National Aeronautics and Space Administration

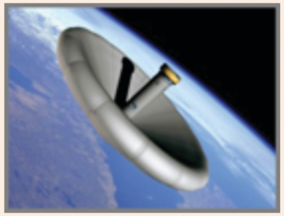
Space Technology FY 2013

NAC Technology and Innovation Committee Meeting

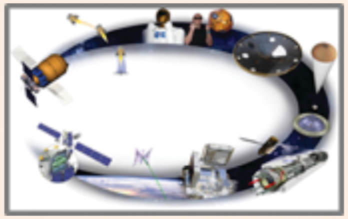
Presented By
Dr. Michael Gazarik
November 15, 2012

Space Technology Programs

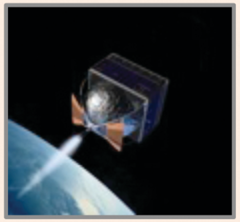
Transformative & Crosscutting Technology Breakthroughs



Game Changing Development Program



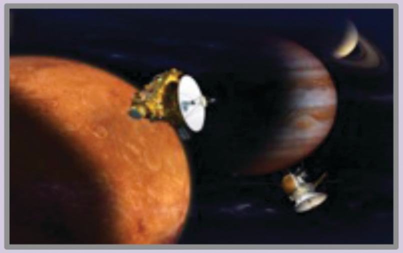
Technology Demonstration Missions Program



Small Spacecraft Technologies Program

Pioneering Concepts/ Developing Innovation Community

Space Technology Research Grant Program



NASA Innovative Advanced Concepts (NIAC) Program

Center Innovation Fund Program

Creating Markets & Growing Innovation Economy

Centennial Challenges Prize Program

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

Flight Opportunities Program

Space Technology FY 2013 President's Budget Request

Budget Authority ($M)	FY 2012 Appropriation	FY 2013	Notional FY 2014	Notional FY 2015	Notional FY 2016	Notional FY 2017
FY 2013 President's Budget Request	**573.7**	**699.0**	**699.0**	**699.0**	**699.0**	**699.0**
Partnership Development and Strategic Integration	29.5	29.5	29.5	29.5	29.5	29.5
SBIR/STTR	166.7	173.7	181.9	187.2	195.3	206.0
Crosscutting Space Technology Development	187.7	293.8	272.1	266.6	259.7	247.0
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
Exploration Technology Development	189.9	202.0	215.5	215.7	214.5	216.5
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

FY 2012 Space Technology Accomplishments & Awards: Innovative Technology Programs





NIAC:
- 30 Phase 1 studies from 2011 nearing completion
- Selected 18 new Phase I, and 10 new Phase II studies for 2012
- 2 patent applications pending
- Generated over 200 national and international media articles (*Time*, *Washington Post*, etc.)

STRG:
- Continued 80 fellowship students from 2011
- Selected 48 fellowship students as Space Technology Research Fellows in 2012
- 128 graduate students, spanning 50 universities, currently conducting space technology research
- Selected 10 early career faculty researchers to receive Space Technology Research Grants
- Issued a solicitation seeking space technology Early Stage Innovations from US Universities

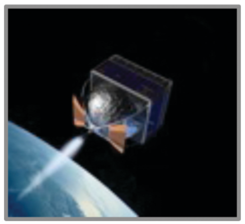
Centennial Challenges:

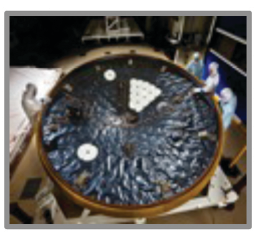
Sample Return Robot Challenge:
- 6 US teams participated in the June 2012 competition at the Worcester Polytechnic Institute
- No winners selected in 2012, but gearing up for the June 2013 competition
- Nearly 7,000 people attended a WPI/NASA outreach event in connection with the competition

SBIR/STTR:
- Selected 258 SBIR Phase I and 92 SBIR Phase II awards
- Selected 40 STTR Phase I and 10 STTR Phase II awards
- Issuing an SBIR/STTR Phase I solicitation in September 2012
- Lithium ion batteries flown on MSL Curiosity Rover funded through SBIR

Game Changing Development
- Selected two solar array system tech development proposals leading to advanced solar electric propulsion
- Successfully launched the Inflatable Reentry Vehicle Experiment-3 (IRVE-3) on July 23, 2012 at the Wallops Flight Facility in Virginia, demonstrating the feasibility of Hypersonic Inflatable Aerodynamic Decelerators (HIAD), inflatable heat shields.
- Initiated development of a 3-D Woven Thermal Protection System, to create heat shield flexibility and through the thickness variability, allowing tailoring for a wide range of entry systems such as Venus probes, balloons, landers, Saturn & Uranus probes, Mars sample returns, and alternatives for Orion Multi-purpose Crew Vehicle project
- Developed a 2.4 diameter composite lightweight cryogenic propellant tank, which will be scaled to 5 meters. This technology can significantly reduce the mass cost of the next generation Space Launch System.

FY 2012 Space Technology Accomplishments & Awards: Flight Demonstrations & Technology Transfer





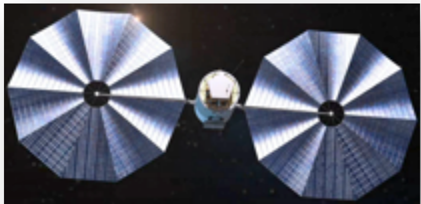
Flight Opportunities:
- Selected 38 advanced space technology payloads for parabolic and suborbital flight
- 2 parabolic flight campaigns and 4 reusable sub orbital flight campaigns completed to-date in FY 2012
- 1 more parabolic flight campaign and 3 more sub orbital flight campaigns planned this calendar year

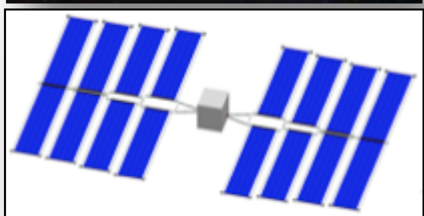
Small Spacecraft:
- Selected three teams to advance the state of the art for small spacecraft in the areas of communications, formation flying and docking systems. Technology demonstration flights will take place in 2014-2016.
- Completed preliminary design of the Edison Demonstration of Smallsat Networks spacecraft cluster, for launch in late 2013.
- Completed preparations for the launch of the PhoneSat mission, scheduled for later in 2012.

Technology Demonstration Mission:
- Mars Curiosity rover mission successful with the MSL Entry, Descent and Landing Instrument (MEDLI) on board. MEDLI streamed atmospheric data in real-time from the shield sensors, which will be analyzed and published, and used to help engineers design safer, more efficient entry systems for future missions
- Selected technology demonstration of a high performance "green" in-space mono-propellant alternative to the highly toxic fuel hydrazine in order to reduce health hazardous, improve processing efficiency and decrease operational costs
- Remotely controlling robots on the International Space Station, including Robonaut, NASA's humanoid robot handyman
- Completed tethered flight tests demonstrating advanced landing sensors at JSC

Innovative Partnerships Office, Technology Transfer:
- Published the *2011 Spinoff* book, featuring 44 life-saving, efficient, or performance-enhancing technologies that provided extraordinary benefits to society. NASA spinoff technologies yielded thousands of jobs, reduced billions of dollars in costs, assisted in the preservation of resources and generated over a billion dollars in revenue.
- Publication of *2012 Spinoff* in progress, featuring 45 technologies in the fields of medicine, manufacturing, consumer goods, transportation, public safety and environmental protection.

FY12 Awards for Solar Array Systems & Green Propellants





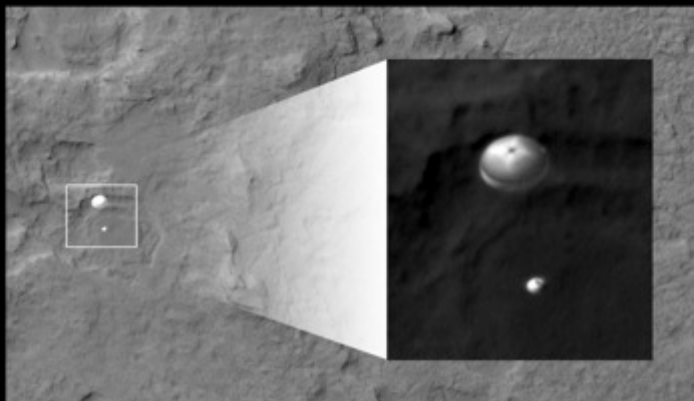
Solar Array Systems

- High Power Solar Electric Propulsion (SEP) –power generation and propulsion – extensible to human exploration missions at 300kW
  - required architecture element within the human exploration roadmap
- STP developing and demonstrating critical technologies necessary to an integrated SEP demonstration
  - Efficient, low mass, deployable and extendable solar arrays are a key precursor
- Awarded two industry-lead teams, ATK & DSS, to develop deployable Solar Array Systems through a 2 Phase process
  - In Phase 1 the two teams will design, develop, analyze and ground test candidate systems, maturing their TRL to 5

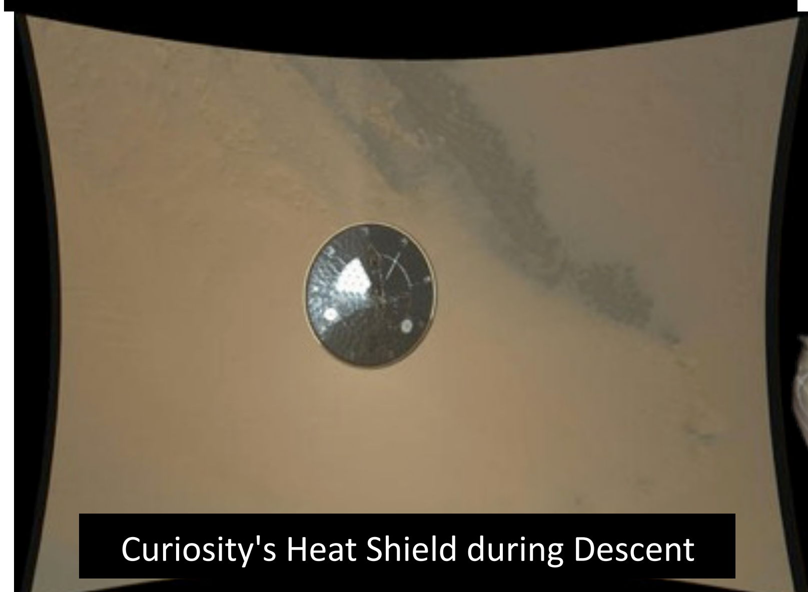
Green Propellants

- Hydrazine has a long-legacy in spacecraft prolusion.
- Reliable, but is highly corrosive and toxic complicating transportation, handling and ground and flight operations.
- Selected team lead by Ball Aerospace to demonstrate a high performance green propulsion system
  - The cross-cutting team of industry, NASA, and DoD will develop and fly an operational green propulsion subsystem for a small spacecraft.
  - The demonstration will pave the way to replacing hydrazine for most of U.S. missions

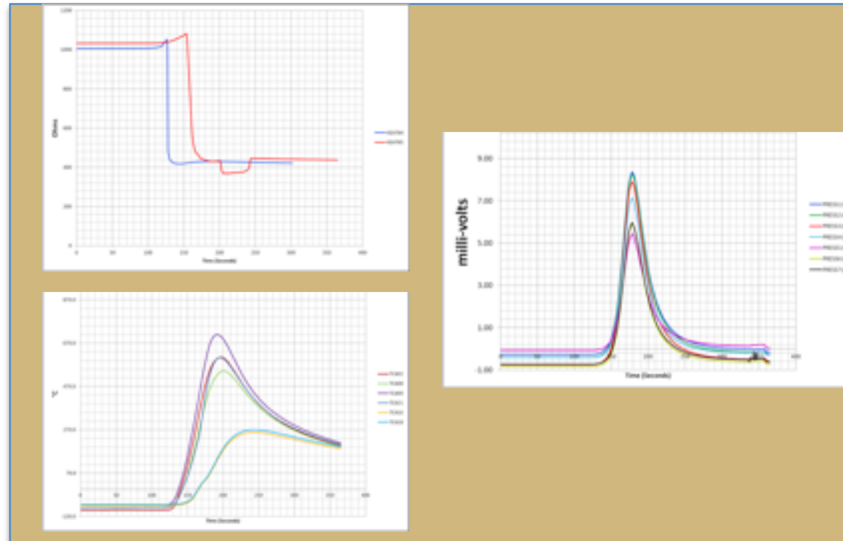
Technology Success: One of Many on Mars

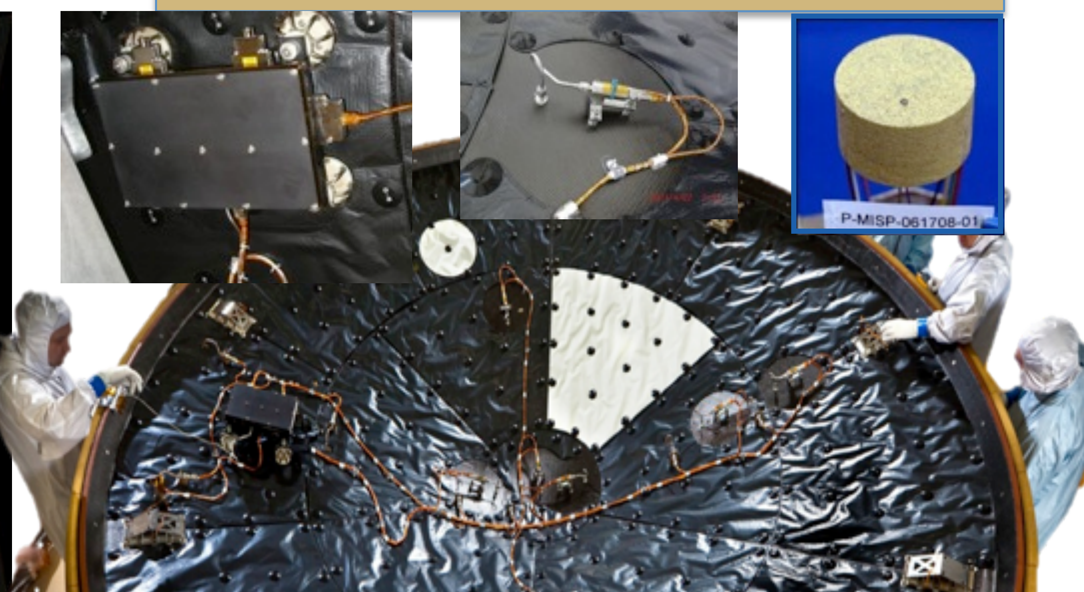


Curiosity with chutes deployed during descent to Mars Surface

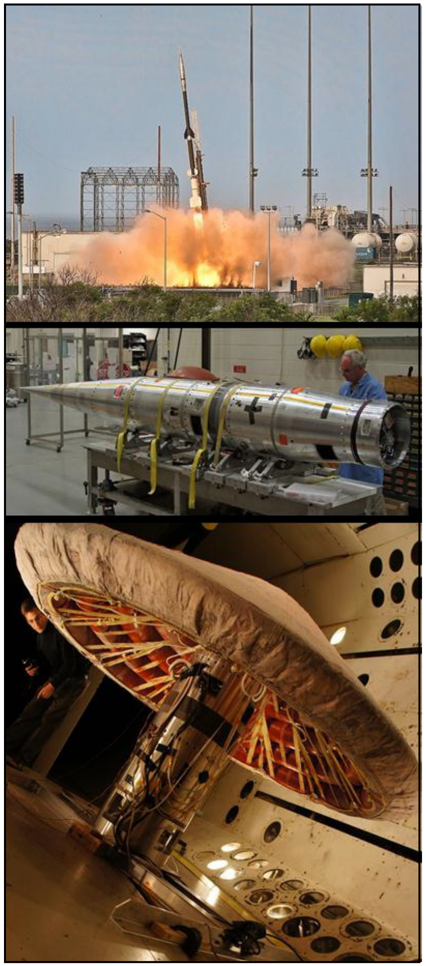


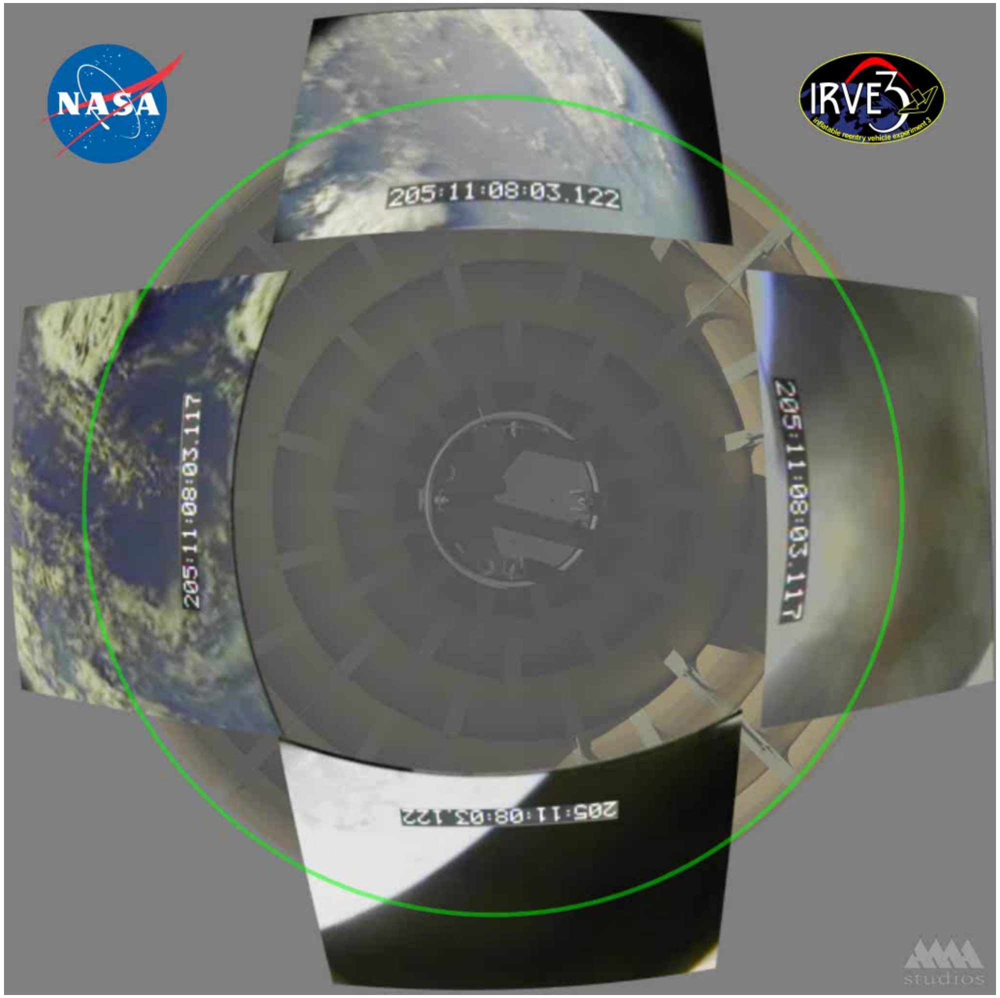
Curiosity's Heat Shield during Descent

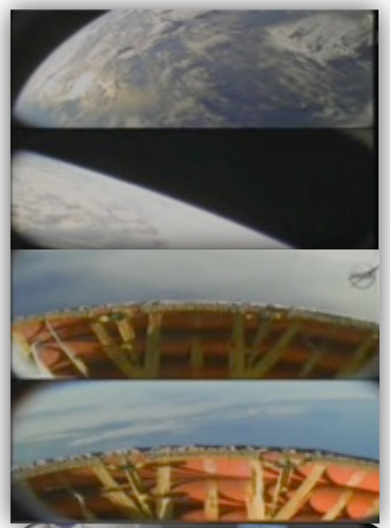




IRVE-3 Mission Success!





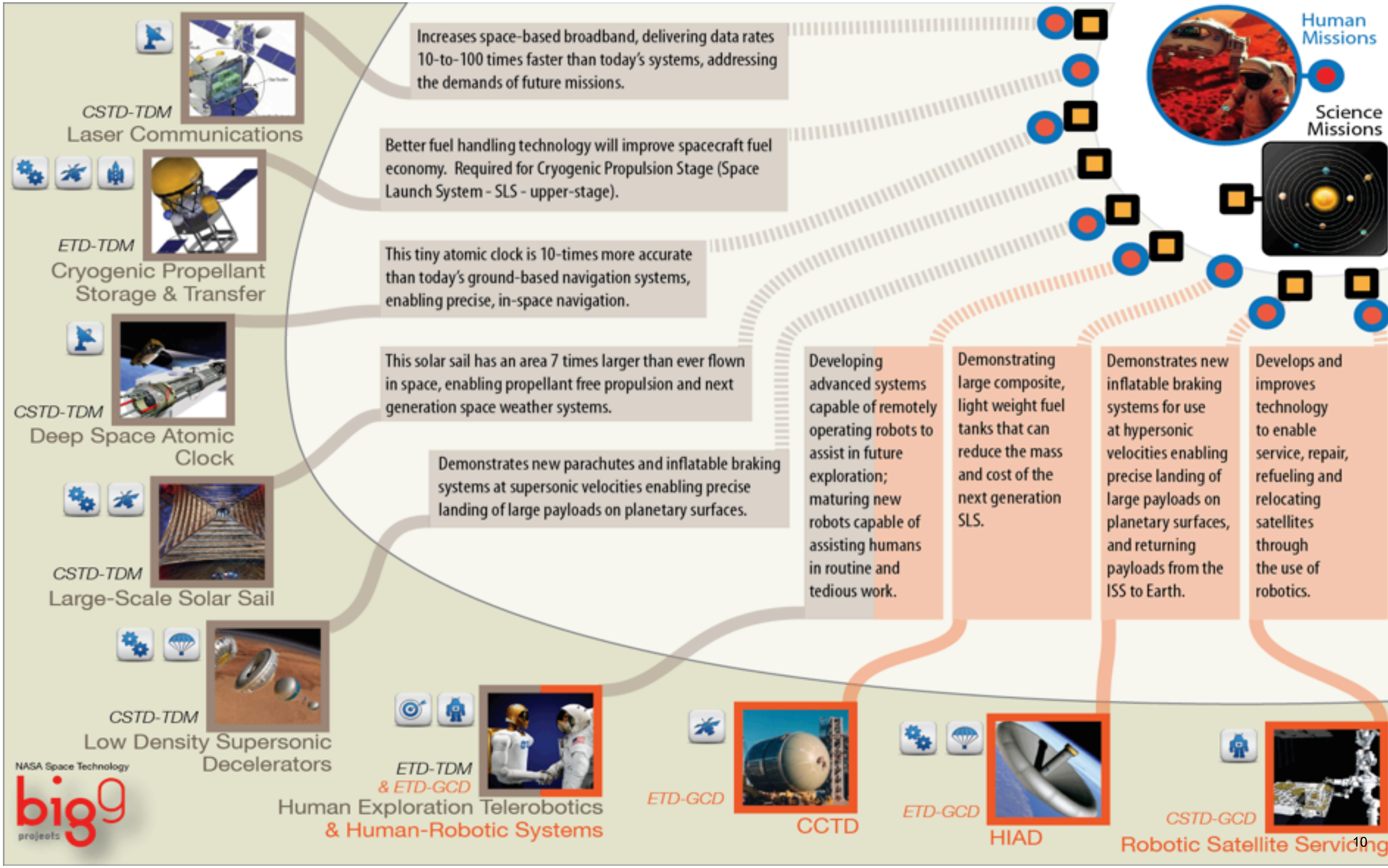


Technology and Innovation

Jet Propulsion Laboratory, California Institute of Technology

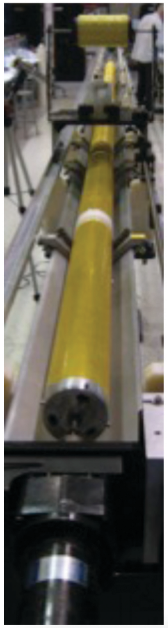
This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Current (FY2012) Big Nine Programs

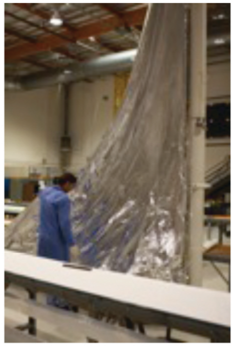


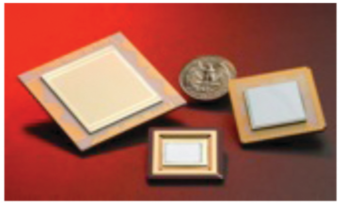
Space Technology Hardware & Testing

Boom Fabrication

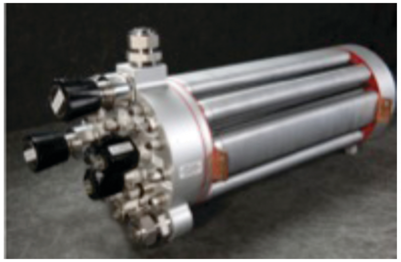


Sail Fabrication



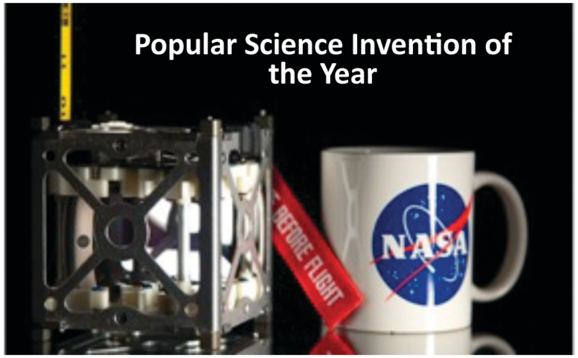


BIRD focal plane arrays

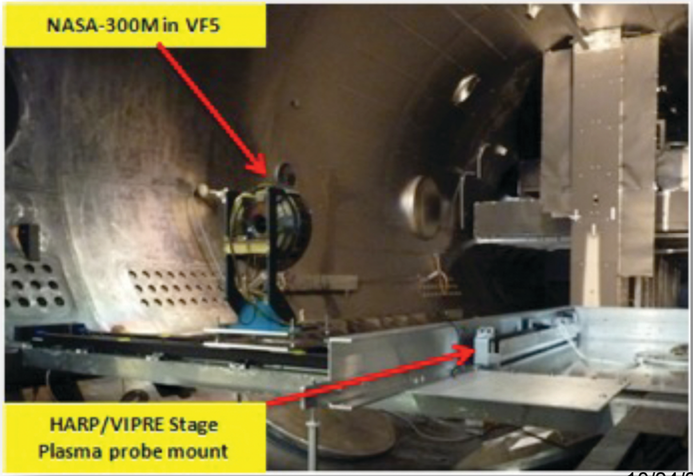


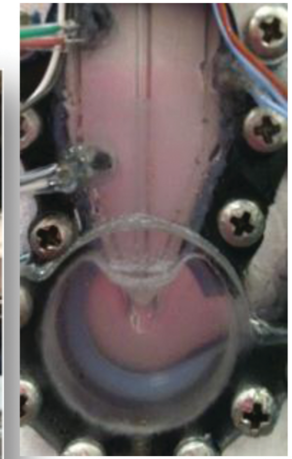
Model of 3-kW Non-Flow-Through Fuel Cell

Composite Strut Structural Testing



Popular Science Invention of the Year





Water Droplet Visualization Test

Exoskelton

Testing at 300 MPH

"Big 9" FY 2012 Milestones

Projects (FY 2012)	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; KDP-E; Launch; 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

Projects	FY 2013											
	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sept-13
Composite Cryotank Tech and Demo				CDR; MRR	Preliminary Test Plan & Fixture Review			Janicki Fab. Complete				Fab. Complete
Hypersonic Inflatable Aerodynamic Decelerators	HIAD Annual Review	Final LCAT Tests Complete				1st Generation Inflatable Structure Fabrication Complete	2nd Generation TPS Fabrication Complete			Structural Model V 2.0 Complete; HIAD Annual Review		
Human Robotic Systems			Design Review for SEV Grapple & Dextrous Arms								Complete Testing Prototypes of EVA Jetpack	
Low Density Supersonic Decelerators	SIAD-R Rapid Inflation Test 3	KDP-C; SIAD 1 VIT			SDV 2 Test		SDV 1A Test		PDV 1 Tests	SDV 1B Tests		PDV 3 Tests
Deep Space Atomic Clock			KDP-C	PDR						CDR		KDP-D
Mission Capable Solar Sail	KDP-C											CDR
Cryogenic Propellant Storage and Transfer	MLI/BAC Shield Vibration TDR	SRR	Draft RFP Release	LH2 Active Cooling TDR					Final RFP Release		LH2 Active Cooling TDR	
Laser Comm. Relay Demo.			KDP-A		SRR (Re-phasing)	KDP-B			PDR (Re-phasing)		KDP-C	
Robotic Satellite Servicing	RRM- Phase 2 CDR		Free Flying Mission SRR		RRM-On Orbit Operations				RRM- Phase 3 SRR; RRM-Phase 2 HW Delivery		Free Flying Mission PDR; RRM-Phase 2 Launch	

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

Game Changing Technology Areas

Technology Areas	ETD: GCD	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
In-Space Propulsion (ISP)	Including SEP Development Activities			4	→	5			
Space Power Generation and Storage	Including SEP Development Activities			4	→	6			
Lightweight Materials and Structures	Including SEP Development Activities			2	→	5			
Nuclear Systems				2	→	5			
Human-Robotic Systems (inc. National Robotic Initiative)			3	→	→	→	→	7	
Autonomous Systems (AS)				4	→	5			
Next-Generation Life Support (NGLS)				4	→	5			
Deployable Aeroshell Concepts & Conformal TPS				2	→	5			
In-Situ Resource Utilization (ISRU)				4	→	5			
Composite Cryotank Technologies and Demonstration (CCTD)		4	→	→	→	6			
Hypersonic Inflatable Aerodynamic Decelerator (HIAD)		3	→	→	6				
Advanced Radiation Protection (ARP)				2	→	4			

Technology Areas	CSTD: GCD	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Manufacturing Innovation				3	→	5			
Robotic Satellite Servicing		3	→	→	→	5			
Nanotechnology				3	→	5			
Space Synthetic Biology				2	→	3			
Solar Array System					4	→	5		

Technology Areas (TA)

- TA.1. Launch Propulsion
- TA.2. In-Space Propulsion
- TA.3. Space Power/Storage
- TA.4. Robotics
- TA.5. Comm./Navigation
- TA.6. Human Health
- TA.7. Human Expl. Dest.
- TA.8. Sci. Instr./Sensors
- TA.9. EDL
- TA.10. Nanotechology
- TA.11. Modeling/Simulation
- TA.12. Materials/Structures
- TA.13. Ground/Launch
- TA.14. Thermal

Technology Readiness Levels (TRL) 1 → 9

Technology Demonstration Missions
Technology Areas

Technology Areas / ETD: TDM	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Human Exploration Telerobotics (HET)			5 →		7			
Cryogenic Propellant Storage and Transfer (CPST)			5 →					7
Materials ISS Experiment-X (MISSE-X)			5 →			8		
Green Propellant Infusion Mission				5 →		9		

Technology Areas / CSTD: TDM	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
Low Density Supersonic Decelerators (LDSD)			5 →		6			
Laser Communications Relay Demonstration (LCRD)			6 →					→
Deep Space Atomic Clock (DSAC)			5 →				7	
Solar Sail Demonstration (SSD)			5 →				9	

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

Small Spacecraft Technologies Technology Areas

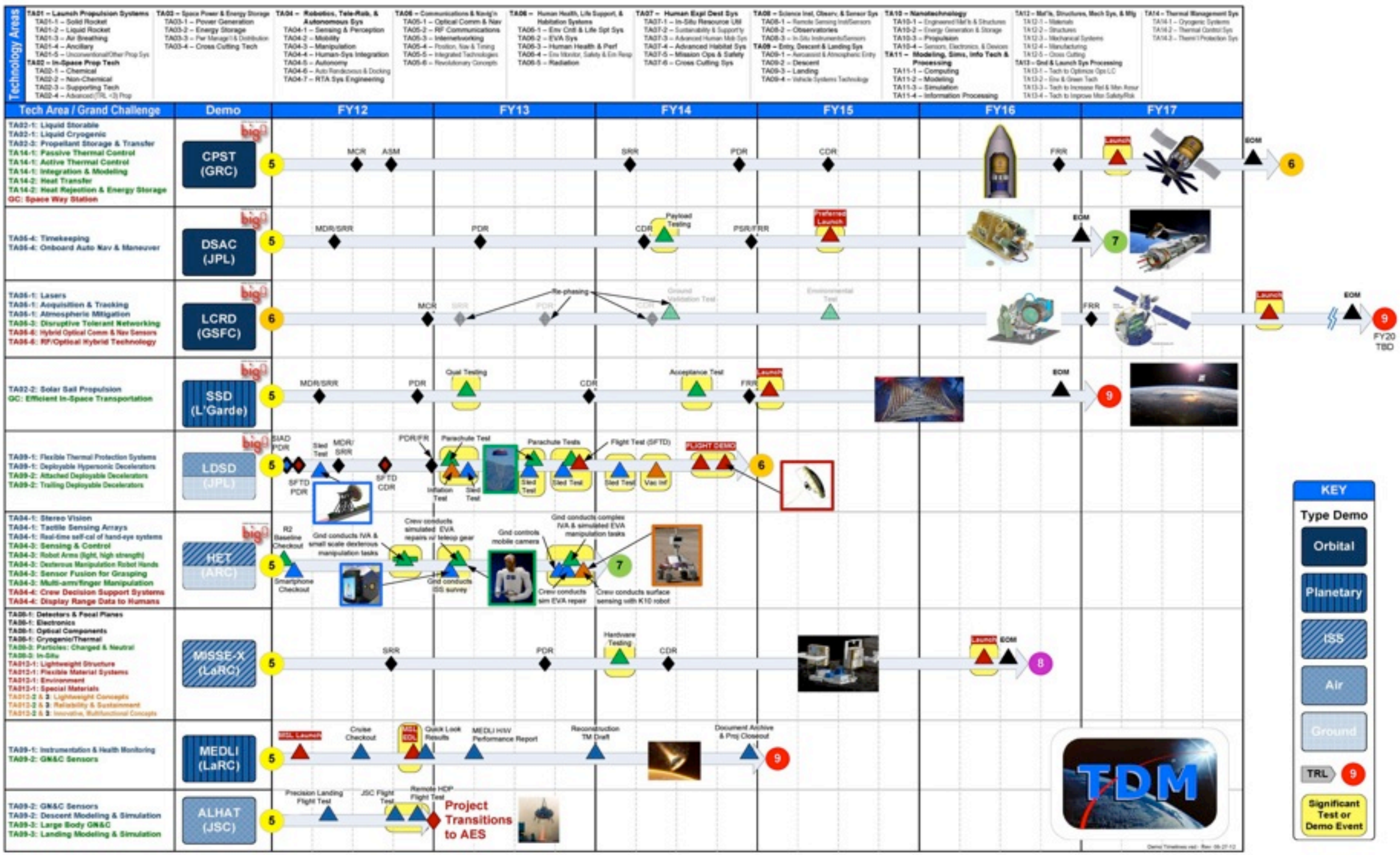
Technology Areas	CSTD: Small Spacecraft Technologies	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17
	Integrated Solar Array and Reflectarray Antenna for High Bandwidth CubSat §				⑤ →		⑦		
	Integrated Optical Communications and Proximity Sensors for Cubesats §				⑤ →		⑦		
	Proximity Operations Nano-Satellite Flight Demonstration §				⑤ →			⑦	
	Edison Demonstration of Smallsat Networks (EDSN)			⑤ →	⑦				
	PhoneSat		⑤ →	⑦					

§NOTE: these three projects have been selected but not yet awarded

Technology Areas (TA)

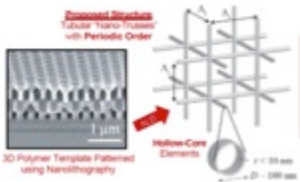
- TA.1. Launch Propulsion
- TA.2. In-Space Propulsion
- TA.3. Space Power/Storage
- TA.4. Robotics
- TA.5. Comm./Navigation
- TA.6. Human Health
- TA.7. Human Expl. Dest.
- TA.8. Sci. Instr./Sensors
- TA.9. EDL
- TA.10. Nanotechology
- TA.11. Modeling/Simulation
- TA.12. Materials/Structures
- TA.13.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

Technology Demonstration Missions
Major Events and Milestones



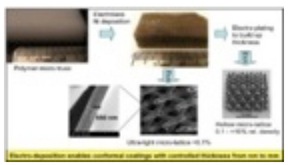
Space Technology Research Grant Program – Engaging the Nation's Universities

Space Technology Early Career Faculty FY 2012 Awards

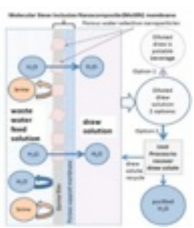


Ultralight Nanolattices with Co-Optimized Mechanical, Thermal, and Optical Properties
Chih-Hao Chang NC STATE UNIVERSITY

Autonomous Food Production
Nicolaus Correll
Colorado



Development of Lightweight, Radiation- and Damage-Tolerant Micro-trusses
Julia R. Greer
Caltech

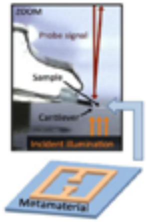


Development of Corrosion-resistant Molecular Sieve Inclusion Nanocomposite (MoSIN) Membranes to Recover Water from Urine Through Osmotic Processes
Mary Laura Lind

Arizona State University

Self-repair and Damage Mitigation of Metallic Structures
Michele Manuel

UF University of Florida



Radiation Pressure on Tunable Optical Metamaterials for Propulsion and Steering Without Moving Parts
Jeremy Munday University of Maryland

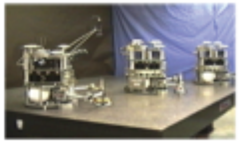
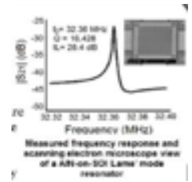


Figure 3: Stanford's space robotics facility

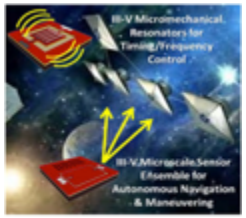
Algorithmic Foundations for Real-Time and Dependable Spacecraft Motion Planning
Marco Pavone

Stanford University



Chip-Scale Precision Timing Unit for PicoSatellites
Mina Raies-Zadeh

University of Michigan



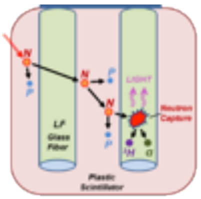
III-V Microsystems Components for Positioning, Navigation and Timing in Extreme Harsh Environments
Debbie Senesky

Stanford University

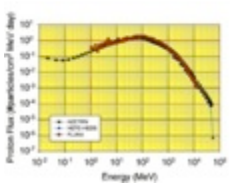
Environmental Control & Life-Support Systems
Wei-Chuan Shih

University of Houston

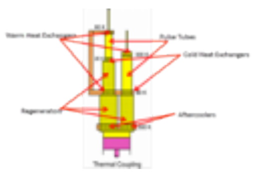
Space Technology Faculty FY 2012 Awards



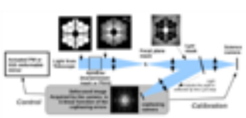
Advanced Scintillating Fiber Technology in High Energy Neutron Spectrometers for Exploration
James Adams — UAHuntsville, The University of Alabama in Huntsville



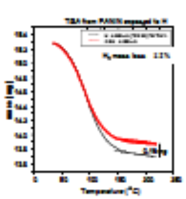
Computational Approaches for Developing Active Radiation Dosimeters for Space Applications Based on New Paradigms for Risk Assessment
Thomas Borak — Colorado State University



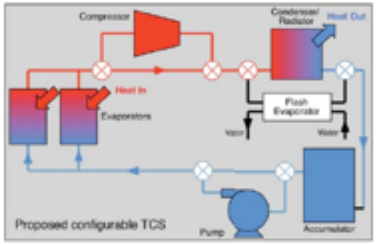
Light Weight, 20 K Pulse Tube Cryocooler for Active Thermal Control on Future Space Exploration Missions
Seyed Ghiaasiaan — Georgia Institute of Technology



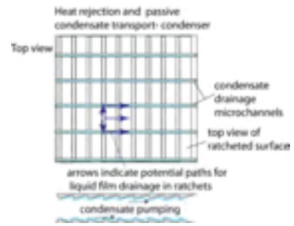
Wavefront Control for High Performance Coronagraphy on Segmented and Centrally Obscured Telescopes
Olivier Guyon — The University of Arizona



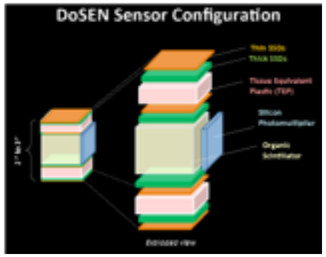
High Hydrogen Content Nanostructured Polymer Radiation Protection System
Alex Ignatiev — University of Houston



Heat Rejection System for Thermal Management in Space Utilizing a Planar Variable-Conductance Heat Pipe
Yasuhiro Kamotani — Case Western Reserve University



Adaptable Single Active Loop Thermal Control System (TCS) for Future Space Missions
Issam Mudawar — Purdue University



Enabling Self-Propelled Condensate Flow During Phase-Change Heat Rejection Using Surface Texturing
Vinod Narayanan — Oregon State University OSU

Small Active Readout Device for Dose Spectra from Energetic Particles and Neutrons (Dosen)
Nathan Schwadron — University of New Hampshire

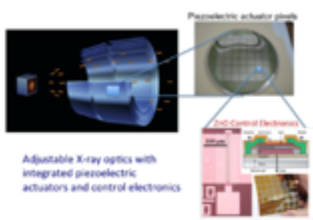


Fig. 1: Grazing incidence optics with piezoelectric actuation and integrated control electronics

Integrated Control Electronics for Adjustable X-Ray Optics
Susan Trolier-Mckinstry — PennState

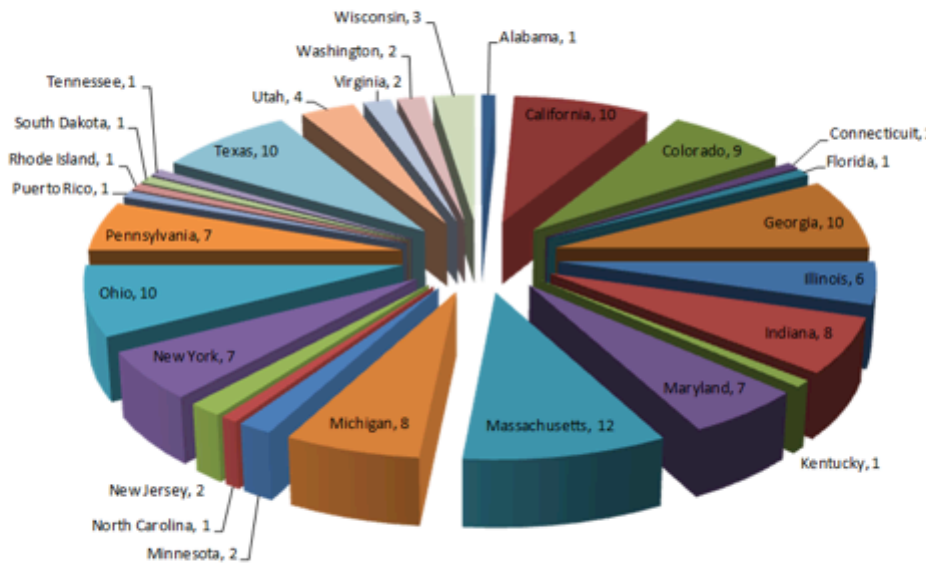
Space Technology Fellow Summary

Covering 13 Technology Areas

NSTRF

26 states, 1 U.S. territory… and 50 universities

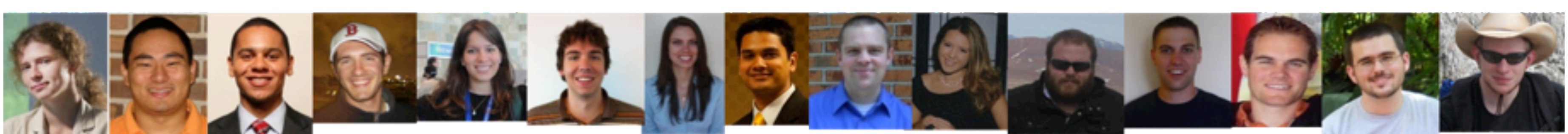
Auburn
Boston U
Brigham Young
Brown
Cal Tech
Carnegie Mellon
Case Western Reserve
Colorado State University
Columbia
Cornell
Duke
Georgia Tech
Illinois Institute of Tech
Johns Hopkins
Michigan State
MIT
Northwestern
Ohio State
Penn State
Princeton
Purdue
Rice
Rochester Institute of Tech
SD School of Mines
Stanford



NSTRF 11 and 12

128 graduate students conducting space technology research

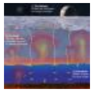
SUNY – Stony Brook
Texas A&M
U of Cal – Irvine
U of Cal – Santa Barbara
U of Colorado – Boulder
U of Florida
U of Illinois
U of Kentucky
U of Maryland
U of Massachusetts
U of Michigan
U of Minnesota
U of Pennsylvania
U of Puerto Rico
U of Rochester
U of Southern California
U of Tennessee - Knoxville
U of Texas – Austin
U of Utah
U of Washington
U of Wisconsin
Utah State
Virginia
Virginia Tech
Yale



2012 NIAC Fellows Engage the Nation's Universities

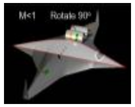
2012 Phase I & Phase II Fellows

2012 Phase I Fellows



Leigh McCue, Virginia Polytechnic Institute and State University
Exploration of Under-Ice Regions with Ocean Profiling Agents (EUROPA)

Robert Winglee, University of Washington, Seattle
Sample Return Systems for Extreme Environments



Gecheng Zha, University of Miami
Silent and Efficient Supersonic Bi-Directional Flying Wing

2012 Phase II Fellows

Behrokh Khoshnevis, University of Southern California
ISRU-Based Robotic Construction Technologies for Lunar and Martian Infrastructures

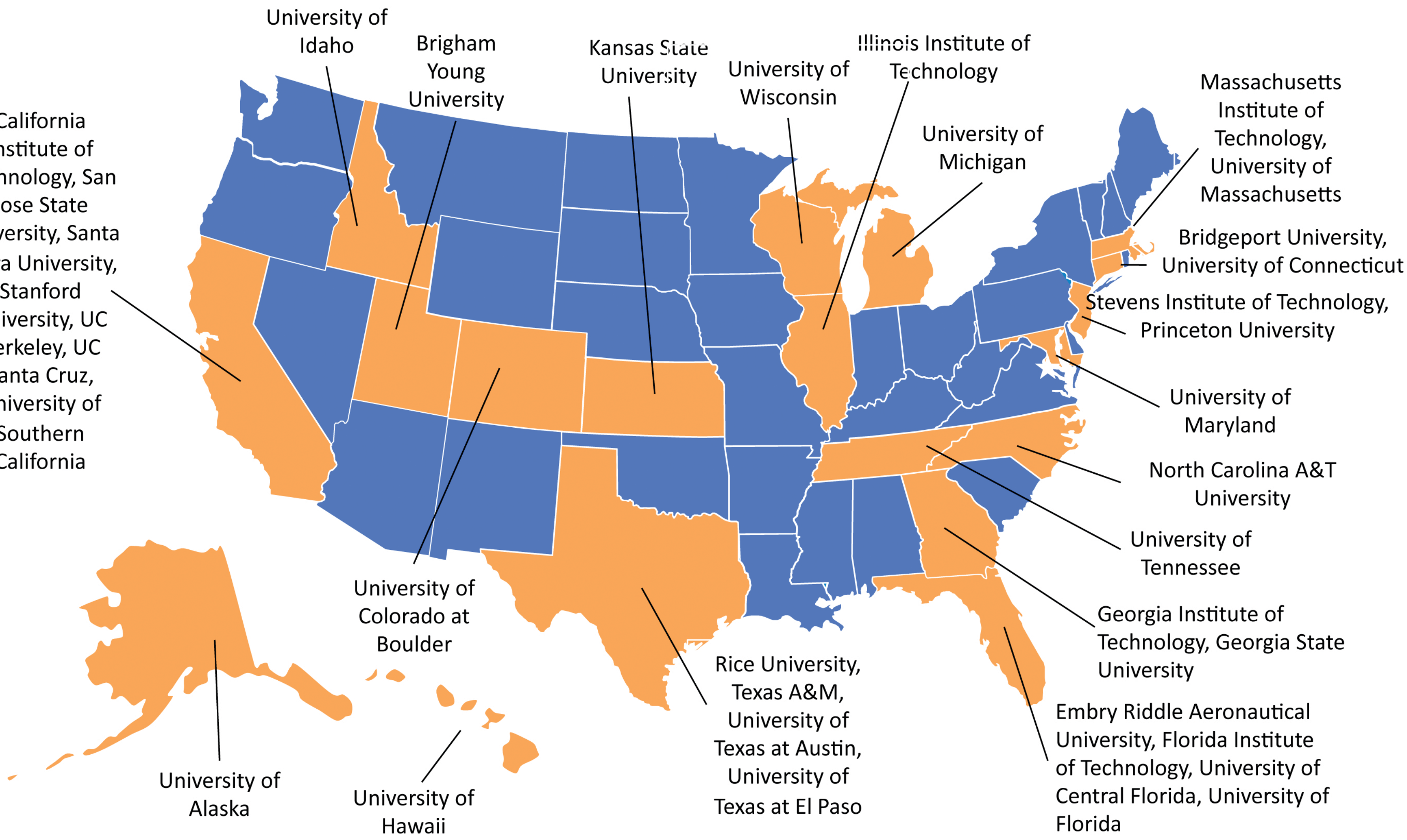
David Miller, Massachusetts Institute of Technology
High-Temperature Superconductors as Electromagnetic Deployment and Support Structures

Bong Wie, Iowa State University
An Innovative Solution to NASA's NEO Impact Threat Mitigation Grand Challenge and Flight Validation Mission Architecture Development

CIF: Fostering Innovation at Universities across the Nation

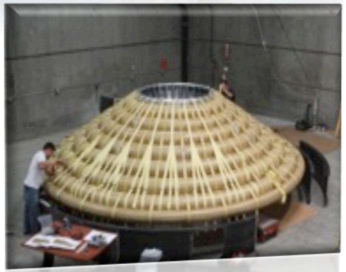
2012 Project Collaborations

Exploring new concepts to expand aerospace possibilities



Space Technology: Investments in Our Future

- **Through NASA, America Continues to Dream Big:** NASA's future aeronautics, science and exploration missions are grand in scope and bold in stature.
- **Technological leadership is the "Space Race" of the 21st Century:** NASA's *Space Technology* 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.
- **NASA makes a difference in our lives every day**: Knowledge provided by weather and navigational spacecraft, efficiency improvements in both ground and air transportation, super computers, solar- and wind-generated energy, the cameras found in many of today's cell phones, improved biomedical applications including advanced medical imaging and even more nutritious infant formula, as well as the protective gear that keeps our military, firefighters and police safe, have all benefitted from our nation's investments in aerospace technology.
- **The Nation's investments in *Space Technology* enable NASA to make a difference in the world around us.**



National Aeronautics and
Space Administration

BACKUP

Technology Success: Human Exploration Telerobotics Project

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.

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.

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.

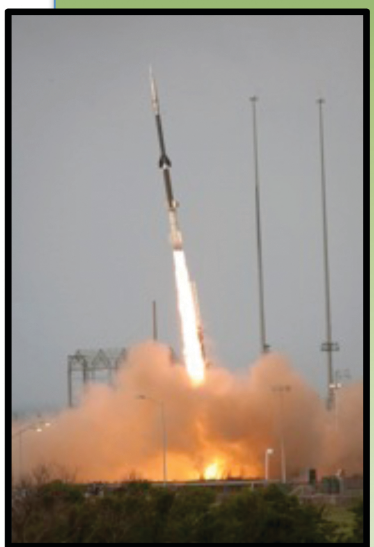
Project Summary: The Telerobotics project demonstrates how advanced, remotely operated robots can improve human exploration missions. The project develops and test drives robots that increase astronaut performance and productivity by executing routine, repetitive, dangerous or tedious work.

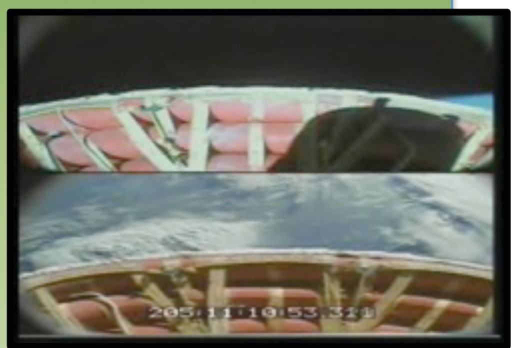
FY 2012 Milestones: Robonaut 2 launched as part of STS-133 and is currently in operations with the ISS crew and NASA ground team. SPHERES is another ongoing experiment of telerobotic assistance for astronauts on ISS.

NASA/Government/Commercial Application: The Telerobotics project uses consumer hardware to reduce cost and speed development. For example, Smart SPHERES uses a commercial smartphone as its main processor. The project is also maturing software standards to encourage interoperability, reusability, and commercial development of telerobots. Integrated human-robotic missions are supporting exploration capabilities on the ISS, Moon, Mars, and other destinations.

Partnerships: Joint NASA mission offices co-fund the development and operations of R2 and Smart SPHERES. General Motors partnered with NASA to develop R2. A partnership is being formalized with the European Space Agency to jointly study space telerobots.

Technology Success:
Hypersonic Inflatable Aerodynamic Decelerator (HIAD)





Top left, Technicians at NASA's Wallops Flight Facility mated the components of the Inflatable Reentry Vehicle Experiment-3 (IRVE-3) into the nosecone and sounding rocket.
Bottom right, Images of IRVE-3 successfully inflated, reconfigured to generate lift prior to atmospheric entry, and demonstrated re-entry steering capability.

Project Summary: NASA's Hypersonic Inflatable Aerodynamic Decelerator project (HIAD) focuses on the development and demonstration of hypersonic inflatable heat shield technologies through analysis, ground-based testing and flight tests.

FY 2012 Milestone: On July 23, 2012, the Inflatable Reentry Vehicle Experiment (IRVE-3) successfully demonstrated key technologies, including flexible TPS materials for hypersonic entry conditions, attachment, and inflation mechanisms, along with high-strength, lightweight, inflatable bladder materials capable of withstanding high temperatures.

NASA/Government/Commercial Application: IRVE-3 will provide foundational data to develop and integrate HIAD technology, enabling future missions that require delivering larger mass/payloads to destinations with sizable atmospheres, or accessing Mars at higher elevations.

Partnerships: NASA is working with Airborne Systems/HDT Global, Oceaneering and Bristol Aerospace on this project. NASA, as well as other industry partners, could incorporate this technology for future ISS or LEO down mass applications or planetary science and exploration missions.

Technology Success:
Mars Science Laboratory Entry, Descent and Landing Instrumentation (MEDLI)

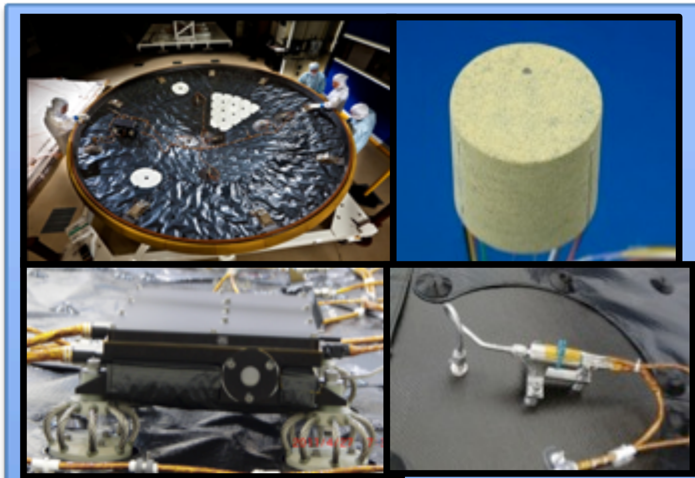
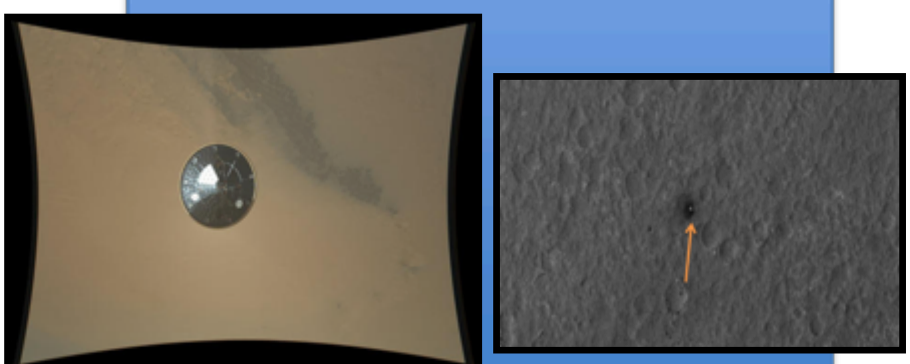


Image group: Top left photo of NASA Team preps for launch of Mars rover and check of sensors. **Top right** image is of thermal plugs containing instruments to measure changes in thickness and in-depth temperatures. **Bottom right** photo of pressure transducers attached to the inside of the aeroshell structure. **Bottom left** image is the custom-built electronics box collects the <1 MB of MEDLI data.



Left image of Mars Curiosity Rover heat shield deployment before landing.
Right image shows the heat shield landing on the Mars surface

Project Summary: Mars Science Laboratory Entry, Descent and Landing Instrumentation (MEDLI) was installed in the MSL heatshield, designed to gather engineering data on MSL's aerothermal, aerodynamic, and thermal protection system performance during atmospheric entry.

FY 2012 Milestone: On August 6, 2012 (August 5th PDT) during MSL's approach to Mars, MEDLI successfully collected data in real-time, measuring heat, pressure and other conditions on the shield as the Curiosity rover touched down. Only about 10 percent of MEDLI's data is now in the hands of the research team; the rest will be relayed, analyzed and published in the coming months.

NASA/Government/Commercial Application: MEDLI data improves the state-of-the-art predictive models used on every entry vehicle, helping NASA engineers design safer, more efficient entry systems for future missions to Mars and other destinations. Specific MEDLI components are being used on the Exploration Flight Test-1. Manufacturing standards established to support MEDLI are now applicable to other spacecraft, and updated aerothermal performance models will reduce the cost and mass while improving the risk quantification of future commercial, science and exploration missions requiring planetary entry.

Partnerships: MEDLI is a successful partnership between NASA Mission Directorates Aeronautics, Exploration, Science, and the Space Technology Program.

Technology Success:
Low Density Supersonic Decelerator

Robotic class supersonic inflatable aerodynamic decelerator prototype after rapid inflation test at China Lake

Helicopter, cargo parachute, mass simulator and attach cabling during first Parachute Development Verification test at China Lake

In March 2012, NASA performed a trial run on a rocket sled test fixture, powered by rockets, to replicate the forces a supersonic spacecraft would experience prior to landing.

Project Summary: The Low Density Supersonic Decelerator project will advance the technology of a supersonic inflatable aerodynamic decelerator and a supersonic ring sail parachute. The inflatable decelerators and advanced parachutes are being tested in a series of rocket sled, wind tunnel, and rocket-powered flight demonstrations.

FY 2012 Milestone: Successful drop test and rocket sled test occurred in 2012, illustrating the ability of the drag devices to slow a spacecraft as it would in the Martian atmosphere. The investigators will continue design verification tests of parachutes and supersonic inflatable aerodynamic decelerators in 2013. The first supersonic flight tests are set for 2013 and 2014.

NASA/Government Application: Infusion of new supersonic inflatable aerodynamic decelerator technology and larger supersonic ring sail parachutes into the design of Mars entry vehicles will dramatically increase the capability of landed Mars science and exploration missions, increasing the mass to the surface, landing altitude, and landing precision as early as 2018.

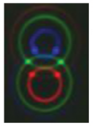
Partnerships: NASA and other government institutions.

2011 NIAC Fellows Engage the Nation's Universities

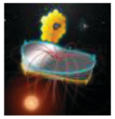
2011 Phase I Fellows

Scott Ferguson, North Carolina State University
Enabling All-Access Mobility for Planetary Exploration Vehicles via Transformative Reconfiguration

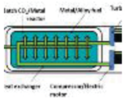
Behrokh Khoshnevis, University of Southern California
Contour Crafting Simulation Plan for Lunar Settlement Infrastructure Build-Up



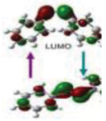
Paul Kwiat, University of Illinois at Urbana-Champaign
Entanglement-assisted Communication System for NASA's Deep-Space Missions: Feasibility Test and Conceptual Design



David Miller, Massachusetts Institute of Technology
High-temperature Superconductors as Electromagnetic Deployment and Support Structures in Spacecraft



Michael Paul, Pennsylvania State University
Non-Radioisotope Power Systems For Sunless Solar System Exploration Missions



Joe Ritter, University of Hawaii
Ultra-Light "Photonic Muscle" Space Structures

Isaac Silvera, Harvard University
Metallic Hydrogen: A Game Changing Rocket Propellant

Grover Swartzlander, Rochester Institute of Technology
Steering of Solar Sails Using Optical Lift Force

Alfonso Tarditi, University of Houston at Clear Lake
Aneutronic Fusion Spacecraft Architecture

Bong Wie, Iowa State University
Optimal Dispersion of Near-Earth Objects

NIAC: Fostering Innovation at Universities across the Nation

2012 Phase I & Phase II Fellows

Exploring new concepts to expand aerospace possibilities