



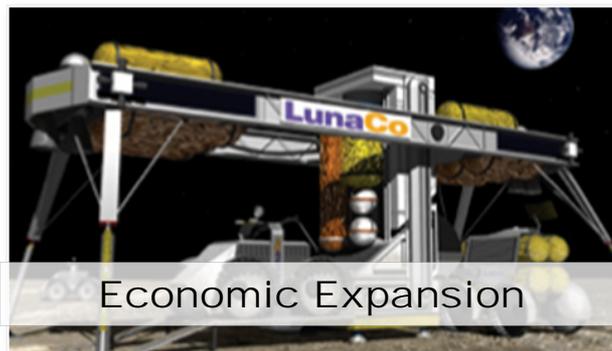
Defining the New Space Age

November 9, 2009

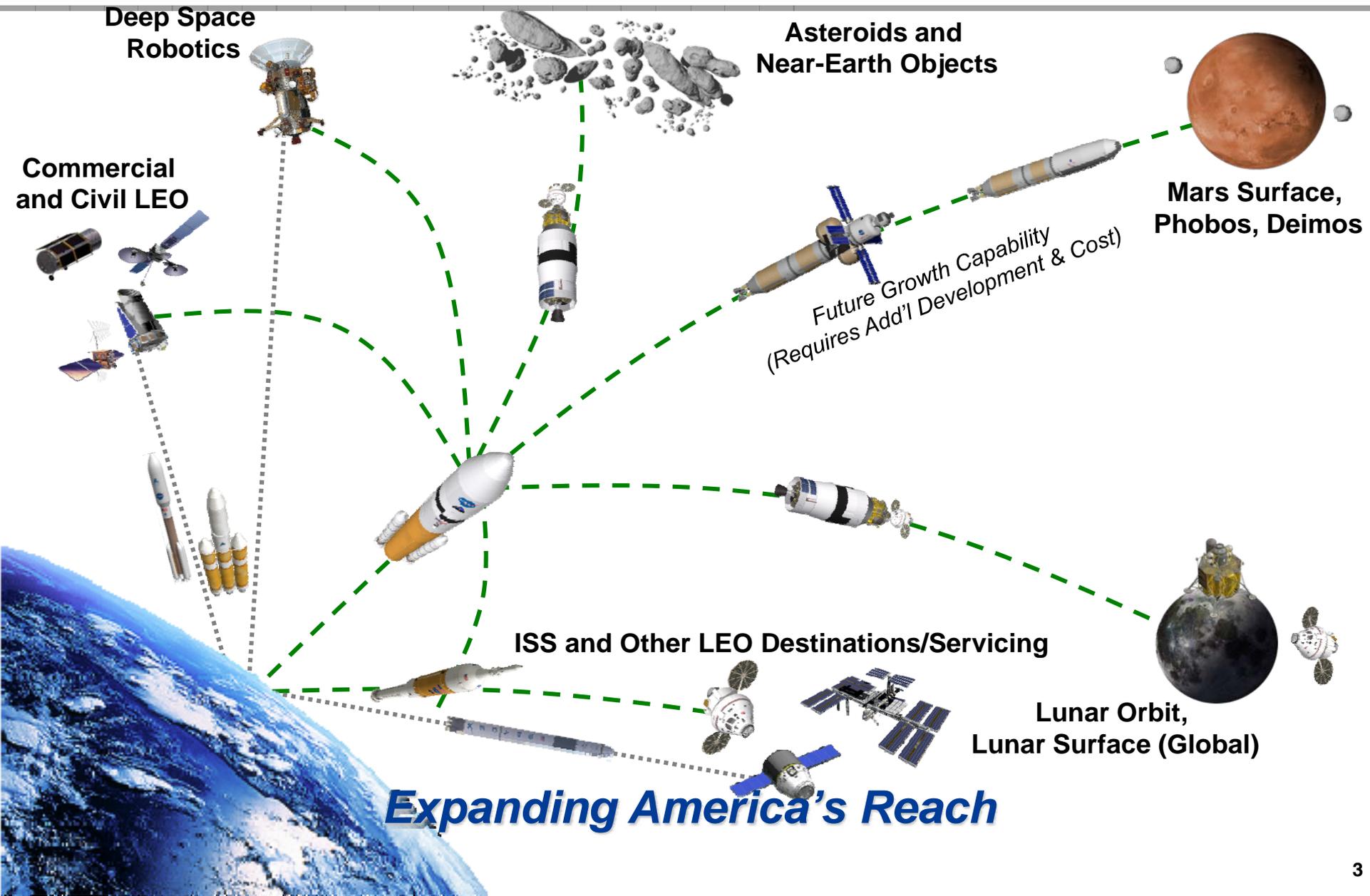


Douglas Craig
Directorate Integration Office
Exploration System Mission Directorate (ESMD)

Global Plan: Exploration Themes



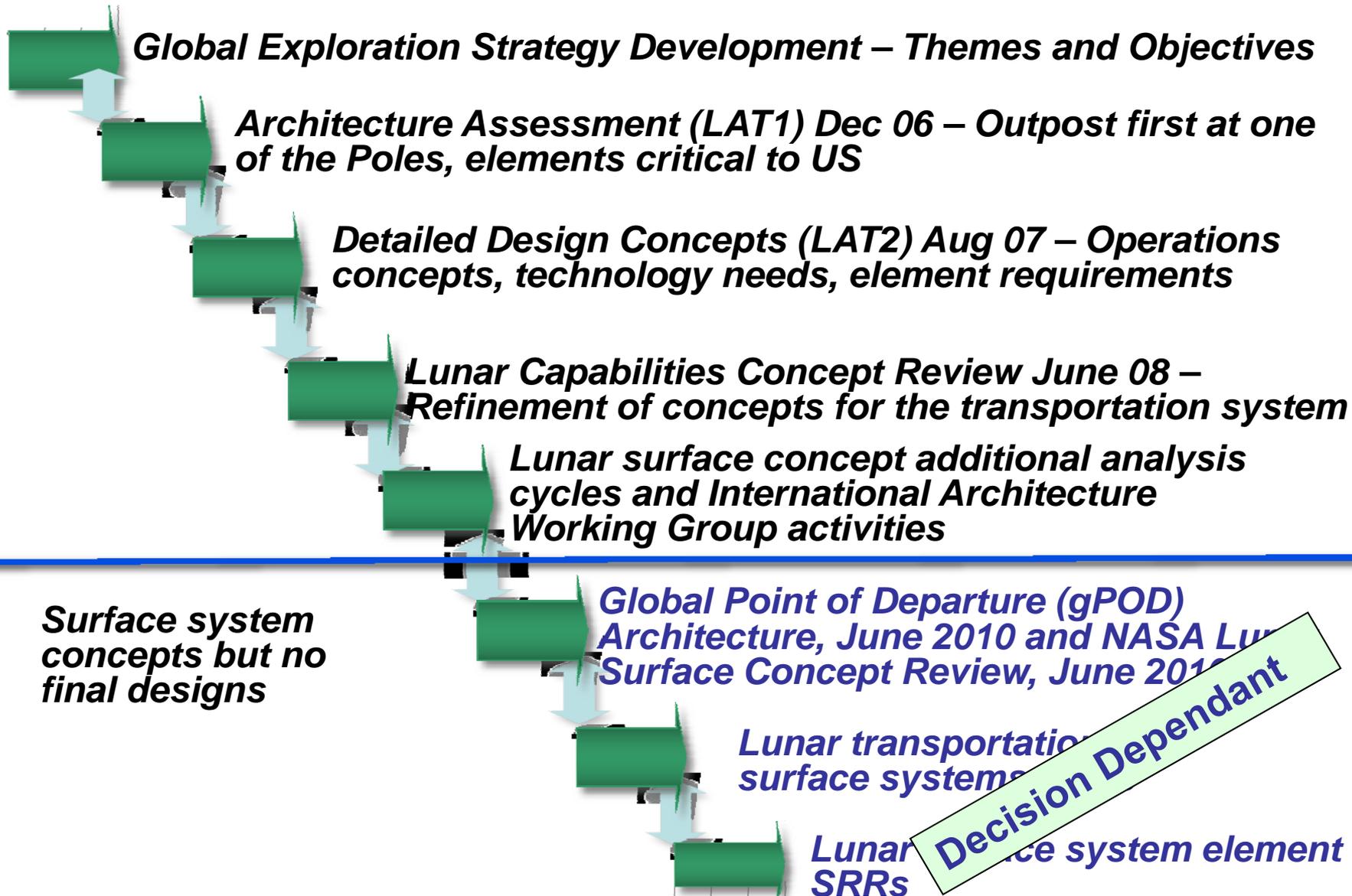
Current Development for Future Exploration Capabilities



Architecture Development Driven By A Strategy



Where We Have Been and Next Steps



Constellation Architecture



Earth
Departure
Stage



Ares I
Crew Launch Vehicle



Ares V
Cargo Launch Vehicle



Orion
Crew Exploration
Vehicle

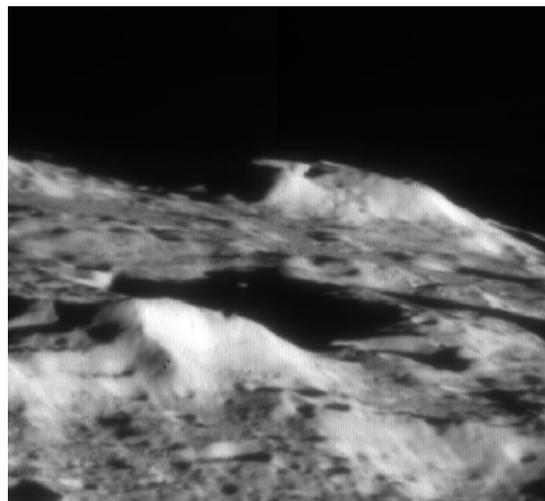


Altair
Lunar Lander

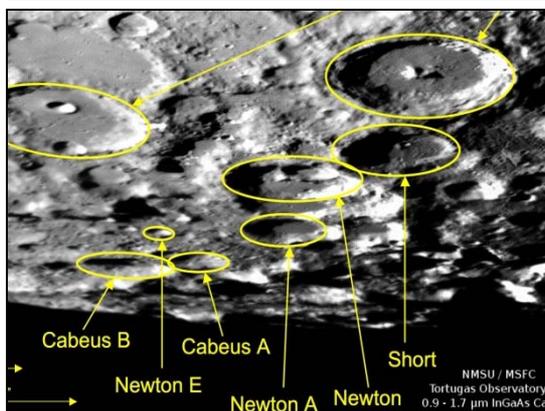




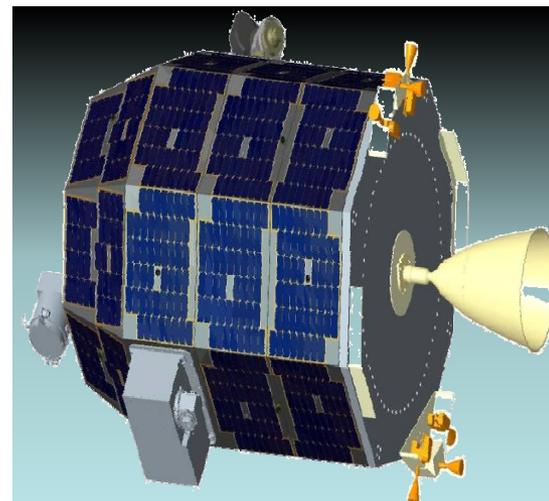
LRO/LCROSS Launch
June 18, 2009
LCROSS Impact
October 9, 2009



Palomar Adaptive Optics
image of Cabeus crater 10
seconds after Centaur impact



Cabeus Crater Targeted



**Lunar Atmosphere and Dust
Environment Explorer
(LADEE)**



**International Lunar
Network Lander**

Orion



Technicians from ATA Engineering Inc. assess data collected during the ground vibration test of the Orion Launch Abort System.

Orion crew module that will be used for the Orion Launch Abort System Pad Abort-1 flight test is positioned for loading and airlift to the White Sands Missile Range in New Mexico



Orion Main Parachute Testing – Yuma Arizona

Ares DM-1 Test



The completed solid rocket booster was installed horizontally in a test stand that was modified from the space shuttle's four-segment configuration to fit the new five-segment Ares I booster.

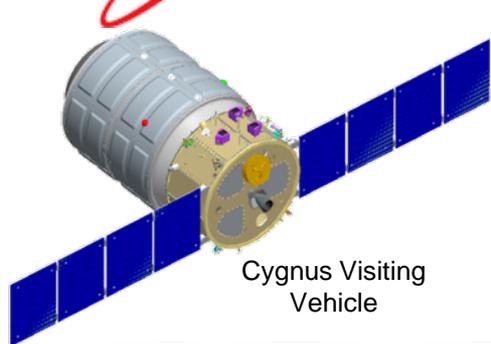


The successful test firing of the 5-segment Ares I solid rocket motor, Development Motor-1 (DM-1), was conducted September 10, 2009.

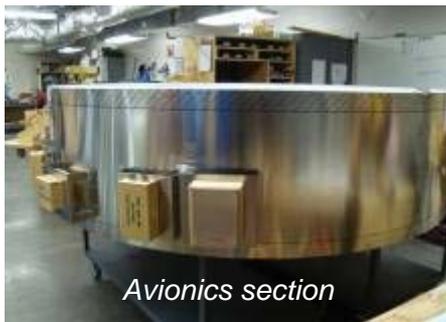
COTS Funded Space Act Agreements



Orbital



Cygnus Visiting Vehicle



Avionics section



Fairing mold tool



Taurus II

SPACEX

Space Exploration Technologies



Falcon 9



Dragon Capsule & Trunk



2nd Stage engine



Draco RCS Thruster



F9-001 1st stage tank

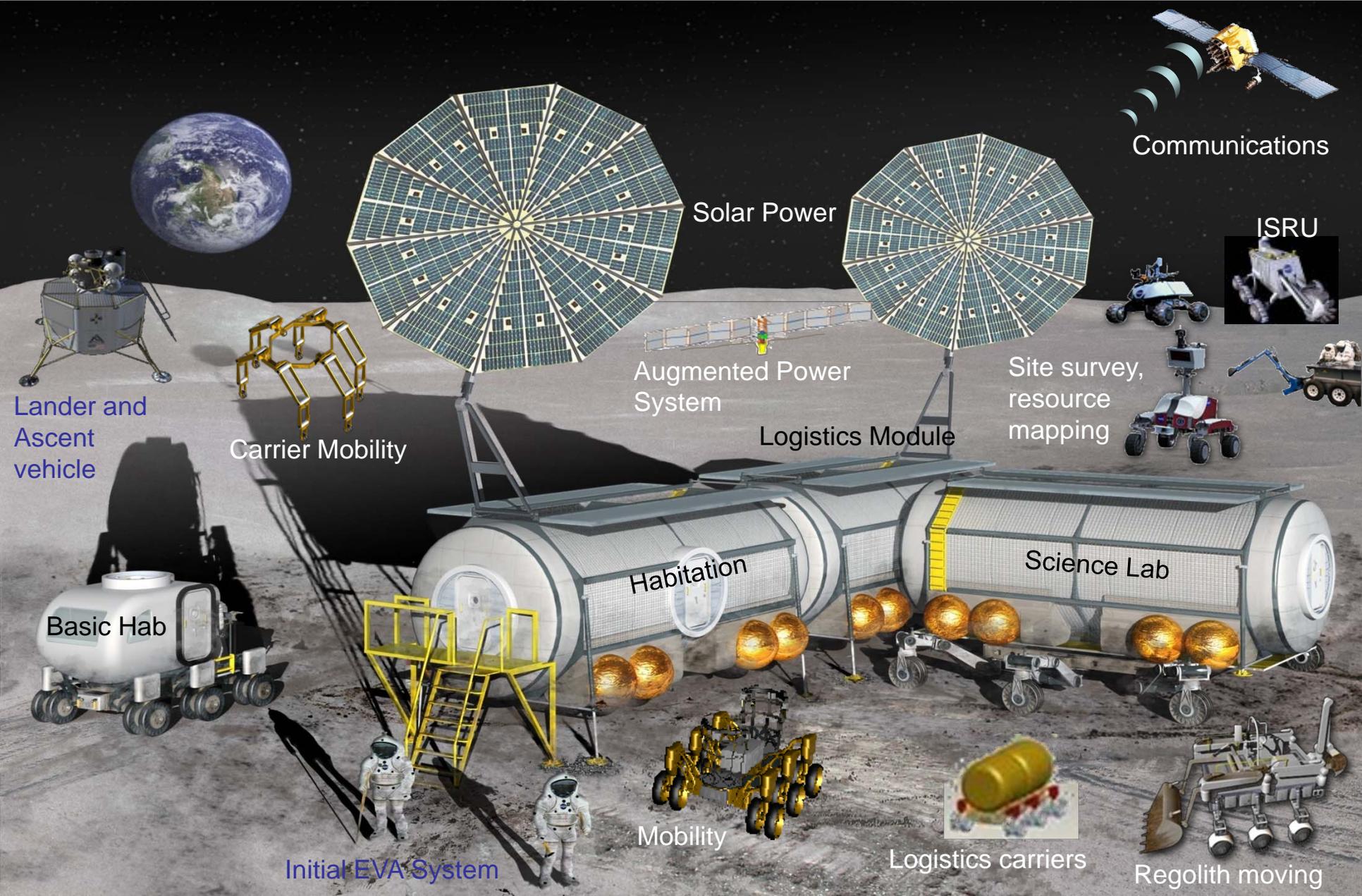
Ares I-X Flight Test



Completed development of the Ares I-X rocket and the vehicle was successfully launched on October 28, 2009

Surface Architecture

Plug-in Electric Rovers and Solar Powered Homes



Communications

ISRU

Solar Power

Augmented Power System

Logistics Module

Site survey, resource mapping

Habitation

Science Lab

Carrier Mobility

Lander and Ascent vehicle

Basic Hab

Initial EVA System

Mobility

Logistics carriers

Regolith moving

Innovation and Concept Validation: Agility to Enable Dynamic Options – An Example



- Broad Area Announcements
- Blue Sky Innovation Forums
- Game-Changing Technologies
- “Partnerships for Progress”
- Space Act Agreements
- Centennial Challenges



BAA Habitat Design by University of Maryland



Lunar Electric Rover and Suitport Concepts Developed by Blue Sky



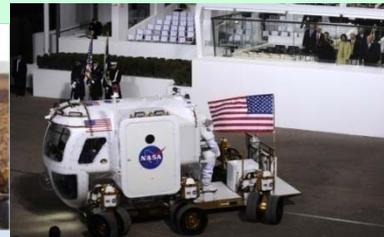
Lithium-sulfur batteries

Concept Formulation



Architecture Enabled by LER Concept

System and Operational Concept Validation



Oct 2008, LER accomplished 3-day mission (supported Inaugural Parade)

LER performed a 14-day mission (Sept 2009)



Human Missions to the Moon

US/NASA Developed initial capabilities

- Launch Vehicle Architecture
- Lunar Lander: ascent vehicle and descent vehicle
- Initial EVA system for CEV and an Initial Surface Suit
- Basic Navigation and Communication

Open for Cooperation

Systems & Capabilities Envisioned for an Outpost including Outpost enabled sorties

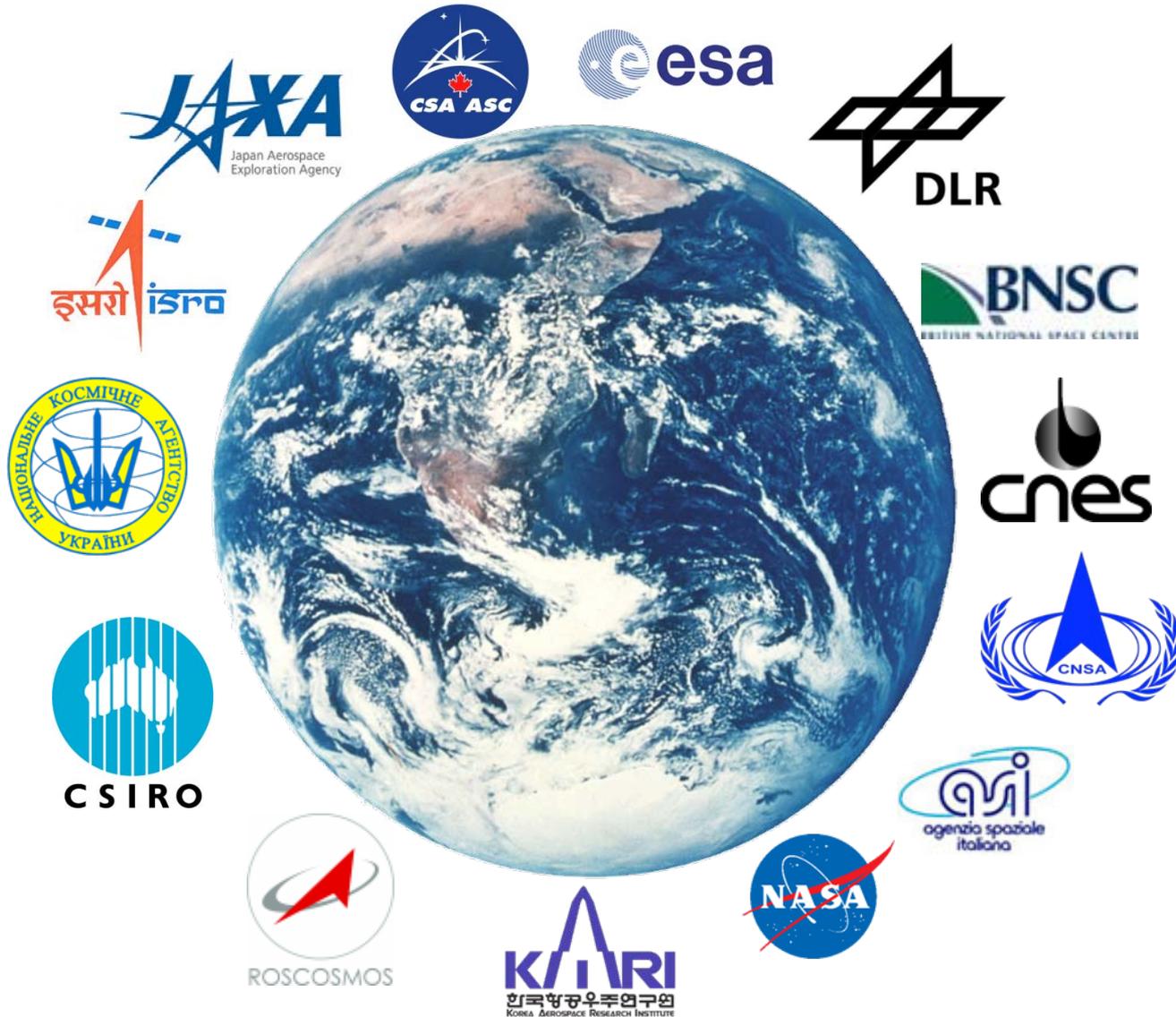
- Long duration surface suit
- Advanced, long-duration Habitation
- Basic and Augmented Power Systems
- Basic, unpressurized rover
- Pressurized rover
- Logistics rover
- Augmented, high bandwidth satellite communication/navigation
- Logistics Resupply
- ISRU Production

Time

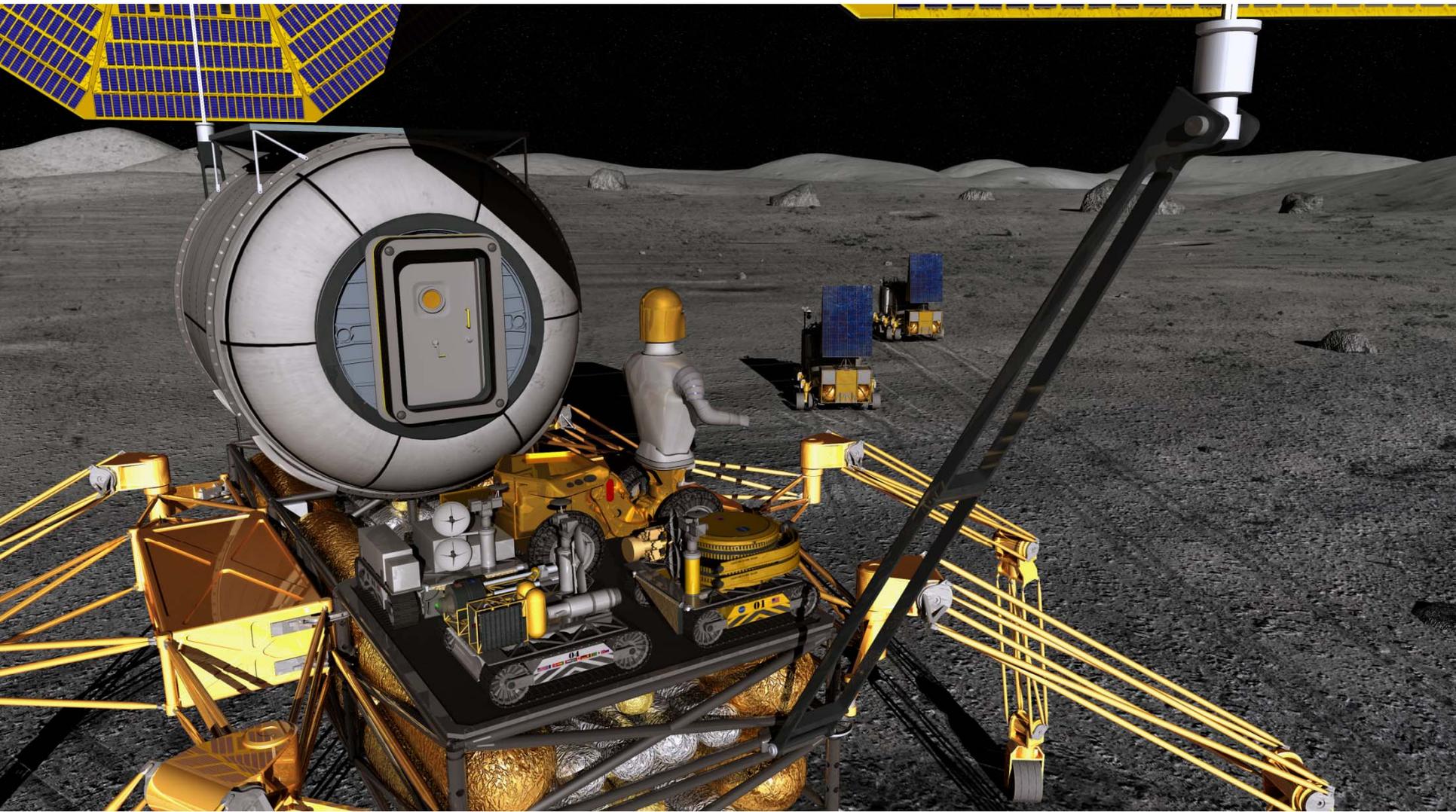
Partner and Participant Flexibility Strategy

- Parallel capabilities while seeking “open architecture” contributions
- Continue success of the Global Exploration Strategy through multilateral engagement in International Space Exploration Coordination Group (ISECG)
- Continue success of International and Commercial engagement
- Build on long-standing bilateral relationships while seeking new relationships when opportunities and conditions permit

International & Partnership Engagement



Mobile Architecture



System and Concept of Operations Validation using Analog Field Tests



Partner Infusion

International, Commercial, Other
Government Agencies



Analog Field
Tests Validate
Key
Integrated
Architecture
Requirements
and Concepts

Analog field tests
emphasize collaboration
between ESMD, SMD, & IPs

Architecture Element Concept
(Rover, Habitat, Robotic Assistants, Power, etc.)

Lunar Science Concepts
(Site Survey's, Geological Sampling/Curation, etc.)

Surface Operations Concepts
(Outpost Maintenance, Exploration, etc.)

Training
(Crew, Science Ops, Exploration Ops, etc.)

Participatory Exploration
(Web 2.0, Virtual Reality, Simulations, etc.)

Technology Development
(Energy Storage, Robotics, Human Factors, etc.)

ESMD Analog Mission and Field Test FY09 Implementation Plans



2009

2010

June

July

Aug

Sept

Oct

Feb



Desert RATS
Robotic Recon Test



Pavilion Lake
– Science
Operations
development



Desert RATS
Pressurized Rover and
Tri-ATHLETE Tests



NEEMO
Engineering and
Science
Operations Tests



Lunar Surface
Operations
Concept/ISRU
Testing



Haughton Mars Project (HMP)
Science Ops Concepts Tested



Training using all Analog and Field Test Activities

Web: www.nasa.gov/exploration/analog

YouTube: [NASAanalogTV](#)

Lunar Architecture Field Testing



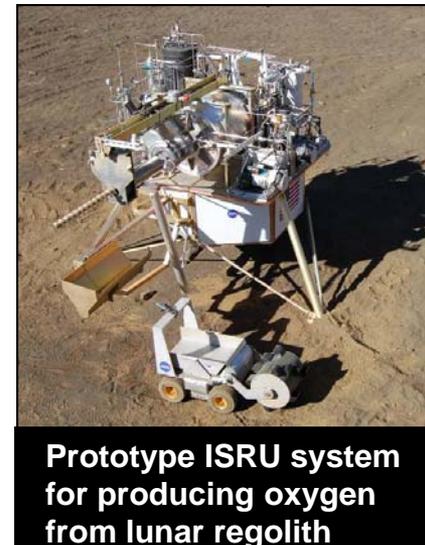
The Lunar Electric Rover (LER) concept vehicle traverses across the desert terrain



The ATHLETE rover demonstrates extreme lift capabilities.

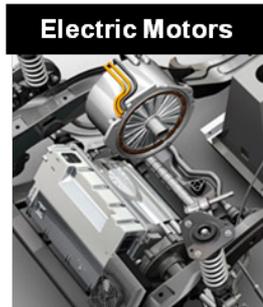
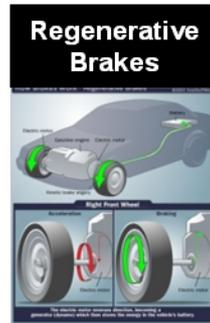


Scarab rover designed to prospect for ice in lunar



Prototype ISRU system for producing oxygen from lunar regolith

Example Technologies Needed for Lunar Exploration that have Earth Applications



ESMD Architecture



[CLICK HERE FOR VIDEO](#)



- **ESMD has developed a structured approach for developing and refining the human space exploration architecture**
 - Emphasizes Partnerships
 - International
 - Commercial
 - Other Government Agencies
 - Academia
- **Awaiting Direction from the New Administration**

- **Review of U.S. Human Space Flight Report**



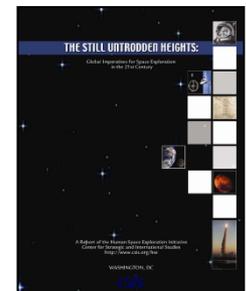
- **Global Exploration Strategy**



- **America's Future in Space (NRC)**



- **Global Imperatives for Space Exploration (CSIS)**





- The final report from the Review of U.S. Human Space Flight Plans Committee (Augustine committee) was released Oct. 22.
 - The committee examined NASA’s ongoing and planned human space flight development activities, as well as potential alternatives, and options to ensure that the Nation’s human space flight program will be safe, innovative, sustainable, and affordable in the years following Space Shuttle retirement
 - NASA is grateful for the analytical rigor and commitment that Norman Augustine’s team demonstrated.
 - The final report will be a key step in making sure America’s human spaceflight program is headed in the right direction. The committee worked exhaustively to draw information from a multitude of sources, including prior independent reviews of NASA activities and public meetings. The committee’s findings were made after receiving an enormous amount of public input.
- NASA is now working with the Administration to plan the next steps leading to a decision by the President about future U.S. human space flight plans. It remains premature for anyone at NASA to draw conclusions or speculate about future space flight plans or policies based on the committee's final report.
- Staying focused on current missions remains the Agency's top priority.



Review of U.S. Human Space Flight Report - Discussions



- * The Committee identified the following questions that, if answered, would form the basis of a plan for U.S. human space flight:
 1. What should be the future of the Space Shuttle?
 2. What should be the future of the International Space Station (ISS)?
 3. On what should the next heavy-lift launch vehicle be based?
 4. How should crews be carried to low-Earth orbit?
 5. What is the most practicable strategy for exploration beyond low-Earth orbit?

* **From Review of U.S. Human Space Flight Final Report**



Global Exploration Strategy (GES): Highlights on Progress and Future Opportunities

Douglas A. Craig
Exploration Systems Mission Directorate
NASA Headquarters

November 9, 2009



- **GES Framework Document** developed by 14 space agencies
 - Released in May 2007
- **Sustained and Affordable Agenda of Globally Coordinated Space Exploration serving society by:**
 - Securing new knowledge and solving global challenges in space and on Earth through innovative technology
 - Permanently extending human presence into space, physically and culturally
 - Enabling economic expansion and new business opportunities
 - Creating global partnerships by sharing challenging and peaceful goals
 - Inspiring society through collective effort and personal endeavor
- **Based on agreement that sustainable space exploration brings significant social, intellectual and economic benefits to people on Earth and a challenge that no one nation can meet on it's own**

5 Themes:

1. New Knowledge in Science and Technology
2. A Sustained Presence – Extending Human Frontiers
3. Economic Expansion
4. A Global Partnership
5. Inspiration and Education

Global Exploration Strategy: Progress to Date



- **Established the International Space Exploration Coordination Group (ISECG)**

- Voluntary, non-binding coordination mechanism
- Promoting robotic and human exploration coordination

- **Major ISECG accomplishments**

- Established increasingly effective mechanism for regular communication and coordination of exploration activities
- Started work on INTERSECT tool
- Established *ISECG Annual Report* to communicate global landscape of exploration progress and status of collaborative activities
- Published reference human lunar exploration scenarios
- Working on International docking system standard



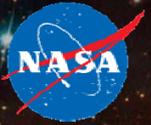


- **ISECG Work plan outlines priorities for the next year**
- **Current priorities (2009) are:**
 - Development of a common set of goals and objectives regarding human lunar exploration (December 2009 ISECG meeting)
 - Development of a global Point of Departure architecture for human lunar exploration, building on agreed scenarios (sortie, extended stay sortie and polar outpost (June 2010 ISECG meeting)
 - Continue work to identify and advance relevant standards
 - Continue development of the INTERnational Space Exploration Coordination Tool (INTERSECT)
 - Enhancement of public engagement
 - Establishment and maintenance of working relationships with relevant existing international working groups/organizations
 - Preparation and organization of a workshop on International Collaboration
- **ISS Partner/participant agencies most active participants but new participants becoming much more actively engaged**

Future Outlook: Strong and Increasing Relevance



- GES and ISECG engage the international community, open the door for tremendous commercial opportunity, and support a cohesive, sustainable, and affordable exploration agenda
- Many nations are defining/refining policy, strategies, long term plans
- Building on past experience (ISS Lessons Learned) and innovative new approaches/concepts – Linking with other organizations
- Several nations are at a critical crossroads – The next year will be historic leading to a global Point of Departure (gPOD) architecture in June 2010
- gPOD is an input to NASA Lunar Surface System Concept Review in Summer 2010 and a starting point for integrated system of systems
- NASA Leadership is important for shaping future activities, addressing US objectives/interests, and ensuring timely progress -- Leveraging US experience, processes, and open systems approach
- Interoperability, standards/specifications are key drivers
- Nations building plans and organizations, budgets, and schedules to engage and co-evolve
- Increased China, Russia, and India engagement



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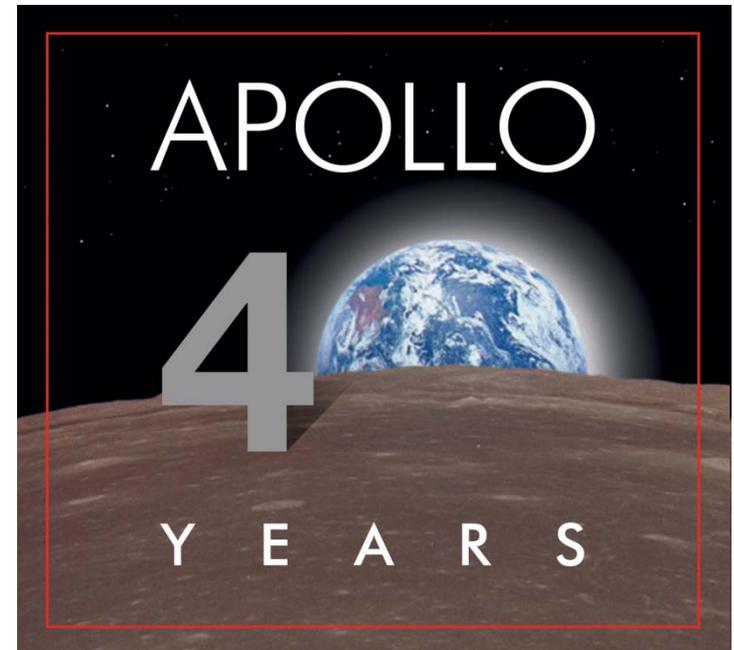
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- **The Global Exploration Strategy is an Important Framework for discussing individual agency objectives and identifying opportunities for multi-lateral cooperation – vital link to the Future of Space Exploration**
- **Many Nations are at a Critical Crossroads - - June 2010 gPOD Architecture milestone is important**
- **NASA leadership and partnership is key**
- **Exploration needs will drive us toward new technologies and new global partnerships;**
 - Enables new economic activity
 - Strengthens national security & peace
 - Engages our technical and engineering workforce
 - Provides international partner opportunities
 - Inspires the next generation of explorers
- **Cooperation is the Key to Success!**



Boldly Going Back in the Spirit of Sustained International Cooperation