National Aeronautics and
Space Administration

Overview of NASA's Space Technology Program

Venus Exploration Analysis Group

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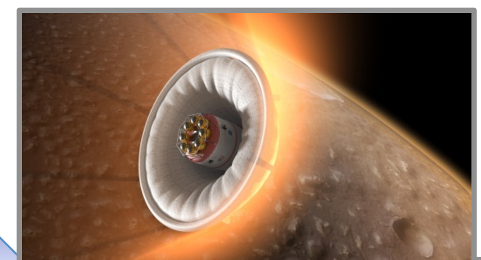
Space Technology: Investments in Our Future

- **Enabling Our Future in Space:** By investing in **high payoff**, **disruptive technologies** 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 for other government agencies and commercial space activities.
- **NASA at the Cutting Edge:** **Pushing the boundaries** of aerospace technology and seizing opportunities, *Space Technology* allows NASA and our Nation to remain at the cutting edge.



Space Technology Programs

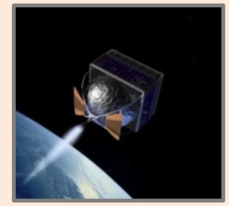
Transformative & Crosscutting Technology Breakthroughs

Pioneering Concepts/ Developing Innovation Community

Creating Markets & Growing Innovation Economy

Game Changing Development Program

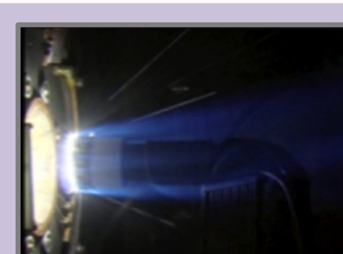
Technology Demonstration Missions Program



Small Spacecraft Technologies Program

Space Technology Research Grant Program

NASA Innovative Advanced Concepts (NIAC) Program



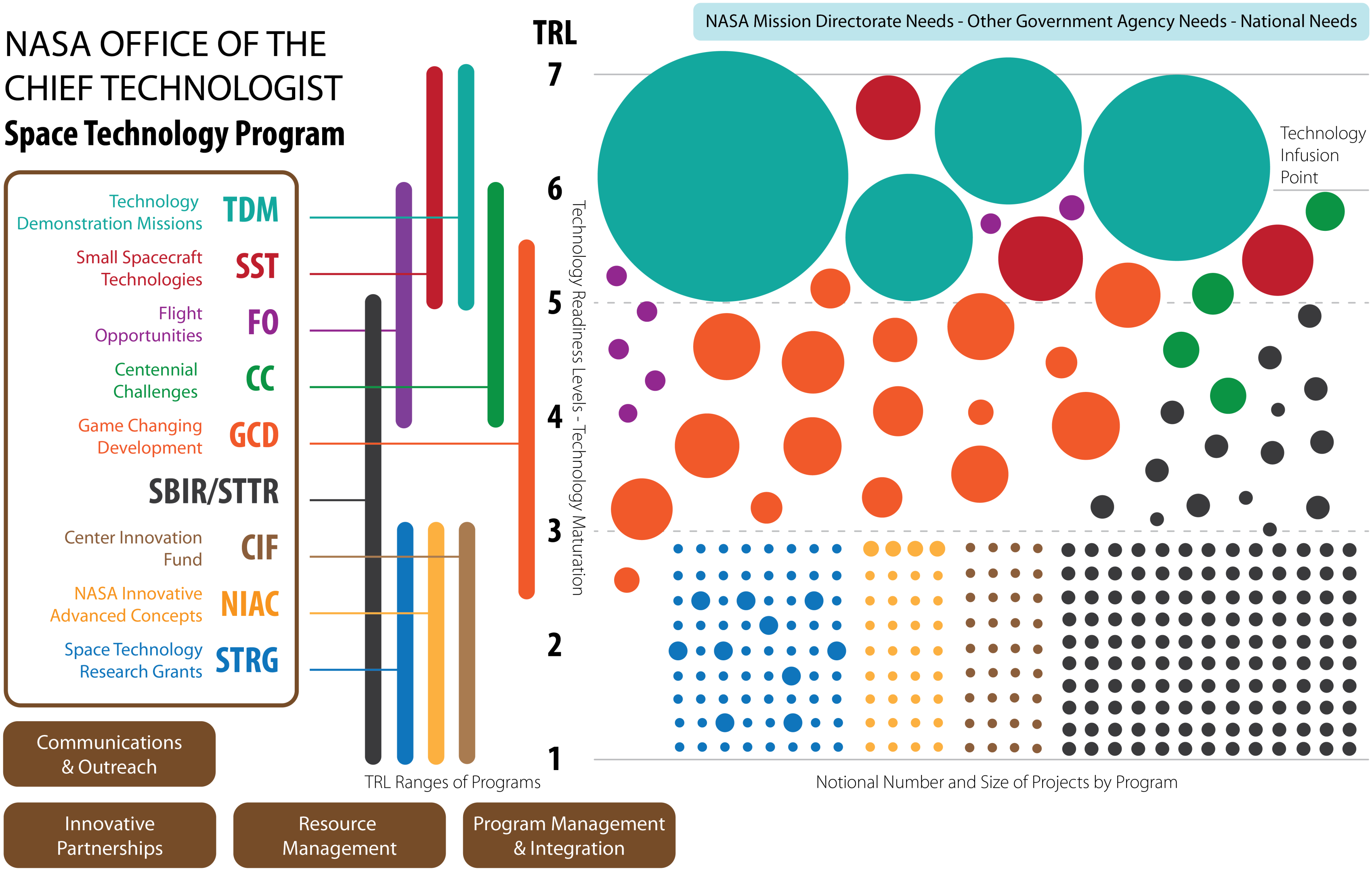
Center Innovation Fund Program

Centennial Challenges Prize Program

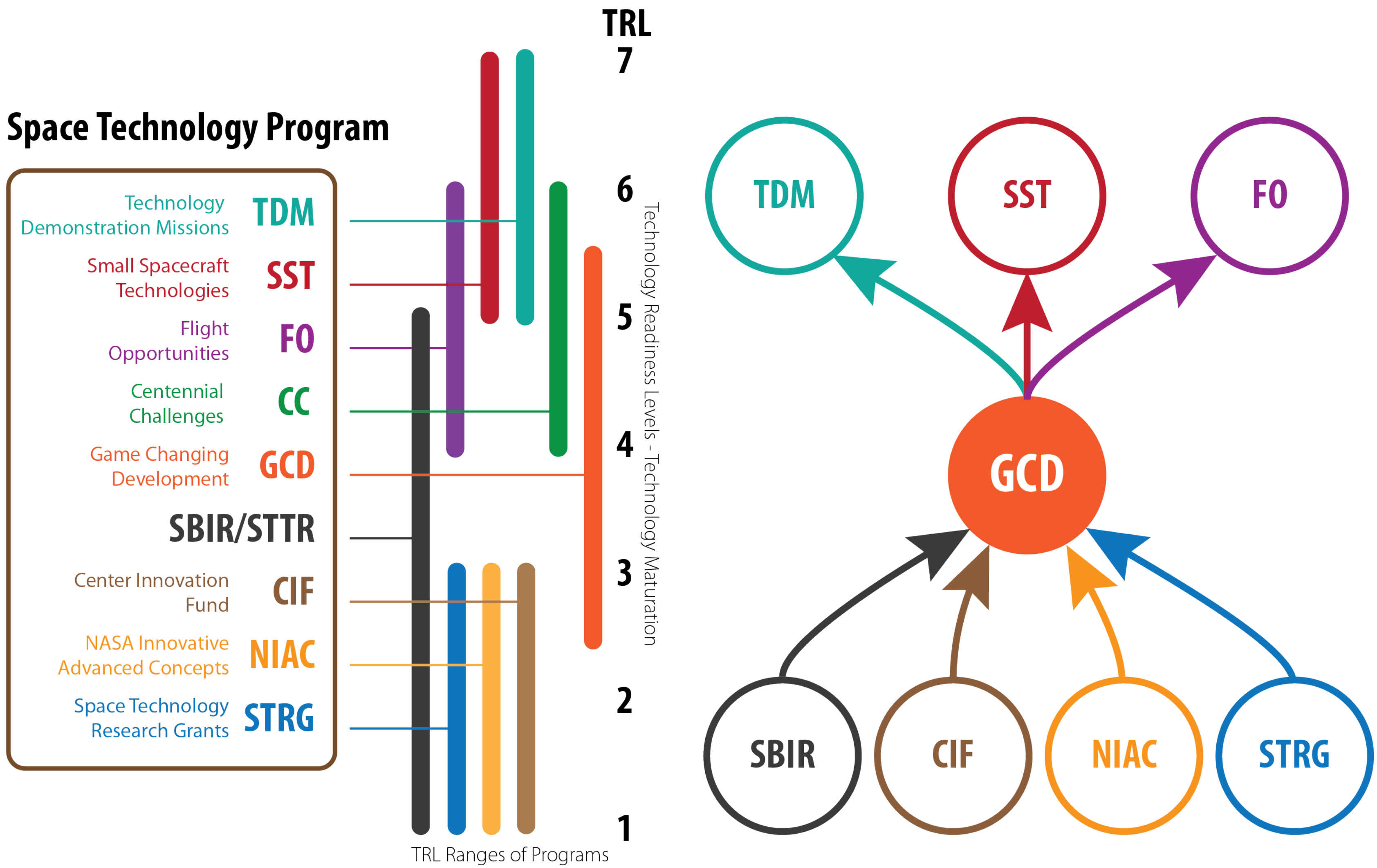
Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR) Program

Flight Opportunities Program

STP TRL Coverage



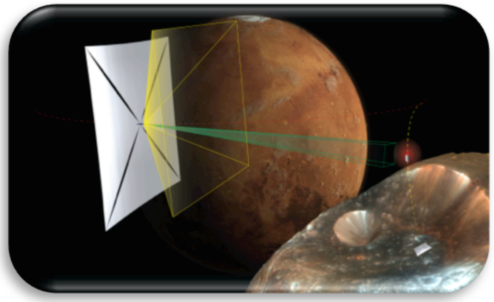
STP Pipeline and Infusion Patways

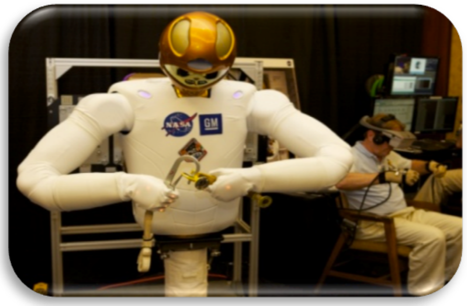


Guiding Principles of the Space Technology Program

Space Technology Program

- **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
- **Selects Using 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.
- **Infuses Rapidly or Fails Fast:** 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 Status

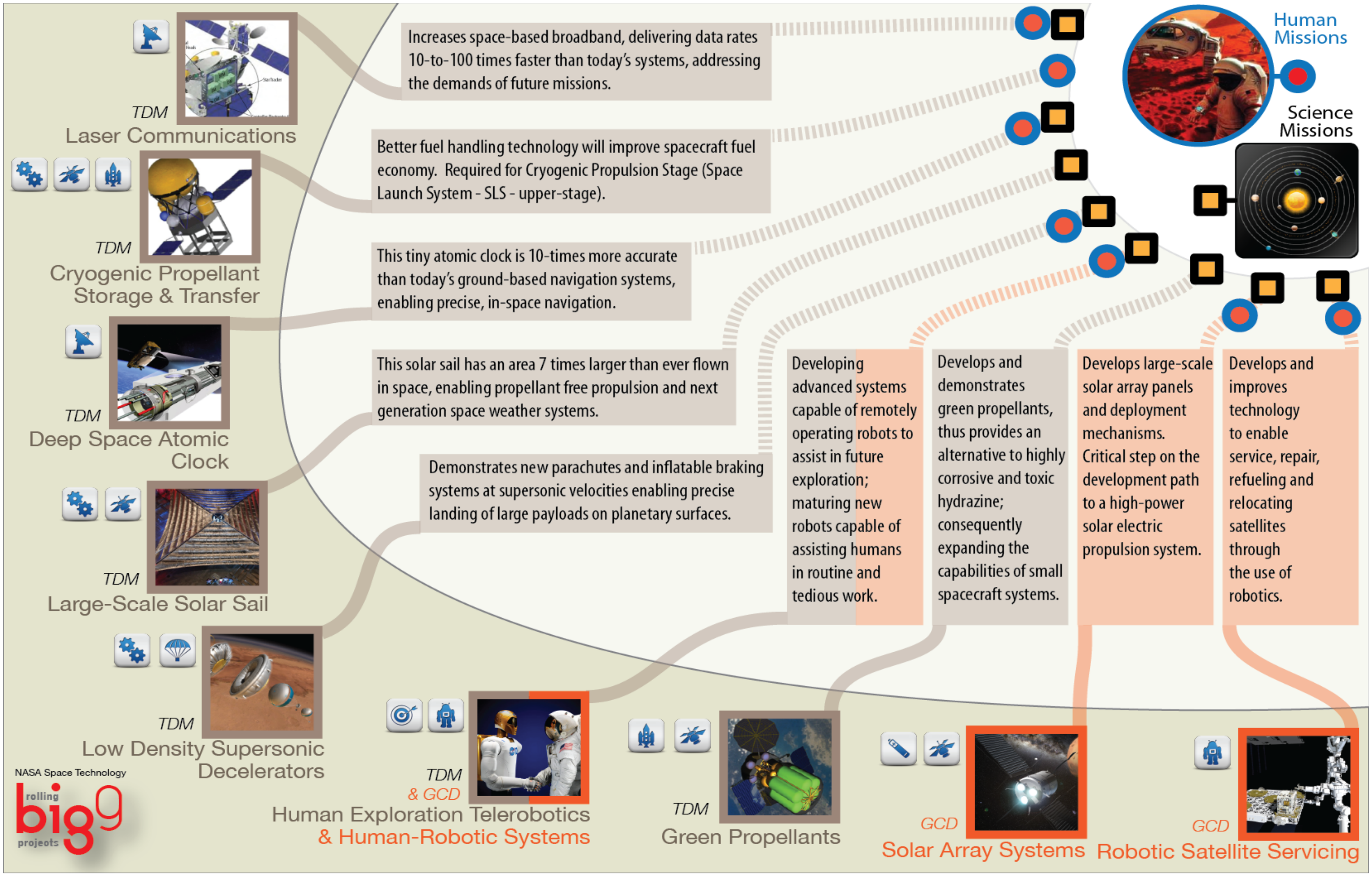
- **Space Technology included in NASA Authorization Act of 2010**
- **FY 2011 Operating Plan funded STP at approximately $350M**
- **FY 2012 Space Technology Program funded at $575M**
- **The Space Technology Program formulated a "Portfolio" with 9 programs:**
  - Combination of new programs and existing programs
  - Combination of directed and new, competitively selected content
  - Approximately 400 NASA employees in FY11; ~900 NASA employees in FY 2012
- **Portfolio Commitment Agreement signed August 2011**
- **FY2011 & FY2012 solicitations released**
- **Over 1000 projects in execution from continued projects & new awards**

30	NASA Innovative Advanced Concepts (NIAC)
80	Space Technology Research Grants (STRG) - Fellowships
~750	SBIR/STTR
~100	Center Innovation Fund (CIF)
2	Centennial Challenges
4	Small Spacecraft
23	Flight Opportunities (FO)
~34	Game Changing Developments (GCD)
9	Technology Demonstration Missions (TDM)

FY 2012 Solicitation Status

	FY 11 Status	FY 12 Solicitation Date	FY 12 Award Date	FY 12 # of awards
STRG Fellowships	80 awards made – all continuing	Nov 2011	Aug 2012	48
STRG Early Career Faculty	NA	Feb 2012	Sep 2012	10
STRG Early Stage Innovation	NA	May 2012	Oct 2012	~10
NIAC Phase I	30 awards	Feb 2012	Aug 2012	18
NIAC Phase II	NA	Mar 2012	Aug 2012	10
SBIR / STTR Phase I	450 / 45 awards	Jul 2011	Nov 2011	260 / 40
SBIR / STTR Phase II	239 / 27 awards	Jul 2011	Dec 2011	85 / 10
Centennial Challenges	Green aviation prize award	NA	Robotics Challenge Jun 2012	10 teams – no winner
FO Flight Services	7	NA	NA	NA
FO Payloads	16	Jun 2011 / Dec 2011	Oct 2011 / Mar 2012	9 / 24
GCD / FO Payloads	NA	Feb 2012	Jul 2012	14
Small Spacecraft	NA	Feb 2012	Aug 2012	3
GCD Unique & Innovative	1 award	open	Aug 2012	7
GCD Solar Array	NA	Apr 2012	Aug 2012	2
TDM Green Propellants	3 awards	Feb 2012	Aug 2012	1

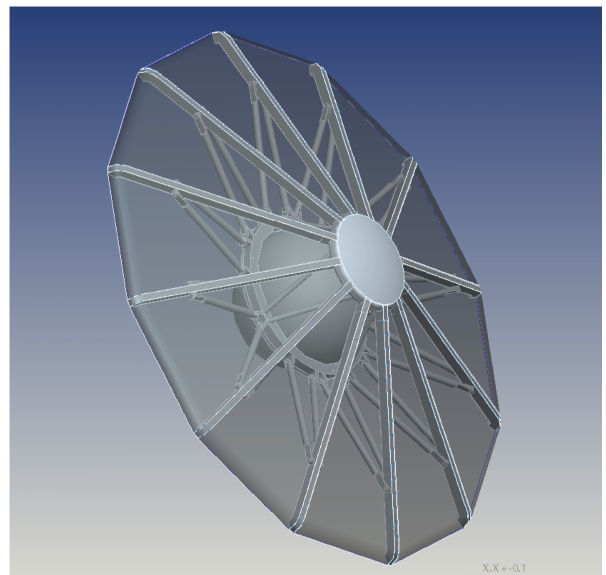
Rolling Big Nine Projects (FY2014)



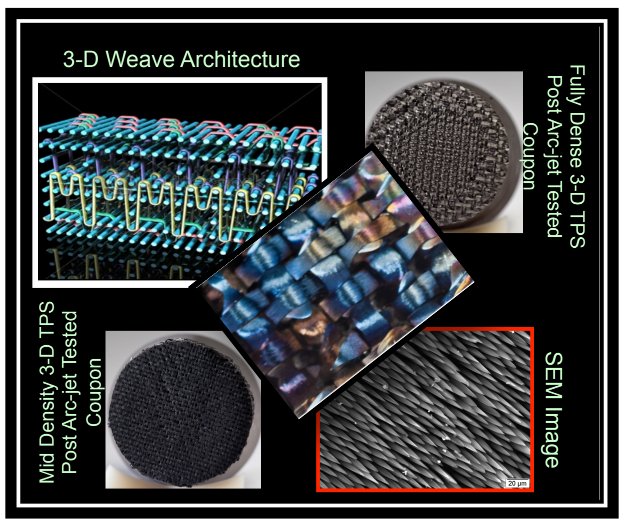
EDL Technologies

- HIAD – Hypersonic Inflatable Aerodynamic Decelerators

- DACC – Deployable Aeroshell Concepts – Conformal TPS



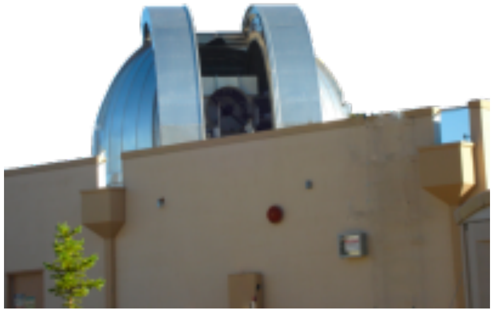
- Woven TPS



- Hypersonics

Laser Communications Relay Demonstration

Project Summary: The **Laser Communications Relay Demonstration** mission is NASA's **first, long-duration optical communications mission**. The project will help mature concepts and deliver technologies applicable to both near-Earth and deep-space communication network missions.

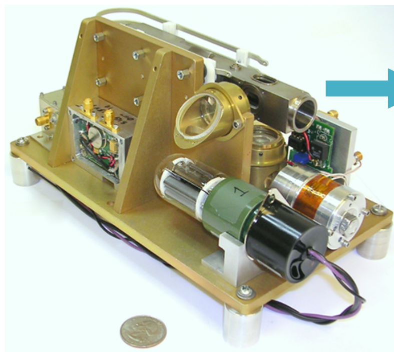


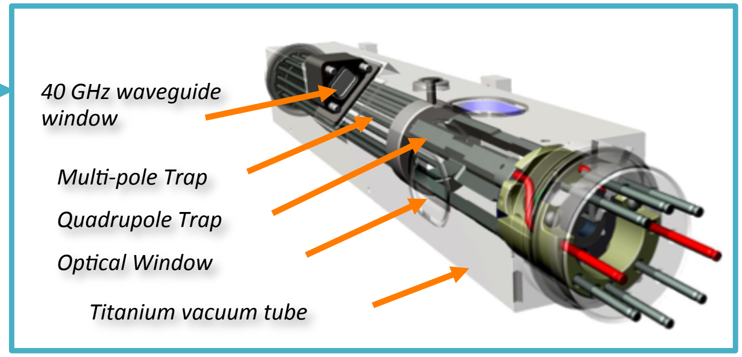
Benefits: The demonstration will use lasers to encode and transmit **data at rates 10-to-100-times faster than radio** -- or at the same data rate as today's fastest RF radios, but using significantly less mass and power.

The investigation will enable a variety of robust future science and exploration missions -- providing a higher data rate, and delivering more accurate navigation capabilities with reduced size, weight and power requirements.

Deep Space Atomic Clock

Project Summary: Develop an **advanced prototype mercury-ion atomic clock** and demonstrate for a year in space, providing the unprecedented accuracy (Allan Deviation < 2.0E-14 at one day) needed for the next generation of deep space navigation and radio science. **Identify steps** needed **to build 5 kg/20 W** infusible **flight version**.





Benefits: **The Deep Space Atomic Clock will be orders of magnitude smaller, lighter and more stable than any other atomic clock flown in space**.

- Improve clock accuracy of the next GPS system by 100×
- Increase navigation & radio science tracking data quantity by 2×, Improve tracking data accuracy up to 10×
- Enable a shift to a more flexible/extensible 1-Way radio navigation architecture
- Enable multiple spacecraft per aperture tracking
- Designed for reliable in-space use: no lasers, cryogenics or consumables, utilizes existing vacuum technology and is radiation tolerant at levels similar to GPS Rb Clocks

Composite Cryogenic Propellant Tanks

Project Summary: The primary objective of the Composite Cryotank Technologies and Demonstration (CCTD) project is to mature the technology readiness of composite cryogenic propellant tanks at diameters that are suitable for future heavy lift vehicles and other in-space applications. The concept being developed and demonstrated by this project involves advanced materials (composites), structural concepts (joints, splices, fasteners, etc), and manufacturing techniques.

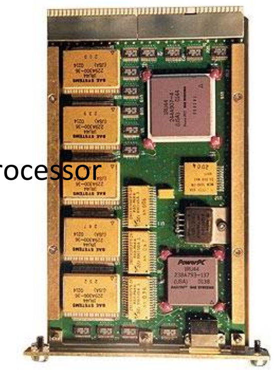
Benefits: Project will produce a major advancement in technology readiness; successfully test a 5.5-meter diameter composite hydrogen fuel tank, achieve 30% weight savings and 25% cost savings compared to SoA metallic tanks (Al-Li). Develops and demonstrates composite tank critical technologies: Materials, Structures, and Manufacturing. Focuses on achieving affordability and technical performance that is verified through agreement between experimental results and analysis predictions.

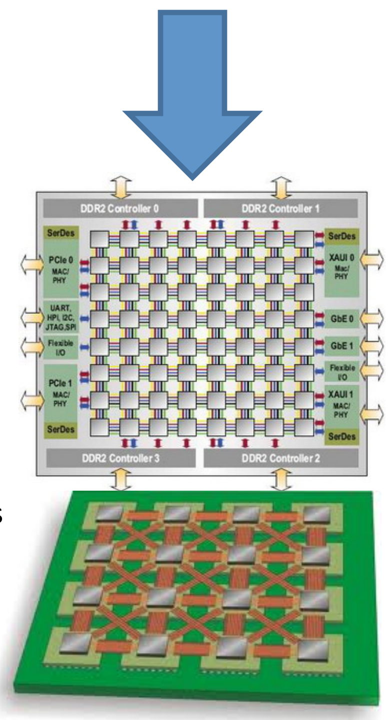
High Performance Spaceflight Computing

Formulation Activity designed to answer these important questions:

- Promises a 100-1000 fold performance increase in processing power
- What are the paradigm-shifting NASA space-based applications that will drive next generation flight computing?
- What are the future onboard computing requirements?
- Which computing architecture(s) will make the most impact?
- Given investment in computing technologies by commercial and military industry, how can NASA invest its limited resources to advance this technology into the Agency's space systems?

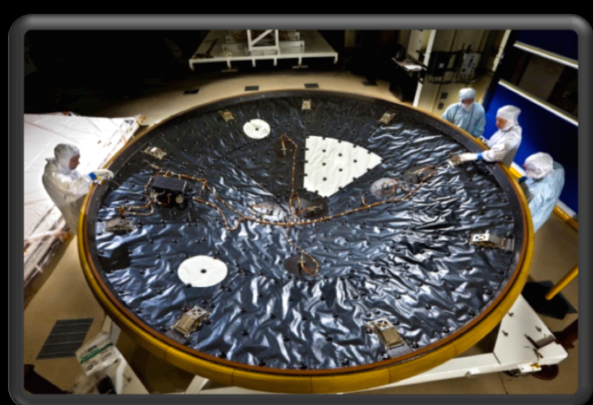
RAD750 Processor





Advanced Processors

Flying, Building, Testing Technologies For Tomorrow



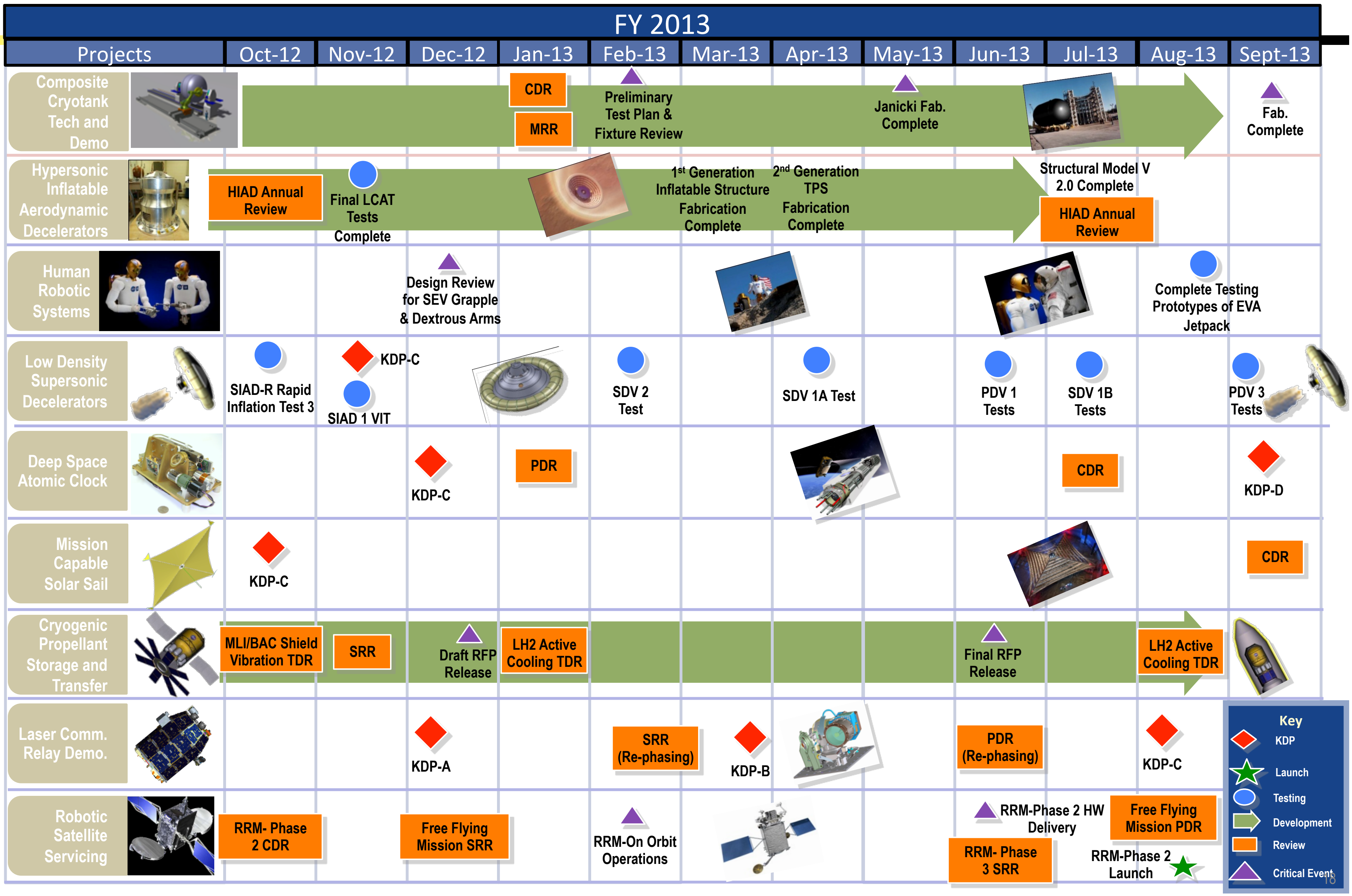
- Backup slides

"Big 9" FY 2012 Milestones

Projects	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sept-12
Composite Cryotank Tech and Demo								PDR			Develop and complete 2m-Tank Fab.	2m Pressure Tank Test Readiness Review
Hypersonic Inflatable Aerodynamic Decelerators			IRVE-3 Delta CDR	System Tests						MRR; Launch; KDP-E; Build-to-Print Fab. Complete	NFAC/Next Generation Tests	HIAD Annual Review
Human Robotic Systems					Integrate Software on Rover			Complete Design Drawings	Complete Rover Cannon Assembly			Multiple Tests
Low Density Supersonic Decelerators												PDR; SDV 1 Test
Deep Space Atomic Clock					SRR; MDR	KDP-B						
Mission Capable Solar Sail			SRR; MDR	Tubes Test; Sail Test		KDP-B	Mechanism Test				PDR	
Cryogenic Propellant Storage and Transfer							MCR		KDP-A			
Laser Comm. Relay Demo.												MCR
Robotic Satellite Servicing	RFI Released		RFI Complete			RRM OPS		Workshop				

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

"Big 9" Projects FY 2013 Milestones



Human Exploration Telerobotics

Project Summary: The Telerobotics project demonstrates how advanced, remotely operated robots can improve human exploration missions. The project develops and test drives robots that increase astronaut performance and productivity by executing routine, repetitive, dangerous or tedious work.

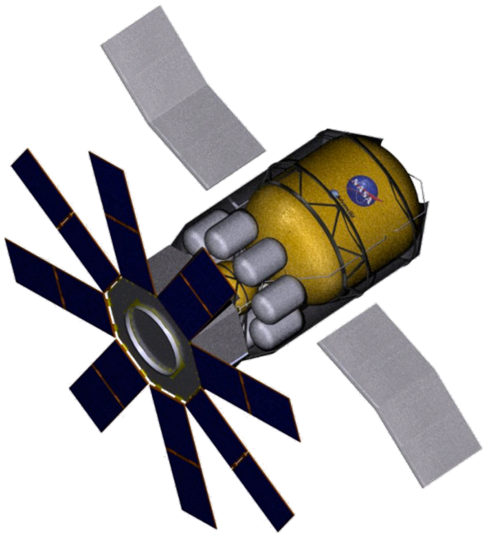
Surface Telerobotics is testing how astronauts in space can remotely operate a robot on the ground. The robot is used by astronauts to perform scouting, surveys, and other field work.

Smart SPHERES are free-flying space robots that can perform mobile sensor tasks, such as environmental surveys and camera work inside the International Space Station.

Robonaut 2 (R2) is the first humanoid robot in space. The robot can work with the same hand tools and hardware (switches, connectors, etc.) as used by astronauts.

Cryogenic Propellant Storage and Transfer

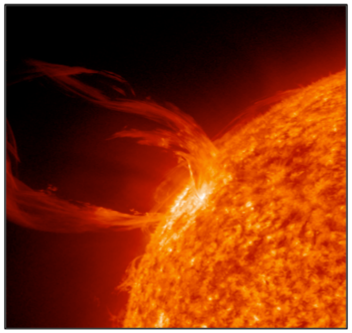
Project Summary: The CPST project will demonstrate the capability to safely and efficiently store, transfer and measure cryogenic propellants on-orbit, enabling next-generation flight vehicles to store large quantities of fuel for their journeys of discovery.

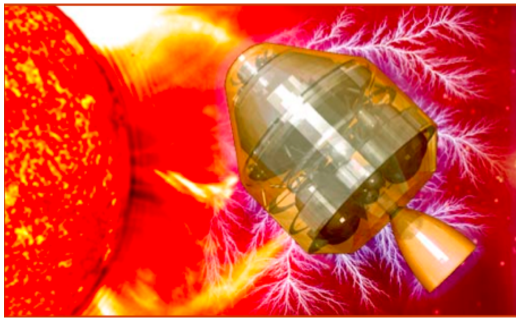


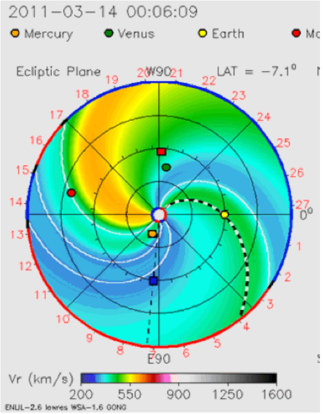
Key Facts: Current State of the Art for on-orbit storage of cryogenic propellants is several hours with boil-off rates on the order of 30%. The CPST project will demonstrate long duration (order 6 months) storage and transfer of cryogenic propellants as well as accurate methods to gauge propellant quantities accurately in microgravity. Once demonstrated, this technology will provide much higher performance than conventional propellants and permitting longer-range, higher-payload missions.

Advanced Radiation Protection

Project Summary: The advanced radiation protection project element will assess and mature disruptive technologies that show the potential to dramatically improve the radiation protection capabilities of future deep space exploration vehicles and habitats. This project will assess and develop technologies that perform radiation protection functions, particularly active radiation protection approaches.



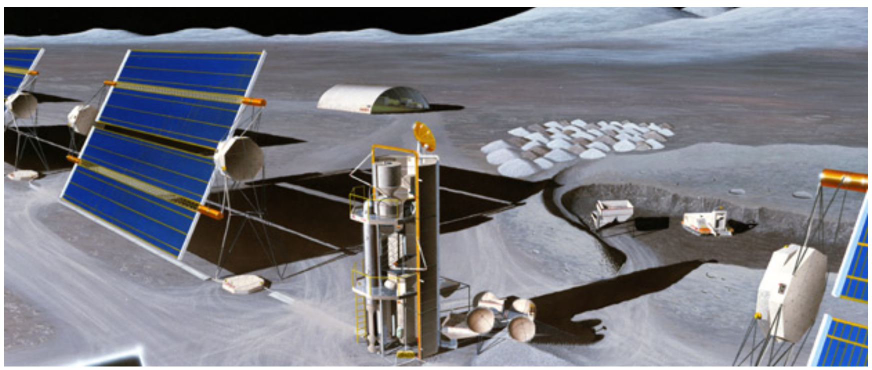


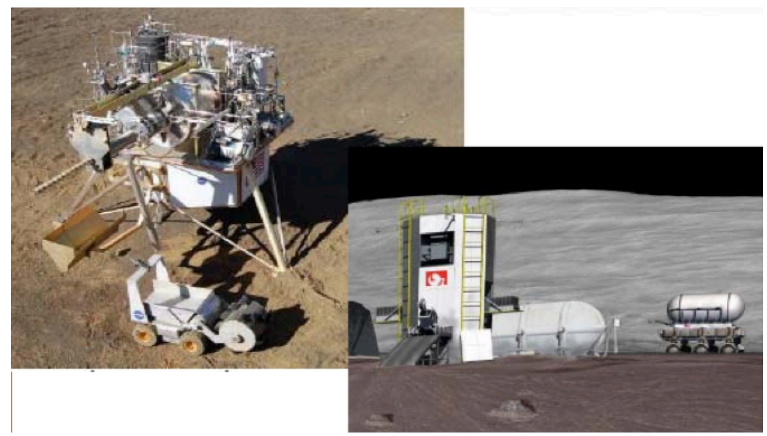


Key Facts: The project will deliver an early warning space weather capability to forecast impact of Solar Particle Events (SPE) over the full mission profile and project total SPE dose to crews. In addition, more accurate assessments of SPE will reduce the mass penalties of overly conservative shielding designs. Reducing radiation risk uncertainties may also have a significant impact by extending the radiation-limited duration of human missions beyond LEO

In-Situ Resource Utilization (ISRU)

Project Summary: Current Exploration missions require all propellants and consumables to be launched from Earth, which severely limit mission durations and payload size and increases launch costs. Determining that polar lunar volatiles are a viable and harvestable resource can change exploration architectures and allow sustainable exploration beyond Low Earth Orbit.





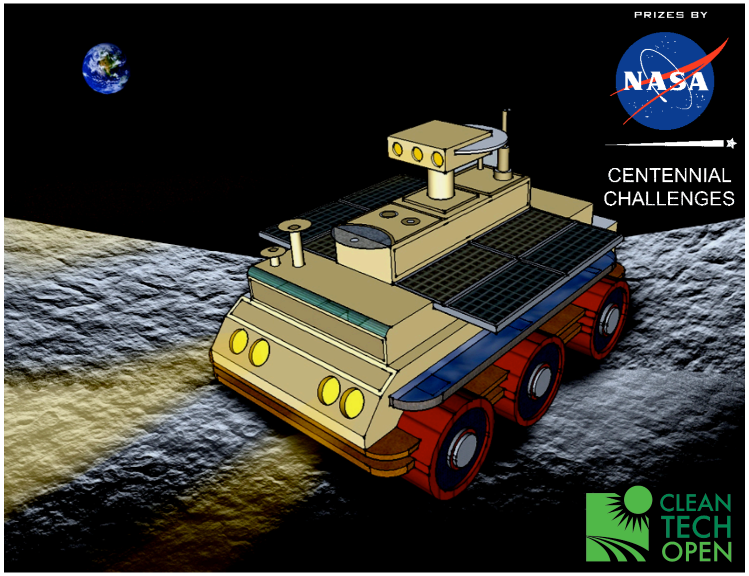
Key Facts: ISRU Project is developing the key instruments needed by the RESOLVE mission to assess the viability of lunar water as a resource. The demonstration focused on processing regolith to acquire water, produced oxygen, and determine the distribution of water. The project will deliver several key instruments to quantify lunar volatile resources: Neutron spectrometer, Near Infrared Spectrometer, Lunar Advanced Volatiles Analysis (LAVA) system.

FY12 Investments: Responsive to Customer's Needs – Solar Electric Propulsion

- High Power Solar Electric Propulsion (SEP) – consisting of power generation and propulsion – that is extensible to human exploration missions at 300kW – is a required architecture element within the human exploration roadmap
- STP is developing and demonstrating critical technologies that are necessary precursors to an integrated SEP demonstration – advanced (efficient, low mass, deployable and extendable) solar arrays are a key precursor
- GCD recently awarded two industry-lead teams – under an NRA – to develop deployable Solar Array Systems (SAS) through a 2 Phase process
  - In Phase 1 the two teams (ATK & DSS) will design, develop, analyze and ground test candidate systems, maturing their TRL to 5
  - In Phase 2 – under TDM – one team will further develop the down-selected Solar Array System, that concludes with an ISS demo

Night Rover Challenge

To stimulate innovations in energy storage technologies of value in extreme space environments and in renewable energy systems on Earth--demonstrate a high energy density storage systems that will enable a rover to operate throughout lunar darkness cycle



Goal:
Demonstrate storage system with energy density of at least 300w-hr/kg.

PRIZE PURSE: $1.5 Million

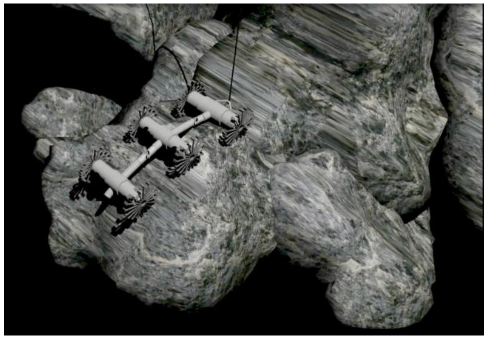
Status

- Rules Under Development
- Expect Registration to open in December 2012
- Competition in Fall 2013

http://NightRover.org/

NIAC Recent Awards

- **Cavehopping Exploration of Planetary Skylights and Tunnels**
  – Develop the enabling technologies to explore a lunar skylight and cave



- **ISRU-Based Robotic Construction Technologies for Lunar and Martian Infrastructures**
  – visionary concept for automated construction technology to efficiently build habitat and infrastructure on the moon.