Exploration Systems
Research & Technology

NASA Institute of Advanced Concepts Fellows Meeting
16 March 2005

Dr. Chris Moore
Exploration Systems Mission Directorate
NASA Headquarters
THE FUNDAMENTAL GOAL OF THIS VISION IS TO ADVANCE U.S. SCIENTIFIC, SECURITY, AND ECONOMIC INTEREST THROUGH A ROBUST SPACE EXPLORATION PROGRAM

Implement a sustained and affordable human and robotic program to explore the solar system and beyond

Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and

Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.
Key Elements of the Nation’s Vision

• Objectives
  – Implement a **sustained** and **affordable** human and robotic program
  – Extend human presence across the solar system and beyond
  – Develop supporting innovative technologies, knowledge, and infrastructures
  – Promote international and commercial participation in exploration

• Major Milestones
  – 2008: Initial flight test of CEV
  – 2008: Launch first lunar robotic orbiter
  – 2009-2010: Robotic mission to lunar surface
  – 2011 First Unmanned CEV flight
  – 2014: First crewed CEV flight
  – 2012-2015: Jupiter Icy Moon Orbiter (JIMO)/Prometheus
  – 2015-2020: First human mission to the Moon
Exploration Systems
Spiral Objectives

• **Spiral 1 (2008-2014)**
  – Provide precursor robotic exploration of the lunar environment
  – Deliver a lunar capable human transportation system for test and checkout in low Earth orbit

• **Spiral 2 (2015-2020)**
  – Execute extended duration human lunar exploration missions
  – Extend precursor robotic technology demonstrations at Mars

• **Spiral 3 (2020-TBD)**
  – Execute a long-duration human lunar exploration campaign using the moon as a testbed to demonstrate systems (e.g., Lander, habitation, surface power) for future deployment at Mars

• **Spiral 4 (~2025-TBD)**
  – Execute human exploration missions to the vicinity of Mars

• **Spiral 5 (~2030-TBD)**
  – Execute initial human Mars surface exploration missions
ESR&T Strategic Focus: **TIMEFRAME**
(By which Technology Must be Proven)

Next 3 Years

Next 6 Years

Next 9 Years

Next 12 Years

15+ Years

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ESR&T Strategic Focus: **IMPACT**
(of the Technology Expected to be Seen in Missions/Systems)

Sub-system Level

System-of-Systems Level (Architecture)

“Definition of Goals” Level

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**Timeframe**
(When Maturity Must be “Proven”)

**Scale of Impact**
(What Influence Will the Technology Have, if “Proven”)

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Investment “Balance” - 2 Views
Advanced Space Technologies Program

Element Programs

Advanced Studies, Concepts, & Tools
Revolutionary exploration system concepts and architectures; technology assessments to identify and prioritize mission enabling technologies; advanced engineering tools for systems analysis and reducing mission risk; exploratory research and development of emerging technologies with high potential payoff.

Advanced Materials & Structural Concepts
Development of high-performance materials for vehicle structures, propulsion systems, and spacesuits; structural concepts for modular assembly of space infrastructure; lightweight deployable and inflatable structures; highly integrated structural systems for reducing launch mass and volume.

Communications, Computing, Electronics, and Imaging
Development of advanced space communications and networking technology; high-performance computers and computing architectures for space systems and data analysis; low-power electronics to enable operations in extreme environments; imaging sensors for machine vision systems and the characterization of planetary resources.

Power, Propulsion, & Chemical Systems
Development of high-efficiency power generation, energy storage, and power management and distribution systems to provide abundant power for space and surface operations; advanced chemical and electrical space propulsion systems for exploration missions; chemical systems for the storage and handling of cryogens and other propellants; chemical systems for identifying, processing, and utilizing planetary resources.

Software, Intelligent Systems, & Modeling
Development of reliable software and revolutionary computing algorithms; intelligent systems to enable human-robotic collaboration; intelligent and autonomous systems for robotic exploration and to support human exploration; advanced modeling and simulation methods for engineering design and data analysis.
Advanced Studies, Concepts, & Tools (ASCT) Themes

Advanced Concepts

Technology Systems Analysis

Systems Design & Engineering Analysis Tools

Technology Databases
• In August 2004, 48 new technology development projects led by the NASA Centers were competitively selected through Intramural Call for Proposals.
  – Received over 1300 Notices of Intent outlining new ideas.
  – Awarded $573M over 4 years.

• In November 2004, 70 new technology development projects led by industry, academia, and other external organizations were competitively selected through Broad Agency Announcement.
  – Received over 3700 Notices of Intent.
  – Awarded $1.1B over 4 years.

• Intramural and Extramural projects will be implemented in two phases:
  – Phase 1: Initial development in pilot projects lasting 1 year. Continuation Review at end of Phase 1 to select projects that will proceed into Phase 2.
  – Phase 2: Full development projects lasting 3 years, delivering useful technology products by 2009.
Strategic Technical Challenge

Modularity

<table>
<thead>
<tr>
<th>Technologies</th>
<th>System Concepts</th>
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<tbody>
<tr>
<td>Modular Systems</td>
<td>Modular outpost in lunar orbit</td>
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<tr>
<td>Autonomous Rendezvous &amp; Docking</td>
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<td>Mechanisms &amp; Interconnects</td>
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Strategic Technical Challenge
In-Space Assembly

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<tr>
<th>Technologies</th>
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<tr>
<td>Modular Structures</td>
<td>Large space systems with capability for growth, maintenance, and reconfigurability</td>
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<tr>
<td>Advanced Manipulators &amp;</td>
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<td>Telerobotics</td>
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<td>Microspacecraft</td>
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<td>Inspectors</td>
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Strategic Technical Challenge
Affordable Logistics Pre-Positioning

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<tr>
<td>Electric Propulsion</td>
<td>Solar Electric Cargo Transfer Vehicles</td>
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<td>High Specific Power Solar Arrays</td>
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<tr>
<td>Composite Cryotanks</td>
<td>In-Space Propellant Depots</td>
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<td>Zero-Boil-Off Cryogen Storage</td>
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Strategic Technical Challenge
Energy Rich Systems & Missions

Technologies

- Solar & Nuclear Power Generation
- Chemical & Electric Propulsion
- Energy Storage
- Aero-Assist Systems

System Concepts

- High Energy Space Systems
Strategic Technical Challenge
Autonomy

Technologies

Intelligent Robotics

Multi-Agent Teaming

Health Management Systems

System Concepts

Autonomous & flexible exploration systems
Strategic Technical Challenge
Space Resources Utilization

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<tr>
<td>Regolith handling</td>
<td>Sustainable lunar base</td>
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<tr>
<td>Propellant &amp; oxygen production</td>
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<td>Common fuel rocket engines</td>
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• Issued RFP for Crew Exploration Vehicle (CEV) on March 1, 2005.

• RFP solicits proposals for preliminary design of CEV, and a flight test program to reduce risk by 2008.

• Planning a research and technology Broad Agency Announcement (BAA) for May/June, 2005. BAA will solicit proposals for rapid maturation of critical technologies needed for Spirals 1 and 2.

• Solicitations can be found on the web at: http://exploration.nasa.gov
Summary

- The Advanced Space Technology Program is the front-end of the technology development pipeline that supplies new system concepts and technologies for future exploration missions.

- NIAC is the leading edge of advanced concepts development for the Advanced Space Technology Program.

- Technology development is guided by a set of Strategic Technical Challenges and target system concepts.

*Human exploration of Jovian moons*