

National Aeronautics and
Space Administration



Space Technology FY 2013

NAC Technology and Innovation
Committee Meeting

Michael Gazarik
Office of the Chief Technologist
March 6, 2012

Office of the Chief Technologist



Serves as Advisor to Administration



Direct Technology Management and Budget Authority for the Space Technology Program



Office of the Chief Technologist



Demonstrates and Communicates Societal Impacts of NASA Technology Investments



Advocates Externally NASA's R&D Programs



Integrates Technology Investment Across the Agency



Leads Tech Transfer, Partnerships and Commercialization Activities Across the Agency

Space Technology



In 2013, Space Technology will build, test and fly the technologies required for NASA's missions of tomorrow.

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



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

Space Technology FY 2013 President's Budget Request

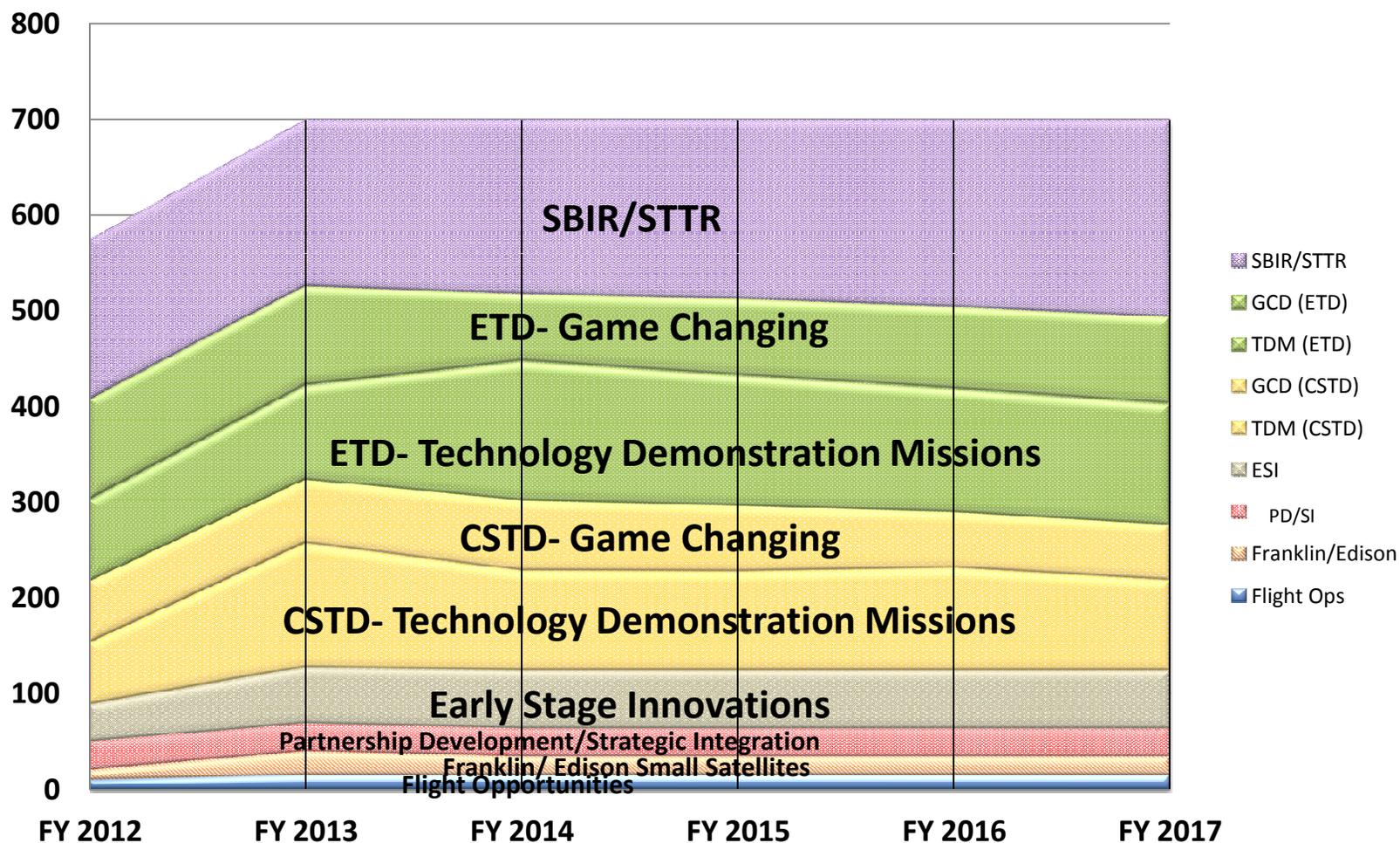


Budget Authority (\$M)	FY 2012	FY 2013	Notional			
	Appropriation		FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	573.7	699.0	699.0	699.0	699.0	699.0
<u>Partnership Development and Strategic Integration</u>	<u>29.5</u>	<u>29.5</u>	<u>29.5</u>	<u>29.5</u>	<u>29.5</u>	<u>29.5</u>
<u>SBIR/STTR</u>	<u>166.7</u>	<u>173.7</u>	<u>181.9</u>	<u>187.2</u>	<u>195.3</u>	<u>206.0</u>
<u>Crosscutting Space Technology Development</u>	<u>187.7</u>	<u>293.8</u>	<u>272.1</u>	<u>266.6</u>	<u>259.7</u>	<u>247.0</u>
Early Stage Innovation	39.8	59.0	61.0	61.0	61.0	61.0
CSTD Game Changing Technology	61.5	66.7	73.7	69.1	58.4	58.4
CSTD Technology Demonstration Missions	65.3	128.9	103.4	102.5	106.3	93.6
Edison/Franklin Small Satellites	11.2	24.2	19.0	19.0	19.0	19.0
Flight Opportunities	10.0	15.0	15.0	15.0	15.0	15.0
<u>Exploration Technology Development</u>	<u>189.9</u>	<u>202.0</u>	<u>215.5</u>	<u>215.7</u>	<u>214.5</u>	<u>216.5</u>
ETD Game Changing Technology	111.2	104.0	70.5	79.8	85.9	90.9
ETD Technology Demonstration Missions	78.7	98.0	145.0	135.9	128.6	125.6

Space Technology Budget Horizon



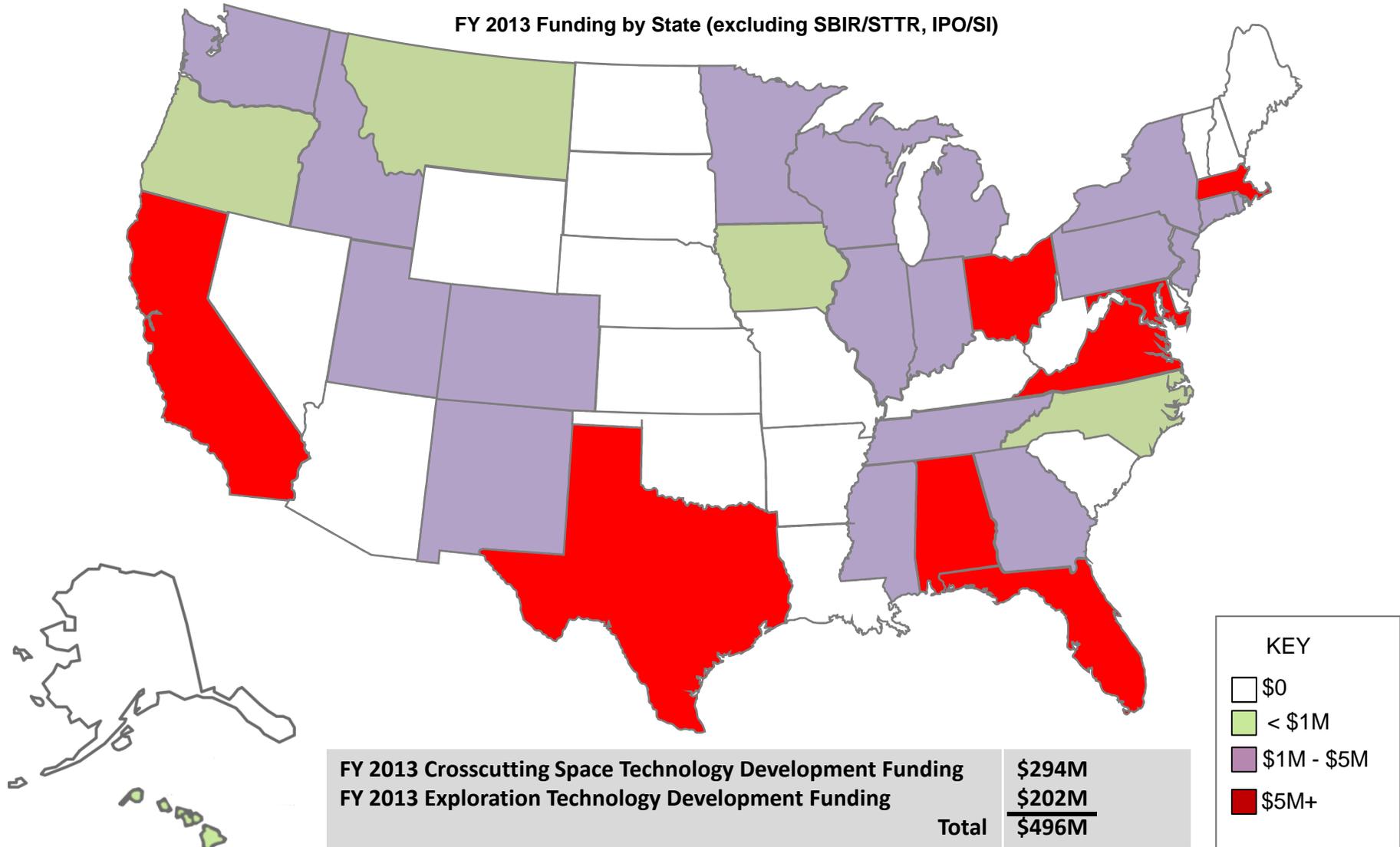
A modest increase above the FY 2012 Congressionally enacted level is required to support the current phasing profiles of on-going, priority Space Technology projects



Crosscutting Space Technology Development and Exploration Technology Development FY 2013 Funding



FY 2013 Funding by State (excluding SBIR/STTR, IPO/SI)



KEY	
	\$0
	< \$1M
	\$1M - \$5M
	\$5M+

The Ten Programs of Space Technology



Early Stage Innovation



Space Technology Research Grant Program



NASA Innovative Advanced Concepts (NIAC) Program



Center Innovation Fund Program



Centennial Challenges Prize Program

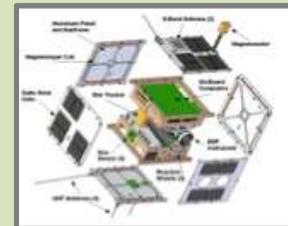


Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Program

Game Changing Technology



Game Changing Development

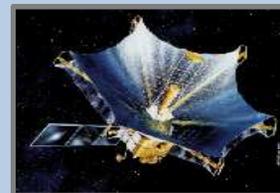


Franklin Small Satellite Subsystem Technology

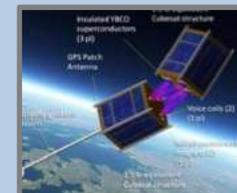
Technology Capability Demonstrations



Flight Opportunities



Technology Demonstration Missions



Edison Small Satellite Demonstration Missions



FY 2011 Competitive & Protest Free Selections

- **NIAC** selected 30 advanced concept proposals from hundreds of submittals. Addresses early-stage concepts address challenging problems in space operations research and development.
- **STRF** selected inaugural class of 80, highly-qualified and talented graduate students from 37 universities and colleges.
- **Green Flight Challenge:** 14 teams registered for competition. Three teams met requirements and competed. First prize of \$1.35M awarded to Pipistrel-USA.com. Second place prize of \$120,000 awarded to team eGenius.
- **SBIR:** -Awarded 450 SBIR Phase 1 awards across 37 states - Awarded 215 SBIR Phase 2 awards across 35 states
-Awarded 24 SBIR Phase 2E awards
- **STTR:** - Awarded 45 STTR Phase I awards across 15 states - Awarded 27 STTR Phase II awards across 18 states
- **Game Changing Development** is soliciting proposals for research and technology development for revolutionary improvements in America's space capabilities. Initial selections:
 - Lightweight Composite Cryogenic Propellant Tank – Boeing
 - Ultra-high energy density Silicon Nanowire Lithium Ion Batteries – Amprius
 - Ride the Light (Formulation Phase) – 9 companies/universities
- **Flight Opportunities** selected seven companies to integrate and fly technology payloads on commercial suborbital reusable platforms. The seven companies receiving IDIQ contracts are:
 - Armadillo Aerospace; Near Space Corp; Masten Space Systems; Up Aerospace; Virgin Galactic; Whittinghill Aerospace; XCOR.
 - Flight Opportunities made 25 Suborbital/Parabolic Payload Selections
- **Technology Demonstration Mission** proposals were sought in four areas:
 - High-bandwidth deep space communication, navigation and timing; orbital debris mitigation or removal systems; advanced in-space propulsion systems; autonomous rendezvous, docking, close proximity operations and formation flying
 - Selected three proposals for award: Solar Sail (L'Garde); Deep Space Atomic Clock (JPL); Laser Communications Relay Demo (GSFC)



Space Technology Status



- Space Technology included in NASA Authorization Act of 2010
- Space Technology Program account (STPX) created and appropriated in FY 2012 at \$575M
- The Space Technology Program formulated a “Portfolio” with 10 programs:
 - combination of new programs and existing programs
 - combination of directed and new, competitively selected content
 - transitioned from ~400 FTE in FY 2011 to ~900 FTE in FY 2012
- Portfolio Commitment Agreement (PCA) signed August 2011
- Released 5 Space Technology Solicitations from Dec 2011- Feb 2012 include:
 - Space Technology Research Grants
 - Game Changing Technology
 - Technology Demonstration Missions
 - Edison Small Satellites
 - NASA Innovative Advanced Concepts
- Established processes – OCT Program Management Council
- Executing over 1000 projects

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



- **PROGRAM:** Stimulate technological innovation and support NASA's innovative research to develop technologies for NASA projects while spurring economic growth through commercialization.
- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
 - Selected 260 SBIR Phase 1 proposals selected across 37 states and 85 SBIR Phase 2 proposals selected across 26 states*
 - Selected 40 STTR Phase I proposals selected across 18 states*
 - STTR Phase 2 selections expected in April 2012
 - Expect to award Phase 2E awards in FY 2012
 - Working with Small Business Administration (SBA) to assess implementation of new requirements in recent SBIR/STTR Reauthorization. Expecting Policy Guidelines from SBA in accordance with schedule from reauthorization.



*Selections still undergoing contract negotiations



Highlights of Recent Selections

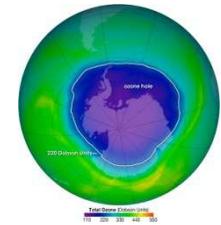
- SBIR/STTR Phase 1 Selections

- Improved technologies related to in-flight airframe and engine icing hazards for piloted and drone vehicles to prevent encounters with hazardous conditions and the mitigation of their effects when they occur
- Design of electronics, hardened for radiation and thermal cycling, which are capable of enduring the extreme temperature and radiation environments of deep space, the lunar and Martian surface
- Development of small, low-cost remote sensing and in situ instruments to enable science measurement capabilities with smaller or more affordable spacecraft that meet multiple mission needs while making the best use of limited resources
- Innovative research in the areas of positioning, navigation and timing that will enable accurate and precise determination of location and orientation of spacecraft to allow corrections to course, orientation and velocity to attain a desired destination



- SBIR Phase 2 Selections

- Development of design and fabrication techniques that will be used to create better UV detectors useful to NASA's missions to monitor ozone, aerosols, and air pollution, which also are essential in the semiconductor, food processing, and healthcare industries, where bacterial sterilization is important.
- New composite material manufacturing process which could decrease manufacturing costs for NASA's future heavy lift launch vehicles, as well as for military and commercial aircraft, wind blades and towers, civil and automotive infrastructure and marine vessels.
- New high performance lubricants beneficial to robotic spacecraft operations in extreme temperature ranges that also may benefit automobile performance
- A laser ranging technology that can be used as the next generation air data system for aircraft that will measure velocity, wind speed, air pressure and temperature. This will help to predict turbulence, ensuring a safer and more comfortable flight.





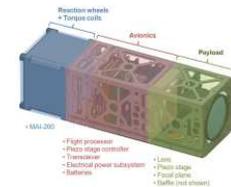
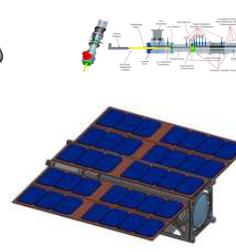
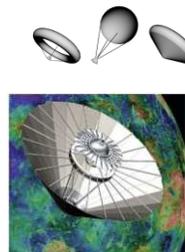
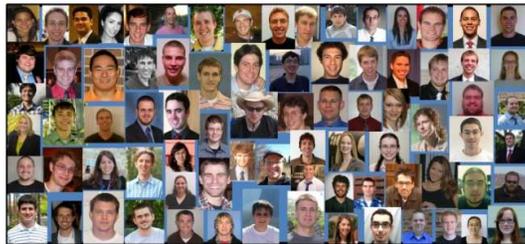
Space Technology Research Grants Program Overview

PROGRAM: To accelerate the development of push technologies through innovative efforts with high risk/high payoff and develop the next generation of innovators through:

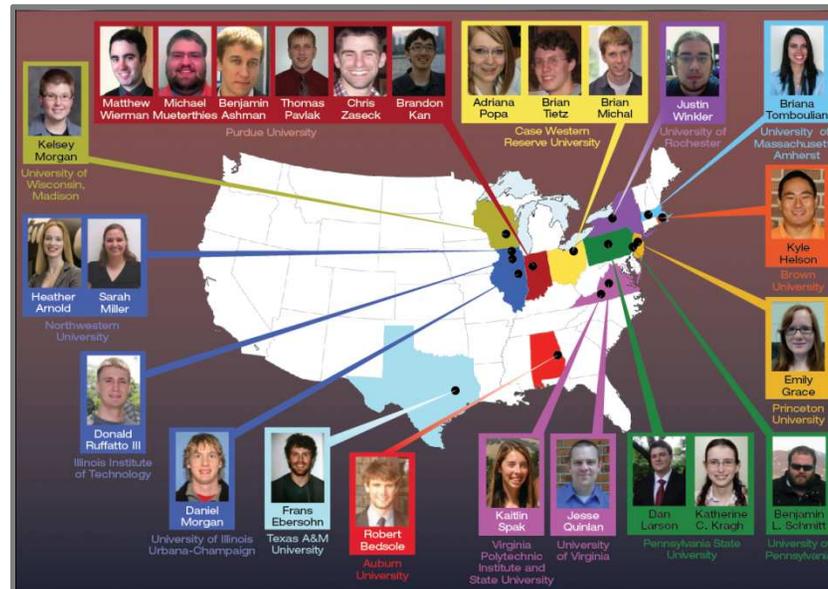
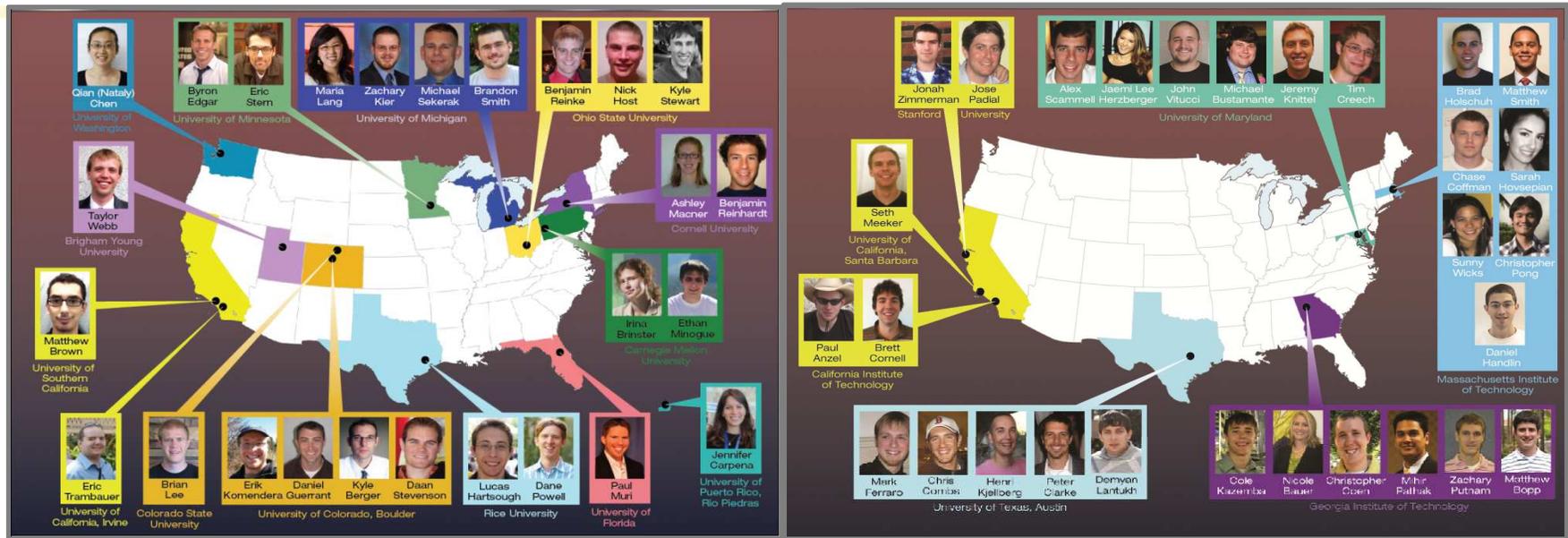
- **Space Technology Research Opportunities – Early Stage Innovation (STRO-ESI):** technology portfolio of groundbreaking research in advanced space technology
- **NASA Space Technology Research Fellowships (NSTRF):** Competitive selection of U.S Citizen / permanent resident graduate students developing promising technologies in support of future NASA missions and strategic goals

ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):

- STRO-ESI: One year awards with possible renewals; ~\$200K/year
- NSTRF: 80 Fellows in inaugural class; NSTRF12 class will be announced ~ August 2012



NSTRF Inaugural Class Student Fellowship FY 2011



Center Innovation Fund and NASA Innovative Advanced Concepts (NIAC) Program Overview



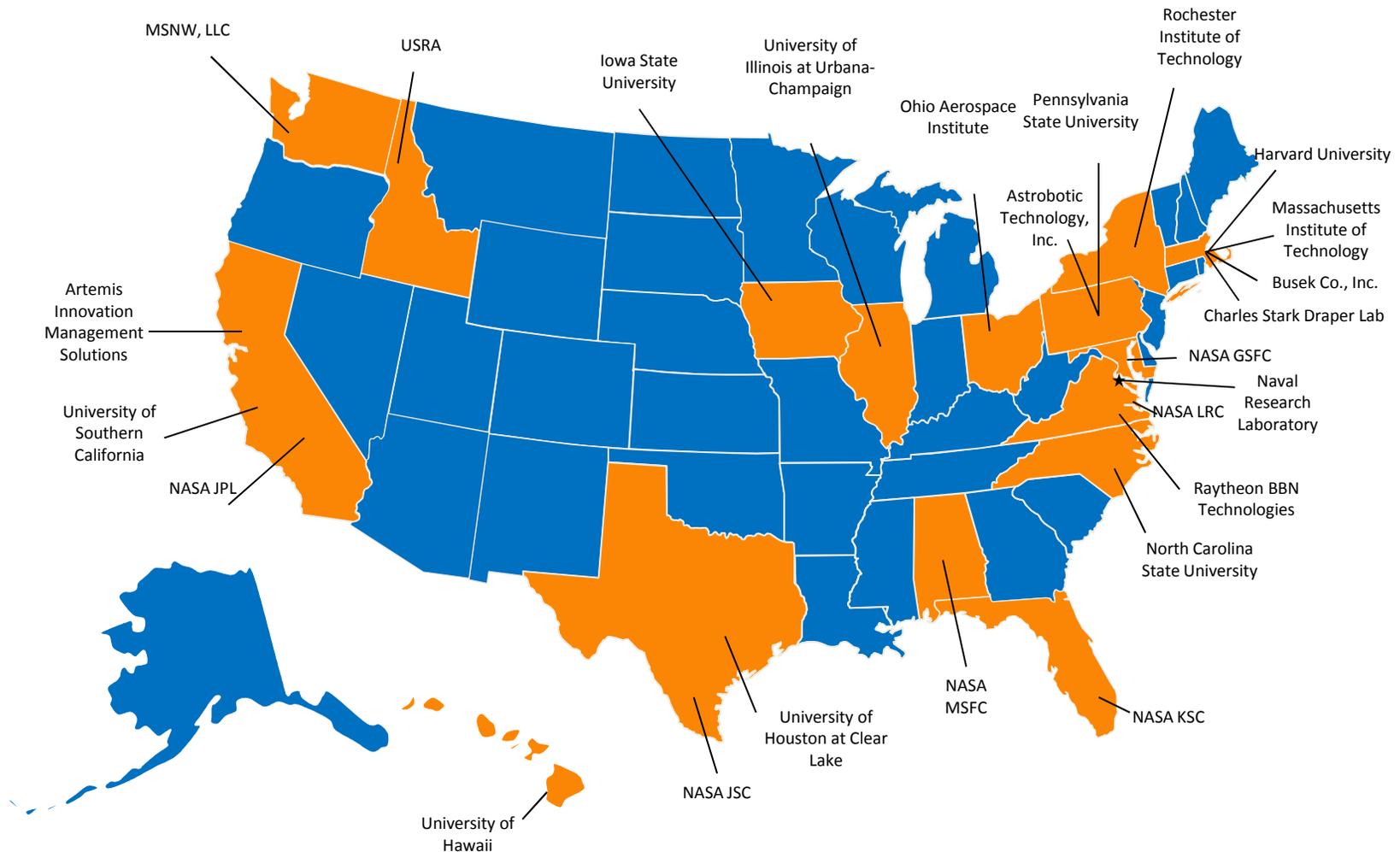
- **PROGRAM:** The objective of the **Center Innovations Fund (CIF)** is to stimulate and encourage creativity and innovation from within the NASA Centers. Distributed among the NASA Centers, this program will provide seed funding for new technologies, innovations and creative ideas. These funds will allow Centers to support low TRL innovative technology initiatives that leverage Center talent and capability.
- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
 - In FY 2011 150 Projects and studies were selected and implemented.
 - In FY 2012 CIF Selections of projects will be completed by March 1.
- **PROGRAM: NASA Innovative Advanced Concepts (NIAC)** funds early studies of visionary, long term concepts - aerospace architectures, systems, or missions (not focused technologies). The intended scope is very early concepts: Technology Readiness Level 1-2 or early 3; 10+ years focus
- **ACCOMPLISHMENTS/ MILESTONES (2012-2013):**
 - Jan 9 -- NIAC Phase I NRA released
 - March 27-29 -- NIAC Spring Symposium in Pasadena, CA
 - April 3 -- NIAC Phase II NRA released
 - July -- announce Phase I and II selections
 - Sept 1 -- FY12 studies (Phase I and II) commence
 - Sept 30 -- FY11 final reports due



NIAC: Funding Innovation across the Nation



Exploring new concepts to expand aerospace possibilities



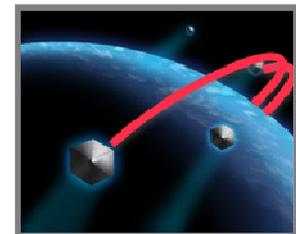
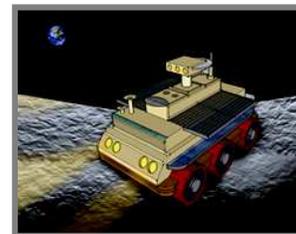


Centennial Challenges

PROGRAM: The Centennial Challenge Program (CCP) directly engages non traditional sources advancing technologies of value to NASA's missions and to the aerospace community. CCP offers challenges set up as competitions that award prize money to the individuals or teams to achieve the specified technology challenge.

ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):

- Green Flight Challenge awarded the largest ever aviation prize for demonstration of over 400 mpg energy efficiency in a full scale, piloted, electric powered aircraft.
- Sample Return Robot Challenge will host a competition in June 2012 to demonstrate a that a robot that can locate and retrieve geologic samples from a wide and varied terrain without human control.
- In FY 2013 the Night Rover Challenge will have a competition to demonstrate a high energy density storage systems that will enable a rover to operate throughout lunar darkness cycle and the Nano-Satellite Challenge will have competitions to demonstrate placement of at least one small satellite into Earth orbit, twice within one week.

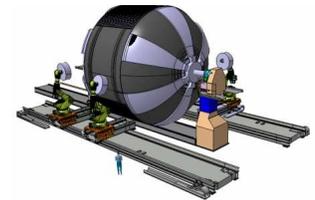


Game Changing Development (GCD) Program Overview



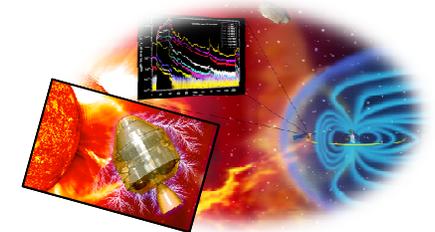
PROGRAM

- To identify and rapidly mature innovative/high impact capabilities and technologies that may lead to entirely new approaches for the Agency's future space missions.
- The program will investigate novel ideas and approaches that have the potential to revolutionize future space missions.



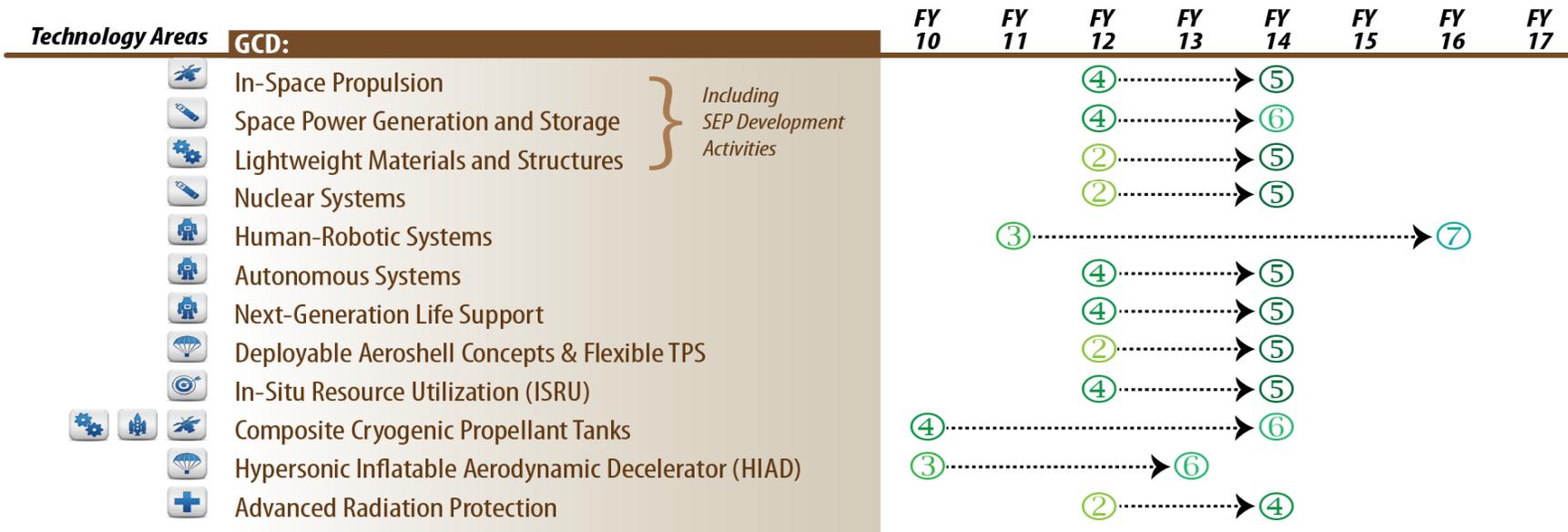
MILESTONES/ACCOMPLISHMENTS FY2012-2013

- **Composite Cryotank Technologies and Demonstration (CCTD):**
 - Develop 2m-diameter Composite Cryotank Fabrication
 - Conduct 2m-diameter Composite Cryotank Pressure Testing at NASA MSFC
 - Test 5m-diameter Composite Cryotank at liquid hydrogen temperatures, under load at NASA MSFC
- **Hypersonic Inflatable Aerodynamic Decelerators (HIAD):**
 - Suborbital flight demonstration test of IRVE-3 at Wallops Flight Facility – May 2012
 - Conduct Next Generation Wind Tunnel Tests & 8ft. Wind Tunnel Tests at NASA LaRC
 - Conduct National Full-Scale Aerodynamics Complex, NFAC-2 testing at NASA ARC
 - Conduct 6 meter Large Core Arc Tunnel (LCAT) testing with packed coupons at Boeing
- **Human Robotic Systems (HRS):**
 - Integrate NASA-ARC developed navigation software on NASA-JSC-based Centaur Rover
 - Complete Rover Ballistic Cannon assembly at NASA JSC
 - Ready for testing of the Next Generation Jet Pack Prototype at NASA JSC
 - Ready for testing of the Rover Ballistic Cannon and Free Flyer at NASA JSC





Game Changing Technology Areas

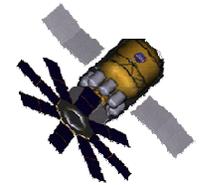
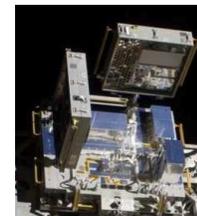
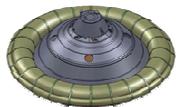
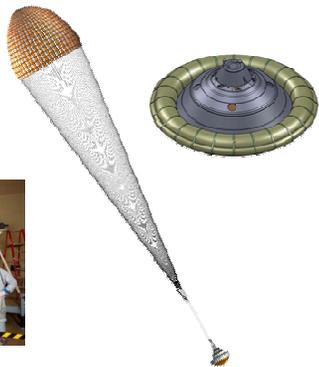


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|------------------------------|-------------------------|----------------------------------|---|
| Technology Areas (TA) | TA.4. Robotics | TA.8. Sci. Instr./Sensors | TA.12. Materials/Structures |
| TA.1. Launch Propulsion | TA.5. Comm./Navigation | TA.9. EDL | TA.13. Ground/Launch |
| TA.2. In-Space Propulsion | TA.6. Human Health | TA.10. Nanotechnology | TA.14. Thermal |
| TA.3. Space Power/Storage | TA.7. Human Expl. Dest. | TA.11. Modeling/Simulation | Technology Readiness Levels (TRL) ① → ⑨ |

Technology Demonstration Missions



- **PROGRAM:** The Technology Demonstration Missions (TDM) program provides demonstration opportunities, bridging the gap between early developments and mission infusion by maturing crosscutting, system-level, technologies through demonstration in a relevant operational environment.
- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**
 - Supersonic sled testing and parachute testing in the Low Density Supersonic Decelerator (LDSD) Project at China Lake
 - Multiple SPHERES and Robonaut demonstrations on ISS under the Human Exploration Telerobotics (HET) Project
 - Multiple Precision Landing/Hazard Avoidance flight tests on the Vertical Test Bed under Autonomous Landing Hazard Avoidance Technology (ALHAT) Project
 - Aerothermal data collection during Mars Science Lab Entry and Descent under the MSL Entry Descent and Landing Instrumentation (MEDLI) Project
 - Qualification testing of Solar Sail components and subsystems under the Solar Sail Demonstration (SSD) Project



Technology Demonstration Missions Projects Overview



Technology Demonstration	Lead	Team
Cryogenic Propellant Storage & Transfer (CPST)	GRC	GSFC, MSFC, KSC, ARC
Deep Space Atomic Clock (DSAC)	JPL	NASA HEOMD/SCaN
Laser Communications Relay Demo (LCRD)	GSFC	NASA HEOMD/SCaN, MIT LL
Solar Sail Demo Mission (SSD)	L'Garde	Micro Aerospace Solutions, NOAA
Low Density Supersonic Decelerators (LDSD)	JPL	GSFC, WFF, ARC, GRC SPF
Human Exploration Telerobotics (HET)	ARC	JSC, JPL
Materials on International Space Station Experiment – X (MISSE-X)	LaRC	ARC, GRC, JPL, JSC, KSC, MSFC, DoD STP, AFRL
Autonomous Landing & Hazard Avoidance Technology (ALHAT)	JSC	LaRC, JPL
MSL Entry, Descent, and Landing Instrumentation (MEDLI)	LaRC	JPL, ARC



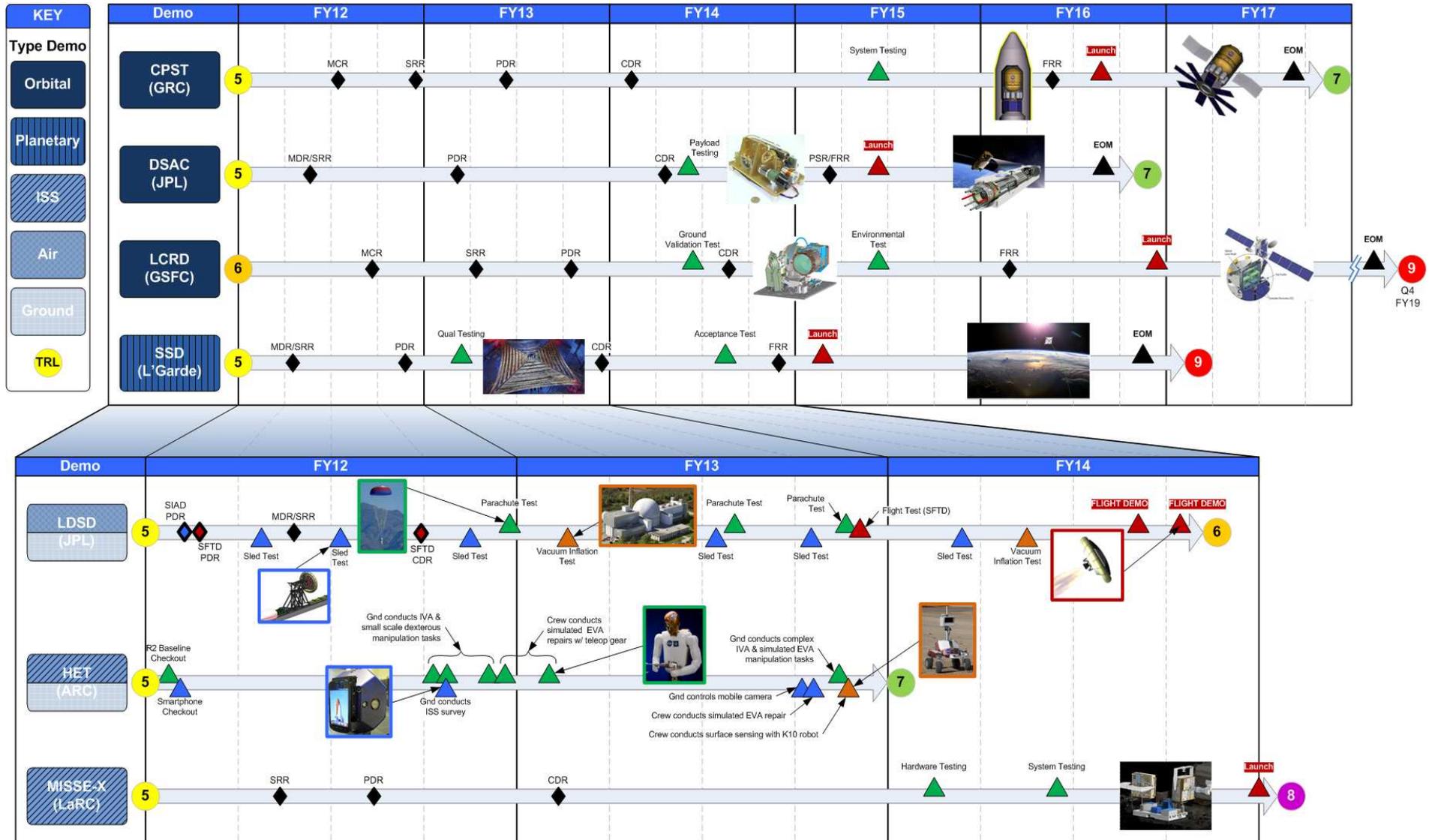
Technology Demonstration Missions Technology Areas



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| TA.3. Space Power/Storage | TA.7. Human Expl. Dest. | TA.11. Modeling/Simulation | Technology Readiness Levels (TRL) ① → ⑨ |

Technology Demonstration Missions

Major Events and Milestones



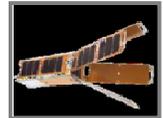
Edison Small Satellite Demonstration Missions and Flight Opportunities Program Overview



EDISON SMALL SATELLITE DEMONSTRATION MISSIONS PROGRAM: Low-cost flight demonstrations of new capabilities and technologies for small spacecraft.

- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**

- Preparing PhoneSat 1.0 for launch in Summer 2012 demonstrating use of commercial smart phones for onboard satellite navigation, control and communications
- Began development of EtherSat mission to demonstrate capabilities of satellite swarms for a range of missions projected launch in 2013
- Released open solicitation for proposed small spacecraft demonstration missions for communications, propulsion and proximity operations
 - Selecting projects for award in August 2012
 - 2 to 3 year projects, less than \$10 to \$15 million per project



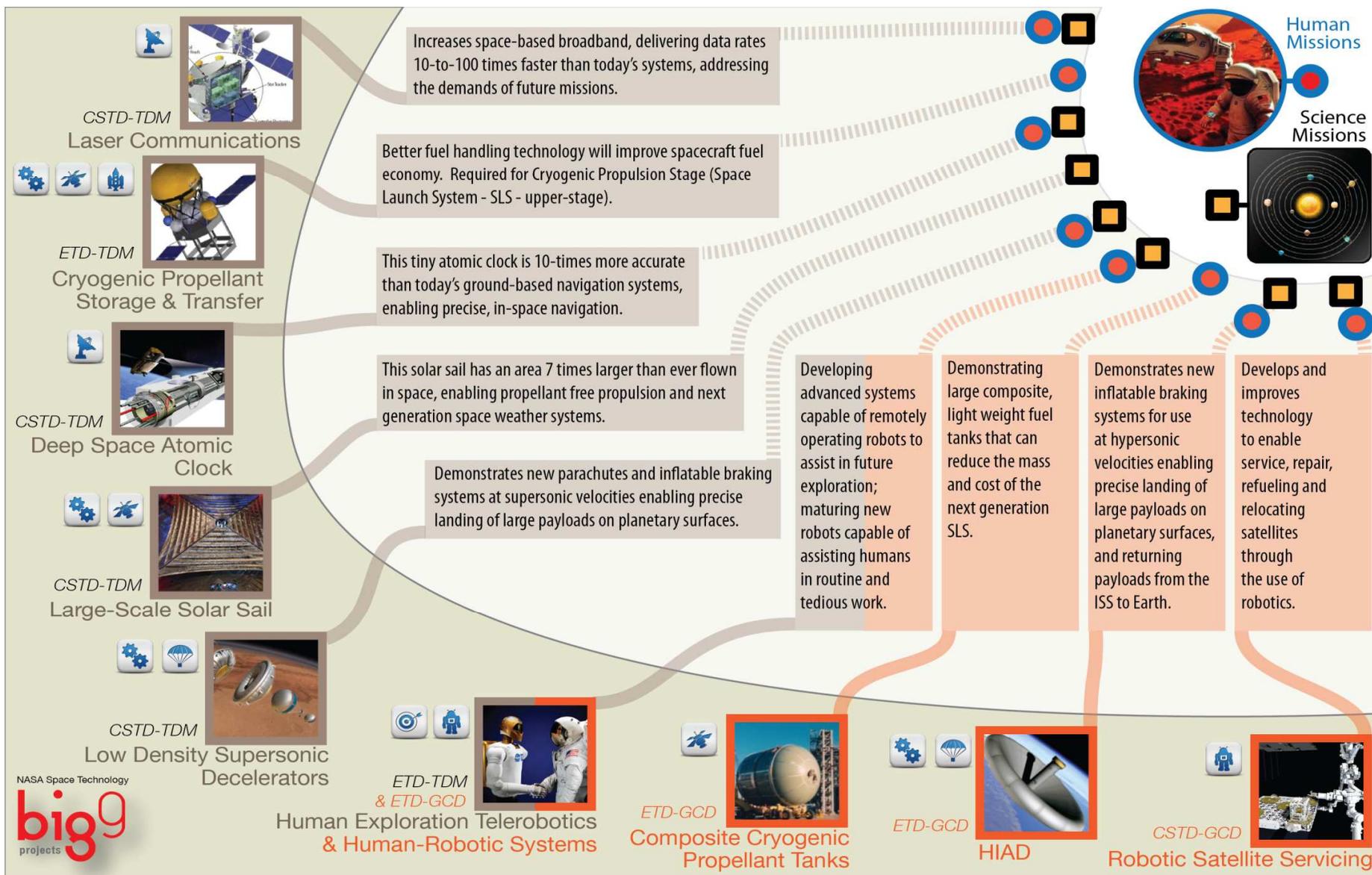
FLIGHT OPPORTUNITIES PROGRAM: Develops and provides opportunities for space technologies to be demonstrated and validated in relevant environments. Fosters the development of the commercial reusable suborbital transportation industry.

- **ACCOMPLISHMENTS/MILESTONES (FY 2012/2013):**

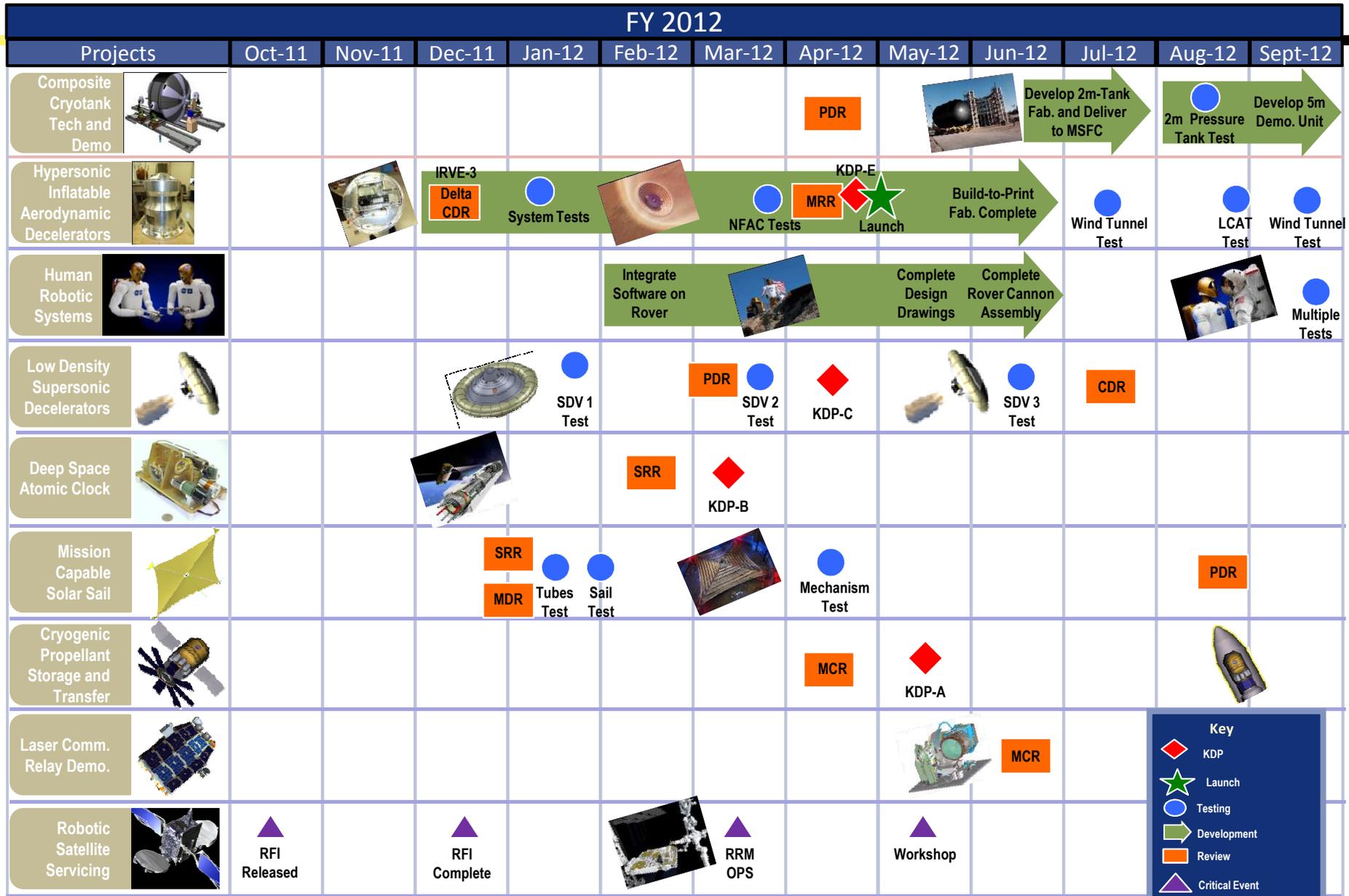
- Establishing a pipeline of technology payloads to utilize the anticipated commercial suborbital flight opportunities
 - Received 35 proposals for payloads in response to payload solicitation
 - Collaborating with Game-Changing Development Program to release NASA Research Announcement for payload development
- Planned commercial flight opportunities
 - Three Parabolic Flight Campaigns
 - Flights on Masten Space Systems, Near Space Corp, UP Aerospace, and Virgin Galactic
 - Qualification flights of Armadillo Aerospace, Whittinghill Aerospace, and XCOR Aerospace
- Formed Partnership with New Mexico Space Grants for flying Student Payloads
- Development of Commercial Vertical Testbed
 - Integration of Draper Labs Technology on Masten Space Systems' Vehicle
 - Successfully completed a free-flight demonstration



Big Nine Projects



"Big 9" FY 2012 Milestones



Key

-  KDP
-  Launch
-  Testing
-  Development
-  Review
-  Critical Event

NASA Space Technology: Building, Testing and Flying Technologies for Tomorrow



- **Space Technology is the central NASA contribution to a revitalized research, technology and innovation agenda for the Nation.**
- These investments will stimulate the economy and build our Nation's global economic competitiveness through the creation of new products and services, new business and industries, and high-quality, sustainable jobs.
- A renewed technology emphasis balances NASA's long-standing core competencies of research and technology, spaceflight hardware development, and mission operations.
- Across our Nation's universities and small businesses, the ten NASA Centers and U.S. commercial aerospace industry, Space Technology is engaging over a thousand technologists and innovators in our Nation that will develop and test cutting-edge technologies in the Nation's laboratories and test facilities to make a better life here on Earth, create jobs, and enable tomorrow's missions of discovery.
- By investing in high payoff, disruptive technology that industry cannot tackle today, Space Technology matures the technology required for NASA's future missions in science and exploration while proving the capabilities and lowering the cost of other government agencies and commercial space activities

“Don't let other countries win the race for the future. Support the same kind of research and innovation that led to the computer chip and the Internet; to new American jobs and new American industries.” - President Obama State of Union 2012- Jan. 24, 2012