Panel Session III - NASA's Long-Term Strategy for Space: Opening the New Frontier

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Space Architect

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NASA’s Long-Term Strategy for Space: Opening the New Frontier

Gary L. Martin
Space Architect

April 30, 2003
The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.

The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

www.nasa.gov
Robust Exploration Strategy

Traditional Approach: A Giant Leap (Apollo)

- Cold War competition set goals, National Security justified the investment
- Singular focus on the Moon
- Humans in space an end unto itself
- Robotic exploration secondary to crewed missions
- Rigid timeframe for completion with unlimited resources
- Technologies are destination- and system-specific
- Inspirational outreach and education secondary to programs

New Strategy: Stepping Stones and Flexible Building Blocks

- NASA Vision and Mission drive goals and must justify investment
- Robust and flexible capability to visit several potential destinations
- Human presence is a means to enable scientific discovery
- Integrate/optimize human-robotic mix to maximize discovery
- Timeframe paced by capabilities and affordability
- Key technologies enable multiple, flexible capabilities
- Inspiration and educational outreach integral to programs

In today's environment, this approach to exploration is high-risk with limited vision beyond demonstrating a technology capability

This approach is robust and flexible, driven by discovery, and firmly set in the context of national priorities
<table>
<thead>
<tr>
<th>Science Questions</th>
<th>Pursuits</th>
<th>Activities</th>
<th>Destinations</th>
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</thead>
<tbody>
<tr>
<td>How did we get here?</td>
<td>How did the Solar System evolve?</td>
<td>History of major Solar System events</td>
<td>Planetary sample analysis: absolute age determination “calibrating the clocks”</td>
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<td></td>
<td>How do humans adapt to space?</td>
<td>Effects of deep space on cells</td>
<td>Measurement of genomic responses to radiation</td>
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<tr>
<td>Where are we going?</td>
<td>What is Earth’s sustainability and habitability?</td>
<td>Impact of human and natural events upon Earth</td>
<td>Measurement of Earth’s vital signs “taking the pulse”</td>
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<tr>
<td>Are we alone?</td>
<td>Is there Life beyond the planet of origin?</td>
<td>Origin of life in the Solar System</td>
<td>Detection of biomarkers and hospitable environments</td>
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<td></td>
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<td>Origin of life in the Universe</td>
<td>Cometary nuclei</td>
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<td>Europa</td>
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<td>Libration points</td>
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<td>Mars</td>
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<td>Titan</td>
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Stepping Stones
Capability Development

- Understand solar variability and the Sun-Earth connection
- Enhance security and the quality of life on Earth
- Improve how humans can live and work in space

**EARTH AND EARTH ORBIT**
- Earth
- Moon

**EARTH'S NEIGHBORHOOD**
- Build revolutionary telescopes to study planets around other stars, explore the universe, and observe Earth
- Use as gateways for future human exploration
- Follow the water on Mars and seek ancient or present life
- Seek clues to the origins of the solar system and the building blocks of life
- Seek the origins of the universe

**SUN**
- Exploit unique viewpoints in space:
  - Characterize threats and study primitive bodies
  - Explore possible subsurface oceans on moons and search for life
  - Discover Kuiper Belt objects
Strategic Building Block Investments: High-Leverage, Broadly Enabling Capabilities

**Technological Barriers**

**Power:** Providing ample power for propulsion and science

**Transportation:** Providing safe, reliable and economical transportation to and from space and throughout the solar system

**Human Capabilities:** Understanding and overcoming human limitations in space

**Communications:** Providing efficient data transfer across the solar system

<table>
<thead>
<tr>
<th><strong>FY 2003 Request</strong></th>
<th><strong>FY 2004 Request</strong></th>
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<tbody>
<tr>
<td><strong>Nuclear Systems Initiative</strong></td>
<td><strong>Project Prometheus</strong></td>
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<tr>
<td>Ø Greatly increased power for space science and exploration</td>
<td>Ø Nuclear power and propulsion for revolutionary science and orbital capabilities</td>
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<tr>
<td><strong>Integrated Space Transportation Plan</strong></td>
<td>Ø First mission to Jupiter’s Moons</td>
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<td>Ø Orbital Space Plane</td>
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<td>Ø Extended Shuttle Operations</td>
<td></td>
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<tr>
<td>Ø Next Generation Launch Systems</td>
<td></td>
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<tr>
<td><strong>In-Space Propulsion Program</strong></td>
<td><strong>Human Research Initiative</strong></td>
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<tr>
<td>Ø Efficient Solar System Transportation</td>
<td>Ø Accelerate research to expand capabilities</td>
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<td></td>
<td>Ø Enable 100-plus day missions beyond low-Earth orbit</td>
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<td><strong>Space Station Restructuring</strong></td>
<td><strong>Optical Communications</strong></td>
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<tr>
<td>Ø Research Priority Focused</td>
<td>Ø Vastly improve communication to transform science capability</td>
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<td>Ø Management Reforms</td>
<td>Ø First demonstration from Mars</td>
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<td>Ø Sound Financial Base</td>
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<tr>
<td><strong>Bioastronautics Program</strong></td>
<td></td>
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<tr>
<td>Ø Roadmap to address human limitations</td>
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Integrated Space Transportation Plan

Space Shuttle

Orbital Space Plane

Next Generation Launch Technology

- International Space Station
  - US Core Complete
  - IP Core Complete
- Space Shuttle
- Orbital Space Plane
- Next Generation Launch Technology

- FSD Decision
- Development
- ISS Crew Return Capable
- Crew Transfer on Human-Rated EELV
- Operations
- ISS Extend?
- Further Extend as Crew and/or Cargo Vehicle?
- Extend Until 2020+
- Extend?

- Launch System Decision (Based on Reqt, $, DoD)
- Risk Reduction
- FSD Decision
- 1st Flight
- OSP Bridge To New Launcher
- Long-Term Technology Program
- Hypersonic FSD?
Progressive Capability Development
Exploration Metro Map

Sun, Mercury, Venus

Earth

High Earth Orbit
Earth-Moon L₁, L₂

Low Earth Orbit
Moon

Sun-Earth L₁, L₂

Earth's Neighborhood

Accessible Planetary Surfaces

Mars

Outer Planets and beyond
Flow Down

Space Act & NASA Strategic Plan

Science: Questions, Pursuits, Activities

Requirements and Systems Engineering

Architectural Studies & Technology Trades

Programmatic and Technology Road Maps

Gap Analysis

Products:
Integrated Space Plan, Technology Requirements, Priorities, and New Initiatives
Progressive Capabilities

**Earth’s Neighborhood Capability**
- Current launch systems: Payload: 40mt
- In-space propulsion, Isp>1000 sec, high thrust
- Power systems, >200 w/kg
- Integrated Human/robotic capabilities
- Crew countermeasures for 100 days
- Closure of water/air systems
- Materials, factor of 9
- IVHM - Integrated Vehicle Health Monitoring

**Accessible Planetary Surface Capability**
- ETO $/kg (under review)
- Payload: ~100mt
- In-space propulsion, Isp>3000 sec, high thrust
- Power systems, >500 w/kg
- Robotic aggregation/assembly
- Crew countermeasures for 1-3 years
- Complete closure of air/water; options for food
- Materials, factor of 20
- Micro-/Nano- avionics

**Sustainable Planetary Surface Capability**
- ETO $/kg (under review)
- Payload: 100+mt
- In-space propulsion, Isp>3000 sec, high thrust
- Sustainable power systems
- Intelligent systems, orbital and planetary
- Crew countermeasures for indefinite duration
- Closure of life support, including food
- ISRU for consumables & spares
- Materials, factor of 40
- Automated reasoning and smart sensing
Enabling the Strategy

The Hurdles

• Space Transportation
  – Safe, fast, and efficient

• Affordable, Abundant Power
  – Solar and nuclear

• Crew Health and Safety
  – Counter measures and medical autonomy

• Optimized Robotic and Human Operations
  – Dramatically higher productivity; on-site intelligence

• Space Systems Performance
  – Advanced materials, low-mass, self-healing, self-assembly, self-sufficiency…
“As for the future, your task is not to foresee it, but to enable it.”

Antoine de-Saint-Exupery