A New Space Enterprise - Exploration Technology and Capability Development

2010 Presidential Space Conference

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April 15, 2010
Strategy for Future Human Missions

**Common Capabilities**

- Efficient In-Space Aerocapture
- Low-cost Engines
- Cryo Fluid Management
- Robust/Efficient Space Structures
- Lightweight Electronics
- Radiation Research
- Zero/Low-g Research
- Regenerable Life Support
- Advanced Lightweight EVA

**Technology Building Blocks**

- Hypersonic Inflatable aeroshell
- Regenerative Aerobraking
- Revolutionary ETO Rockets
- Innovative Mission Concepts

**Potential Destinations**

- Mission Analyses
- Exploration Technology and Demonstrations
  - Flagship Technology Demonstration Program
  - Enabling Technology Development and Demonstration Program

- Heavy-Lift and Propulsion Technology
  - First Stage Engine Research and Development
  - In-space engine demonstrations
  - Foundational Propulsion Research

- Exploration Precursor Robotic Missions
  - Medium Exploration Class Missions
  - Small Exploration Scout Missions
  - Missions of Opportunity

- Human Research Program increased funding
Exploration Technology Development and Demonstration Approach

**Foundational Technology Domains**

- Advanced In-Space Propulsion
- Autonomous Systems & Avionics
- Cryogenic Propellant Storage & Transfer
- Entry, Descent, & Landing Technology
- EVA Technology
- High-Efficiency Space Power Systems
- Human-Robotic Systems
- In-Situ Resource Utilization
- Life Support & Habitation Systems
- Lightweight Spacecraft Materials & Structures

**Demo Projects**

- **Demo 1** Lunar Volatiles
- **Demo 2** High-Power Electric Prop
- **Demo 3** Autonomous Precision Landing
- **Demo 4** Operating Robots from Orbit
- **Demo 5** Fission Power Systems

**Future Demos**
• **Biomedical technologies** investment increased
  – Solutions to problems of human spaceflight with potential Earth applications
  – Space Station as a test bed for advanced medical care

• **Space radiation research** investment increased
  – Increases critical research to reduce uncertainty of radiation risks
  – Coordination with shielding and protection technology demonstrations

• **Behavioral Health** Research investment increased
  – Related to behavioral factors and physiological implications of long-duration missions.

• **Space Station utilization** investment increased
  – New human health related technology demonstrations
  – Additional research addressing human risks during long-duration exposure to microgravity
  – New research projects to be solicited via research announcements

• **STEM education** investment increased
  – Involve larger numbers of students, teachers, and general public in ongoing projects

• **National Space Biological Research Institute** investment increased
Flagship Technology Mission-
Candidate Technology Content

<table>
<thead>
<tr>
<th>Key Technologies</th>
<th>SEP Mission*</th>
<th>Propellant Storage Mission*</th>
<th>Inflatable Mission*</th>
<th>AeroCapture EDL Mission</th>
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</thead>
<tbody>
<tr>
<td>Propellant Transfer and Storage</td>
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<tr>
<td>Lightweight/Inflatable Modules</td>
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<td>AR&amp;D</td>
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<td>Closed Loop Life Support</td>
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<td>Aero-capture and EDL</td>
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<tr>
<td>Advanced Space Propulsion</td>
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*Flagship Service Vehicle* is a common element needed across multiple FTD missions, but is not a separate mission.
In Space Propulsion Technology Demonstrations (Preliminary)

<table>
<thead>
<tr>
<th>Technology Demonstration Complexity and Available Power</th>
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<tbody>
<tr>
<td>State-of-Art</td>
</tr>
<tr>
<td>• &lt; 3 kWe Devices</td>
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<tr>
<td>SEP Stage 30 kW</td>
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<tr>
<td>SEP Stage 90 kW</td>
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<tr>
<td>Full scale high efficiency Spacecraft</td>
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<tr>
<td>200 kWe SEP Stage</td>
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<tr>
<td>Advanced Thruster Demo</td>
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<tr>
<td>Fission Power Demo</td>
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<tr>
<td>Multi MegaWatt Nuclear Stage</td>
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<tr>
<td>• Magneto-Plasma and/or nuclear thermal</td>
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<tr>
<td>SEP Stage Upgrade</td>
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<tr>
<td>Advanced EP Thruster + 90 kWe</td>
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<tr>
<td>FTD-1 SEP Stage/AR&amp;D</td>
</tr>
<tr>
<td>NEXT Ion + 30 kWe FAST Array</td>
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<tr>
<td>2014 2016 2018 2020 2022 2024 2026</td>
</tr>
</tbody>
</table>
In-Space Propellant Transfer & Storage Demonstrations (Preliminary)

- Six Month Cryo storage
- Cryo propellant transfer (intra-vehicular)
- First generation quantity gauging
- Automated Cryo coupling
- Small O_2/CH_4 thruster
- AR&D

- Long duration Cryo storage with Cryo coolers
- Cryo propellant transfer (inter-vehicular)
- High efficiency solar arrays
- Gas transfer
- Second generation quantity gauging
- Larger thrusters
- AR&D
Inflatable Mission Module Capability Demonstrations (Preliminary)

Inflatable Mission Module
• Advanced shielding – MMOD
• Flexible power arrays
• Composite core
• Deployed walls
• Scarred for:
  • Advanced ECLSS
  • EVA suitport

Small Inflatable Test Module Demonstration

Advanced EVA

Advanced ECLSS

Technology Maturation and Closure

Time

Aero Entry, Descent and Landing Capability Demonstrations (Preliminary)

Technology Maturation and Closure

Technology Development and Maturation (2011-2015)
Demonstrate viability of Hypersonic Inflatable Aerodynamic Decelerator in Earth atmosphere.

Earth Based Flagship Mission

• Earth Based Supersonic-Retro Propulsion Demonstration

Mars Flagship Mission
• Mid L/D rigid or
• Supersonic –Retro propulsion
• Terminal descent and landing

OR

Mars Based Flagship Mission

• Earth Based Flagship Mission
ESMD: Blazing a Trail Into the Solar System

- NASA’s human spaceflight program seeks to extend human presence throughout the solar system.
- The President's FY2011 Budget Request takes a new approach to this goal, focusing on developing the capabilities that will allow us to reach multiple potential destinations, including the Moon, Asteroids, Lagrange points, and Mars and its environs.
- The investments seek to create the new knowledge and capabilities required for humans to venture beyond low Earth orbit to stay.
- Approach expands alternatives available for human exploration through timely strategic investment in essential technologies.