

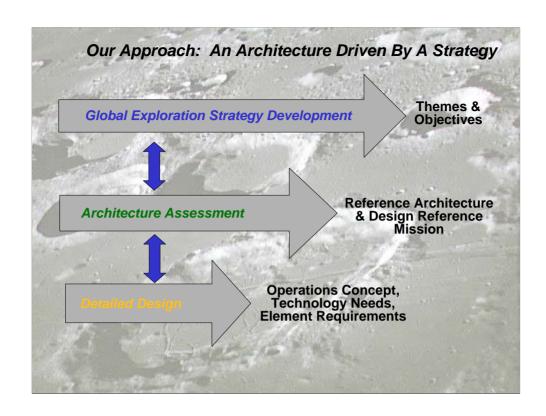
## A Bold Vision for Space Exploration, Authorized by Congress

- Complete the International Space Station
- Safely fly the Space Shuttle until 2010
- Develop and fly the Crew Exploration Vehicle no later than 2014 (goal of 2012)
- Return to the Moon no later than 2020
- Extend human presence across the solar system and beyond
- Implement a sustained and affordable human and robotic program
- Develop supporting innovative technologies, knowledge, and infrastructures
- Promote international and commercial participation in exploration



#### **NASA Authorization Act of 2005**

The Administrator shall establish a program to develop a sustained human presence on the Moon, including a robust precursor program to promote exploration, science, commerce and U.S. preeminence in space, and as a stepping stone to future exploration of Mars and other destinations.



### But Wait - We Jumped Out of Order ....

- ◆In 2005 NASA Initiated the Exploration Systems Architecture Study (ESAS)
  - ESAS Defined some early elements of the transportation architecture required to support post-Shuttle crew and cargo transfer to/from Earth-orbit and the moon
  - ESAS took an initial look at lunar surface architecture elements that might drive the requirements for this transportation system
- 2006 Readdressing the Exploration Strategy
  - NASA has initiated a significant effort to identify the compelling reasons why NASA and other stakeholders would benefit from a concentrated focus on lunar exploration

### What is a 'Global Exploration Strategy'?

- The compelling answer to the following questions:
  - · "Why" we are going back to the moon?
  - "What" do we hope to accomplish when we get there?
- Not a definition of 'how' we will explore (operations & architecture)
- Global refers to the inclusion of all stakeholders in the strategy development process - to ensure that as NASA moves forward in planning for future exploration missions - we understand the interests of:
  - International Space Agencies
  - Academia
  - Private Sector
- Includes the moon, Mars, and beyond as potential destination for exploration:
  - Initially focused on human and robotic exploration of the moon
  - An evolving plan that will expand to include Mars and other destinations

### What Is a 'Global Exploration Strategy' Used For?

- A high-level compelling story of the value of lunar exploration that can be used to explain this effort to policy makers and the general public
- A blueprint that will serve as a starting point for:
  - Coordination: coordination among participants to maximize what can be accomplished
  - Collaboration: discussions between participants regarding areas of potential collaboration
  - · Mission Design: detailed technical analyses that address,
    - Time Phasing of activities and identification of dependencies among them
    - Prioritization based on individual stakeholder goals
    - Operational and Architecture Impacts of implementation of the strategy

# Components of the Global Exploration Strategy

- ◆ Themes: Address the question:
  - Why should we return to the moon?
- Objectives: Address the question:
  - What are we going to do when we get there?

# Components of a Global Exploration Strategy Current Draft Themes (1)

# Core Themes Address the Primary Activities to be Conducted on the Moon:

- Stepping Stone:
   Use the Moon to prepare for future human and robotic missions to Mars and other destinations
- Science:

   Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them
- Sustained Presence:
   Extend sustained human presence to the Moon to enable eventual settlement

USE THE MOON: Reduce risks and cost and increase productivity of future missions by testing technologies, systems, and operations in a planetary environment other than the Earth

PURSUE SCIENTIFIC: Engage in scientific investigations Of the Moon (solar system processes), On the Moon (use the unique environment), and From the Moon (to study other celestial phenomena)

EXTEND PERMANENT HUMAN PRESENCE: Develop the capabilities and infrastructure required to expand the number of people, the duration, the self-sufficiency, and the degree of non-governmental activity

EXPAND EARTH'S ECONOMIC SPHERE: Create new markets based on lunar and cis-lunar activity that will return economic, technological, and quality-of-life benefits

ENHANCE GLOBAL SECURTIY: Provide a challenging, shared, and peaceful global vision that unites nations in pursuit of common objectives

ENGAGE, INSPIRE: Excite the public about space, encourage students to pursue careers in high technology fields, ensure that individuals enter the workforce with the scientific and technical knowledge necessary to sustain exploration

# Components of a Global Exploration Strategy Current Draft Themes (2)

# **Crosscutting Themes**

Address ways to maximize the benefit of the core themes:

Economic Expansion:
 Expand Earth's economic sphere to encompass

the Moon and pursue lunar activities with direct benefits to life on Earth

- Global Partnership:
   Strengthen existing and create new global partnerships
- Inspiration:
   Engage, inspire, and educate the public

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# Components of a Global Exploration Strategy Objectives

# Objectives

- Describe the discrete set of activities that the global community has defined as important in supporting the exploration themes
- For example, the theme of using lunar exploration to prepare for future human missions to more distant destinations can be described by a set of associated objectives, such as scientific measurements, mission simulations, and technology and operations validation.
- Serve as a means for breaking down the theme areas into achievable parcels of work that can be time-phased and prioritized – while still being at a strategic level

# Components of a Global Exploration Strategy Objectives - Categories

### 180 Objectives are grouped into 23 categories:

- 1. Astronomy & Astrophysics
- 2. Earth Observation
- 3. Geology
- 4. Materials Science
- 5. Human Health
- 6. Environmental Characterization
- 7. Operational Support
- 8. Life Support & Habitat
- 9. Environmental Hazard Mitigation
- 10.Power
- 11.Communication
- 12.Guidance, Navigation & Control

- **13.**Surface Mobility
- 14. Transportation
- 15.Operational Environmental Monitoring
- **16.**General Infrastructure
- 17. Operations Test & Verification
- 18.Lunar Resource Utilization
- 19. Historic Preservation
- 20.Development of Lunar Commerce
- 21. Global Partnership
- 22. Public Engagement
- 23. Program Execution

### Strategic Framework for Sustainable Global Space Exploration - A New Document

- Discussions with international space agencies revealed:
  - Many nations have an interest in lunar exploration
  - Six nations already have plans for robotic exploration of the moon
  - Most other space agencies have a policy commitment to pursue robotic exploration - but - not a driving goal to participate in human lunar exploration by a specific date:
    - The U.S. Vision reflects a policy decision to return humans to the moon by 2020
  - Decision made to develop high level document that outlines the framework for international coordination and cooperation in future exploration of the moon, Mars, and beyond

# Strategic Framework for Sustainable Global Space Exploration - Outline

- 1. Introduction (Methodology / Approach)
- 2. Joint Vision Statement and Guiding Principles
- 3. Why a Global Exploration Strategy Benefits to Humanity
- 4. Exploration Themes/Benefits
- 5. Overall Exploration Goals
- 6. Next Step: The Moon (Includes the Lunar Themes and Objectives)
- 7. Strategy Implementation
- 8. Global Open Architecture
- 9. Consultation, Coordination, & Cooperation
- **10.**Tentative Roadmap and Timeline
- 11.Summary

# Using Strategy to Drive Architecture Design: NASA's Lunar Architecture Study

### Study Objectives

- Define a series of lunar missions constituting NASA's lunar campaign to fulfill the Lunar Exploration elements of the Vision for Space Exploration
  - Multiple human and robotic missions
- Develop process for future Architecture updates
- Drive architecture studies from exploration strategy objectives

### Two Phase Process

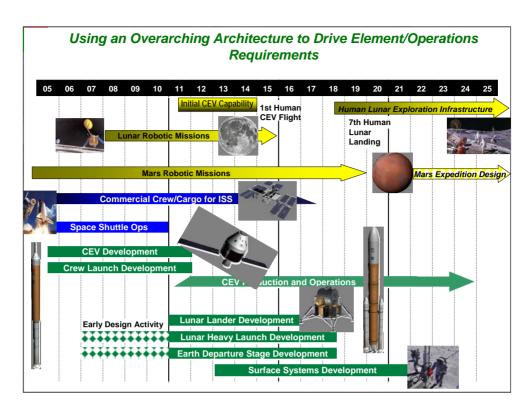
- Phase I (Initial Internal NASA Studies)
  - Understand architecture and operational impacts associated with the implementation of the key objectives that NASA is interested in achieving based on the Vision
- Phase II (Maturation and Discussion With International Space Agencies and Private Sector)
  - Provide sufficient definition and supporting rationale for near term missions to enable commitment to these missions
  - · Define areas of potential coordination and collaboration



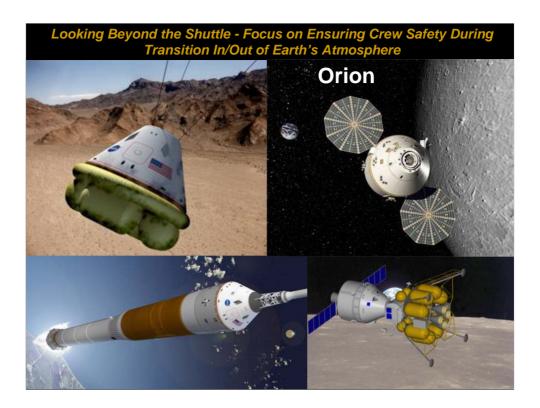


### 2006 Products

- NASA developed video and brochure that address the two basic questions - "Why" and "What"
- Internationally developed "Strategic Framework for Sustainable Global Space Exploration" to establish a framework for future coordination and collaboration







### **Benefits of CEV Approach**

ESAS Baseline was to use LOx/Methane Propulsion

Initial Studies Showed Performance Advantage, Coupled with an ISRU strategy for Mars, Made Investment in LOx/Methane Worthwhile Cost Savings Possible Through Common Development for CEV, Lander Lunar Ascent Stage and Mars ascent/descent Propulsion Further Analysis Indicated

LOx/Methane Not Required to Implement Lunar Architecture

LOx/Methane Added Considerable Risk and Cost to CEV Development

Mars Mission ISRU Strategy is Very Conceptual Today

Lox/Methane R&D Continuing

ESAS Baseline Required a Dedicated Docking Adapter for ISS

Limited Options for Supporting ISS

Required Separate Development of ISS Adapter

Changed Strategy to Allow for Multiple Hardware Interfaces

ESAS Baseline Required an Unpressurized ISS Cargo Delivery Vehicle

Will Pursue Alternatives

Options Include Currently Planned ISS Missions, Commercial Capabilities, International Partners, and Residual Capabilities of the Service Module

#### Command Module

Mold Line: Apollo-Derived Capsule Crew: 6 for ISS & Mars, 4 for Moon Size: 16.4 ft (5 Meter) Diameter Docking Mechanism: APAS or LIDS

Service Module

Propulsion: Industry Propose Best Solution

Some Capability for Delivering Unpressurized Cargo

Ongoing Analysis

Impact of Reducing Volume

Trading Functionality between Command and Service Module

Eventual Migration to Non-Toxic Propellants



#### Reduces Risk for Lunar Program

Addressing Critical Systems Sooner

Eliminates a Top ESAS Identified Risk

(SSME airstart) and Addresses Another Earlier

(J-2 development)

#### Fewer Launch Vehicle Development Steps to Lunar Missions

Single Upperstage Engine Development (J-2X)

More robust upperstage engine cycle for altitude start / capable of restart - proven in Saturn.

Single Solid Rocket Booster Development (RSRM)

Single Core Engine Development (SSME)

More 'Balanced' Engine Production Rate Requirement Between J-2X and SSME

#### Crew Launch Vehicle

Single 5 segment RSRB/M 1st stage

Upper stage powered by a single engine derived from the Saturn J-2

### Cargo Launch Vehicle

Twin 5 segment RSRB/M 1st stage (from CLV)

Core stage derived from the External Tank

Powered by 5 RS-68s

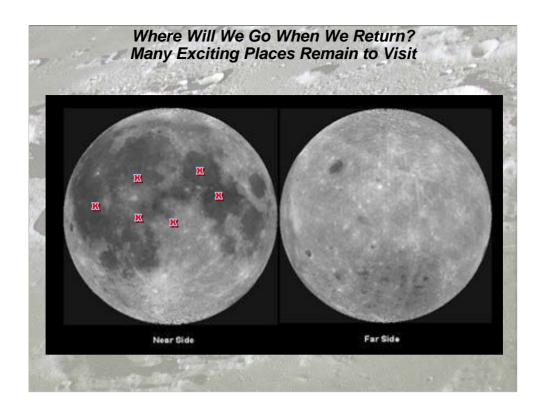
CLV-derived avionics

#### Earth Departure Stage

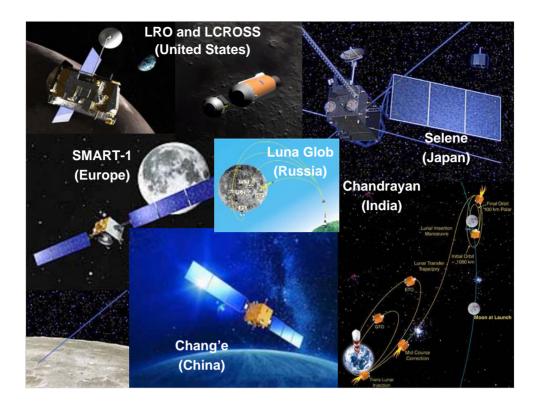
Upper stage derived from the External Tank

Powered by a single J-2 derived engine - 2 burn capability

CLV-derived main propulsion systems and avionics



We have only bee to 6 unique sites -- lots more left to go - the poles may have trapped cometary material (including maybe water ice) in shadowed craters -- the far side has the largest impact crater in the solar system - a 12 km deep hole called the Aitken Basin -- and the far side has never been explored by humans (it is far away from the Imbrium basin) - these are just a few examples -- remember - Apollo played it safe - so any high places (mountains) or low places (craters) have been left unexplored



Lots of countries are planning lunar missions - some have already succeeded (SMART) and some are being done as multinational partnerships (the Chandrayan picture shows it co-orbiting with LRO for instance)

Provide early information for human missions to the Moon

Evolvable to later human systems

Most unknowns are associated with the North and South Poles – a likely destination for a lunar outpost

Make exploration more capable and sustainable

Key requirements involve establishment of

### Terrain and surface properties

### **Knowledge of polar regions**

### **Support infrastructure**

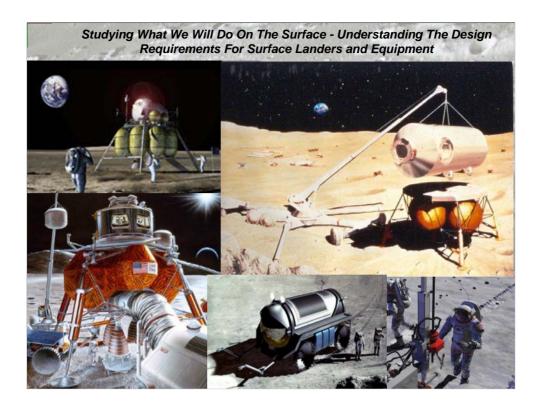
Lunar Reconnaissance Orbiter (LRO)

Provides major scientific and exploration benefit by 2009

Selected instruments complement other foreign efforts

LRO launch planned for October 2008; one-year mission

RLEP 2



We don't know yet what exactly we are going to do on the Moon and in what order - we are developing a strategy - working with other countries, academia and commercial industry to do just that -- it may include landers (upper left), habitats (upper right), habitats that connect to landers (lower left), pressurized long-range rovers (lower middle), new science equipment (lower right - a deep core driller) - or lots of other interesting stuff

Regaining and extending operational experience in a hostile planetary environment

Developing capabilities needed for opening the space frontier

Preparing for human exploration of Mars

Science operations and discovery

Enabling national, commercial and scientific goals for the development and use of the Moon



We are also focused on learning more about how radiation in space will effect astronaut health, how astronauts can safely work in space, and how microgravity effects the long term health of astronauts

We are developing safe and more efficient rockets, increased efficiency power systems, new thermal protection systems (spacecraft returning from Mars will be traveling much faster then spacecraft returning from the Moon) and many other technologies

Human Research Major Areas of Investment:

Space Radiation Research

**Exploration Medical Capability** 

ISS Research Capability

Physiological Countermeasures

Behavioral Health

**Human Factors and Environmental Standards** 



- Dr. Sharon Cobb (upper right) checking out the space station materials processing furnace
- Dr. Carol Stoker (upper middle) with a Spanish geologist looking for how life on Earth survives in harsh climates - the way it might on Mars
- Matt Golombeck at JPL (upper left) talking with the press about the success of the Mars rovers
- Dr. John Phillips (lower right) taking an ultrasound on Sergei Krikalov to see how his organs have shifted in microgravity Spacecamp



Bases on the Moon - human exploration of Mars - large orbiting Space Stations - human voyages to Jupiter - human voyages to the stars -- ghee wouldn't that all be great someday -- notice that these pictures have the black of space and the colors of other planetary bodies as their dominant colors

