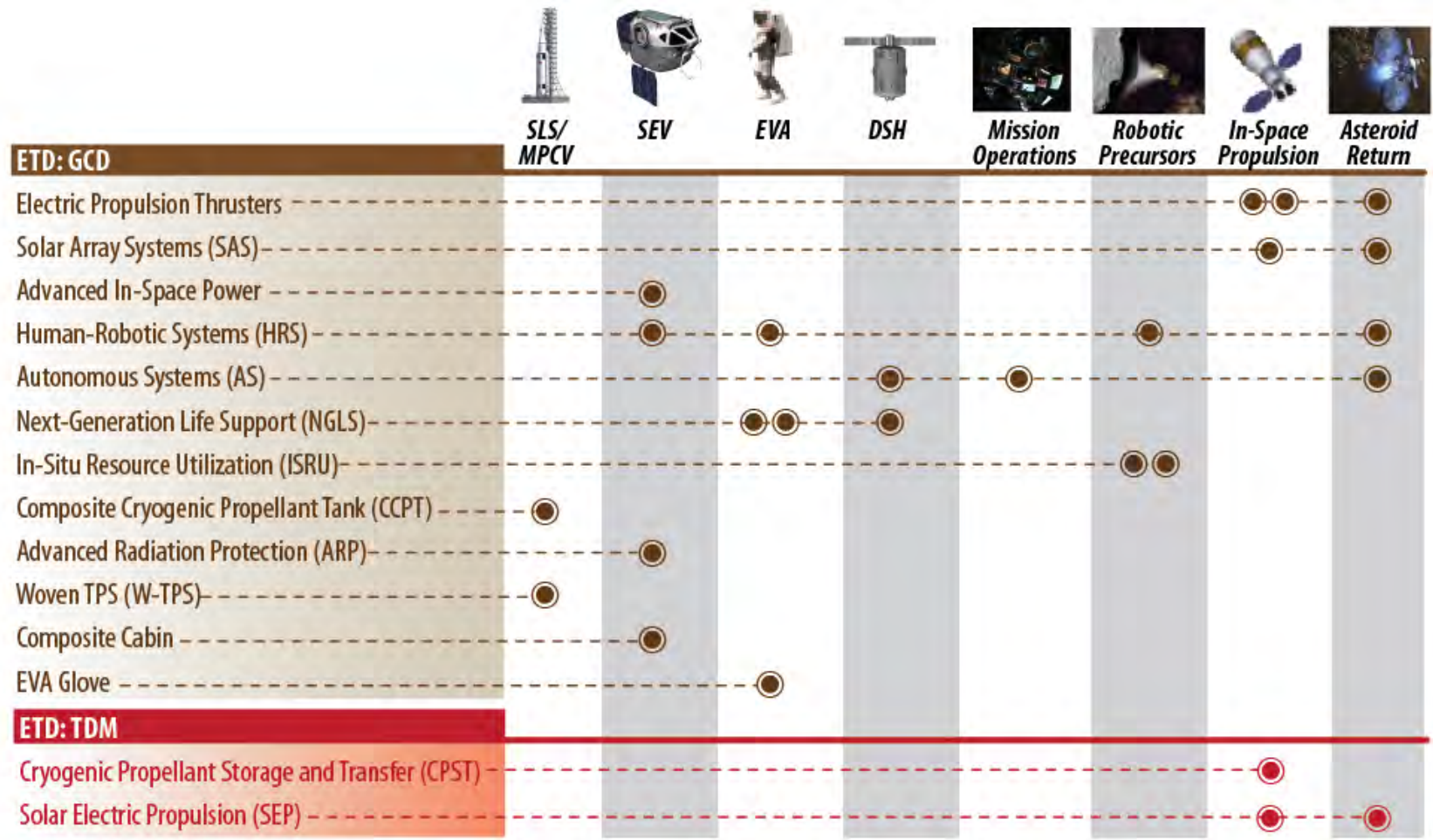




Exploration Technology Development

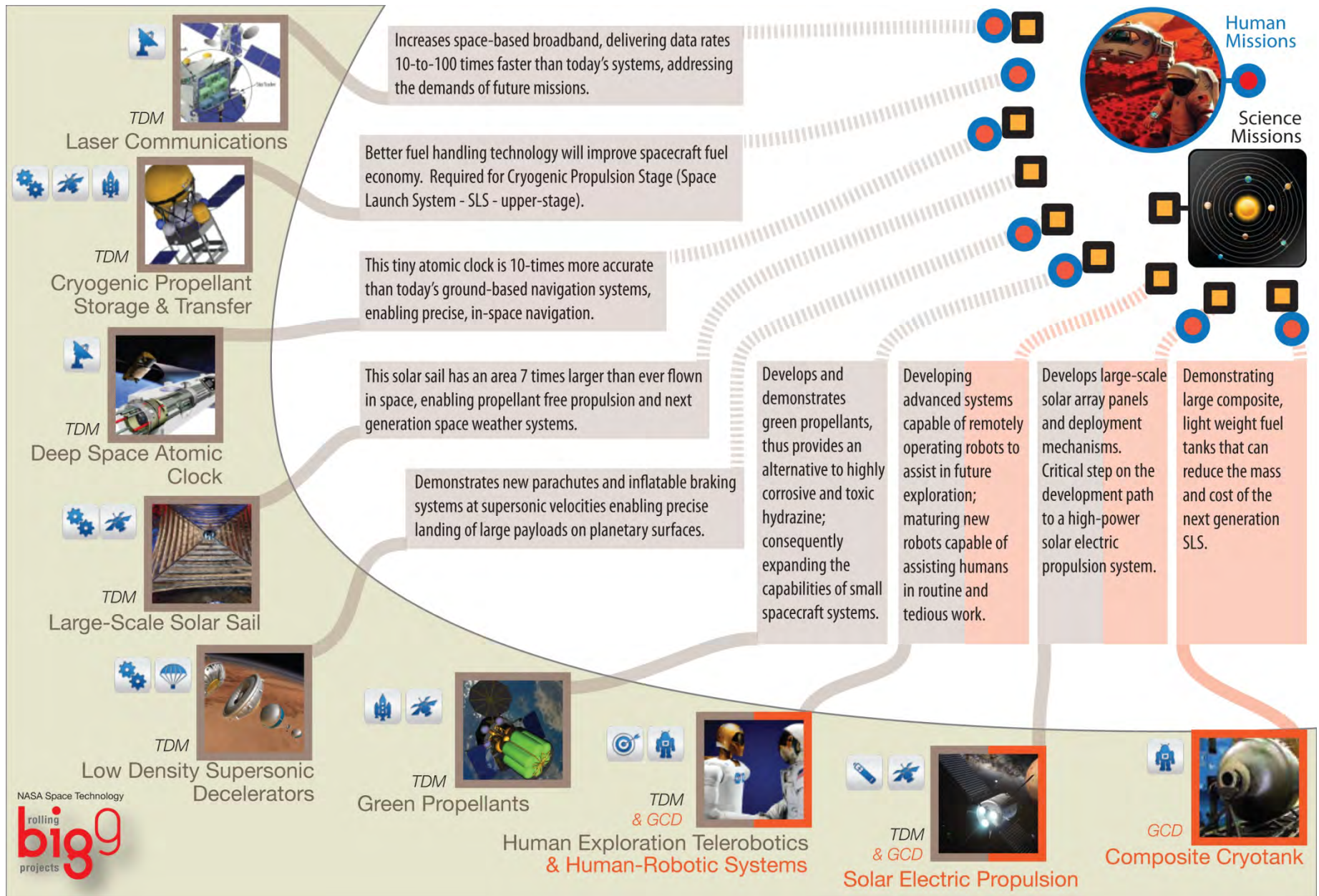


Infusion





FY2014 Big Nine



NASA Space Technology
rolling
big9
projects

Space Technology Major Events & Milestones

2012



HIAD
IRVE 3



Telerobotics



MEDLI

2013



Telerobotics



PhoneSat



Edison Demo
SmallSat

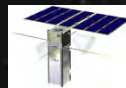
2014



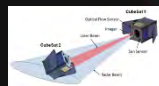
Solar
Sail



Telerobotics



ISARA

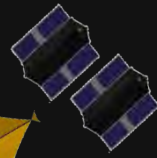


OCSD



Supersonic
Inflatable
Aerodynamic
Decelerator

2015



CPOD

Atomic
Clock



Green
Propellant



Supersonic
Inflatable
Aerodynamic
Decelerator

2016



Cryogenic
Propellant



SEP Demo
Mission

2018



Laser
Communications

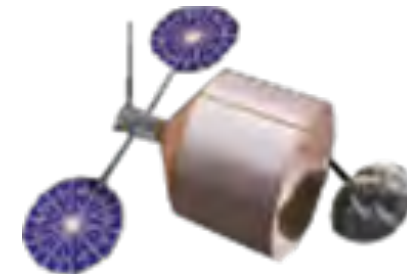
Future Planning



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

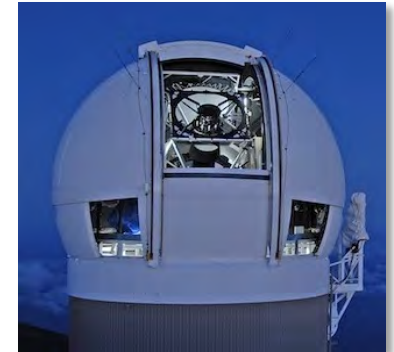


Space Tech Role in Agency Asteroid Strategy



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



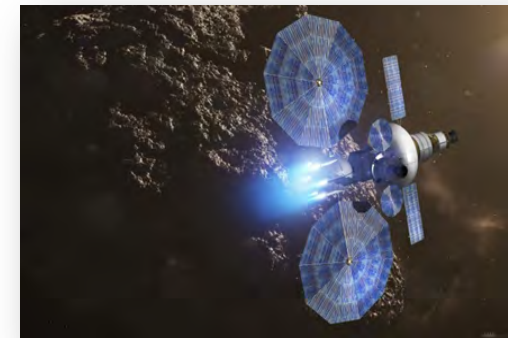
Game Changing will complete high power SEP tech development:

- 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:

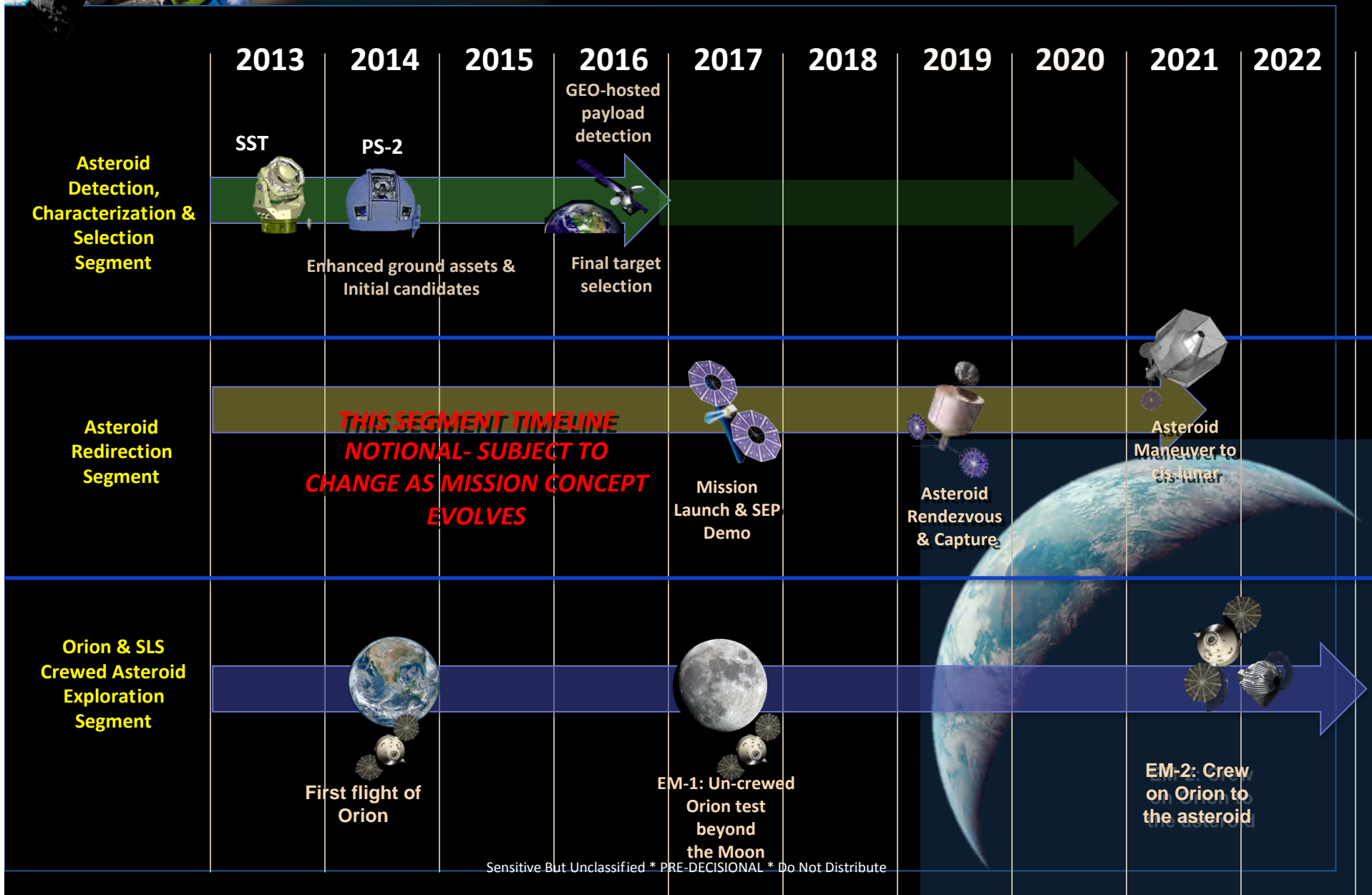
- 30kW – 50 kW advanced solar arrays
- Magnetically shielded Hall thrusters & Power Processing
- Xenon propellant tanks



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





Partnership Development and Strategic Integration

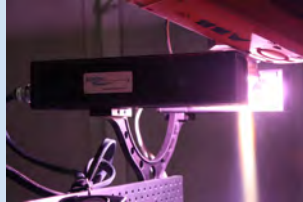


Extending the benefits of NASA's technology investments to have a direct and measurable impact on daily life.

- 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



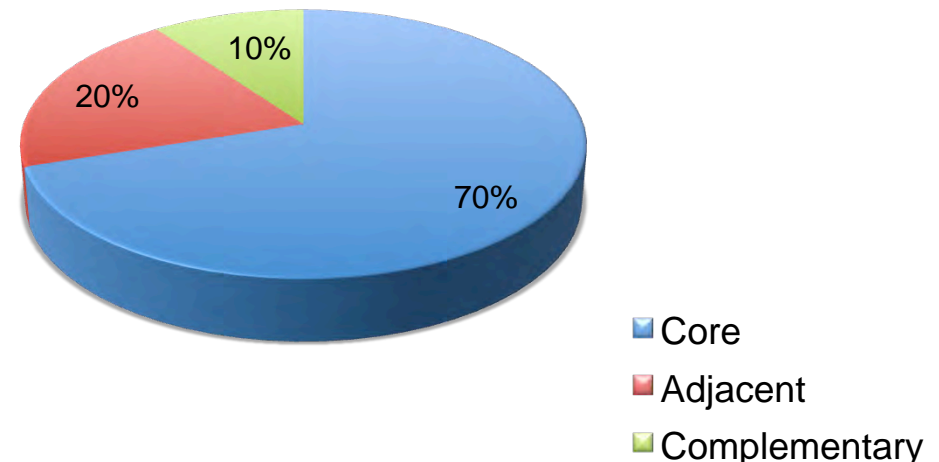
Strategic Investments in Technology



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



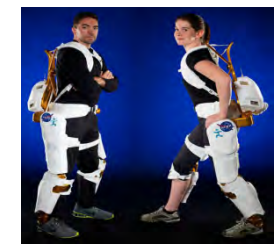
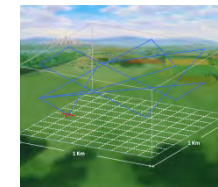
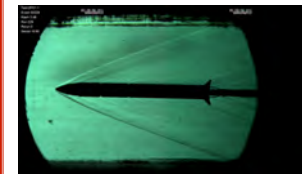
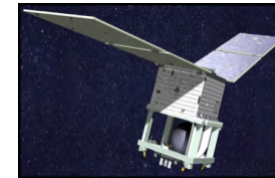
STMD investments are consistent with the Strategic Space Technology Investment Plan (SSTIP)

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





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.