Overview

FY01 Focus Areas

- **Prioritize investments to achieve Agency goals**
  - In-Space propulsion, nuclear power/propulsion and radiation mitigation
- **Improve understanding of the Earth’s Neighborhood**
  - Refine concepts and science needs
- **Improve definition of the robotic/human partnership in space**
  - Capture the state-of-the-art for future robotics
  - Quantify and compare robotic/human performance in projected operations
  - Increase understanding of critical Bioastronautics issues
- **Advance Technology for Human/Robotic Exploration and Development of Space (THREADS)**
  - Discover innovative concepts and technology
  - Show progress in key technology areas
- **Expand leveraging activities**
  - Active investments from; NIAC, RASC, SBIR, SSP
  - DoD - opportunities through Technology Area Review and Assessment (TARA), Advanced Concept Technology Demonstrations (ACTD), etc.
  - Education; Steckler Trust
# Agency Investments

## Prioritized In-Space Propulsion Technologies

<table>
<thead>
<tr>
<th>Process</th>
<th>In-Space Propulsion Technology</th>
<th>High Priority</th>
<th>Medium Priority</th>
<th>Low Priority</th>
<th>High Payoff/High Risk</th>
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<tbody>
<tr>
<td>• Requirements/Goals Established by NASA Enterprises</td>
<td>Advanced Chemical</td>
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<td>Solar Electric Propulsion (SEP)</td>
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<td>Nuclear Electric Propulsion (NEP)</td>
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<td>Solar Sails</td>
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<td>Momentum Exchange Tethers (MXER)</td>
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</tbody>
</table>

Legend:
- Code S Priority
- Code M Priority
- Code M and S

- Technology options identified
- Systems concepts developed
- Systems Concepts Compared
- Technologies Prioritized
Agency Investments

Nuclear Power and Propulsion

- NEP identified as high-priority in space propulsion technology for human and robotic exploration
  - Enables very high delta-V missions
  - Offers abundant power at destination
- Evolutionary approach to fission propulsion proposed (3 phases)
  - 10-500 kW NEP and surface
  - Up to 10 MW NEP, solid-core NTR
  - Up to 100 MW NEP
- Enables non-Keplerian orbits that can avoid hazardous regions (e.g. ring particles)
- Enables complex, long duration missions

![Graph showing flight times and masses for different missions](image)
Agency Investments
Nuclear Power and Propulsion

• Refurbished 2 kWe Brayton testbed and began high power Brayton system design studies with industry
• Conducted Heat Pipe reactor-to-Stirling power conversion integrated test
• Conducted Stirling engine-to-Hall thruster integrated test
• Fabricated and tested plasma injector for compact toroid high power plasma thruster
• Completed design and initial fabrication stages of 50kWe Hall thruster
• Conducted mission/trajectory design and analysis for high and low thrust nuclear propulsion systems
• Prepared conceptual designs of NEP and NEP/NTR vehicles for human and robotic science missions
Agency Investments
Attacking the Radiation Challenge

CURRENT MITIGATION
Safe Havens
Career/Mission Time Constraints
Dosimetry
Historical Data/Modeling
Earth’s Magnetic Field

ADVANCED APPROACHES
Fast Transit
Personnel Screening
Active Shielding*
Pharmaceuticals
Integ. Design of Passive Shields*
Materials*
Tissue Testing/Modeling

Risk/Uncertainty

3% lifetime limit
* NEXT funded Activities

Exploration Location/Duration

- LEO
  - 180 Days
- LEO+
  - 500-1000 Days

As Low As Reasonably Achievable

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**Recommendations for effective dose limits (Sv*) for 3% excess cancer fatality for 10 year careers**

<table>
<thead>
<tr>
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<th>Female 2000</th>
<th>Male 1990</th>
<th>Male 2000</th>
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**Age at First Mission**

<table>
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<th>Age at First Mission</th>
<th>No. of 180-day LEO missions**</th>
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<td>55</td>
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<td>Male 3</td>
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</table>

* 1 SV = 100 REM. 1 REM = measure of effective biological damage as determined by absorbed dose x quality factor

** Administrative limits: 1% risk excess cancer risk; 0.2 Sv/mission; no uncertainty assumed.

**Considerations**

- Costs of training
- Costs of crew replacement
- Career corps vs one-mission astronauts
Agency Investments
Shielding Materials

Multidiscipline Networked Immersive 3D Simulation and Optimization

Polyethylene Augmentation for ISS

Mini Magnetospheric Plasma Propulsion

Radiation Absorbing Materials

Brookhaven National Lab (BNL)

Habitat and EVA Garment Material Testing

Reports Available - “Optimization of Multifunctional Material for Radiation Protection” and numerous papers

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