Space Technology Programs

- 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
# Space Technology FY 2013
## President's Budget Request

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

R2 ISS Climbing Legs
Current (FY2012) Big Nine Programs

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

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

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

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

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

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

Demonstrates new inflatable braking systems for use at hypersonic velocities enabling precise landing of large payloads on planetary surfaces, and returning payloads from the ISS to Earth.

Develops and improves technology to enable service, repair, refueling and relocating satellites through the use of robotics.
## “Big 9” FY 2012 Milestones

<table>
<thead>
<tr>
<th>Projects</th>
<th>Oct-11</th>
<th>Nov-11</th>
<th>Dec-11</th>
<th>Jan-12</th>
<th>Feb-12</th>
<th>Mar-12</th>
<th>Apr-12</th>
<th>May-12</th>
<th>Jun-12</th>
<th>Jul-12</th>
<th>Aug-12</th>
<th>Sept-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite Cryotank Tech and Demo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PDR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypersonic Inflatable Aerodynamic Decelerators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human Robotic Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Density Supersonic Decelerators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep Space Atomic Clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SRR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mission Capable Solar Sail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PDR</td>
</tr>
<tr>
<td>Cryogenic Propellant Storage and Transfer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PDR</td>
</tr>
<tr>
<td>Robotic Satellite Servicing</td>
<td>RFI</td>
<td>RFI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Workshop</td>
</tr>
</tbody>
</table>

### Key
- **KDP**: Development
- **MDR**: Critical Event
- **SRR**: Review
- **PDR**: Workshop
- **MCR**: Multiple Tests
- **HIAD**: Multiple Tests
- **2m Pressure Tank Test Readiness Review**
- **Launch**
- **Build-to-Print Fab. Complete**
- **NFAC/Next Generation Tests**
- **KDP-E**
- **KDP-B**
- **KDP-A**
- **KDP**
- **RRM**
- **OPS**
- **Workshop**
### “Big 9” Projects FY 2013 Milestones

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite Cryotank Tech and Demo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fab. Complete</td>
</tr>
<tr>
<td>Hypersonic Inflatable Aerodynamic Decelarators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>HIAD Annual Review</td>
</tr>
<tr>
<td>Human Robotic Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Complete Testing Prototypes of EVA Jetpack</td>
</tr>
<tr>
<td>Low Density Supersonic Decelerators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SIAD-R Rapid Inflation Test 3</td>
</tr>
<tr>
<td>Deep Space Atomic Clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SIAD 1 VIT</td>
</tr>
<tr>
<td>Mission Capable Solar Sail</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SIAD 1 VIT</td>
</tr>
<tr>
<td>Cryogenic Propellant Storage and Transfer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SRR</td>
</tr>
<tr>
<td>Laser Comm. Relay Demo.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SRR</td>
</tr>
<tr>
<td>Robotic Satellite Servicing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SRR</td>
</tr>
</tbody>
</table>

**Key:**
- KDP
- Launch
- Testing
- Development
- Review
- Critical Event
## Game Changing Technology Areas

### ETD: GCD
- In-Space Propulsion (ISP)
- Space Power Generation and Storage
- Lightweight Materials and Structures
- Nuclear Systems
- Human-Robotic Systems (inc. National Robotic Initiative)
- Autonomous Systems (AS)
- Next-Generation Life Support (NGLS)
- Deployable Aeroshell Concepts & Conformal TPS
- In-Situ Resource Utilization (ISRU)
- Composite Cryotank Technologies and Demonstration (CCTD)
- Hypersonic Inflatable Aerodynamic Decelerator (HIAD)
- Advanced Radiation Protection (ARP)

### CSTD: GCD
- Manufacturing Innovation
- Robotic Satellite Servicing
- Nanotechnology
- Space Synthetic Biology
- Solar Array System

### Technology Readiness Levels (TRL)
- 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.8. Sci. Instr./Sensors
- TA.9. EDL
- TA.10. Nanotechnology
- TA.11. Modeling/Simulation
- TA.12. Materials/Structures
- TA.13. Ground/Launch
- TA.14. Thermal
- Technology Readiness Levels (TRL)
### Technology Demonstration Missions

#### Technology Areas

**ETD: TDM**
- Human Exploration Telerobotics (HET)
- Cryogenic Propellant Storage and Transfer (CPST)
- Materials ISS Experiment-X (MISSE-X)
- Green Propellant Infusion Mission

**CSTD: TDM**
- Low Density Supersonic Decelerators (LDSD)
- Laser Communications Relay Demonstration (LCRD)
- Deep Space Atomic Clock (DSAC)
- Solar Sail Demonstration (SSD)

<table>
<thead>
<tr>
<th>Technology Areas (TA)</th>
<th>FY 10</th>
<th>FY 11</th>
<th>FY 12</th>
<th>FY 13</th>
<th>FY 14</th>
<th>FY 15</th>
<th>FY 16</th>
<th>FY 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA.1. Launch Propulsion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.2. In-Space Propulsion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.3. Space Power/Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.4. Robotics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.5. Comm./Navigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.6. Human Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.8. Sci. Instr./Sensors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.9. EDL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.10. Nanotechnology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.11. Modeling/Simulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.12. Materials/Structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.13. Ground/Launch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA.14. Thermal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology Readiness Levels (TRL)</td>
<td>1→9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Small Spacecraft Technologies

## Technology Areas

<table>
<thead>
<tr>
<th>Technology Areas</th>
<th>FY 10</th>
<th>FY 11</th>
<th>FY 12</th>
<th>FY 13</th>
<th>FY 14</th>
<th>FY 15</th>
<th>FY 16</th>
<th>FY 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Solar Array and Reflectarray Antenna for High Bandwidth CubSat</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Integrated Optical Communications and Proximity Sensors for Cubesats</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Proximity Operations Nano-Satellite Flight Demonstration</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Edison Demonstration of Smallsat Networks (EDSN)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>PhoneSat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*NOTE: these three projects have been selected but not yet awarded*
Technology Demonstration Missions
Major Events and Milestones
Space Technology Research Grant Program – Engaging the Nation’s Universities

148 awards
29 states
1 U.S. Territory
57 universities
Space Technology Early Career Faculty
FY 2012 Awards

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

Autonomous Food Production
Nicolaus Correll

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

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

Self-repair and Damage Mitigation of Metallic Structures
Michele Manuel

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

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

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

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

Environmental Control & Life-Support Systems
Wei-Chuan Shih
Space Technology Faculty
FY 2012 Awards

Advanced Scintillating Fiber Technology in High Energy Neutron Spectrometers for Exploration
James Adams

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

Light Weight, 20 K Pulse Tube Cryocooler for Active Thermal Control on Future Space Exploration Missions
Seyed Ghiaasiaan

Wavefront Control for High Performance Coronagraphy on Segmented and Centrally Obscured Telescopes
Olivier Guyon

High Hydrogen Content Nanostructured Polymer Radiation Protection System
Alex Ignatiev

Heat Rejection System for Thermal Management in Space Utilizing a Planar Variable-Conductance Heat Pipe
Yasuhiro Kamotani

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

Enabling Self-Propelled Condensate Flow During Phase-Change Heat Rejection Using Surface Texturing
Vinod Narayanan

Small Active Readout Device for Dose Spectra from Energetic Particles and Neutrons (Dosen)
Nathan Schwadron

Integrated Control Electronics for Adjustable X-Ray Optics
Susan Trolier-McInstry
Space Technology Fellow Summary

Covering 13 Technology Areas

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

NSTRF 11 and 12
128 graduate students conducting space technology research

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
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

Exploring new concepts to expand aerospace possibilities

2012 Project Collaborations

California Institute of Technology, San Jose State University, Santa Clara University, Stanford University, UC Berkeley, UC Santa Cruz, University of Southern California

Brigham Young University

Kansas State University

University of Wisconsin

University of Michigan

Illinois Institute of Technology

University of Tennessee

University of Maryland

North Carolina A&T University

University of Alaska

University of Hawaii

University of Colorado at Boulder

University of Idaho

Massachusetts Institute of Technology, University of Massachusetts

Bridgeport University, University of Connecticut

Stevens Institute of Technology, Princeton University

University of Texas at Austin, University of Texas at El Paso

Rice University, Texas A&M

Georgia Institute of Technology, Georgia State University

Embry Riddle Aeronautical University, Florida Institute of Technology, University of Central Florida, University of Florida
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.**
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.

Project Summary: The Telerobotics project demonstrates how advanced, remotely operated robots can improve human exploration missions. The project develops and tests 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)

**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.

*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: 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

**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

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 Tardi, University of Houston at Clear Lake
Aneutronic Fusion Spacecraft Architecture

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

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

- University of Washington, Seattle
- University of Southern California
- University of Illinois at Urbana-Champaign
- Pennsylvania State University
- Rochester Institute of Technology
- Harvard University
- Massachusetts Institute of Technology
- Virginia Polytechnic Institute and State University
- North Carolina State University
- University of Miami
- University of Houston at Clear Lake
- University of Hawaii
- Iowa State University
- University of Illinois at Urbana-Champaign
- University of Southern California
- University of Miami