National Aeronautics and Space Administration


# Global Exploration Strategy (GES): A Framework for Coordination, Progress, and Future Opportunities

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**October 28, 2008**

# Global Exploration Strategy: The Framework for Coordination

- August 2006 – 14 Space Agencies, Framework Document (May 31, 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

## 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 (GES)

**"Exploration is not merely a scientific or technical objective, but a true world-level political objective which calls for substantial and sustained investment requiring, *inter alia*, the adhesion of the general public"** Dr. Simonetta Di Pippo, ESA

"Sustainable space exploration is a challenge that no one nation can do on it's own…
GES will bring significant social, intellectual &economic benefits to people on Earth"

"Opportunities such as this come rarely -- migration into space is still in it's infancy"

- GES: The Framework for Coordination – A vision for robotic and human space exploration, focusing on destinations within the solar system where we may one day live and work.
- Outlines an Action Plan to share strategies and efforts of individual nations so that all can achieve their exploration goals more effectively and safely
- Framework does not propose a single global program -- Recommends a single, voluntary, non-binding forum (international Coordination Mechanism) for nations to collaborate to strengthen programs both individually and collectively

# GES: The Foundation of Exploration

- An important, global and visionary initiative
- Both a product and  also an enabling element of the renewed interest in space exploration;

- *Taking stock of our permanent presence in LEO with the ISS, the GES "argues for **a return to the Moon**, a target of intrinsic value and an essential stepping stone to the exploration of Mars and beyond" and that "we are now preparing to **establish a sustained human presence on the Moon** and, eventually, in other parts of the solar system".*

# Why explore the Moon?


Human Civilization


Scientific Knowledge


Exploration Preparation


Global Partnerships

Economic Expansion


Public Engagement

**Our Closest ‘Natural Space Station’ and Strong Cultural Element of Many Peoples**

# Global Exploration Strategy: Progress to Date

- Working with International Partners
  - November 2007: Establishment of the International Space Exploration Coordination Group (ISECG)
  - NASA and other ISECG members are participating in a series of new workshops to examine various architectures and approaches for human exploration beyond low-Earth orbit
  - Develop several lunar exploration scenarios based on potential exploration objectives across the international community
  - Assess respective priorities, identify potential time dependencies between systems, and assess the impact that these dependencies have on the development of standards

# Future Outlook

- Several nations are at a crossroads regarding the role they intend to play in the space exploration endeavours of the 21st century and the scope of their contribution.
- **Many Nations Are Defining/Refining Policy, Strategies, Long Term Plans and Organizations, Budgets, and Schedules to Engage**
- The United States, through NASA, will be continue to be a leader and an engaged collaborative partner in the International Community. This is a long term journey together.
- Impacts of the U.S. Presidential Election: Both candidates' policies support International and Commercial Engagement in human and robotic space exploration.
- Global Economy: Budget challenges will make cooperation vital

# International Space Exploration Coordination Group (ISECG)

- Broad and strategic scope
- Focus on non-binding findings, recommendations and other outputs necessary for use by Participating Agencies
- Areas of initial consideration:
  - Identification of standards to promote interoperability
  - Methods for sharing of scientific data and related analyses
  - Identification of common services, allowing for shared infrastructures
  - Mechanism(s) to allow provision of payload opportunities
  - Ways and means to include broader future participation in planning and coordination process
  - Assessment of requirements for any relevant international legal agreements
  - Development of common international exploration coordination tool to enhance coordination Process

# International Space Exploration Coordination Group (ISECG)

- ISECG Workplan 2008 has 3 Strategic Objectives:
  1. Demonstrate effectiveness and value of ISECG by achieving outcomes within 2008 which further ISECG goals and mutually benefit Participants
  2. Increase visibility of ISECG through communication
  3. Establish all elements of the ISECG structure required to be fully operational
- Specific 2008 Objectives: [Objectives, Activities, Implementation, Deliverables]
  - Space Exploration Interface Standards
  - Mapping Barriers to Human Exploration
  - Prototype version of INTERnatinal Space Exploration Coordination Coordinatino Tool (INTERSECT)
  - Public Engagement
  - Establish Working Relationships with Existing International Working Groups
  - Annual Report
  - ISS Lessons Learned for Exploration & Partnerships

# The U.S. Space Exploration Policy: Foundation for Exploration

- Complete the International Space Station
- Safely fly the Space Shuttle until 2010
- Develop & fly the Crew Exploration Vehicle
- Return to the Moon no later than 2020
- Extend human presence across the solar system & beyond
- Implement a sustained & affordable human & robotic program
- Promote international & commercial participation in Exploration

# Exploration Roadmap and Timelines

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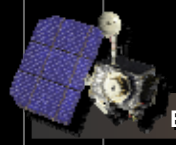


Exploration and Science Lunar Robotics Missions

Lunar Outpost Buildup



Research and Technology Development on ISS

Commercial Orbital Transportation Services for ISS

Space Shuttle Operations

Space Shuttle Program
Transition and Retirement

Ares I and Orion Development

Operations Capability Development
(EVA Systems, Ground Operations, Mission Operations)

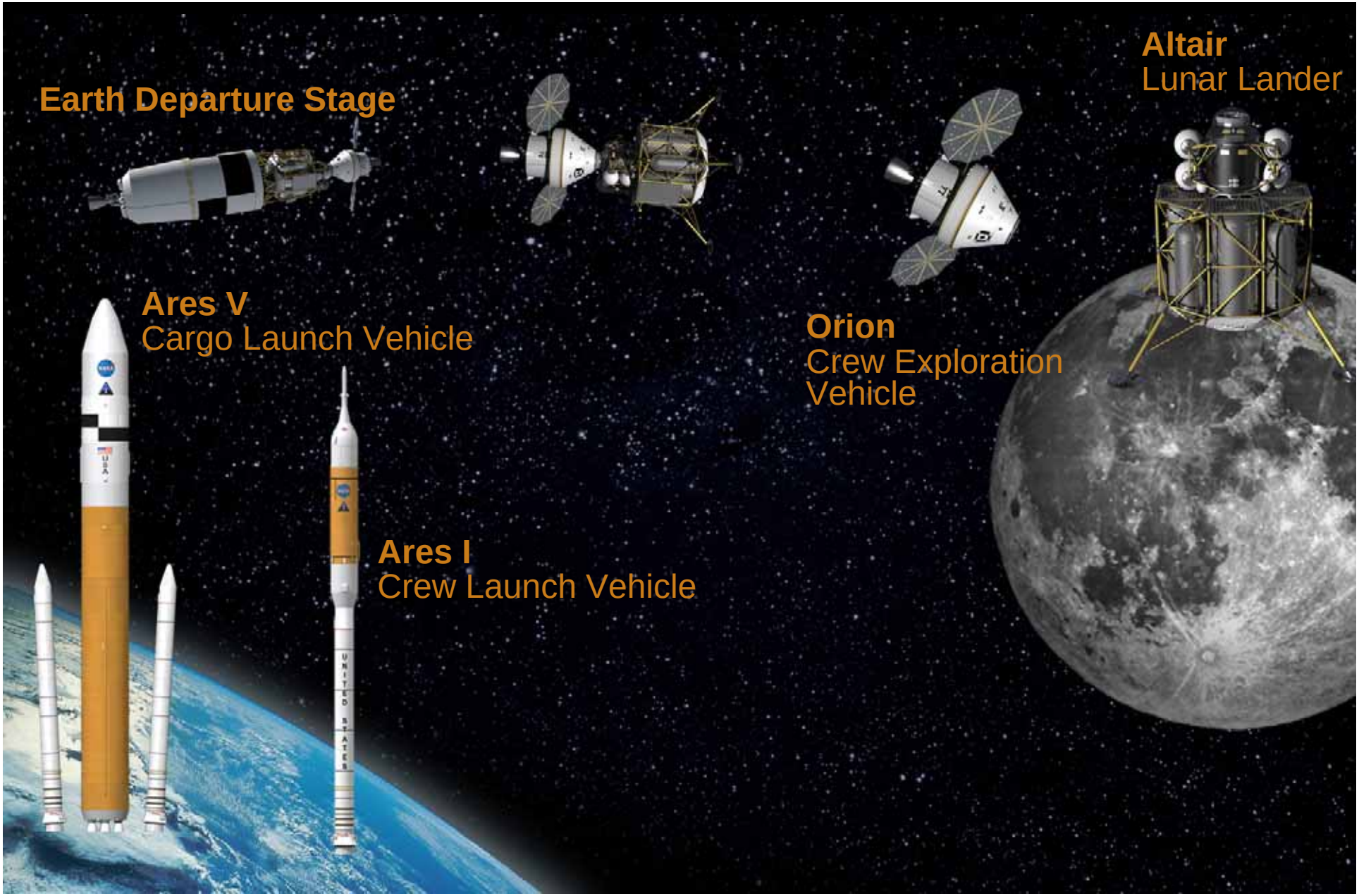
Orion and Ares I Production and Operation

Altair Lunar Lander Development

Ares V and Earth Departure Stage

Surface Systems Development

# The New Fleet for Space Exploration



# Open Architecture
# The Pieces of a Greater Mission

## Human Missions to the Moon

**US/NASA Developed initial capabilities**

- Launch Vehicle Architecture
- Lunar Lander: ascent vehicle, 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***

**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**

# Open Architecture: Infrastructure
## Open for Potential External Cooperation

- Lander and ascent vehicle
- EVA system
  - CEV and Initial Surface capability
  - Long duration surface suit
- Power
  - Basic power
  - Augmented
- Habitation
- Mobility
  - Basic rover
  - Pressurized rover
  - Other; mules, regolith moving, module unloading
- Navigation and Communication
  - Basic mission support
  - Augmented
  - High bandwidth
- ISRU
  - Characterization
  - Demos
  - Production

- Robotic Missions
  - LRO- Remote sensing and map development
  - Basic environmental data
  - Flight system validation (Descent and landing)
  - Lander
  - Small sats
  - Rovers
  - Instrumentation
  - Materials identification and characterization for ISRU
  - ISRU demonstration
  - ISRU Production
  - Parallel missions
- Logistics Resupply
- Specific Capabilities
  - Drills, scoops, sample handling, arms
  - Logistics rover
  - Instrumentation
  - Components
  - Sample return

**** US/NASA Developed hardware**

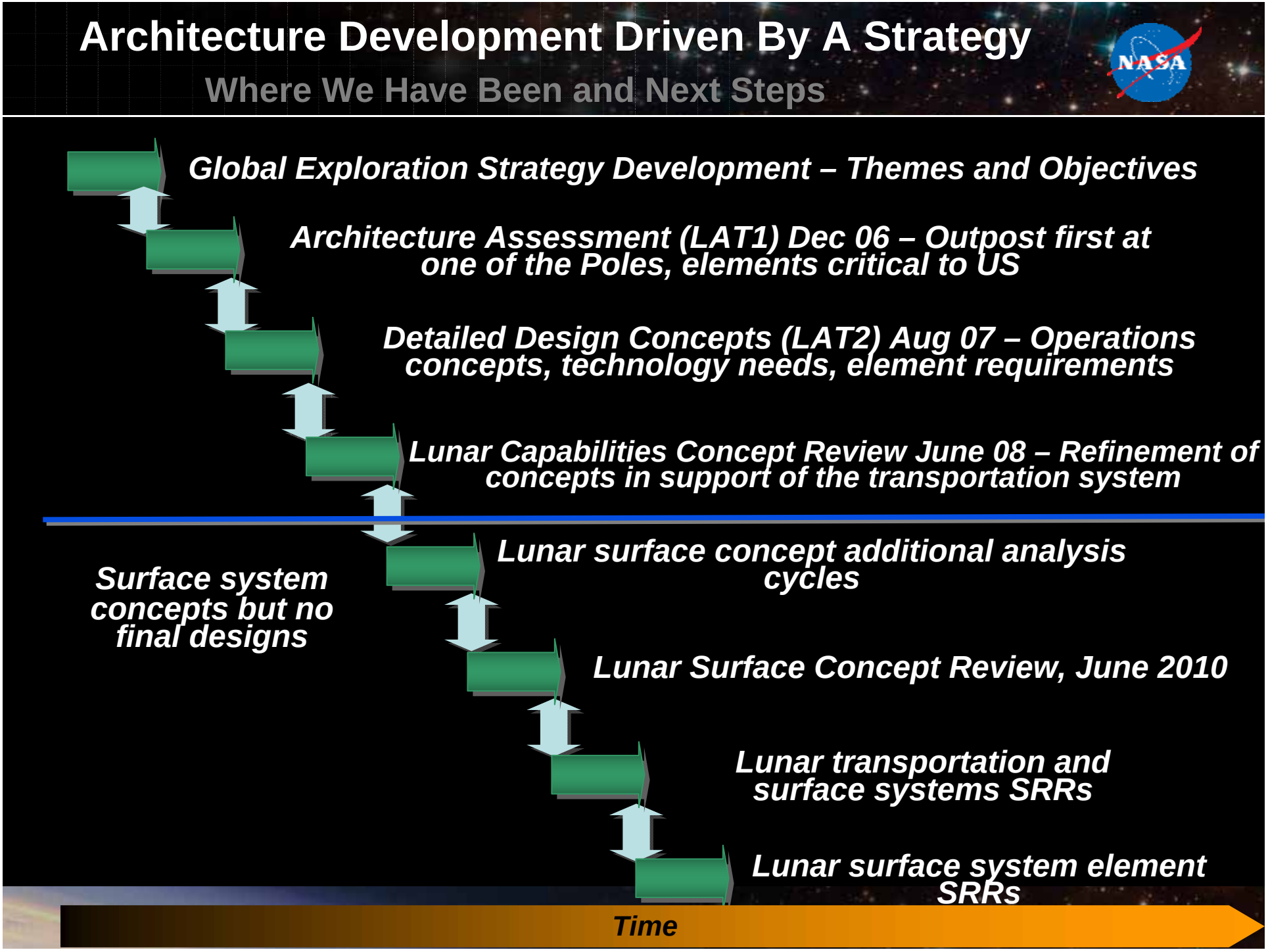
# Summary

- **The Global Exploration Strategy is a an Important Framework and a vital link to the Future of Space and Humanity**
- **Many Nations are at a Critical Crossroads – The next year will be historic**
- **Exploration needs will drive us toward new technologies and new global partnerships;**
  - Enables new economic activity
  - Strengthens national peace & security
  - Engage our technical and engineering workforce
  - Provides international partner opportunities
  - Inspires the next generation of explorers
- **Cooperation is the Key to Success!**


**Inspiration, Innovation and Discovery**

# Architecture Development Driven By A Strategy

## Where We Have Been and Next Steps



# International Multilateral Activities - Two Year Plan



| *Forum* | S | O | N | D | J 09 | F | M | A | M | J | J | A | S | O | N | D | J 10 | F | M | A | M | J | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cx Program** | △ F2F | | | △ F2F | | | △ F2F | | | △ F2F | | | △ F2F | | | △ Ckp (TBD)t | | | △ F2F | | | △ LSCR (TBD) | |
| **ISECG** | | | | | | | △ Japan<br>*-Reference Scenarios*<br>*-Interfaces for Standization*<br>*-Role of the Moon* | | | | | | | △ TBD<br>*-Lunar Exploration Science Objectives* | | | | | | | | △ Houston (TBD)<br>*-Global POD Architectur*<br>*-Elements Defined* | | |
| **ISECG Interface Standards Working Group** | △ Bremen | | △ KSC | | △ Houston (TBC) | | | | | | | | | | | | | | | | | | | |
| **Lunar Arch Working Group** | | | | | | | | | △ | | | △ | | | △ | | | △ | | | | | | |
| **ISS** | | | △ ISS Celebration | | | | | | | *- Receive ISS Lessons Learned* | △ MCB/HOA | | | | | | | | | | | △ MCB/HOA | |

Key: △ DIO Activity  △ Requires AA/DAA Participation

# International Bilateral Activities- Two Year Plan

| *Forum* | S | O | N | D | J<br>09 | F | M | A | M | J | J | A | S | O | N | D | J<br>10 | F | M | A | M | J | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Global Milestones | | IAC Glagow | | | | | ISECG Japan | | | | | | IAC Daejon | | | | | | | | | LSCR (TBD) | |
| CSA | | | CSA Study Outbrief | | | | | | | | | | | | | | | | | | | | |
| | | Analog Activity - Hawaii | | | | | | | | | | | | | | | | | | | | | |
| JAXA | Bilat | Bilat<br>- *Define CAA* | | | | CAA Meeting | | | | | | | | | | | | | | | | | |
| ESA | | CAA Phase 2 Planning | | | CAA Meeting | | | | | | | | | | | | | | | | | | |
| Russia | | | | | | | Soyuz Launch/Landing | | | | | | | | | | | | | | | | |
| DLR | | | | | | | | | | | | | | | | | | | | | | | |
| | | Analog Activity - Hawaii | | | | | | | | | | | | | | | | | | | | | |
| ISRO | | | | | | | | | | | | | | | | | | | | | | | |
| ASI | | | | | | | | | | | | | | | | | | | | | | | |
| KARI | | | | | | | | | | | | | | | | | | | | | | | |

Key: △ DIO Activity

△ Requires AA/DAA Participation

# Defining Partnership Roles & Responsibilities (still need to improve this chart)

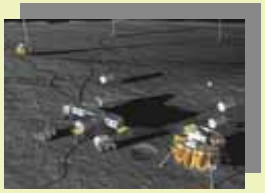
## Crafts the Policy and Deals

PIC

(ESMD AA/DAA)
**Policy**
**Deals**

Other Mission Directorates and Support Organizations

## Crafts the Architecture and Partnerships



OSEWG
ESMD/SMD Science Requirements Coordination

ESMD coordination of external groups

Lunar Life Science

MEPAG

LEAG

ILEWG

(DIO)
**Architecture**
Coordination
Integration
Requirements

Commercial

International

Inter Agency

***With assistance from CxP etc.***

## Crafts the Design

**Other Non CxP Program Implementation Schemes**

Other Mission Directorates, IP's, etc

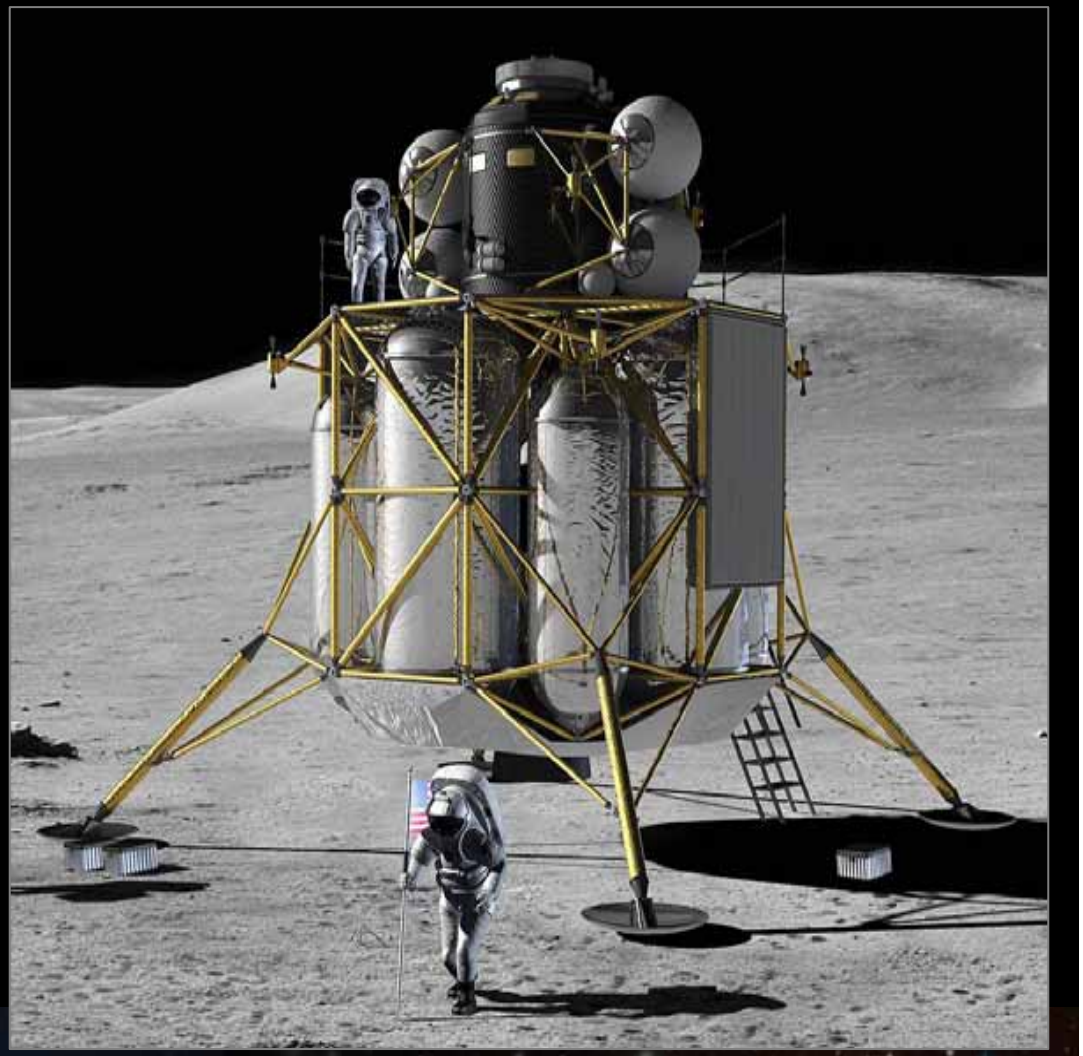
**(CxP)**
**CxLunar/Surface Systems**
Future elements that could augment US architecture

Center Assigned Work

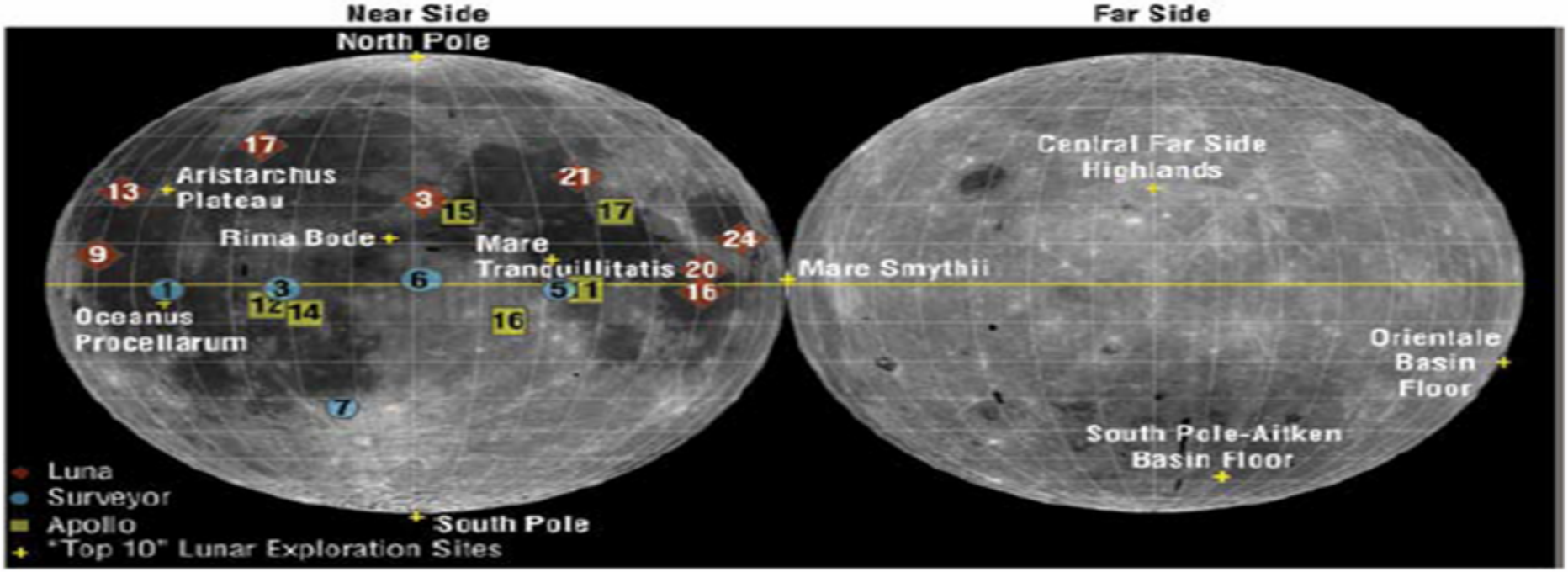
DIO – Directorate Integration Office, ISECG – International Space Exploration Coordinating Group, IP – International Partners, LEAG – Lunar Exploration Advisory Group, ILEWG – International Lunar Exploration Working Group, MEPAG – Mars Exploration Program Advisory Group, OER – Office of External Relations, OSEWG – Outpost Science Exploration Working Group, PIC – Partnership Integration Committee

# The Altair Lunar Lander – Access to the Lunar Surface

- Four (4) crew to and from the surface
  - Seven days on the surface
  - Lunar outpost crew rotation
- Global access capability
- Anytime return to Earth
- Capability to land 14 to 17 metric tons of dedicated cargo
- Airlock for surface activities
- Descent stage:
  - Liquid oxygen / liquid hydrogen propulsion
- Ascent stage:
  - Hypergolic propellants or liquid oxygen/methane
- Critical element in an international architecture for exploration of the Moon

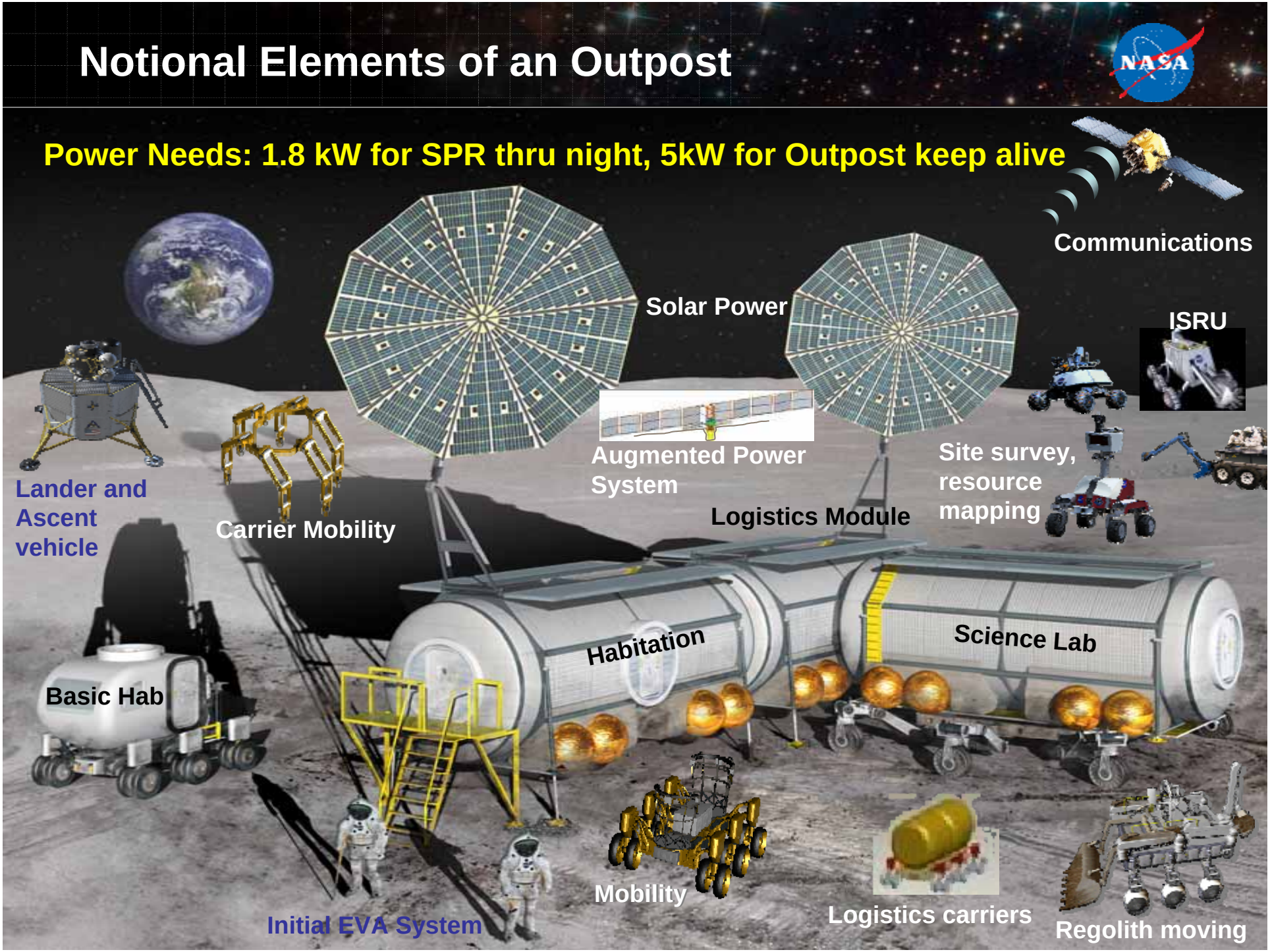


# Lunar Science Exploration Sites




| LOI Delta-V (m/s) | | | |
|---|---|---|---|
| **Landing Site** | **Latitude** | **Longitude** | **Delta-V** |
| South Pole | 89.9 S | 180 W | 835 |
| Far side SPA floor | 54 S | 162 W | 1,078 |
| Orientale basin floor | 19 S | 88 W | 944 |
| Oceanus Procellarum | 3 S | 43 W | 841 |
| Mare Smythii | 2.5 N | 86.5 E | 826 |
| W/NW Tranquilitatis | 8 N | 21 E | 852 |
| Rima Bode | 13 N | 3.9 W | 851 |
| Aristarchus plateau | 26 N | 49 W | 881 |
| Central far side highlands | 26 N | 178 E | 925 |
| North Pole | 89.5 N | 91 E | 835 |

# Notional Elements of an Outpost



# Lunar Surface Mobility Capability Comparison

## The Original Rover

The Apollo Lunar Roving Vehicle (LRV) was an electric vehicle designed to operate in the low-gravity vacuum of the Moon and to be capable of traversing the lunar surface, allowing the Apollo astronauts to extend the range of their surface extravehicular activities.

Specifications:
Weight: 462 lbs (210 kg)
Payload: 490 kg (1080 lbs)
Length: 3.1 m (10 ft 2 in)
Wheel Base: 2.3 m (7 ft 6 in)
Height: 3.75 ft (1.1 m)
Wheels: 4 x 32 in diameter, 9 in wide

## The Small Pressurized Rover

The Small Pressurized Rover (SPR) is formed by placing a crew cabin on a mobility chassis. The SPR cabin is designed to expedite EVA and provide a comfortable environment for longer range traverses. The SPR can mate with habitats and other SPRs.

Specifications:
Weight: 6600 lbs (3000 kg)
Payload: 2200 lbs (1000 kg)
Length: 15 ft (4.5 m)
Wheelbase: 13 ft (4 m)
Height: 10 ft (3 m)
Wheels: 12 x 39 in diameter, 12 in wide

## The Chariot

The crew mobility chassis can carry up to four suited astronauts, various payloads, or be driven robotically. The modular system accepts "turrets" for suited crew, bulldozer blades, winches, survey instruments, manipulators, and other construction implements.

Specifications:
Weight: 2200 lbs (1000 kg)
Payload: 6600 lbs (3000 kg)
Length: 15 ft (4.5 m)
Wheelbase: 13 ft (4 m)
Height: 4 ft (3.3 m)
Wheels: 12 x 39 in diameter, 12 in wide