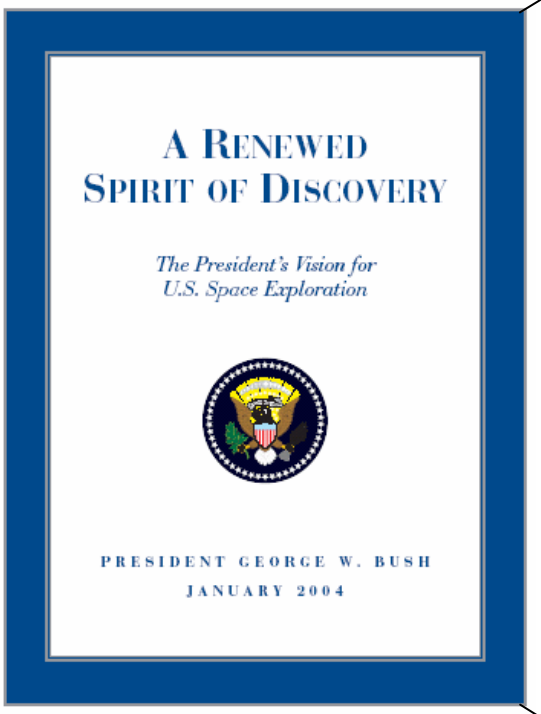
# Exploration Systems Research & Technology

*NASA Institute of Advanced Concepts Fellows Meeting*
*16 March 2005*

*Dr. Chris Moore*
*Exploration Systems Mission Directorate*
*NASA Headquarters*

# Nation's Vision for Space Exploration

## THE FUNDAMENTAL GOAL OF THIS VISION IS TO ADVANCE U.S. SCIENTIFIC, SECURITY, AND ECONOMIC INTEREST THROUGH A ROBUST SPACE EXPLORATION PROGRAM




**Implement a <u>sustained</u> and <u>affordable</u> human and robotic program to explore the solar system and beyond**

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

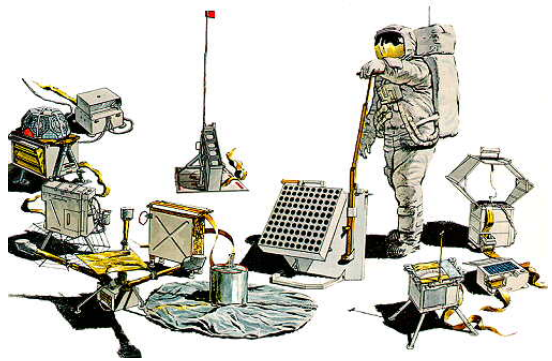
**<u>Develop the innovative technologies</u>, <u>knowledge</u>, and <u>infrastructures</u> both to explore and to support decisions about the destinations for human exploration; and**

**Promote <u>international and commercial participation</u> 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

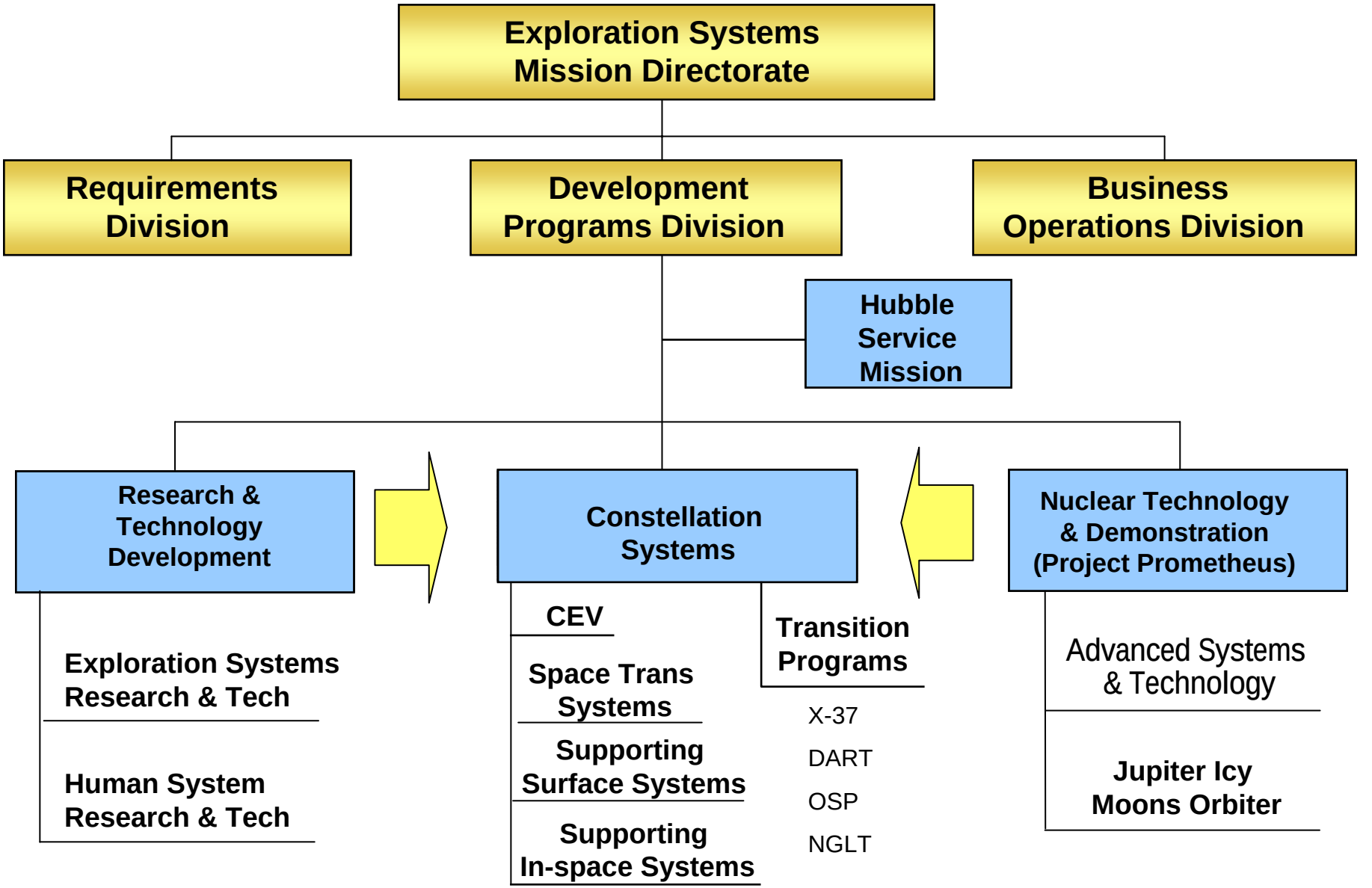
- **Spiral 2 (2015-2020)**
  - Execute extended duration human lunar exploration missions
  - Extend precursor robotic technology demonstrations at Mars

- **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

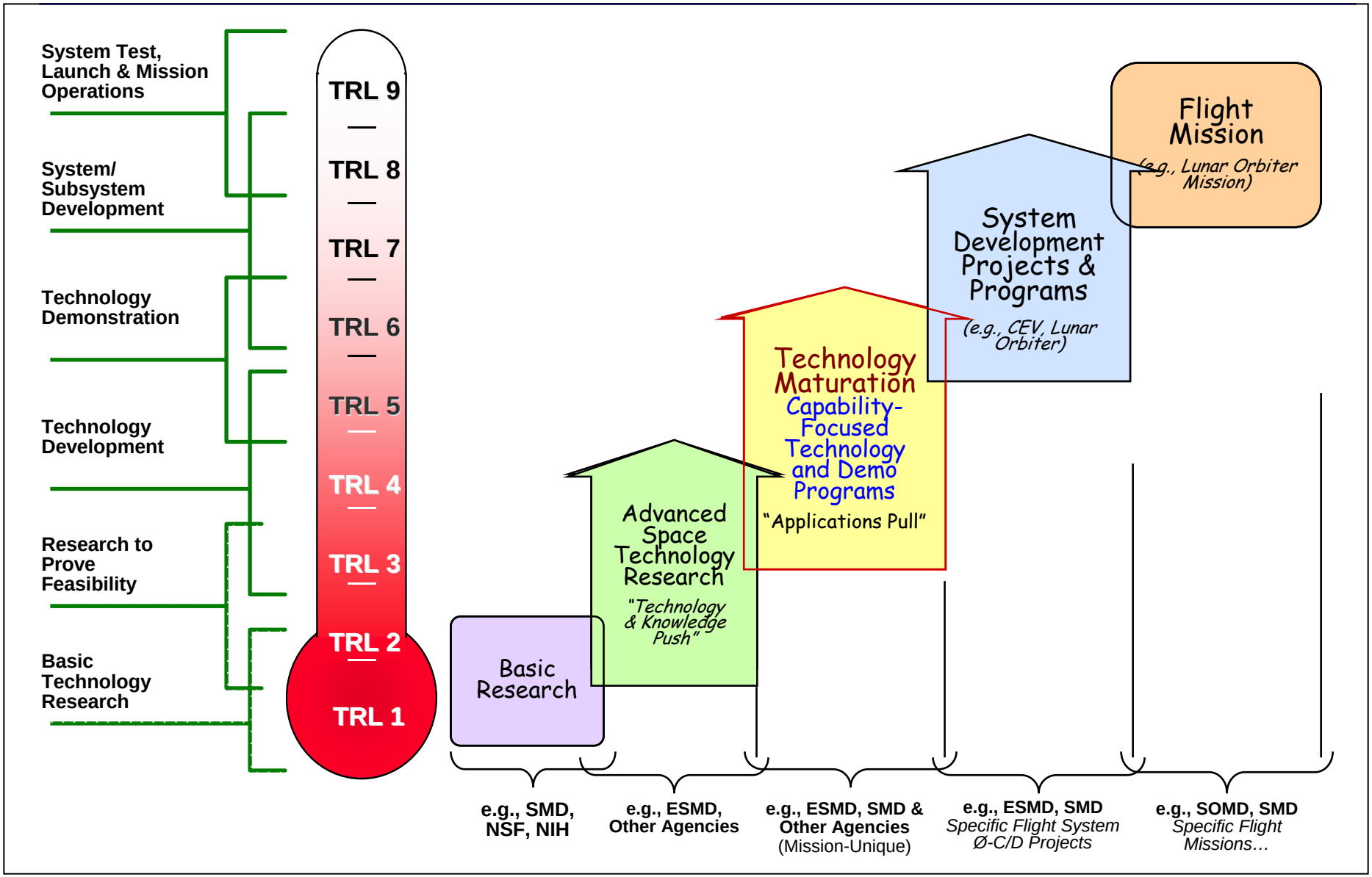
- **Spiral 4 (~2025-TBD)**
  - Execute human exploration missions to the vicinity of Mars

- **Spiral 5 (~2030-TBD)**
  - Execute initial human Mars surface exploration missions

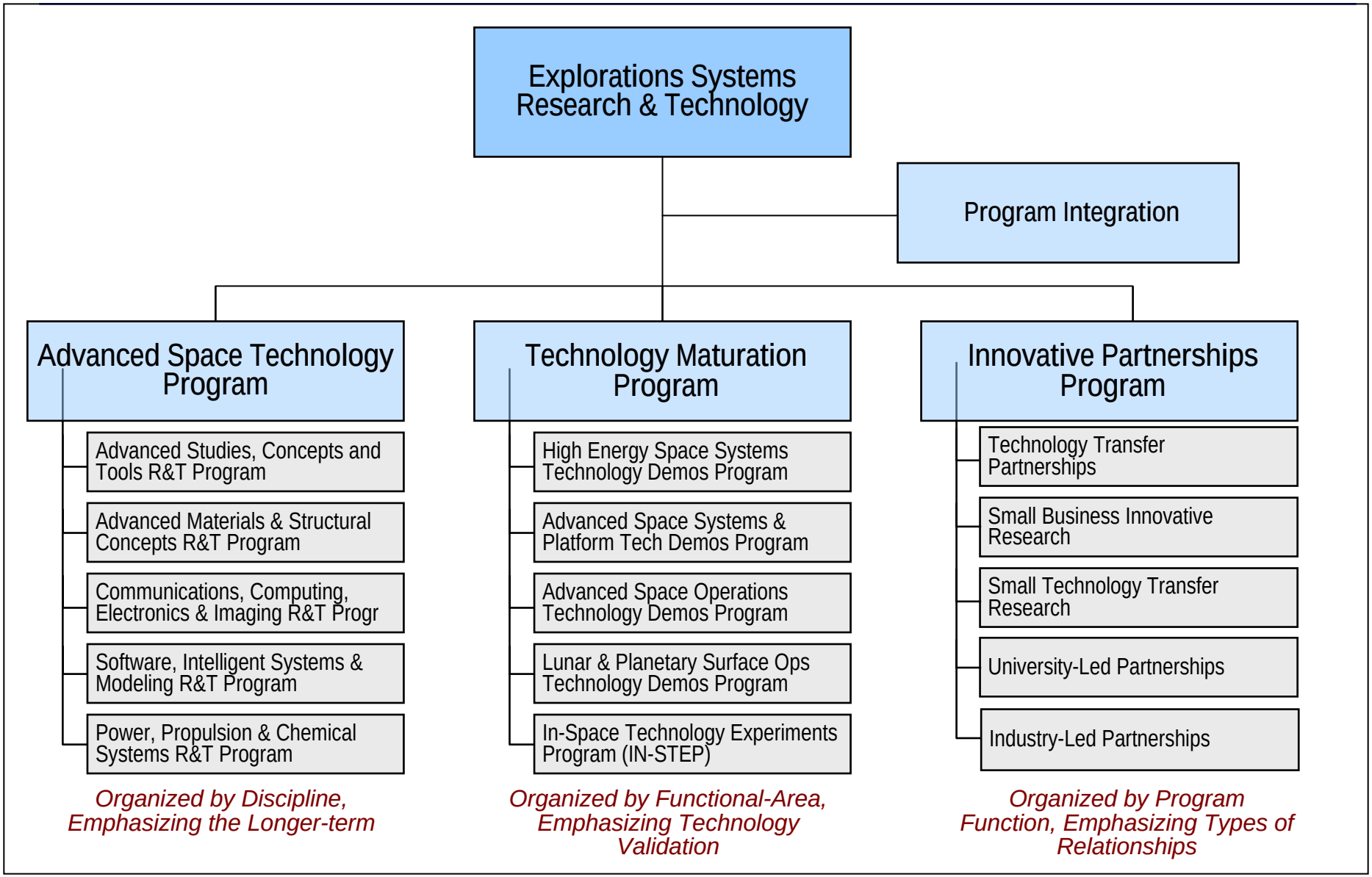
# Exploration Systems Mission Directorate
# Organization



# ESR&T Strategic Technology/Systems Model

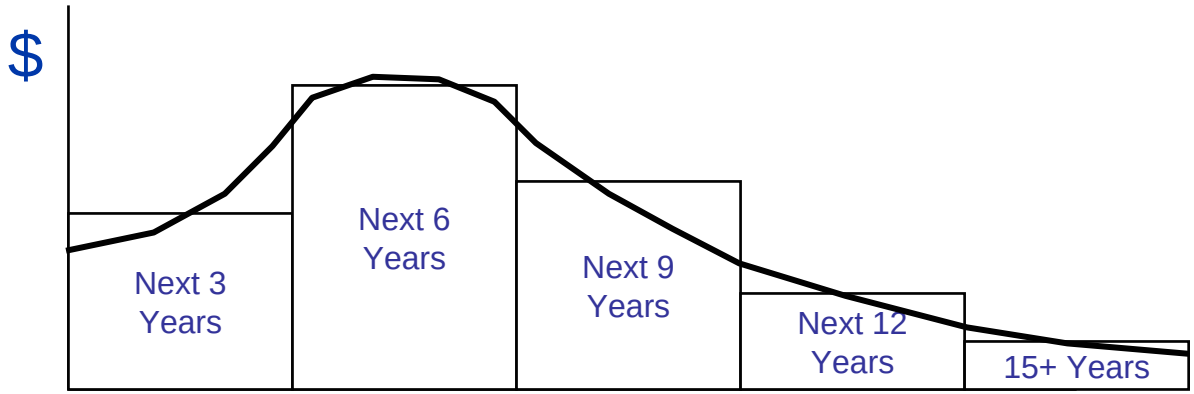


# ESR&T Organization
# Headquarters Office



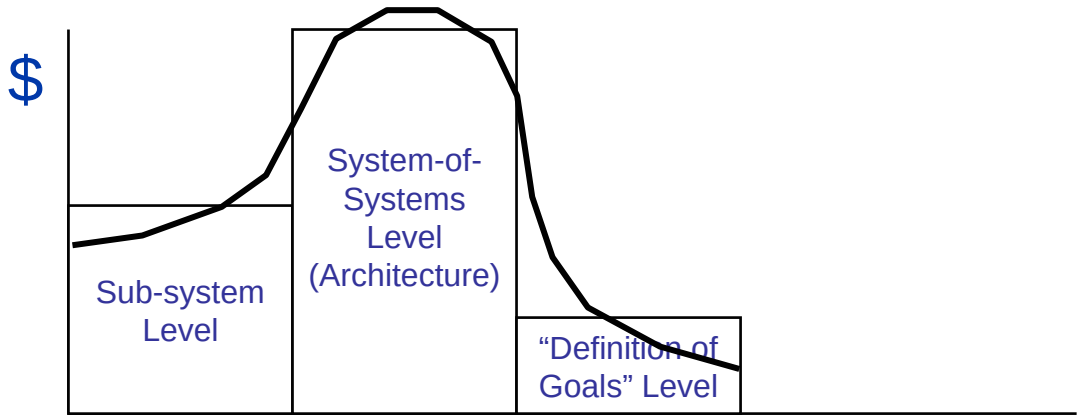
# Exploration Systems Research & Technology
## Investment "Balance" - 2 Views

ESR&T Strategic Focus: TIMEFRAME
(By which Technology Must be Proven)



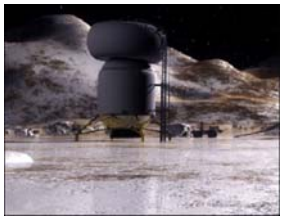

Timeframe
(When Maturity Must be "Proven")

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

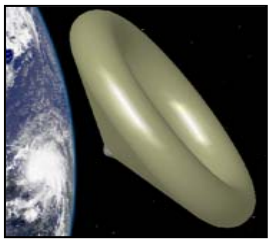



Scale of Impact
(What Influence Will the Technology Have, if "Proven")

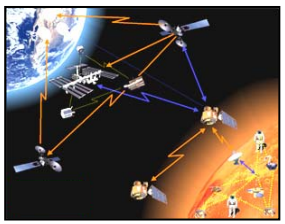
# Advanced Space Technologies Program
## Element Programs



**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.*



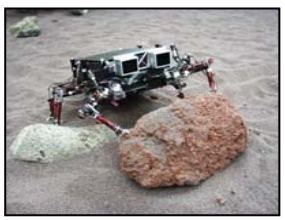
**Advanced Materials & Structural Concepts**
*Development of high-performance materials for vehicle structures, propulsion systems, and spacesuits; structural concepts for modular assembly of space infrastructure; lightweight deployable and inflatable structures; highly integrated structural systems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

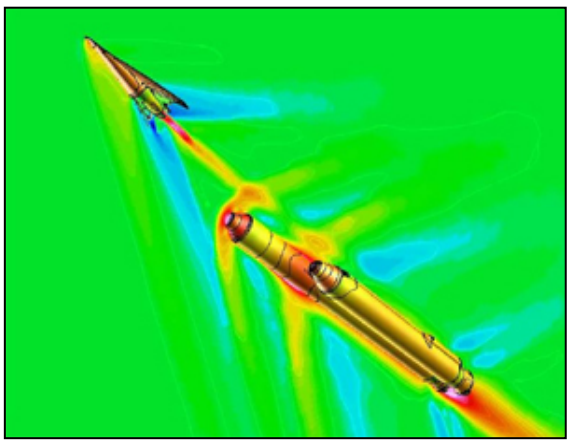


**Software, Intelligent Systems, & Modeling**
*Development of reliable software and revolutionary computing algorithms; intelligent systems to enable human-robotic collaboration; intelligent and autonomous systems for robotic exploration and to support human exploration; advanced modeling and simulation 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

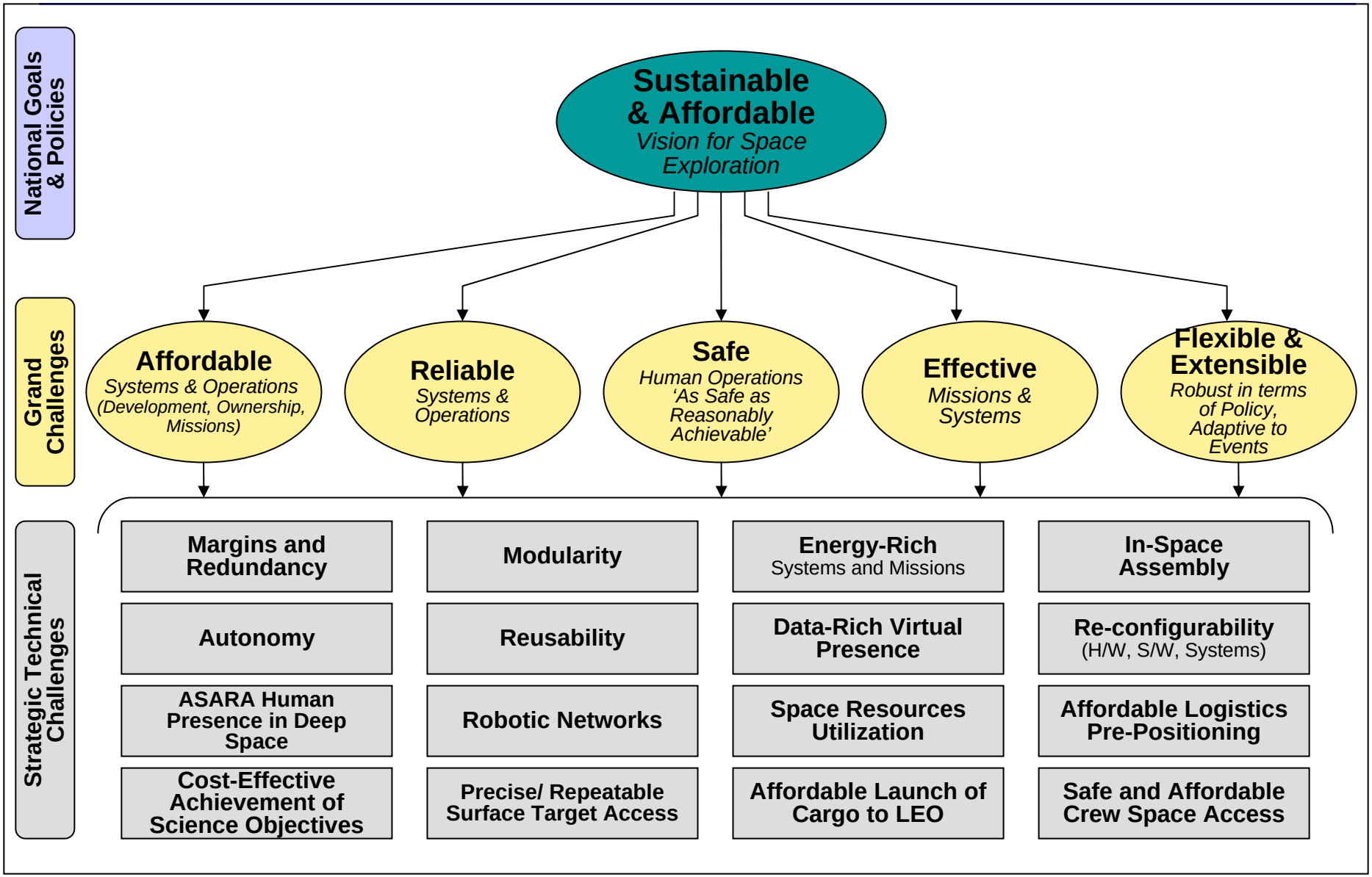
# Exploration Systems Research & Technology
## New Projects

- 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.

# ESR&T Strategic Technical Challenges

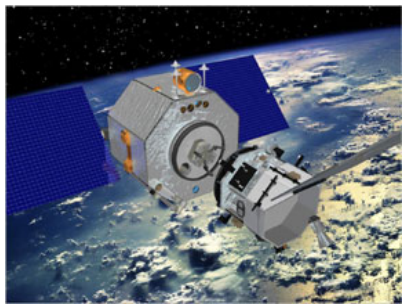


*Strategic Technical Challenge*

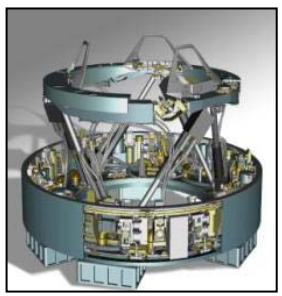
# Modularity

| ***Technologies*** | ***System Concepts*** |
|---|---|

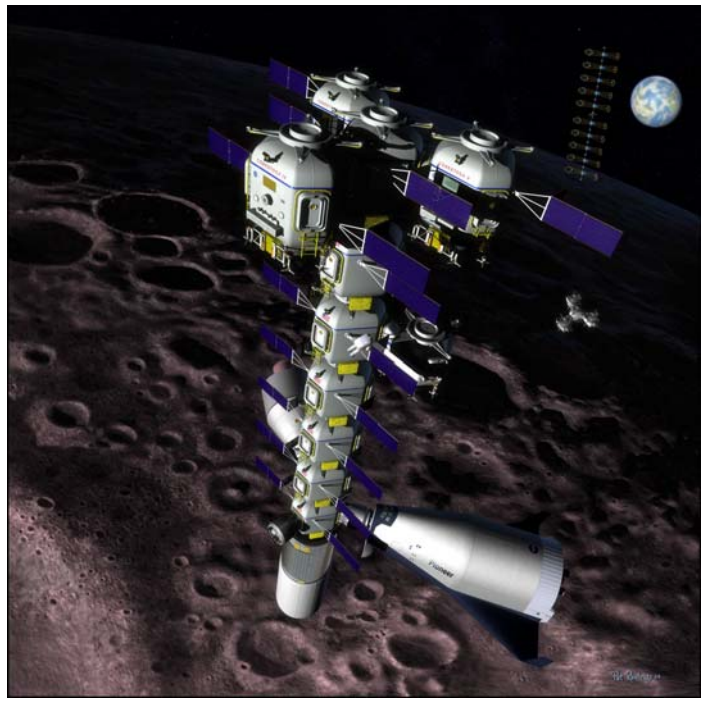
Modular Systems



Autonomous Rendezvous & Docking



Mechanisms & Interconnects

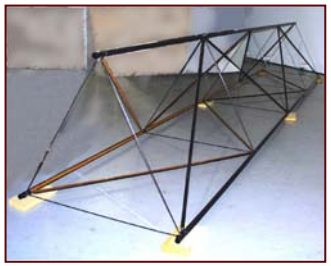


Modular outpost in lunar orbit

*Strategic Technical Challenge*

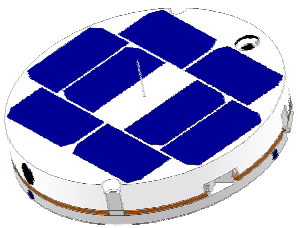
# In-Space Assembly

| ***Technologies*** | ***System Concepts*** |
|---|---|

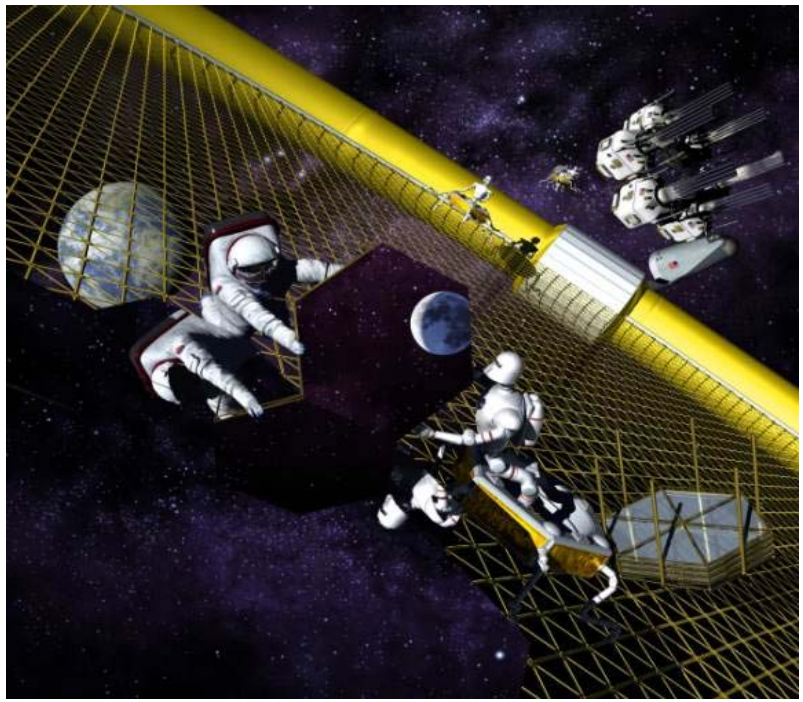


Modular Structures

Advanced Manipulators
& Telerobotics



Microspacecraft
Inspectors



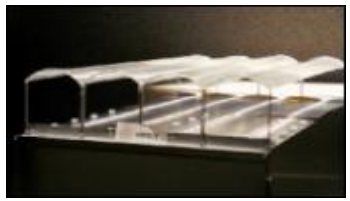
Large space systems with capability for growth, maintenance, and reconfigurability

*Strategic Technical Challenge*

# Affordable Logistics Pre-Positioning

| ***Technologies*** | ***System Concepts*** |
|---|---|

Electric Propulsion



High Specific Power Solar Arrays

Solar Electric Cargo Transfer Vehicles


Composite Cryotanks

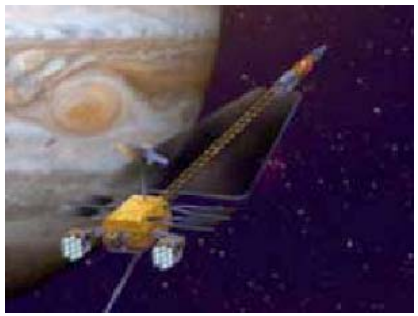
Zero-Boil-Off Cryogen Storage


In-Space Propellant Depots

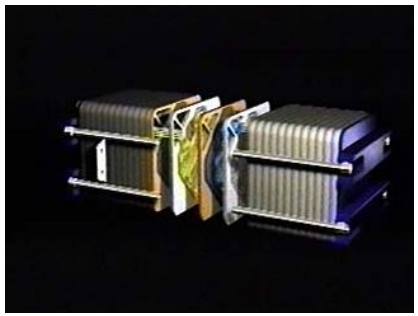
*Strategic Technical Challenge*

# Energy Rich Systems & Missions

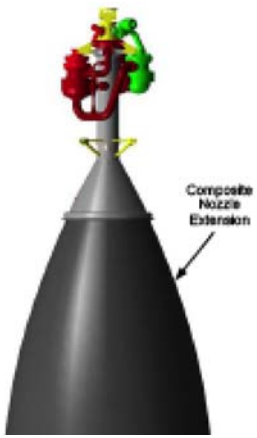
| ***Technologies*** | ***System Concepts*** |
|---|---|



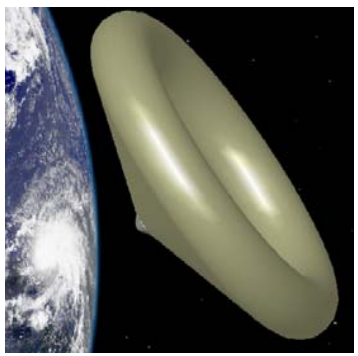
Solar & Nuclear Power Generation



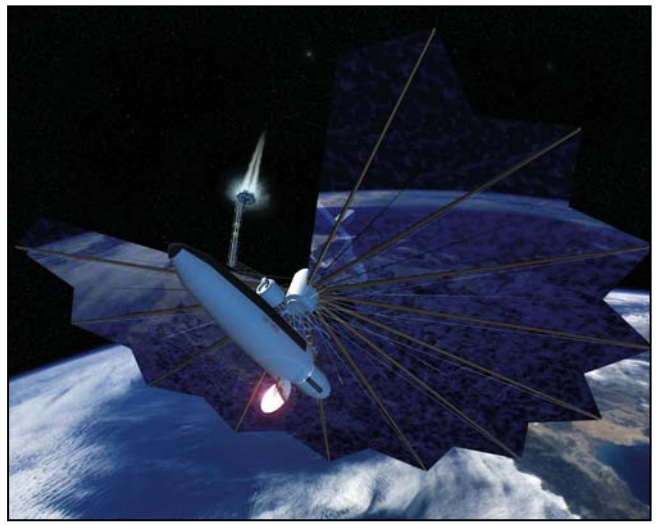
Energy Storage




Chemical & Electric Propulsion



Aero-Assist Systems

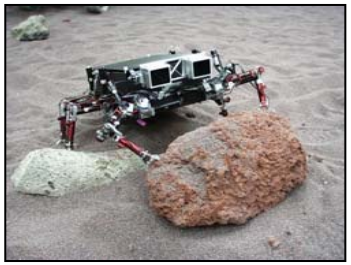


High Energy Space Systems

*Strategic Technical Challenge*

# Autonomy

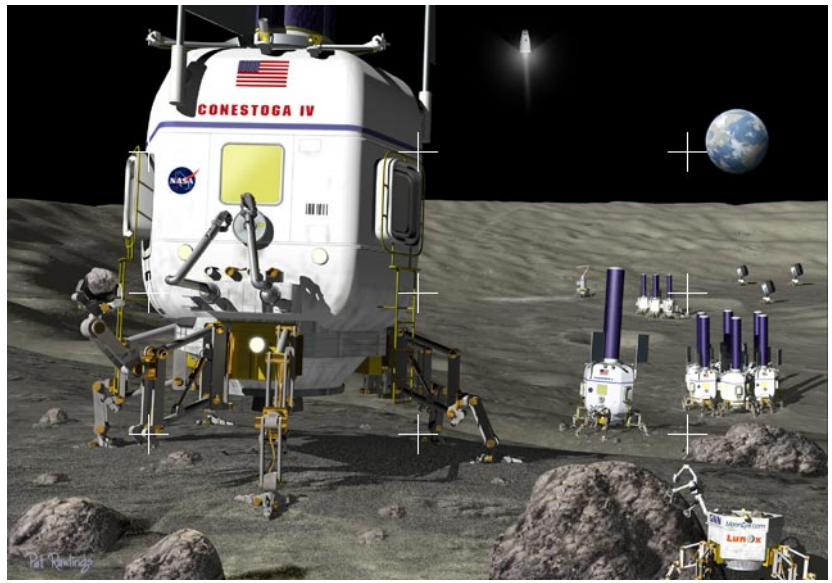
| ***Technologies*** | ***System Concepts*** |
|---|---|



Intelligent Robotics

Multi-Agent Teaming

Health Management Systems



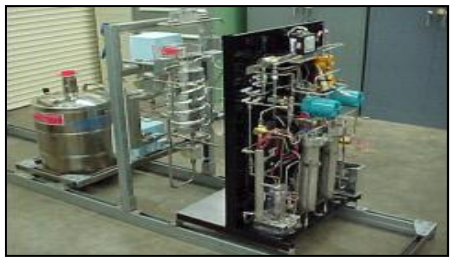

Autonomous & flexible exploration systems

*Strategic Technical Challenge*

# Space Resources Utilization

| ***Technologies*** | ***System Concepts*** |
|---|---|

Regolith handling



Propellant & oxygen production

Common fuel rocket engines

Sustainable lunar base

Exploration Systems Mission Directorate

# Upcoming Solicitations

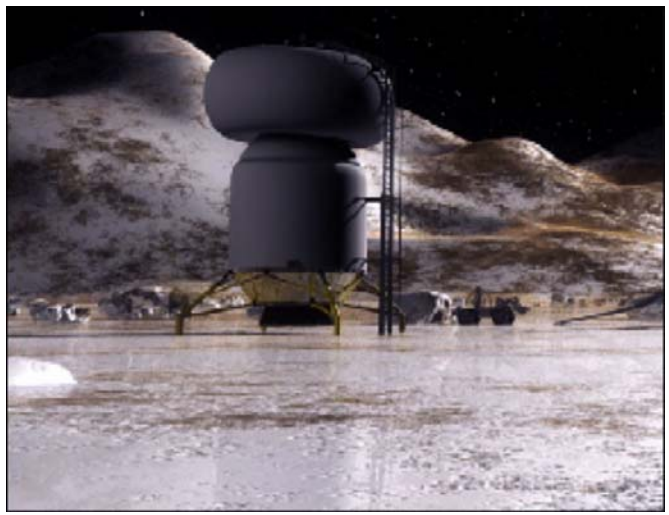
- Issued RFP for Crew Exploration Vehicle (CEV) on March 1, 2005.
- RFP solicits proposals for preliminary design of CEV, and a flight test program to reduce risk by 2008.
- Planning a research and technology Broad Agency Announcement (BAA) for May/June, 2005. BAA will solicit proposals for rapid maturation 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*