Implementing the Vision
2nd Space Exploration Conference

Exploration Strategy and Architecture

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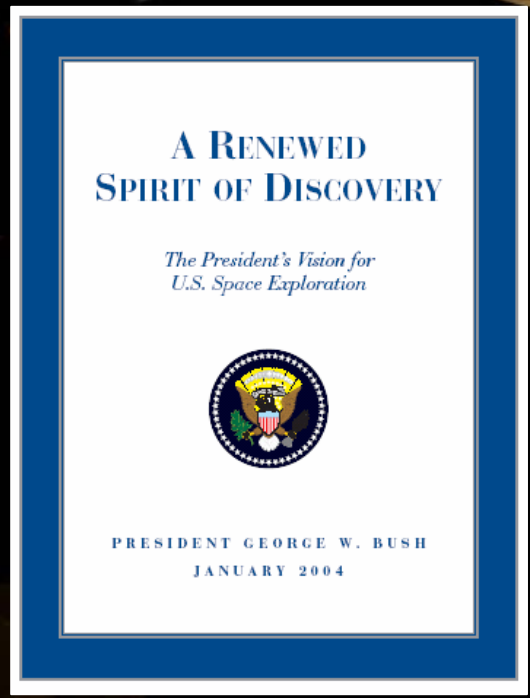
A Bold Vision for Space Exploration, Authorized by Congress

- 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



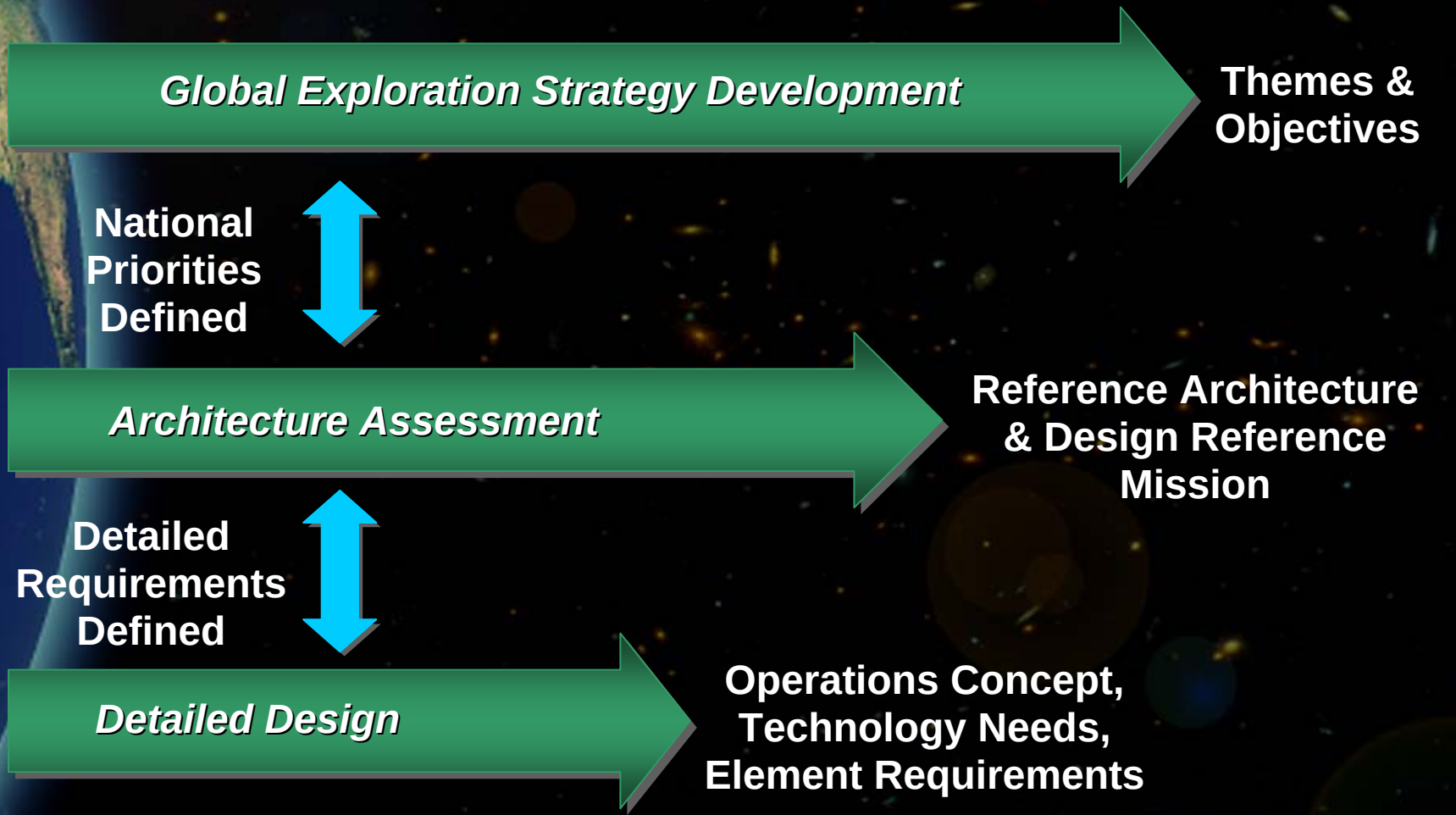
NASA Authorization Act of 2005

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.

US Role in Exploration – Derived from the Vision

- **Leadership in US Exploration Strategy and Architecture Development-**
  - –A collaborative effort
  - –Identifying common interests with others
- **Provide the US Transportation and certain exploration infrastructure.**
- **Extend operational experience in a hostile planetary environment**
- **Early US Robotic and Human mission definition**
- **Prepare for Human exploration of Mars**
- **Early experiments and demos to characterize the planetary environment and test feasibility of planned operations (ISRU for example)**
- **Provide Educational Benefits**
- **Provide and facilitate opportunities for :**
  - –Science
  - –Economic development
  - –International participation

Our Approach: An Architecture Driven By A Strategy



NASA Exploration Lunar Activities addressing Themes

Human Civilization

Global Partnerships

Scientific Knowledge

Economic Expansion

Exploration Preparation

Public Engagement

What is a 'Global Exploration Strategy'?

- **The strategy that supplies 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?

- **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
  - Private Citizens

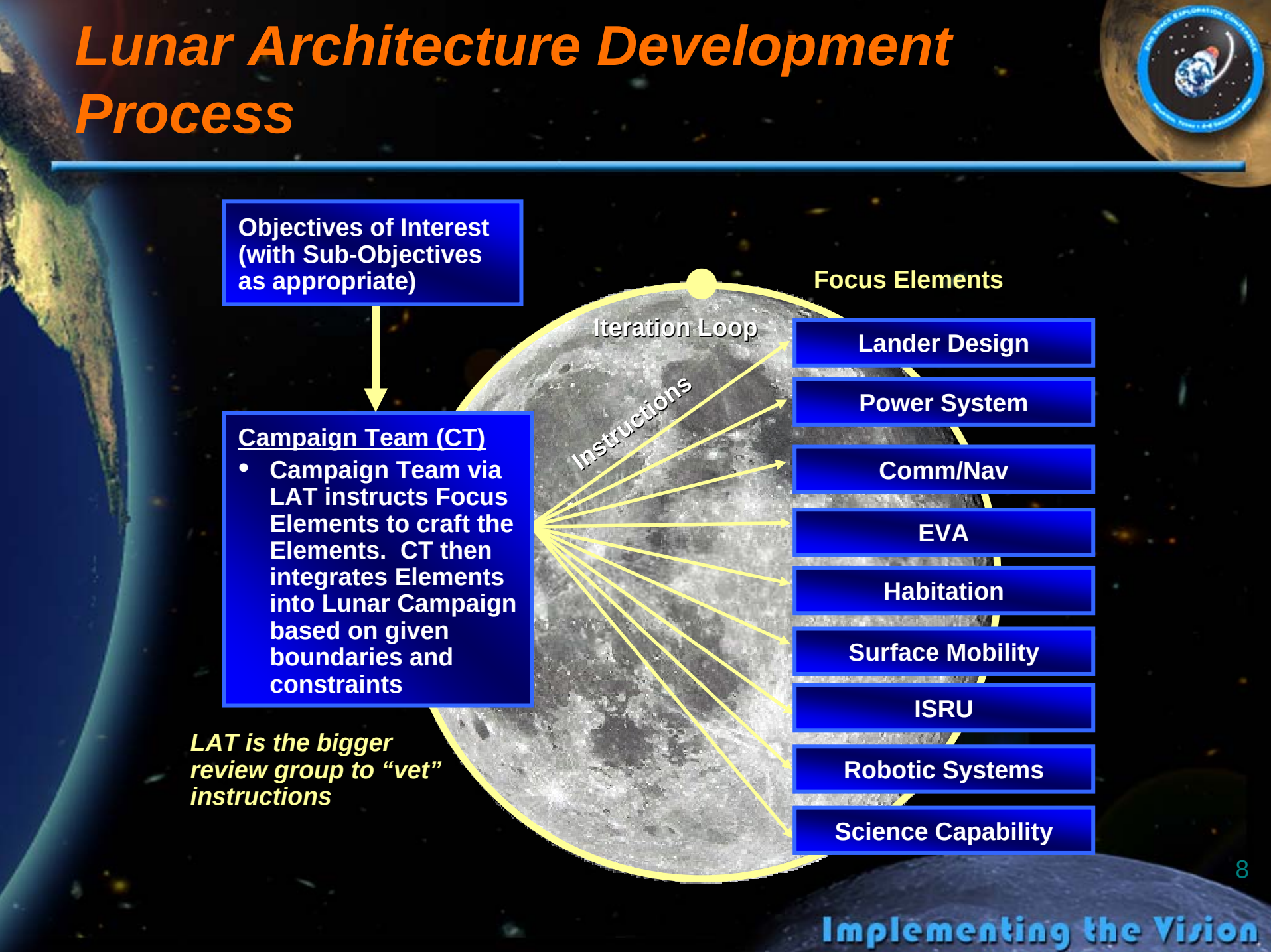
- **Includes the Moon, Mars, and beyond as potential destinations for exploration:**
  - Initially focused on human and robotic exploration of the Moon
  - An evolving plan that will expand to include Mars and other destinations

Lunar Objectives represent all stakeholders interests. Not all objectives are endorsed by NASA

What is the Lunar Architecture Study?

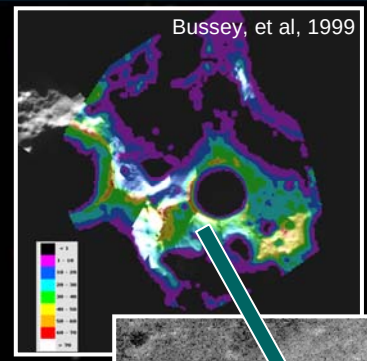
- **Study Objectives**
  - Define a series of lunar missions constituting NASA's Lunar campaign to fulfill the Lunar Exploration elements of the Visions for Space exploration
    - Multiple human and robotic missions
  - Develop process for future Architecture updates
- **Lunar Architecture Team (LAT) Charter**
  - Develop a baseline architecture concept and establish a periodic architecture refinement by December 6, 2006
    - Baseline Architecture traced to Objectives
    - Concept of Operations
    - Exploration Architecture Requirements Document – Level 1 Requirements
    - Functional Needs / Technology Analysis

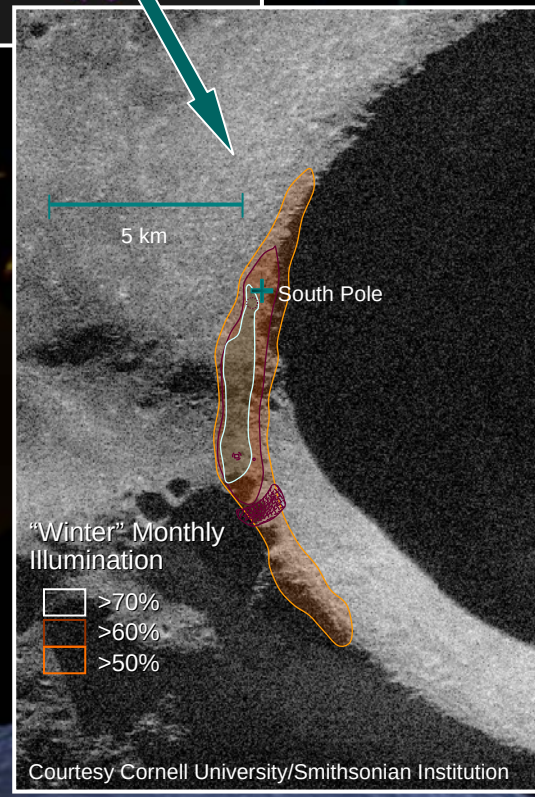
Lunar Architecture Development Process



Key Decisions: Sortie vs. Outpost

- First: What is the fundamental lunar approach?
- LAT concluded outpost first is best approach
- Top 2 Themes – "Exploration Preparation" and "Human Civilization" drive to outpost
- Enables global partnerships
- Allows development and maturation of ISRU
- Results in quickest path toward other destinations
- Many science objectives can be satisfied at an outpost



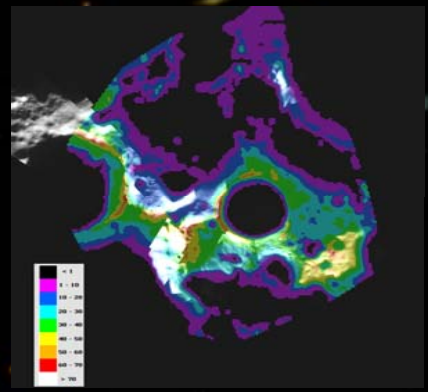


Outpost Site Location

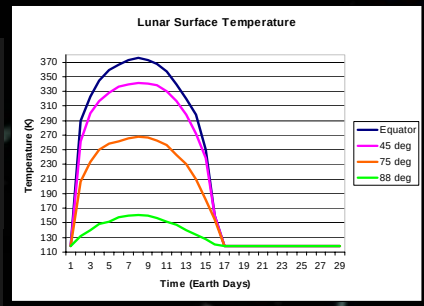
Outpost Site: Polar

- **Safe**
  - Thermally Moderate
- **Cost Effective**
  - High percentage of sunlight
  - Allows use of solar power
  - Least Delta V required
- **Resources**
  - Enhanced hydrogen (possibly water)
  - Potentially other volatiles
  - Oxygen
- **Flexibility**
  - Allows incremental buildup using solar power
  - Enhanced surface daylight ops
  - One communication asset (with backup)
  - More opportunities to launch
- **Exciting**
  - Not as well known as other areas
  - Offer unique, cold, dark craters

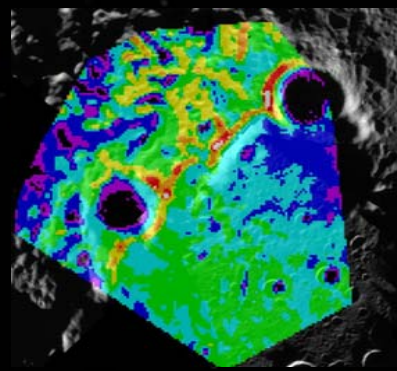
South Pole



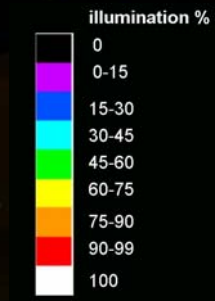
Data obtained during southern winter (maximum darkness)



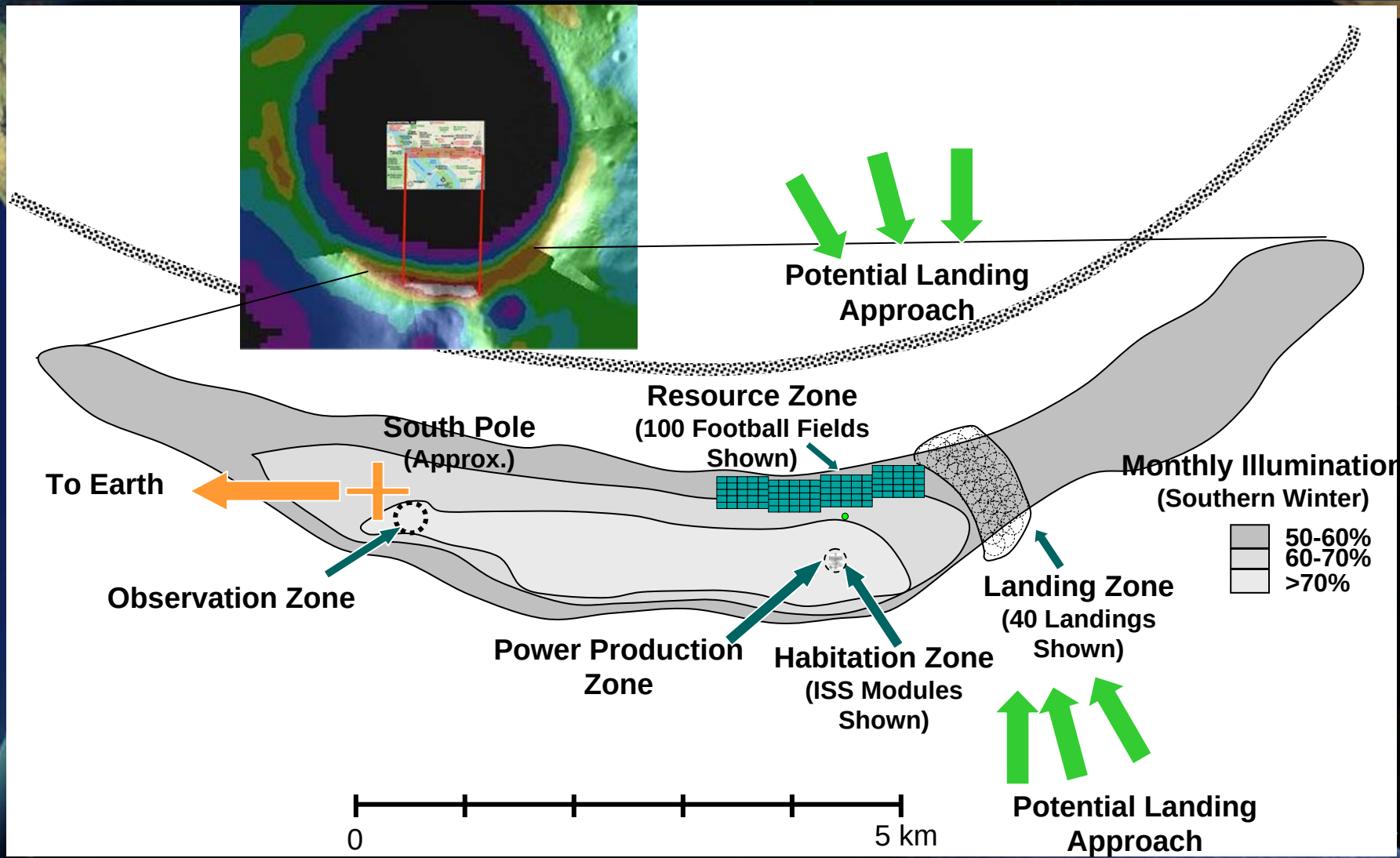
North Pole



Data obtained during northern summer (maximum sunlight)

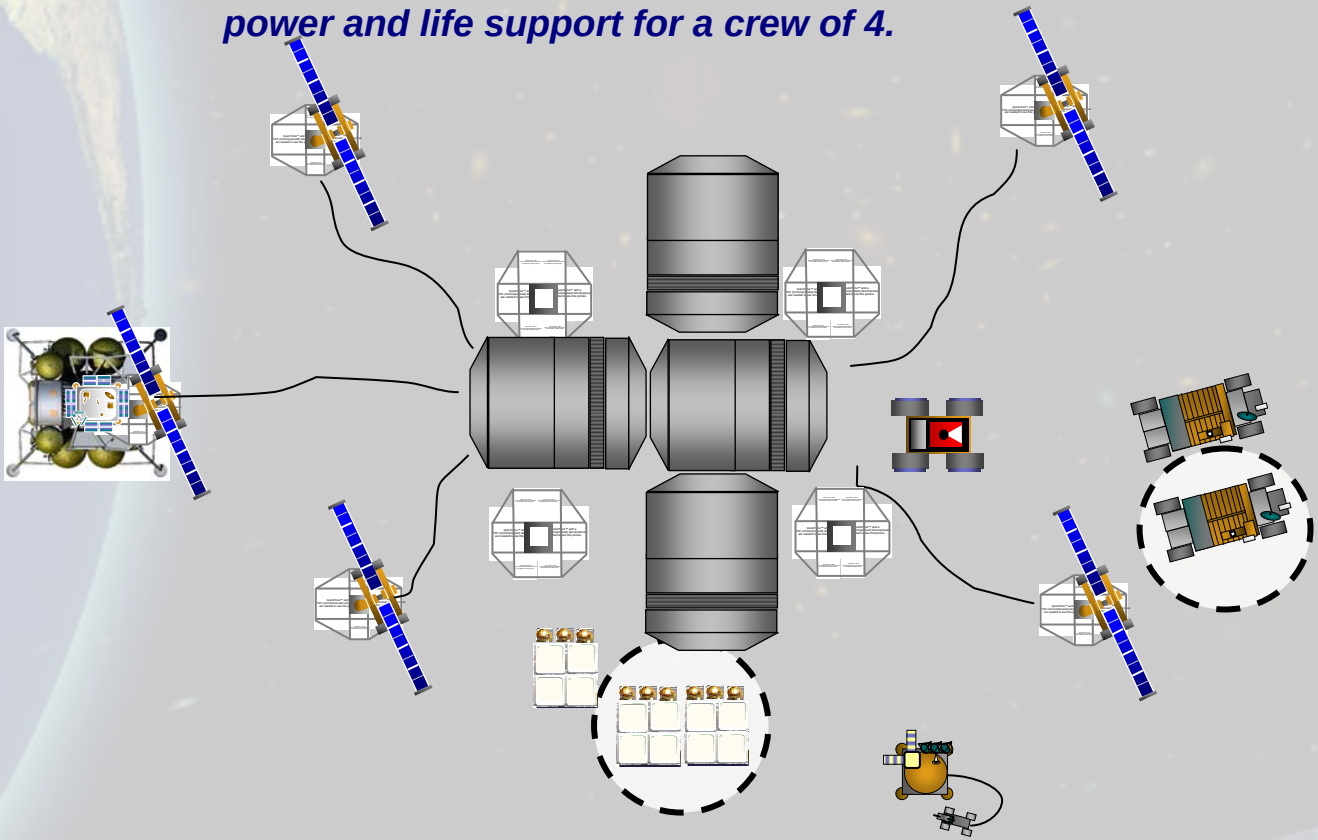


Shackleton Crater Rim with Notional Activity Zones



Key Points: Outpost Build up

The capabilities represented here are the notional minimum systems and facilities that would be needed to support continuous 6-month stays on the surface. This level of buildup would provide infrastructure including power and life support for a crew of 4.



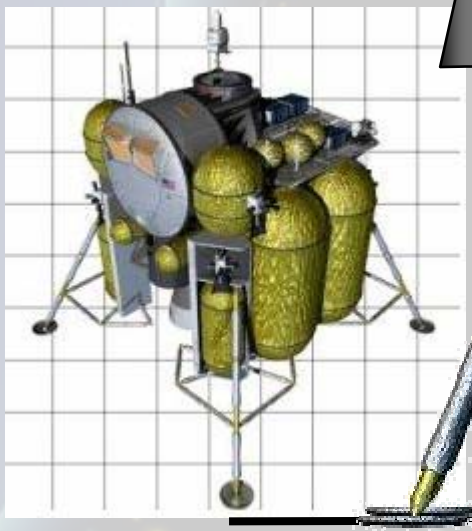
KEY

- Crew/Cargo Lander
- Solar Power Unit
- Unpressurized Rover
- Surface Mobility Carrier
- Habitation
- Power Storage Unit
- Logistics
- ISRU Module
- Pressurized Rover (2027)

Key Points: Lander Basic Architecture

Ascent Module (minimized for mass)

Landed Mass (Cargo, Habitat, Mobility, etc – Maximized for Mass)

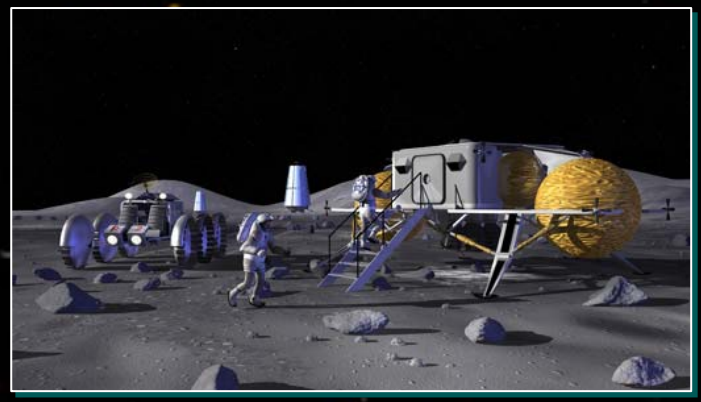


- **Design Goals**
  - Minimize Ascent Module mass
  - Minimize Descent Module mass
  - Maximize landed "payload" mass
  - Simplify interfaces
  - Move functions across interfaces when it makes sense

Descent Module (minimized for mass)

Lunar Architecture Framework — Point of Departure

- Human lunar missions will be used to build an outpost at a polar site
- The ability to fly human sorties and cargo missions with the human lander will be preserved
- Initial power architecture will be solar with the potential augmentation of nuclear power at a later time



- Robotic missions will be used to:
  - Characterize critical environmental parameters and lunar resources
  - Test technical capabilities as needed
- The ability to fly robotic missions from the outpost or from Earth will be a possible augmentation

Post 2025 Opportunities

By 2025 NASA will have developed the capabilities required to enable various future paths. Agency decision: Which future path(s) to take?

Agency Decision on Future Path(s)

2025 Capabilities

- Mature transportation system
- Closed loop habitat
- Long duration human missions beyond LEO
- Surface EVA and mobility
- Autonomous operations
- Advanced robotic missions
- Minimize reliance on Earth via In-Situ fabrication and resource utilization
- Enhanced by Commercial and International Partners

Humans to Mars

NASA Follow-on Strategy

Mars

Expand Lunar Outpost Site Exploration

Expand Lunar Outpost via Commercial and/or International Partners

Human Exploration of Other Lunar Sites via Sorties

NASA Implementation Philosophy

- The US will build the transportation infrastructure and initial communication & navigation and initial EVA
- Open Architecture: NASA will welcome external development of lunar surface infrastructure

- The US will perform early demonstrations to encourage subsequent development
- External parallel development of NASA developed capabilities will be welcomed

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**

Forward Work (January – July 07)

Using current architecture as a point of departure

- Develop global view and mature architecture
- Coordinate lunar exploration plans among international and commercial partners and continue to look for other collaboration opportunities
- Refine campaign and architecture concepts and also element hardware concepts
- Update and baseline ESMD Requirements
- Develop Mars Reference Mission
- Continue to engage academia, the private sector, and other stakeholders in defining a sustainable program of exploration