National Aeronautics and Space Administration

A New Space Enterprise

NASA Advisory Council Technology and Innovation Committee

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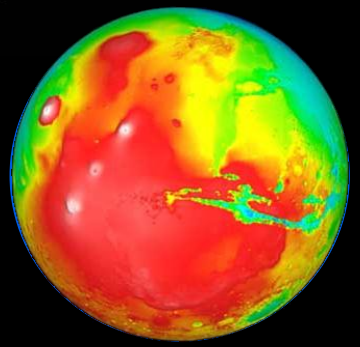
ESMD: Blazing a Trail Into the Solar System

- 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 capabilities that will allow us to reach multiple destinations, including the Moon, Asteroids, Lagrange points, and Mars and its moons
- 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



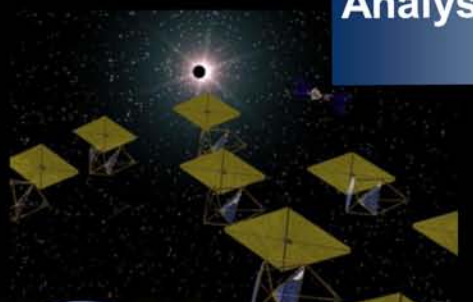
FY 2011 President's Budget Overview

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

- ESMD's proposed budget is $4.3 B for FY11, an increase of $0.5 B over FY10
- 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 capabilities
  - Transformative technology development and flagship technology demonstrations to reduce cost and expand capabilities of future human exploration activities
  - Exploration precursor robotic missions to multiple destinations in the solar system to scout human exploration targets and identify hazards and resources
  - Expanded efforts to develop U.S. commercial human spaceflight capabilities, making space travel more accessible and affordable
  - Increased investment in Human Research to prepare for long journeys beyond Earth
- Budget submission cancels the Constellation Program, retaining a Block Zero Orion which can be used as a crew rescue vehicle for ISS

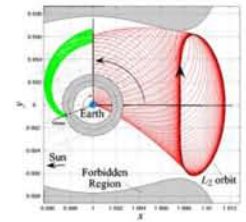
Strategy for Future Human Missions

Potential Destinations



Mission Analyses

Common Capabilities



Systems Design

Technology Building Blocks

- 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
- Regenerative
- Revolutionary ETO
- Innovative Mission Concepts

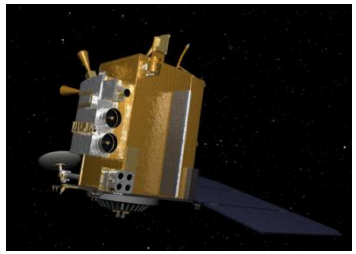
Strategy to Enable Future Human Missions Beyond LEO

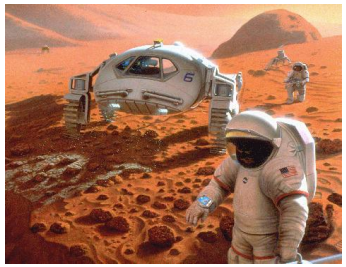
Destinations of Interest

Enabling Human Exploration

Needed Capabilities

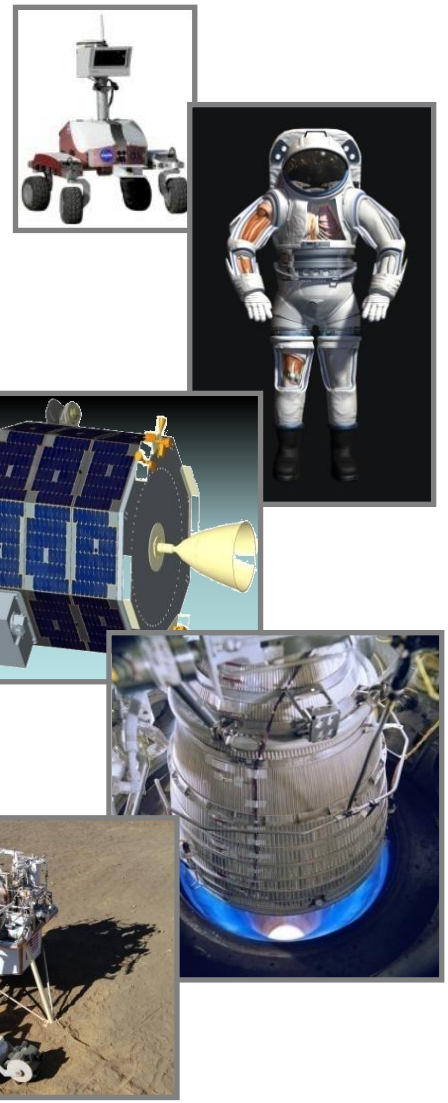
Precursor Knowledge



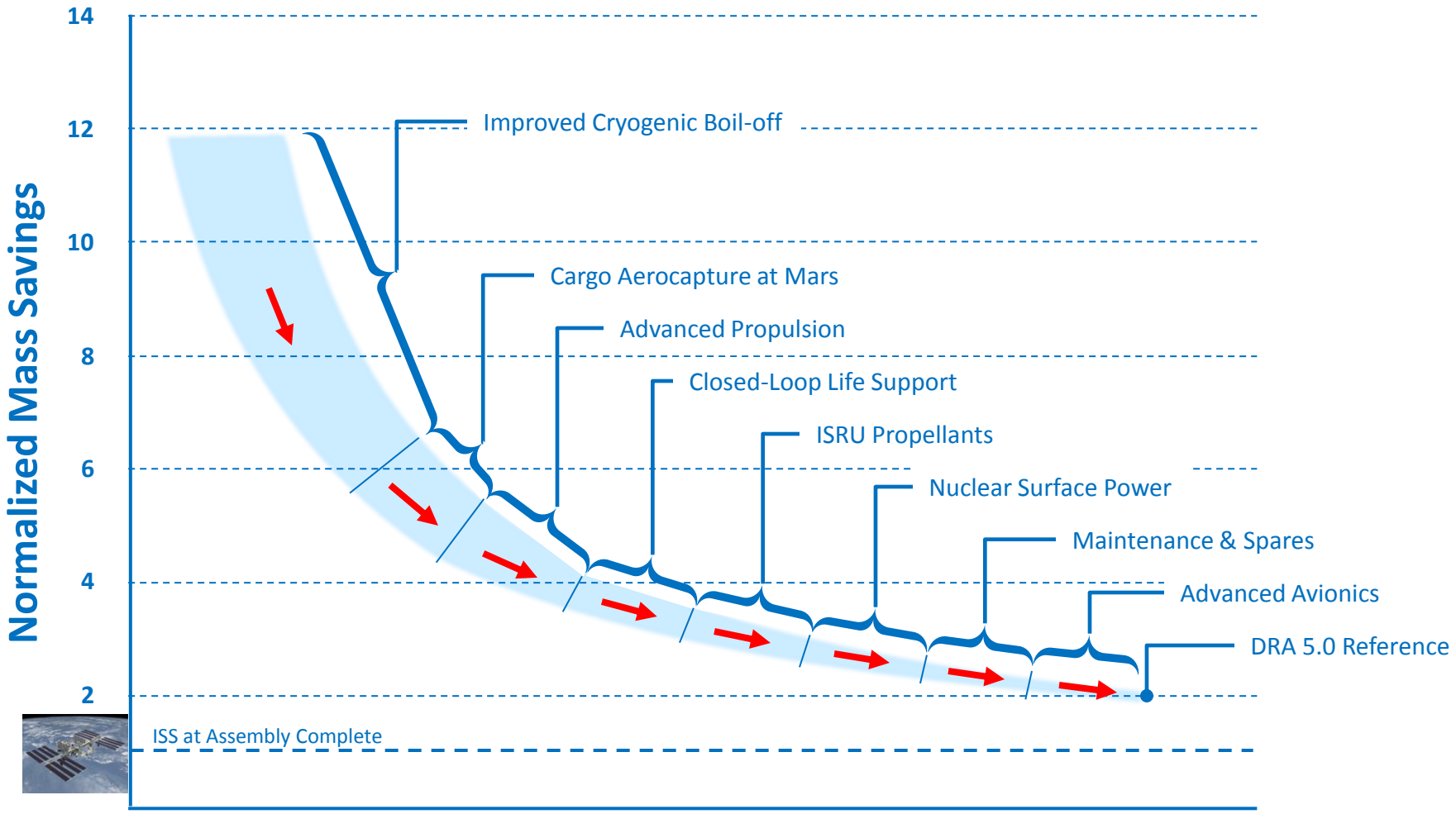


New Exploration Research & Development Activities

- Exploration Technology Demonstrations
  - $7.8 billion over five years
  - *Develop and demonstrate 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 cost-effective propulsion systems, engines, LV materials, etc.*
- Exploration Precursor Robotic Missions
  - $3.0 billion over five years
  - *Scout exploration targets, identify hazards and resources for human visitation and habitation*

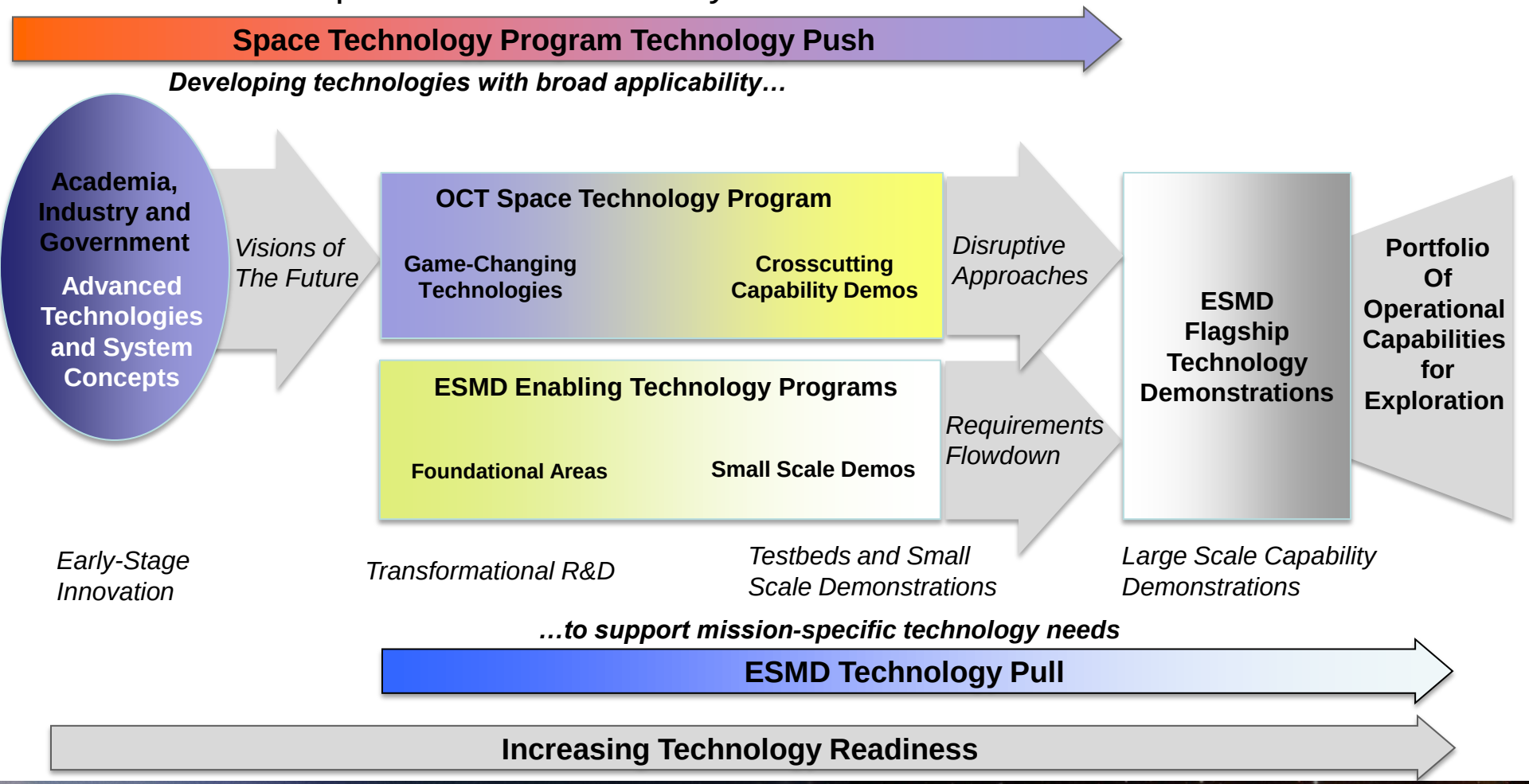


The Value of Technology Investments
Mars Mission Example



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.



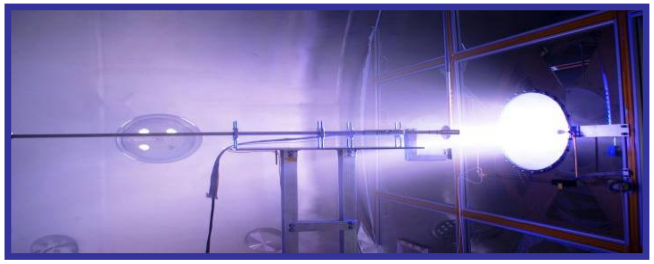
Enabling Technology Development & Demonstration (ETDD)

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

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

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

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



Foundational Technology Domains Address Long-Range Capability Needs for Multiple Destinations

	Moon	Lagrange Points	NEOs	Mars
Advanced In-Space Propulsion: Enabling low-cost and rapid transport of cargo and crew beyond LEO.	✔	✔	✔	✔
Autonomous Systems & Avionics: Extending human exploration capability by reducing workload and dependence on support from Earth.	✔	✔	✔	✔
Cryogenic Propellant Storage & Transfer: Enabling the in-space infrastructure to store and transfer propellants.	✔	✔	✔	✔
Entry, Descent, & Landing Technology: Landing large payloads safely and precisely on extra-terrestrial surfaces and returning to Earth.	✔			✔
EVA Technology: Enabling humans to conduct “hands-on” surface exploration and in-space operations outside habitats and vehicles.	✔	✔	✔	✔
High-Efficiency Space Power Systems: Providing abundant and low-cost power where it is needed.	✔	✔	✔	✔
Human-Robotic Systems: Amplifying human productivity and reducing mission risk by partnering humans and robots.	✔	✔	✔	✔
In-Situ Resource Utilization: Enabling sustainable human exploration by using local resources.	✔		✔	✔
Life Support & Habitation Systems: Enabling humans to live for long periods in deep-space environments.	✔	✔	✔	✔
Lightweight Spacecraft Materials & Structures: Enabling lightweight systems to reduce mission costs.	✔	✔	✔	✔

Exploration Technology Development and Demonstration Approach

Demo Projects

- Demo 1 Lunar Volatiles
- Demo 2 High-Power Electric Prop
- Demo 3 Autonomous Precision Landing
- Demo 4 Operating Robots from Orbit
- Demo 5 Fission Power Systems
- . . .
- Future Demos

Foundational Technology Domains

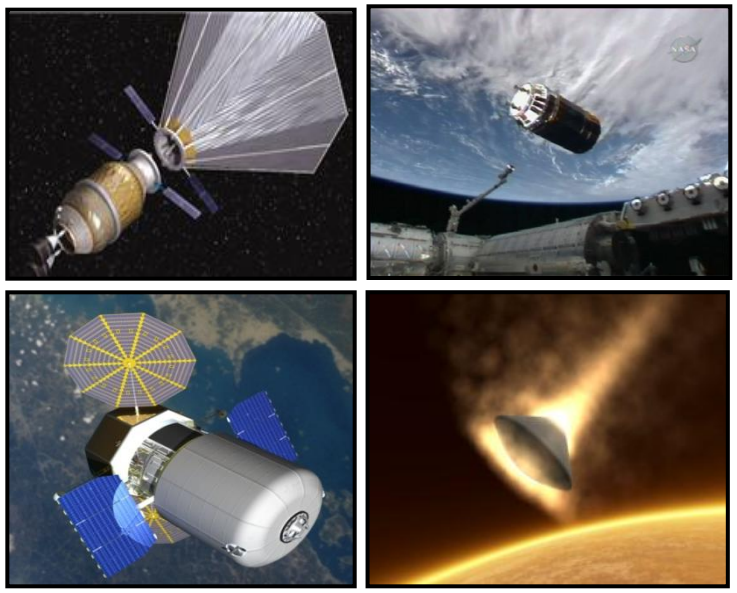
- Advanced In-Space Propulsion
- Autonomous Systems & Avionics
- Cryogenic Propellant Storage & Transfer
- Entry, Descent, & Landing Technology
- EVA Technology
- High-Efficiency Space Power Systems
- Human-Robotic Systems
- In-Situ Resource Utilization
- Life Support & Habitation Systems
- Lightweight Spacecraft Materials & Structures

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

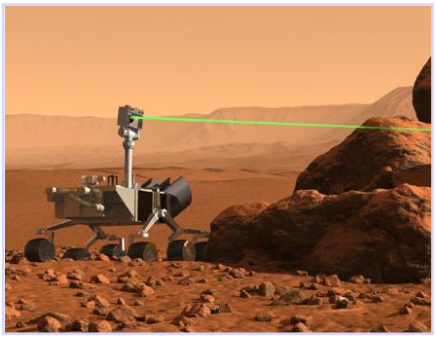
Flagship Technology Demonstrations

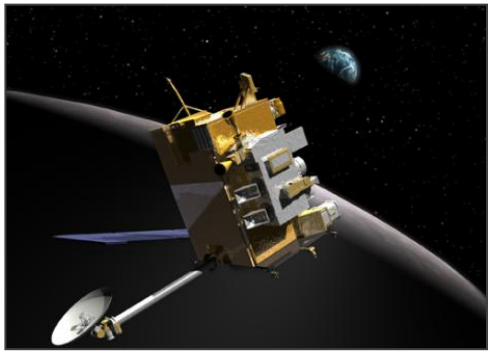
- Evaluation underway of highest leverage demonstrations; Mars destination is a driving case for high leverage demonstration and technology
- First three primary technology targets for single or combined missions to include:
  - In-orbit propellant transfer and storage
  - Lightweight/inflatable modules
  - 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



Exploration Precursor Robotic Missions(xPRM)

- 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. – MOOs on SMD , Int'l, Commercial missions
- Provide venue for flight validation and infusion of developed technology and for Participatory Exploration opportunities





xPRM Priorities

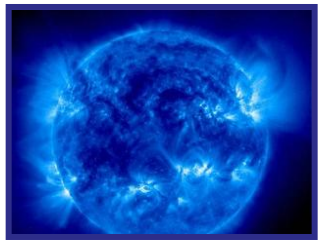
- To conduct **precursor investigations** in support of human exploration.
  - Identify the engineering boundary conditions associated with the environments of human exploration beyond LEO.
  - Indentify hazards (to ensure safety)
  - Identify resources (to facilitate sustainability, lower launch mass, and “living off the land”)
  - Provide knowledge to inform the selection of Human Exploration destinations
- To provide a platform for **technology flight demonstrations** which support human exploration.
- To **coordinate** with other NASA directorates.
  - Avoid overlap, identify complementary objectives, leverage dual-use opportunities
- To **foster competition** in mission/payload/investigation selections.
- To foster opportunities for **international collaboration** which benefit human exploration.
- To foster **participatory exploration** opportunities

xPRM Portfolio Components

- Exploration Precursor Missions
  - Generally capped at $800 million or less (life cycle cost)
  - Destinations selected according to priority data needs of human exploration
  - Payload capability to maximize return of priority information critical to human exploration preparation
  - Payload allocations for partners (inter-Directorate, international, interagency, etc.)
- Small Exploration Scout Missions
  - $100 million to $200 million life cycle cost
  - Small, rapid turnaround, risk tolerant missions
  - Demonstrate new, innovative ways of conducting robotic exploration while providing highly relevant measurements and operational experiences
  - Openly competed, PI-led
- Mission of Opportunity Instrument/Capability Development
  - $15 million to $75 million life cycle cost
  - ESMD developed instruments/investigations to be flown on non-ESMD spacecraft
  - Venue for partnerships (inter-Directorate, international, interagency, etc.)
- Research & Analysis

Human Research Program Augmentation Summary

- **Biomedical technologies** investment increased
  - Solutions to problems of human spaceflight with potential Earth applications
  - Space Station as a test bed for advanced medical care
- **Space radiation research** investment increased
  - Increases critical research to reduce uncertainty of radiation risks
  - Coordination with shielding and protection technology demonstrations
- **Behavioral Health** Research investment increased
  - Related to behavioral factors and physiological implications of long-duration missions.
- **Space Station utilization** investment increased
  - New human health related technology demonstrations
  - Additional research addressing human risks during long-duration exposure to microgravity
  - New research projects to be solicited via research announcements
- **STEM education** investment increased
  - Involve larger numbers of students, teachers, and general public in ongoing projects
- **National Space Biomedical Research Institute** investment increased



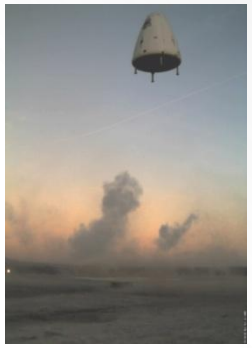
Commercial Crew and Cargo Development

- 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

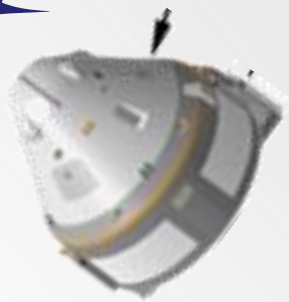
Portfolio of Commercial Crew & Cargo Space Act Agreement Partners

Commercial Crew Development New Space Act Agreements

Blue Origin



BOEING



Existing COTS Demo and CRS Partners for the ISS

SPACEX

Orbital

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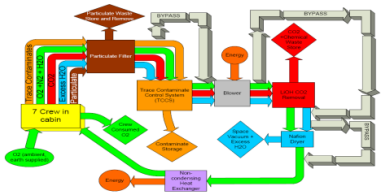


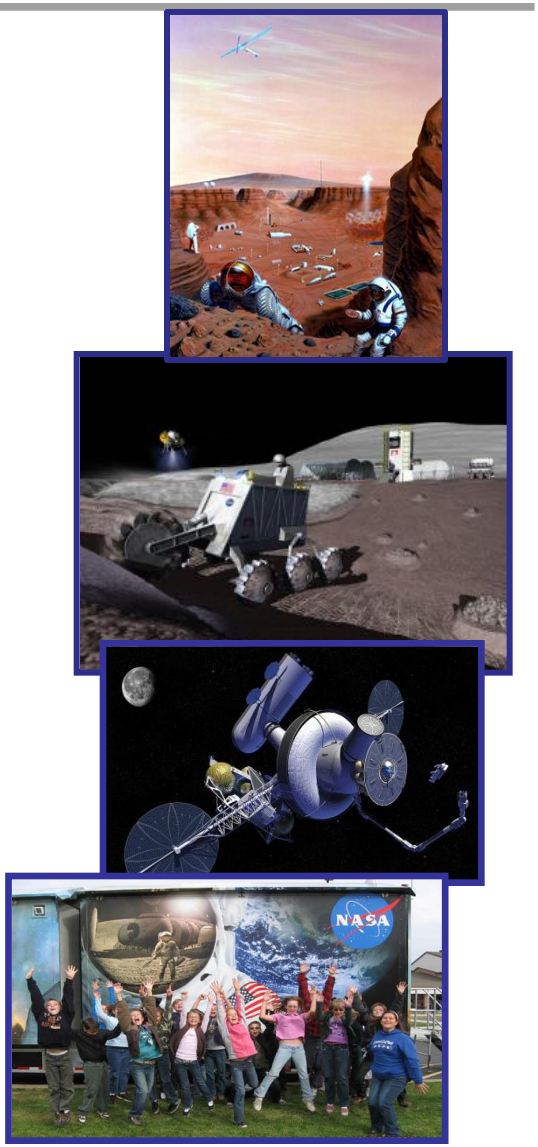
SNC SIERRA NEVADA CORPORATION
Space Systems

ULA
United Launch Alliance

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, check out:

http://www.nasa.gov/budget



BACKUP

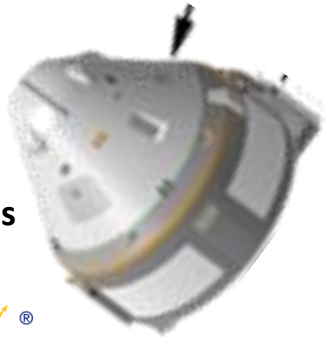
Commercial Crew Development
Space Act Agreement Awards

Blue Origin

Mature Pusher Escape System and Composite Pressure Vessel

BOEING

Mature system architecture and design through SDR and demonstrates key technologies



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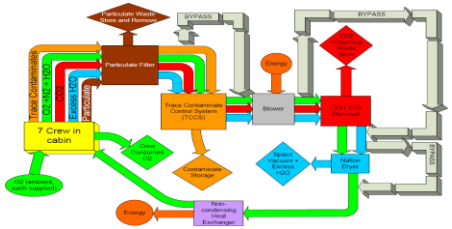

Mature Air Revitalization System (ARS) design through PDR level and Manufacture and test an engineering development unit

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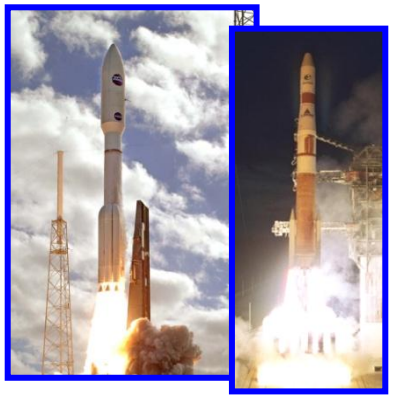

Complete SRR, Build & Test Spacecraft Engineering Test Article, Build & Fly Scale Model for A&L Tests, OMS Motor Build & Test, RCS Thruster Proto Build & Test, TPS Trades, and Atlas V Integration

Comprehensive maturation plan for commercial crew launch vehicles includes addition of modular Emergency Detection System (EDS) which can be used with Atlas V, Delta IV, and other LVs including prototype EDS testing and demo