



A New Space Enterprise for 2011

NASA Advisory Council Exploration Committee

**Mr. Doug Cooke, Associate Administrator
NASA Exploration Systems Mission Directorate**

April 27, 2010



President Outlines Exploration Goals



"Fifty years after the creation of NASA, our goal is no longer just a destination to reach...Our goal is the capacity for people to work and learn, and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite. And in fulfilling this task, we will not only extend humanity's reach in space -- we will strengthen America's leadership here on Earth."

President Obama- April 15, 2010
Kennedy Space Center

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, currently limited by lack of strategic investment in technology development over past decades

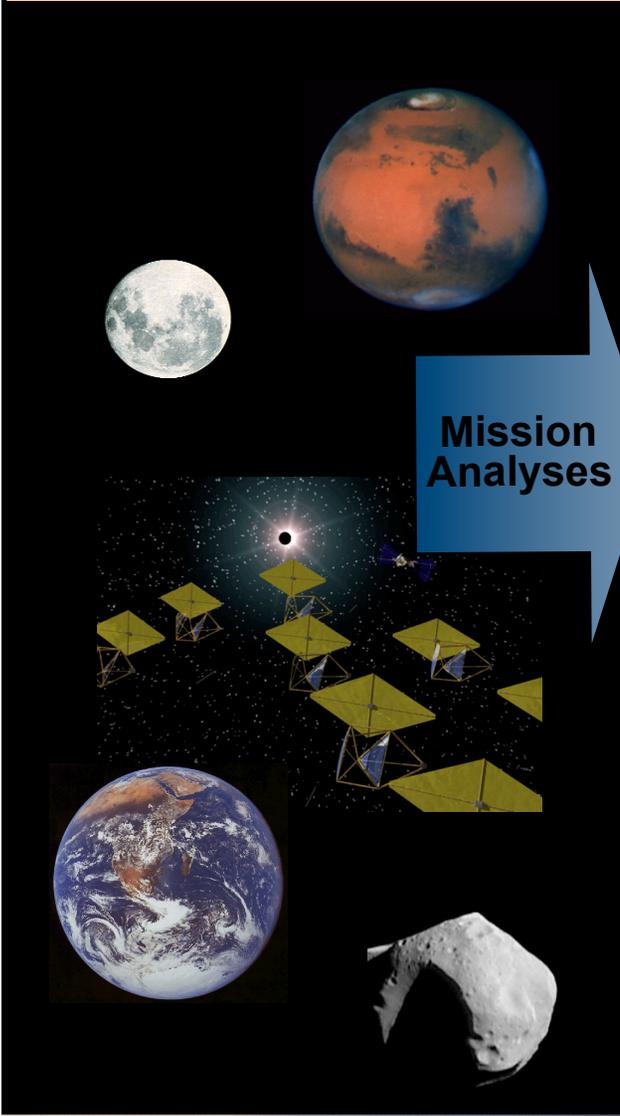
Strategy for Future Human Missions



Potential Destinations

Common Capabilities

Technology Building Blocks



Mission Analyses



Systems Design

- Efficient In-Space
 - Aerocapture
 - Low-cost Engines
 - Cryo Fluid
 - Robust/Efficient
 - Lightweight
 - Radiation Research
 - Zero/Low-g Research
 - Regenerable Life
 - Advanced Lightweight EVA
- “Breakthrough” Technologies

- Hypersonic Inflatable aerocapsule
- Regenerative
- Revolutionary ETO
- Pockets
- Innovative Mission Concepts

FY 2011 President's Budget Overview



The President's budget will invest an additional \$6 billion in NASA over the next five years- an overall \$100 billion commitment to the agency

- President's Budget challenges NASA to embark on a new human space exploration program that invests near-term in obtaining key knowledge about future destinations and demonstrating critical enabling technologies for human spaceflight and exploration, including:
 - Research and development of heavy-lift and propulsion technologies
 - Transformative technology development and flagship technology demonstrations to reduce cost and expand capabilities of future human exploration activities
 - Precursor robotic missions to multiple destinations in the solar system to cost-effectively scout human exploration targets and identify hazards and resources for visitation and habitation
 - Expand efforts to develop U.S. commercial human spaceflight capabilities, making space travel more accessible and affordable
 - Increase investment in Human Research to prepare for long human journeys beyond Earth
 - Recent addition of Orion Crew Return Capability- building to Exploration Vehicle
- Budget submission cancels Constellation Program, builds on research and technology investments in Advanced Capabilities and Constellation Systems

Exploration FY 2011 Budget Request



Budget Authority (\$ millions)	Actuals	Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	3,905.5	3,779.8	4,263.4	4,577.4	4,718.9	4,923.3	5,179.3
<u>Exploration Research and Development</u>			<u>1,551.4</u>	<u>2,577.4</u>	<u>3,318.9</u>	<u>3,623.3</u>	<u>3,979.3</u>
Exploration Technology and Demonstrations			652.4	1,262.4	1,807.9	2,013.3	2,087.3
Heavy Lift and Propulsion Technology			559.0	594.0	597.0	598.0	754.0
Exploration Precursor Robotic Missions			125.0	506.0	699.0	797.0	923.0
Human Research			215.0	215.0	215.0	215.0	215.0
<u>Commercial Spaceflight</u>			<u>812.0</u>	<u>1,400.0</u>	<u>1,400.0</u>	<u>1,300.0</u>	<u>1,200.0</u>
Commercial Cargo			312.0				
Commercial Crew			500.0	1,400.0	1,400.0	1,300.0	1,200.0
<u>Constellation Transition</u>			<u>1,900.0</u>	<u>600.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>
<u>Constellation Systems</u>	<u>3,433.2</u>	<u>3,325.8</u>					
Constellation Systems	3,190.1	3,286.7					
Commercial Crew and Cargo	243.0	39.1					
<u>Advanced Capabilities</u>	<u>472.3</u>	<u>454.0</u>					
Human Research Program	151.9	151.5					
Exploration Technology Development Program	264.1	283.4					
Lunar Precursor Robotic Program	56.3	19.1					
FY 2010 President's Budget Request	3,905.5	3,963.1	6,076.6	6,028.5	5,966.5	6,195.3	-
Constellation Systems	3,433.2	3,505.4	5,543.3	5,472.0	5,407.6	5,602.6	-
Advanced Capabilities	472.3	457.7	533.3	556.5	558.9	592.7	-
Total Change from FY 2010 President's Budget Request		-183.3	-1,813.2	-1,451.1	-1,247.6	-1,272.0	

Study Teams for Exploration



- Total of Ten Internal Study Teams Stood Up
 - 6 pre-formulating new programs: *Flagship Technology Demonstration, Enabling Technology Development and Demonstration, Heavy Lift and Propulsion Technology, Exploration Robotic Precursors, Commercial Crew, Human Research*
 - 1 assessing transition of Constellation
 - 3 Agency cross cutting teams: *Integration, International, Participatory Exploration*
- What the Teams are Doing
 - Providing inputs for very near-term products needed to support required reporting to OMB, Congress and others
 - Developing options for overall program strategy, identifying needs and goals, exploring alternate implementations, establishing high level milestones and a budget profiles
 - Focusing on planning at the program level, generally not specific, final missions
 - Helping tee up decisions for NASA Leadership

NASA Center Assignments



Ames Research Center (ARC)

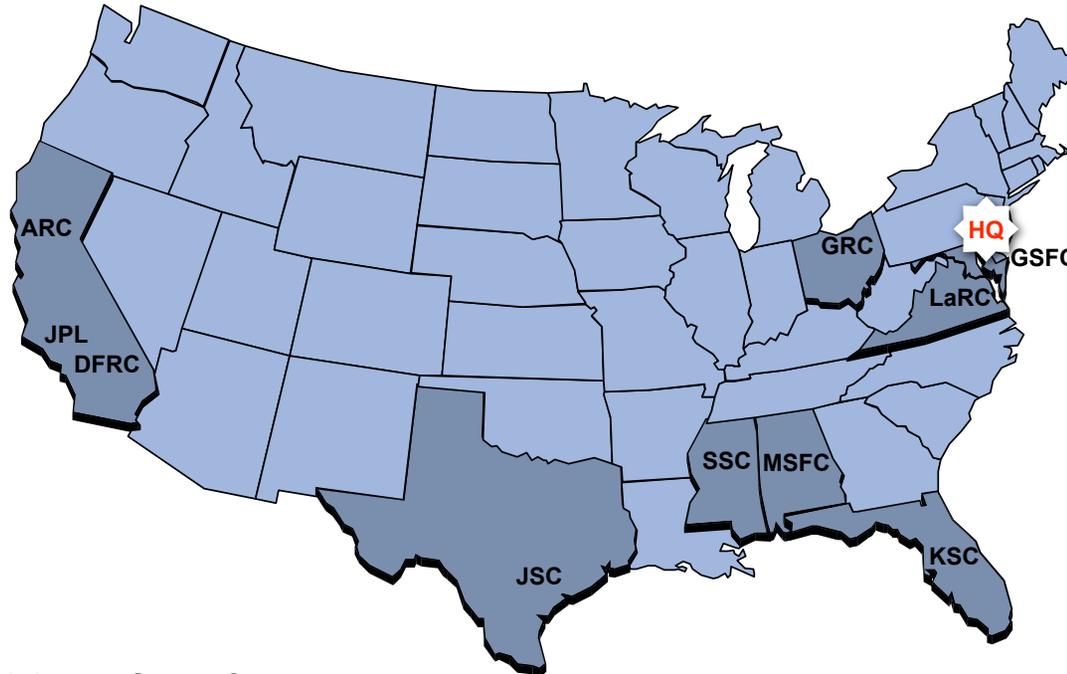
- Exploration Scouts
- Small Satellite Subsystem Technology
- Edison Small Satellite Demonstration
- Aeronautics Research

Jet Propulsion Laboratory (JPL)

- Earth Science Mission accelerations:
- Rapid Development and Launch of Orbiting Carbon Observatory-2
- Decadal Survey Tier 1 Missions:
- Augmented Climate Continuity Missions

Dryden Flight Research Center (DFRC)

- Flight Opportunities
- Aeronautics Research



Johnson Space Center (JSC)

- Flagship Technology Development
- Commercial Crew Development
- Commercial Cargo
- Human Research Program
- International Space Station
- Constellation Transition

Stennis Space Center (SSC)

- Heavy Lift and Propulsion Technology
- Commercial Crew Development

Marshall Space Flight Center (MSFC)

- Heavy Lift and Propulsion Research and Development Program
- Exploration Precursor Robotic Program
- Space Technology Demonstrations
- Centennial Challenges Program

Glenn Research Center (GRC)

- Exploration Technology Development and Demonstration Program
- Space Technology Research Grants
- Aeronautics Research

Goddard Space Flight Center (GSFC)

- Joint Polar Satellite System
- Decadal Survey Tier 1 Missions

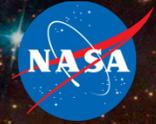
Langley Research Center (LaRC)

- Game Changing Development
- Earth Science Missions
- Aeronautics Research

Kennedy Space Center (KSC)

- Commercial Crew Development
- 21st Century Launch Complex
- Flagship Technology Demonstrations
- Additional Three Months of Shuttle Funding

Exploration Research and Development Theme



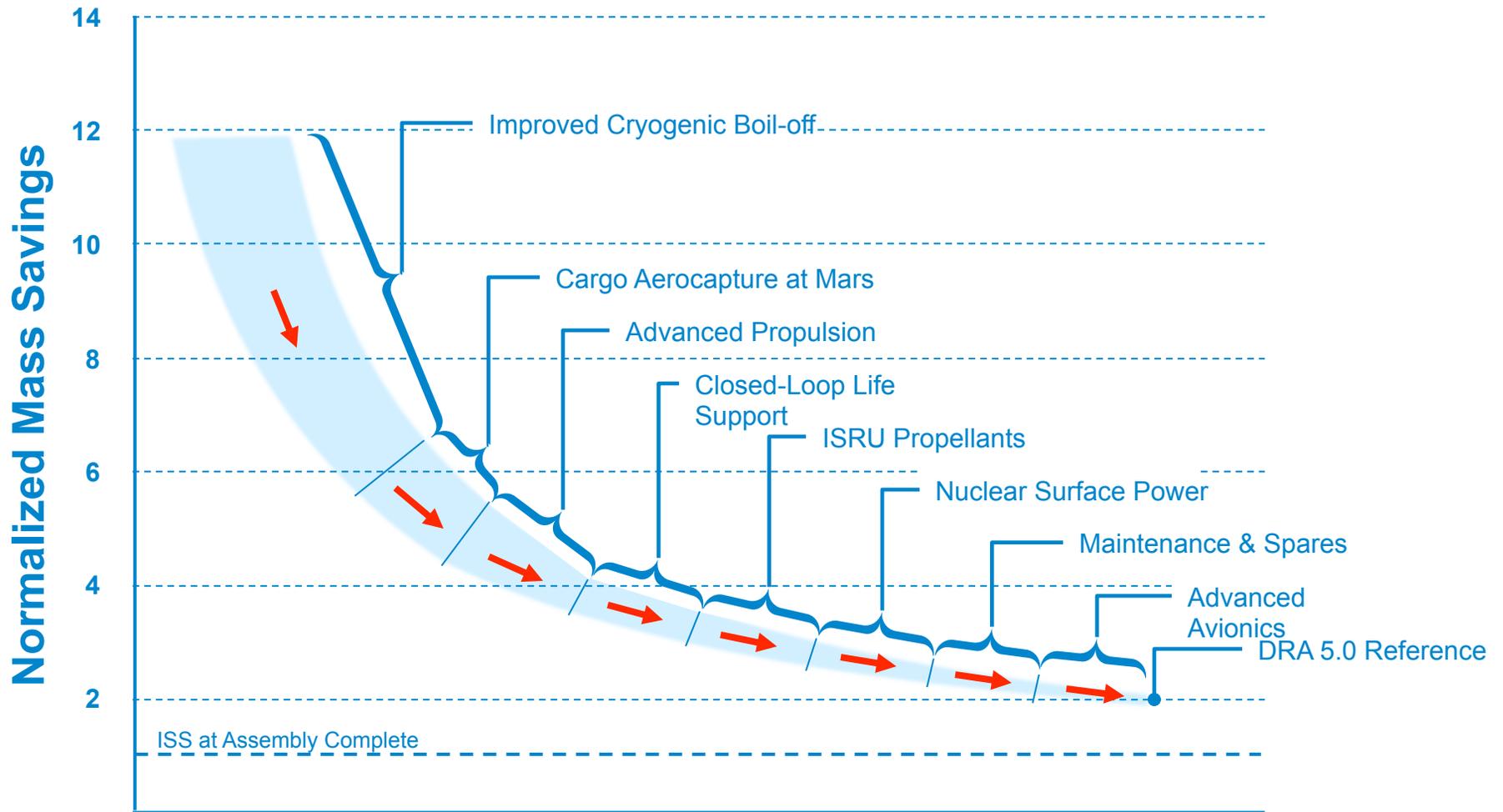
- Theme includes three robust new exploration activities:
 - Exploration Technology and Demonstrations - \$7.8 billion over five years
 - Development and demonstration of technologies to reduce costs and expand capabilities for future exploration
 - Heavy-Lift and Propulsion Technology - \$3.1 billion over five years
 - Research and development of new propulsion systems, propellants, materials and combustion processes
 - Exploration Precursor Robotic Missions - \$3.0 billion over five years
 - Cost effective means to scout exploration targets and identify resources for human visitation and habitation
- Theme budget also increases Human Research Program funding by 42% and supports Participatory Exploration Program at \$5 million per year (for activities across many NASA programs)



Consistent Set of Exploration Capability Investments

	1969	1986	1987	1988	1989	1990	1991	1997	2004	2009
	Post-Apollo Space Program (NASA STG)	Pioneering the Space Frontier (Paine)	America's Future in Space (Ride)	Beyond Earth's Boundaries (NASA)	90-Day Study (NASA)	Future of U.S. Space Program (Augustine)	America at the Threshold, SEI (Stafford)	Human Exploration of Mars DRM (NASA)	President's Commission on U.S. Space Exploration Policy (Aldridge)	Report of U.S. Spaceflight Committee (Augustine)
Advanced/Closed Loop Life Support		X	X	X	X	X	X	X	X	X
Advanced Power Generation & Storage (in-space and surface, Solar and nuclear)	X	X	X	X	X	X	X	X	X	X
Advanced In-Space Propulsion (chemical, solar electric, nuclear thermal, nuclear electric)	X	X	X	X	X	X	X	X	X	X
In-Space Cryo/Propellant Transfer and Storage		X	X	X	X		X	X	X	X
Heavy Lift Launch Vehicle			X	X	X	X	X	X	X	
Autonomous/Expert Systems		X	X			X		X	X	X
Robotics (tele-robotic & autonomous operation)		X	X		X	X	X	X	X	X
EDL (includes aerocapture, aerobraking, aeroentry)		X	X	X	X	X	X	X	X	X
Human Health and Performance (Radiation, gravity, psychological effects and mitigation, medical technologies)	X	X	X		X	X	X	X	X	X
Autonomous Rendezvous and Docking				X	X		X		X	X
In-Situ Resource Utilization (Lunar, NEO, and Mars based)		X	X	X	X	X	X	X	X	X
Lightweight Structures and Materials		X					X	X	X	X
Advanced In-Space Engine					X	X	X		X	X
Advanced EVA Systems		X		X	X	X	X	X	X	
Communication Technology	X				X	X	X		X	
Reliable Efficient Low Cost Advanced Access to Space	X		X							X
Reusable In-Space Transfer	X	X	X		X	X				
Surface Rovers				X			X	X		

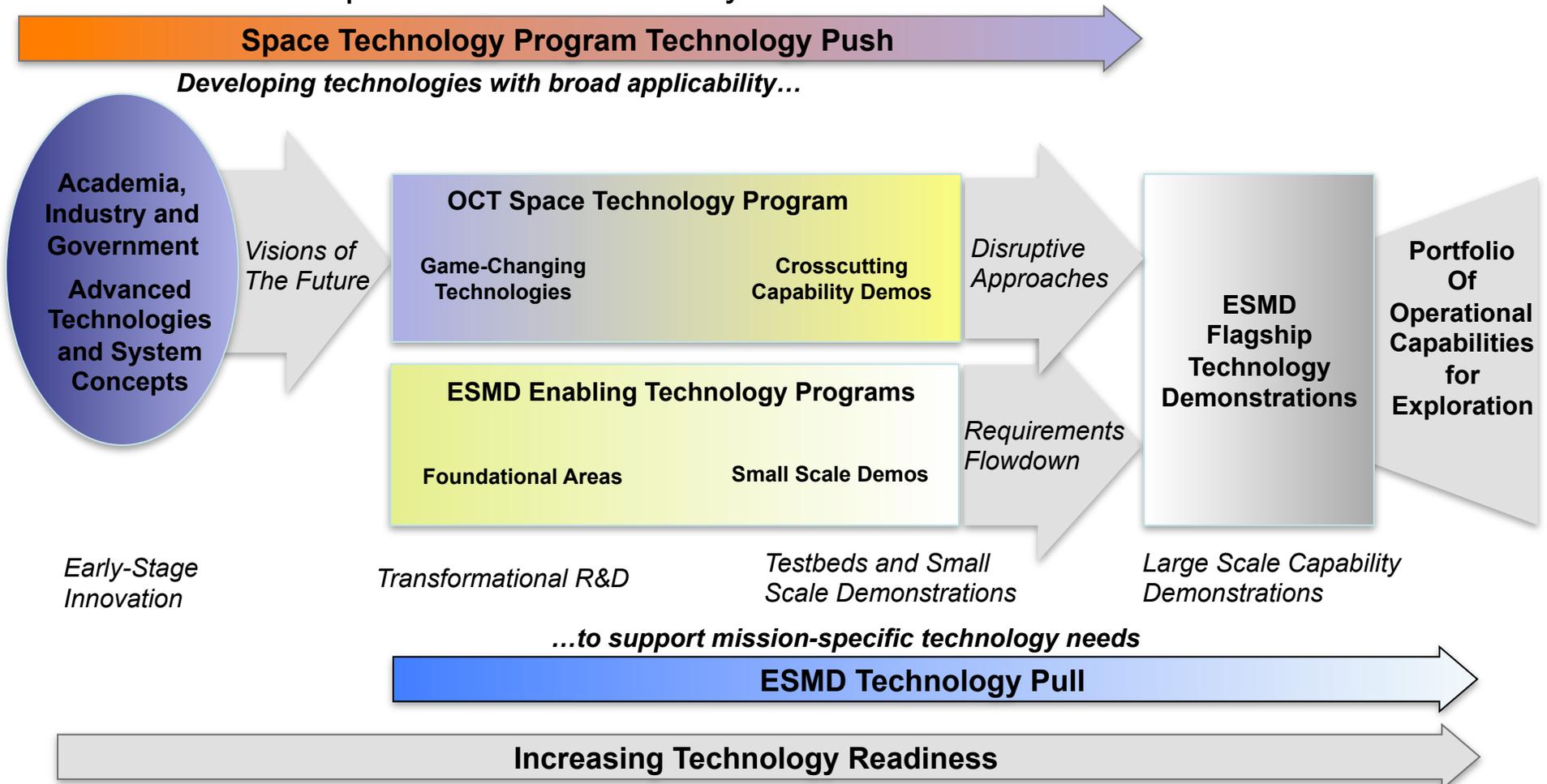
The Value of Technology Investments Mars Mission Example



NASA's Integrated Technology Programs



- A portfolio of technology investments which will enable new approaches to NASA's current mission set and allow the Agency to pursue entirely new missions of exploration and discovery.



Flagship Technology Demonstrations



- Evaluation underway of highest leverage demonstrations; Mars destination is a driving case for high leverage demonstration and technology
- First three primary technology targets for single or combined missions to include:
 - In-orbit propellant transfer and storage
 - Lightweight/inflatable modules
 - Automated/autonomous rendezvous and docking
- Fourth flight program such as
 - Aerocapture/entry, descent and landing
 - Advanced life support
 - Advanced in-space propulsion (ion/plasma, etc)
- Initiate four technology demonstrations in FY2011
- Follow-on demonstrations informed by emerging technologies
- Identify potential partnerships with industry, other agencies, and international partners and leverage ISS for technology demonstrations, as appropriate

Enabling Technology Development & Demonstration



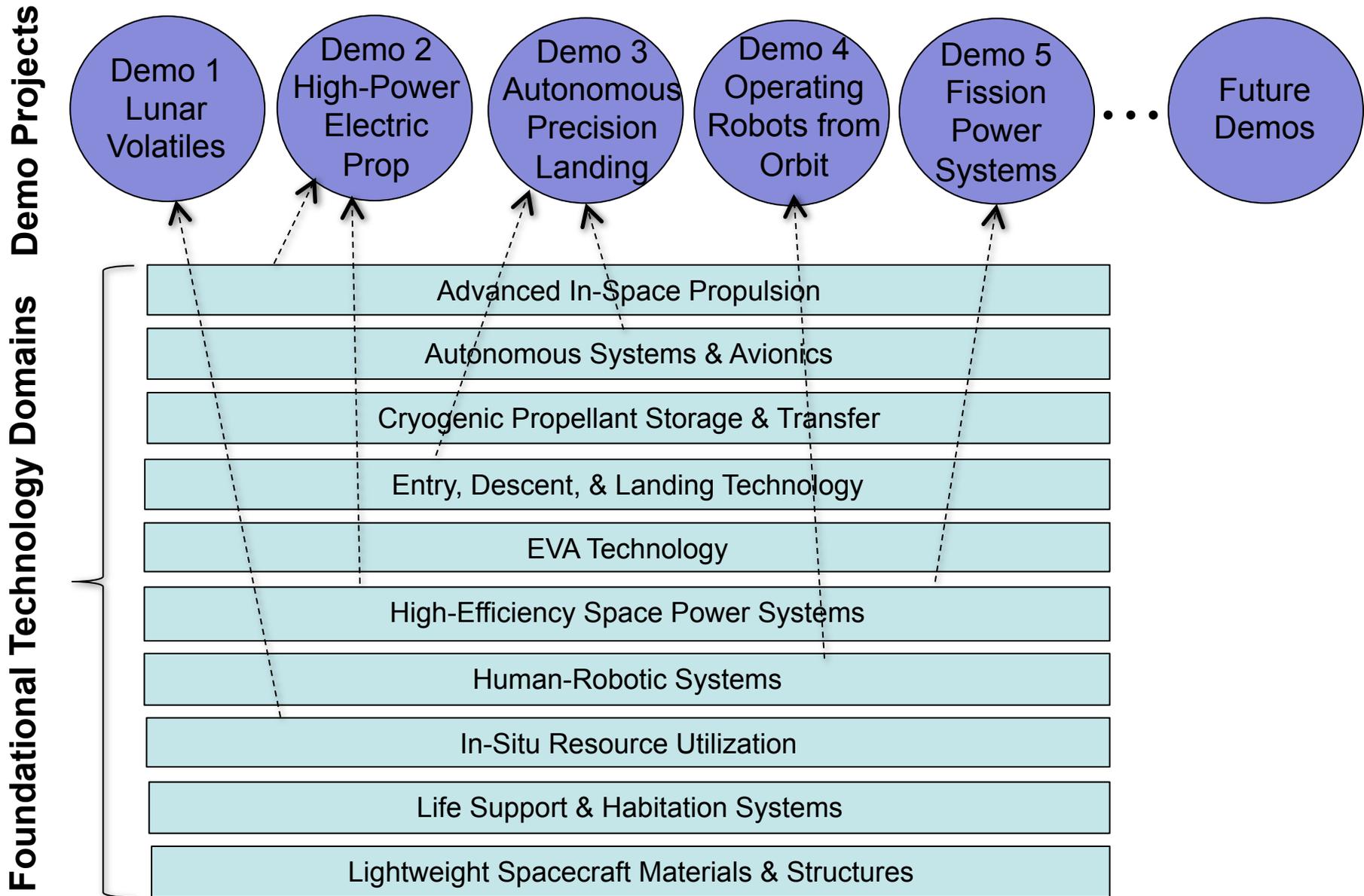
Key Question: How do we use human-robotic partnerships to increase productivity, reduce costs, and mitigate risks?

Key Question: Can we land autonomously, precisely, and safely on an extra-terrestrial surface in uncertain environments ?

Key Question: Can we locate and access in situ resources?

Key Question: How can we reduce travel time and cost for deep-space human exploration?

Exploration Technology Development and Demonstration Approach



Heavy-Lift and Propulsion Technology



- Investigate a broad scope of research and development activities related to space launch propulsion technologies, including:
 - First stage propulsion
 - In-space engine demonstrations
 - Foundational propulsion research
- Program goal: provide new National capabilities, reduce costs, and shorten development time for future heavy-lift propulsion systems
- Projects may include commercial, academic and international partnerships
- Investments will lead to heavy lift vehicle architecture selection in 2015 timeframe

Exploration Precursor Robotic Missions - Approach



- Maintain steady tempo of exploration missions and investigations to address priority needs in preparation for human exploration
- Initiate at least two missions in FY 2011
- Candidate missions include:
 - Lunar missions, following up on LRO/LCROSS results, landers demonstrating tele-operation capable of transmitting near real-time video to Earth, investigations for validating availability of resources for extraction
 - Reconnaissance of and/or landing on near-earth asteroids or on the moons of Mars (Phobos and Deimos)
 - Landing in situ resource utilization capability to process lunar or asteroid materials into fuel and/or other exploration enabling materials
 - Mars precursor measurements and demos
- Emphasize partnerships -- inter-Directorate, international, interagency, etc. – Missions of Opportunity on SMD, Int'l, Commercial missions
- Provide venue for flight validation and infusion of developed technology and for Participatory Exploration opportunities

Human Research



- Augmentation Research and Technology Priorities
 - Biomedical Technologies with advanced medical care capabilities and bioinformatics and capable of being integrated into the ISS as a demonstration of remote medical suite appropriate for long-duration space missions
 - Innovative Biomedical Technologies to enable novel solutions to the problems of human spaceflight with potential Earth applications
 - Space Radiation Research to reduce the uncertainty of radiation risks to space explorers in the areas of carcinogenesis, central nervous system disease, degenerative tissue effects, and acute radiation syndromes (coordinate with Space Radiation Protection Project under ETDD)
 - Behavioral Health Research that enhances the portfolio related to behavioral factors and physiological implications of long-duration missions
- In addition, the augmentation will enable:
 - Development of research and technology projects that fully utilize ISS as a space biomedical laboratory
 - Enhancement of STEM education
 - Leverage U.S. National biomedical research infrastructure through the National Space Biomedical Research Institute
 - Additional collaborations involving National (NIH, DOE, DOD) and International agencies (CSA, ESA, JAXA, RSA, etc.)
 - Additional National research solicitations

Commercial Crew and Cargo Development



- For Commercial Cargo: Additional \$312M in FY11 to accelerate the achievement of already-planned milestones or introduce new milestones that would ultimately improve mission success.
- For Crew: Use a COTS-like approach to support the development of commercial crew transportation providers to whom NASA could competitively award a crew transportation services contract analogous to the CRS services contract for cargo
- NASA will set standards and have appropriate insight/oversight to ensure that all systems meet the agency's human-rating requirements to maintain the necessary level of safety

Portfolio of Commercial Crew & Cargo Space Act Agreement Partners



**Commercial Crew Development
New Space Act Agreements**

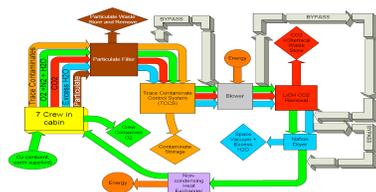
Blue Origin 

**Existing COTS Demo and CRS
Partners for the ISS**

SPACEX 



PARAGON
SPACE DEVELOPMENT CORPORATION



snc SIERRA
NEVADA
CORPORATION
Space Systems

ULA
United Launch Alliance

Constellation Transition Study Team



- The team is comprised of NASA experts in the areas of workforce, contracts, facilities and infrastructure, property and hardware, risk and knowledge management, records management, security, IT, communications, and partnerships.

The purpose of this study team is to:

- Capture the current state of the CxP
- Study and outline the transition plans, actions, and processes to cancel the CxP, if and when authorized by Congress
- Identify the strategic capabilities available and necessary to safely and efficiently develop human spaceflight systems and conduct successful mission operations.

International Partnerships for Sustainable Human Space Exploration



A Global Exploration Roadmap

Leveraging Investments in Technologies



Robotic Precursor Missions

Flagship Technology Demonstration Missions

Summary and Future Plans



- The President's FY11 Budget for ESMD proposes an exciting, vigorous set of new programs that will bring much-needed new capabilities to fruition, and provide critical precursor knowledge that will ultimately enable a sustainable plan for sending humans into the solar system to stay
- Key investments in new and innovative capabilities will:
 - Expand our exploration opportunities,
 - Reduce mission costs,
 - Contribute NASA innovation to broader national needs
 - Promote STEM education for our future
- For more information on the new budget:

<http://www.nasa.gov/budget>

ESMD Web sites



The screenshot shows the NASA Exploration website homepage. At the top is the NASA logo and a navigation menu with links for HOME, NEWS, MISSIONS, MULTIMEDIA, ABOUT NASA, and CONNECT. Below the menu is a search bar and a 'Log In To MyNASA | Sign Up' link. The main content area features a large 'Exploration' header with a background image of a lunar surface. Below this, there are several sections: 'Exploration at NASA' with a sub-header and a paragraph about NASA's future in space exploration; 'Exploration - News Releases' with a date '04.07.10' and a link to 'NASA Invites Media to Preview Test of New Launch Abort System'; 'Exploration Related Sites' with a link to 'Exploration Highlights'; 'Why We Explore' with a sub-header and a paragraph about the importance of exploration; 'Top Featured Stories' with a link to 'NE Live@Sun-Earth Day 2010' and a sub-header 'Magnetic Storms'; and 'Exploration History' with a sub-header 'This Month in Exploration' and a paragraph about the importance of exploration.

The screenshot shows the InsideNASA website homepage. At the top is the NASA logo and a navigation menu with links for InsideNASA, NASA Domain, NASA Engineering Network, Lessons Learned, and Employee Locator. Below the menu is a search bar and a 'Log In To MyNASA | Sign Up' link. The main content area features a large 'InsideNASA' header with a sub-header 'Helping employees get the job done.' Below this, there are several sections: 'Welcome to Inside NASA'; 'Home' with a 'Welcome' message; 'Administration @ HQ'; 'Centers'; 'Communities & Teams'; 'Education'; 'Employee Resources'; 'Financial Resources'; 'Information Resources'; 'Missions & Projects'; 'NASA Engineering Network'; 'NASA Lessons Learned'; 'Science'; 'What's New'; 'POPS Expertise Locator'; 'HOMELAND SECURITY ADVISORY SYSTEM'; 'IF IT'S NOT SAFE, SAY SO! Report any safety concerns to NASA'; 'NASA Emergency Operations'; 'NASA Communication Policy'; 'NASA Radio'; 'Enabling Technology Development and Demonstration Study Team' with a team lead 'Dr. Chris Moore' and a paragraph about the team's mission; 'Commercial Crew and Cargo Study Team' with a team lead 'Geoff Yoder' and a paragraph about the team's mission; 'Flagship Technology Demonstrations Study Team' with a team lead 'Michael Conley' and a paragraph about the team's mission; 'Heavy Lift and Propulsion Technologies Study Team' with a team lead 'Cris Guidi' and a paragraph about the team's mission; 'Exploration Precursor Robotic Missions Study Team' with a team lead 'Jay Jenkins' and a paragraph about the team's mission; 'Human Research Study Team'; 'Budget Rollout Integration Team (BRIT)'; 'Submit a Question or Comment'; and 'FAQ'S'.

<http://www.nasa.gov/exploration>

http://www.insidenasa.nasa.gov/new_space_enterprise