Cross-Cutting Technology Challenges That Must Be Faced

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Advanced Technology at NASA

• NASA pursues **breakthrough technologies** to expand our frontiers in aeronautics and space
• **Advanced technologies are critical** for accomplishing NASA’s current missions, and today’s **technology investments are required** for the bold missions of NASA’s future
• These same investments **benefit the United States economy** through creation of new industries, products, services, scientific discoveries, and societal benefits
• NASA’s basic and applied research programs **span all of NASA’s mission areas**
• NASA is implementing a portfolio of broadly applicable Space Technology programs to take the best ideas of our nation’s innovators **from concept to flight**
Space Technology Grand Challenges

**EXPAND HUMAN PRESENCE IN SPACE**
- Economical Space Access
- Space Health & Medicine
- Telepresence in Space
- Space Colonization

**MANAGE IN-SPACE RESOURCES**
- Affordable Abundant Power
- Space Way Station
- Space Debris Hazard Mitigation
- Near-Earth Object Detection & Mitigation

**ENABLE TRANSFORMATIONAL SPACE EXPLORATION & SCIENTIFIC DISCOVERY**
- Efficient In-Space Transportation
- High-Mass Planetary Surface Access
- All Access Mobility
- Surviving Extreme Space Environments
- New Tools of Discovery
The NASA Space Technology roadmaps, drafted by NASA, and reviewed and vetted for technology investment identification and prioritization by the NRC, will serve NASA as a decadal-like survey, to provide sustained technology investment goals.

- Interim report: Sept 2011
- Final Report: Jan 2012

  - Success in executing future NASA space missions will depend on advanced technology developments that should already be underway.
  - NASA’s technology base is largely depleted.
  - Currently, available technology is insufficient to accomplish many intended space missions in Earth orbit and to the Moon, Mars, and beyond.
  - Future U.S. leadership in space requires a foundation of sustained technology advances.

- NASA will utilize the NRC’s final report recommendations in refining the Space Technology Roadmaps in FY 2012 and as a guide in developing FY 2013 and beyond space technology investment priorities.

Investments in Technology

NASA Technology Investments

Space Technology Grand Challenges

- Expand Human Presence in Space
- Manage In-Space Resources
- Enable Transformational Space Exploration and Scientific Discovery

NASA Mission Directorates

5TH = TADS
TECHNOLOGY AREA BREAKDOWN STRUCTURE

- LAUNCH INFRASTRUCTURE
- IN-SPACE FACTORY
- SPACE POWER & ENERGY
- ROBOTICS, TELE-OPERATION & AUTONOMOUS SYSTEMS
- COMMUNICATION & NAVIGATION
- HUMAN/MACHINE, LIFE SUPPORT & HABITATION SYSTEMS
- HUMAN EXPLORATION SYSTEMS
- INSTRUMENTATION
- SPACECRAFT DESIGN & LANDING SYSTEMS
- SPACECRAFT MATERIALS & MANUFACTURING
- SPACECRAFT PROCESSING

Space Technology Grand Challenges

- Economic Space Access
- Space Health and Medicine
- Terrestrial analog in Space
- Space Colonization
- Affordable Abundant Power
- Space Way Station
- Space debris hazard mitigation
- Near Earth Object detection and mitigation
- In-Space, In-Situ, and 3D Printed Habitation
- In-Space, In-Situ, and 3D Printed habitation
- Life-Support Systems

Enable Transformational Space Exploration and Scientific Discovery

- Efficient In-Space Transportation
- High-Mass Planetary Surface Access
- In-Space Manufacturing
- In-Space, In-Situ, and 3D Printed habitation

NASA Mission Directorates
FY 2011 Basic and Applied Research Funding at NASA

Agency Total = $1115M (plus $300-500M in SMD mission-focused technology)
1. **Execution of Space Technology Program**
   - Comprehensive execution of all ten ST programs (over 1000 projects)
   - Emphasis on FY 2012 “Big Nine” projects

2. **Strengthen cross-agency view (SMD, HEOMD, ARMD)**
   - Ensure appropriate coverage – minimize gaps and overlaps
   - Increase infusion of technologies into missions

3. **Increase engagement with external entities for collaborative technology development**
   - Other Government Agencies (e.g., DARPA, AFRL, NRO)
   - International partners (e.g., ESA, DLR, CSA)

4. **New approach (“co-development”) for simultaneous development of technologies to meet NASA mission objectives and provide broader societal benefit**
   - Co-development strategy involves identification of key requirements, partnership at outset of project (parallel development)
   - Results in faster, less expensive development than if done serially
NASA Technology: Improving Our Lives Everyday

- Advanced Diagnostic Ultrasound in Microgravity
- LED Light Therapy for Pain Management
- Clean Energy
- Groundwater Remediation
- Infrared Thermometers
- Eye Exams
- Aerogel Insulation
- Lithium Batteries for Cars
- Nutritional Supplements
- Winglets Save Fuel Cost
- Weather Forecasting
- Tornado damage near Birmingham, Alabama (5/4/11)
- Flooding at the Junction of the Mississippi and Ohio Rivers (5/3/11)

Totals based on a 2011 survey of technology transfer successes reported in NASA Spinoff from 2003-2008, and on additional data gathered from Spinoff 2009-2011. NASA technologies have:

- Created over 9000 jobs
- Generated over $1B in revenue
- Created more than $6B in cost avoidance
- Saved more than 12,000 lives
- Significantly improved quality of life for more than 80 million people
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<table>
<thead>
<tr>
<th>Technology Needs</th>
<th>Space Technology Response</th>
<th>Space Technology Program</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human Exploration Operations Mission Directorate (HEOMD)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep space optical communications</td>
<td>Laser Communications Relay Demonstration Project</td>
<td>FY 2011 TDM Selection</td>
</tr>
<tr>
<td>Next generation life support</td>
<td>Next Generation Life Support Project</td>
<td>GCD</td>
</tr>
<tr>
<td>International Space Station (ISS) materials testbed</td>
<td>Materials International Space Station Experiment (MISSE)</td>
<td>TDM</td>
</tr>
<tr>
<td>Advanced radiation protection</td>
<td>Advanced Radiation Protection Project, NIAC Projects</td>
<td>GCD, NIAC</td>
</tr>
<tr>
<td>Solar electric propulsion demonstration</td>
<td>Space Power Generation &amp; Storage, Solar Electric Propulsion Demonstration</td>
<td>GCD</td>
</tr>
<tr>
<td>Cryogenic propellant storage &amp; transfer demonstration</td>
<td>Cryogenic Propellant Storage &amp; Transfer Demonstration Mission</td>
<td>TDM</td>
</tr>
<tr>
<td>Key exploration technology projects</td>
<td>Exploration priorities coordinated with HEOMD, complementary with Advanced Exploration Systems (AES) Program</td>
<td>GCD</td>
</tr>
<tr>
<td><strong>Science Mission Directorate (SMD)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep space optical communications</td>
<td>Laser Communications Relay Demonstration Project</td>
<td>FY 2011 TDM Selection</td>
</tr>
<tr>
<td>Robust in-space tech demonstration program</td>
<td>Currently 9 projects in TDM Program</td>
<td>TDM</td>
</tr>
<tr>
<td>Mars entry, descent and landing systems</td>
<td>Inflatable entry and descent technology projects, instrumentation on Mars Science Laboratory, deployable aeroshell and flexible thermal protection systems</td>
<td>GCD and TDM</td>
</tr>
<tr>
<td>Advanced sensors</td>
<td>Opportunities exist in multiple programs</td>
<td>GCD, NIAC, SBIR</td>
</tr>
</tbody>
</table>
### Aeronautics and Chief Offices Technology Priorities

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Aeronautics Research Mission Directorate (ARMD)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entry, descent and landing hypersonics materials and systems</td>
<td>Inflatable entry and descent technology projects, instrumentation on Mars Science Laboratory, deployable aeroshell and flexible thermal protection systems</td>
<td>GCD, TDM</td>
</tr>
<tr>
<td>Aeronautics content in Center Innovation Fund (CIF), NIAC and Centennial Challenges (CC) Programs</td>
<td>Green flight aviation challenge; Program plans consistent with aeronautics content</td>
<td>CIF, NIAC, CC</td>
</tr>
</tbody>
</table>

**Office of the Chief Engineer and Office of the Chief Health and Medical Officer**

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<td>Breakthrough low-cost space access</td>
<td>Airborne Launch Assist Space Access (ALASA), Nanotechnology propellants, Beamed-power project</td>
<td>GCD</td>
</tr>
<tr>
<td>In-space power</td>
<td>Space Power Generation and Storage</td>
<td>GCD</td>
</tr>
<tr>
<td>Low gravity and confinement protection</td>
<td>Lightweight Materials and Structures; Advanced Radiation Protection</td>
<td>GCD</td>
</tr>
<tr>
<td>Deep space communications</td>
<td>Laser Communications Relay Demonstration Project</td>
<td>TDM</td>
</tr>
<tr>
<td>Mars entry descent and landing systems that enable large payload landings</td>
<td>Inflatable entry and descent technology projects, instrumentation on Mars Science Laboratory, deployable aeroshell and flexible thermal protection systems</td>
<td>GCD, TDM</td>
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<tr>
<td>Radiation protection</td>
<td>Advanced Radiation Protection Project, NIAC Projects</td>
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Space Technology consists of hundreds of small projects distributed across the country.

These projects include the following nine ongoing, high-priority, high-visibility, broadly-applicable activities, each of which has major testing milestones in FY 2012 and FY 2013:

- Laser Communications Relay Demonstration (GSFC)
- Low Density Supersonic Decelerators (JPL)
- Cryogenic Propellant Storage and Transfer (GRC)
- Deep Space Atomic Clock (JPL)
- Hypersonic Inflatable Aerodynamic Decelerator (LaRC)
- Composite Cryotanks (MSFC)
- Robotic Satellite Servicing (GSFC)
- Solar Sail (L’Garde Inc.)
- Human-Robotic Systems (JSC)
1. Enable economical and routine access to space
   • We have not made the equivalent progress during the first half-century of space flight that we made during the first half-century of aerial flight. Why not? (It’s not just the energetics.)
2. Enable human exploration/colonization of the solar system
   • Accommodate long missions (radiation protection, logistics, behavioral psychology, etc.)
   • And/or get there faster (better in-space propulsion)
3. Protect Earth from global-scale threats
   • Chronic – understand our global environment to enable objective policy change
   • Acute – low-probability/high-consequence events – how to assess?
NASA is encouraged by the recognition of the Administration and Congress that investing in NASA’s Space Technology Program during tough economic times is an important investment in America’s future.

NASA’s Space Technology Program will allow the agency to continue to develop made-in-America technologies and innovations from across the country to enable NASA’s future missions.

NASA’s Space Technology Program acts as a catalyst for innovation throughout America’s aerospace industries and will create new, high technology jobs and innovations in manufacturing that will guarantee American leadership in the new technology economy.
The 10 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

Crosscutting Capability Demonstration

- Flight Opportunities
- Technology Demonstration Missions
- Edison Small Satellite Demonstration Missions
The Big 9 Highlights

• **Laser Communications Relay Demonstration:** High-bandwidth communications for near-Earth and deep-space applications. Other government agency interest. HEOMD infusion partner. Project start in FY 2011; SRR in FY 2012.

• **Low Density Supersonic Decelerators:** New supersonic decelerator capabilities for high-mass Mars missions and other planetary destinations, enabling pinpoint landing and high-elevation landing sites. FY 2012 milestones: Rocket-sled testing and first high-altitude balloon drop test.

• **Cryogenic Propellant Storage and Transfer:** Long-term storage of cryogenic propellant in space. Highest priority flight demonstration of NASA’s Human Architecture Team. Formulation complete. SRR in FY 2012.

• **Composite Cryotanks:** Large-scale test articles that prove the viability and performance advantages of composite tanks for future SLS, planetary landers, propellant depots and in-space propulsion systems. FY 2012: 5-meter diameter autoclave and out-of-autoclave test articles.

• **Robotic Satellite Servicing:** In FY 2012, complete RRM International Space Station (ISS) demonstration mission, share data with industry, focus future technology investments on those needed to facilitate commercial enterprise.

• **Deep Space Atomic Clock:** Order of magnitude increase in deep space navigation performance. HEOMD infusion partner. Project start in FY 2011; SRR in FY 2012.

• **Hypersonic Inflatable Aerodynamic Decelerator:** New entry system capabilities to enable ISS downmass and high-mass landings on Mars. HEOMD and OSC Cygnus interest. FY 2012 sounding rocket flight.

• **Solar Sail:** Development of solar sail flight demonstration mission. Sail area 7 times larger than previous flight articles; 4 times larger than what can be tested in ground-based facilities. NOAA, SMD and human exploration cargo mission interest. Project start in FY 2011; SRR in FY 2012.

• **Human-Robotic Systems:** In FY 2012, complete Robonaut2 demonstration mission on the ISS, share data with academia and industry, foster U.S. competitiveness in next-generation robotics.
Objective: Develops and demonstrates critical technologies that provide the basis for a broad set of human exploration capabilities to enable future human missions beyond low Earth orbit based on the prioritized needs of NASA’s human spaceflight enterprise.

FY 2012 Status:

- Five of the “Big 9” projects funded in FY 2011 with significant, high-visibility milestones in FY 2012
- Satellite Servicing, Human-Robotic Systems (includes R2 and President’s Robotics Initiative), Composite Cryotank, Hypersonic Inflatable Aerodynamic Decelerator (HIAD) and Cryogenic Propellant Storage and Transfer (CPST)
- Transition and implementation plans complete for activities to transfer from ESMD to Space Technology on October 1, 2011
Space Technology ETD Projects in FY 2012

- In-space Propulsion (GRC)
- Space Power Generation & Storage (GRC)
- Nuclear Systems (GRC)
- Lightweight Materials & Structures (LaRC)
- Human-Robotic Systems (JSC)
- Autonomous systems (ARC)
- Next Generation Life Support (JSC)
- Deployable Aeroshell Concepts & Flexible TPS (ARC)
- In-Situ Resource Utilization (ISRU) (KSC)
- Composite Cryogenic Propellant Tank (MSFC)
- Advanced Radiation Protection (LaRC)
- Hypersonic Inflatable Aerodynamic Decelerator (LaRC)
- Human Exploration Telerobotics (ARC)
- MSL Entry Descent and Landing Instrumentation (MEDLI) (LaRC)
- Autonomous Landing and Hazard Avoidance Technology (ALHAT) (JSC)
- Cryogenic Propellant Transfer and Storage (GRC)
- Solar Electric Propulsion (GRC)
- Satellite Servicing (GSFC)

*Note that the funding level for these activities is dependent on the final appropriations level for Space Technology. As examples, the SEP TDM, and HIAD ISS Downmass TDM projects that had been proposed for an FY12 start will not be initiated until at least 2013.
Crosscutting Space Technology Development (CSTD)

- **Objective:** Spans early-stage conceptual studies to flight demonstration, creating a steady pipeline of broadly-applicable technologies enabling NASA's future Science, Space Operations and Exploration missions. Open solicitation, competitive acquisition approach.

- **FY 2012 Status:**
  - Four of the “Big Nine” projects funded in FY 2011 with significant, high-visibility milestones in FY 2012
    - Low Density Supersonic Decelerator (LDSD), Laser Communications Relay Demonstration (LCRD), Deep Space Atomic Clock (DSAC) and Solar Sail Demonstration
    - Initial FY 2011 competitive awards made for Space Technology Graduate Fellowships (80), NIAC (30), Game Changing Development (2 and 5 new starts planning), Flight Opportunities (25 payloads and 7 platform providers), and Technology Demonstration Missions (3)
Space Technology CSTD Projects in FY 2012

- Nanotechnology (GRC)
- Space Synthetic Biology (ARC)
- Low Density Supersonic Decelerators (JPL)
- ISS Demonstrations - MISSE-X (LaRC)
- Laser Communications Relay Demonstration (GSFC)
- Atomic Clock (JPL)
- Solar Sails (L’Garde Inc.)
Composite Cryotank Technologies and Demonstration Project (CCTD)
Cryogenic Propellant Storage and Transfer