# Exploration Strategy and Architecture

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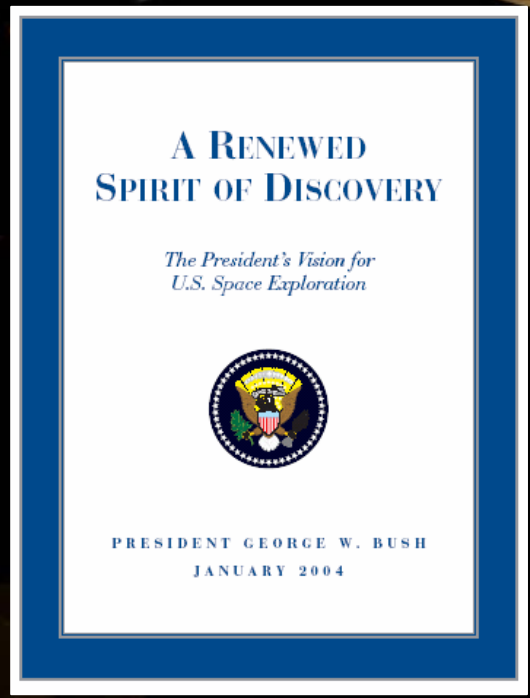
# A Bold Vision for Space Exploration, Authorized by Congress

- 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



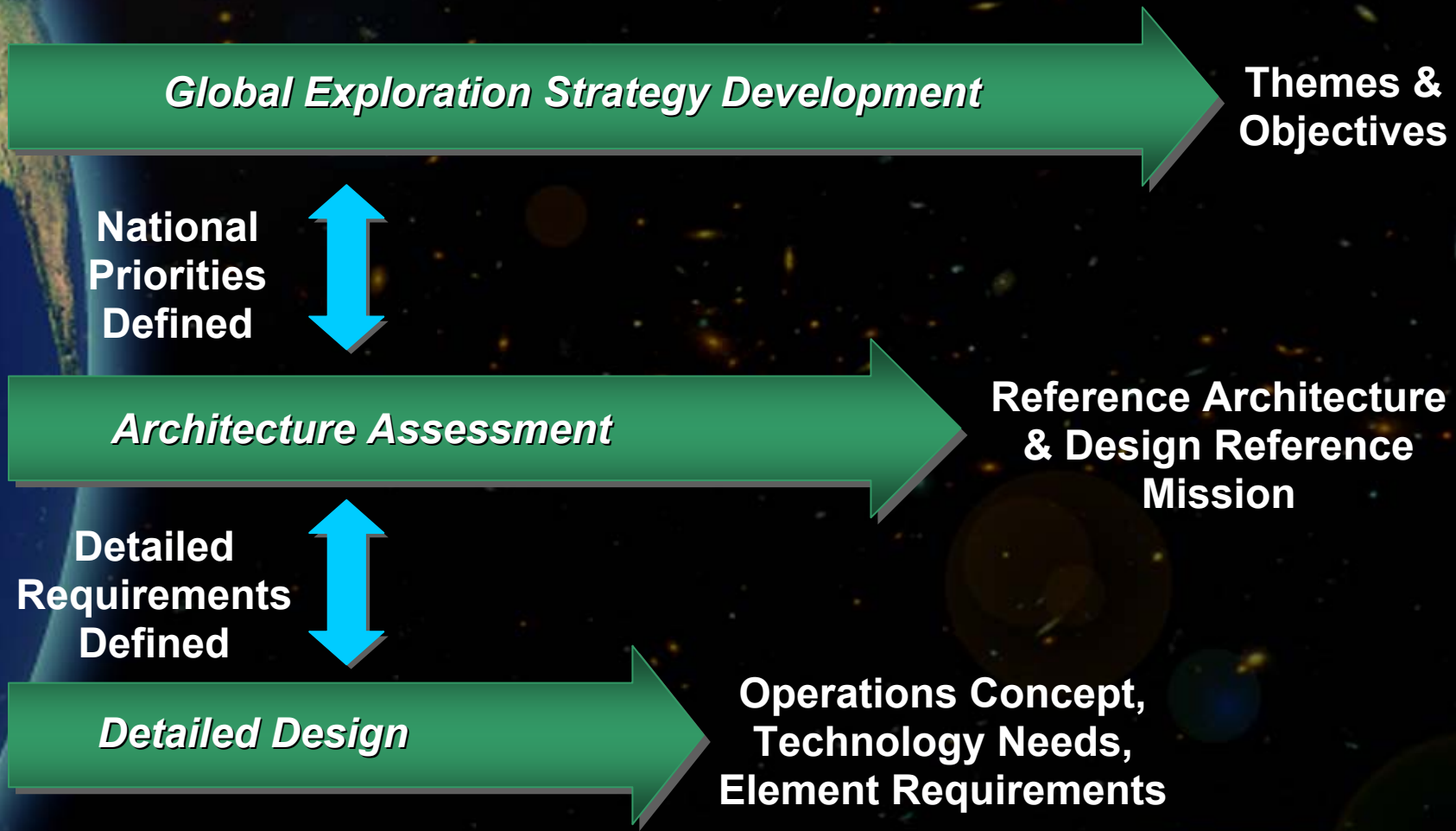

**NASA Authorization Act of 2005**

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

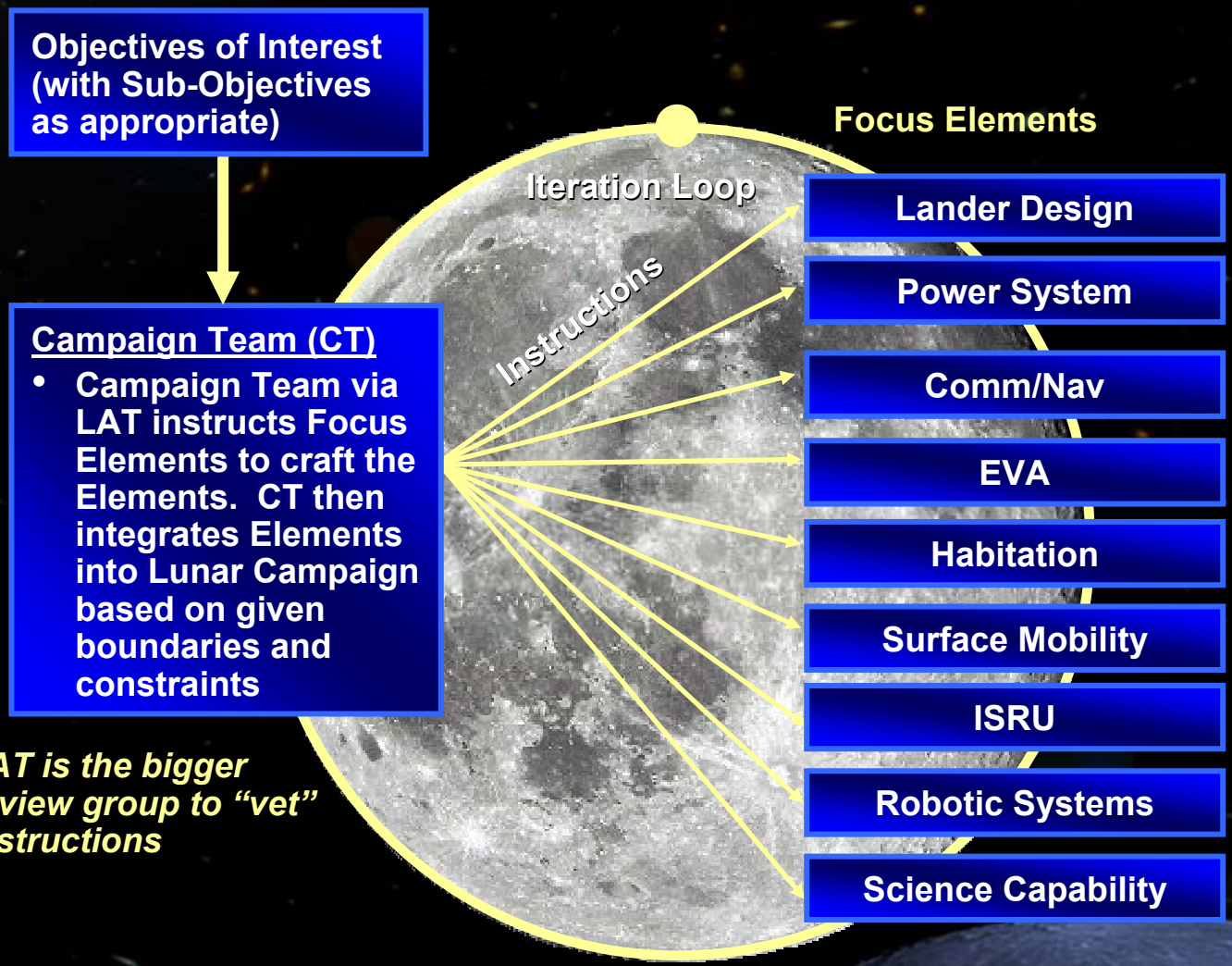
- **Includes the Moon, Mars, and beyond as potential destinations for exploration:**
  - Initially focused on human and robotic exploration of the Moon
  - An evolving plan that will expand to include Mars and other destinations

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

# What is the Lunar Architecture Study?

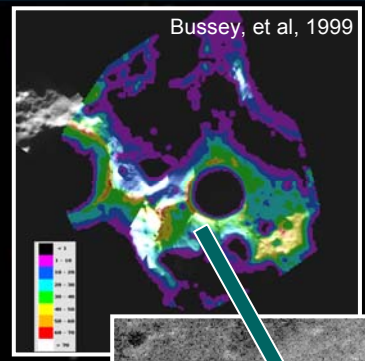
- **Study Objectives**
  - Define a series of lunar missions constituting NASA's Lunar campaign to fulfill the Lunar Exploration elements of the Visions for Space exploration
    - Multiple human and robotic missions
  - Develop process for future Architecture updates
- **Lunar Architecture Team (LAT) 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

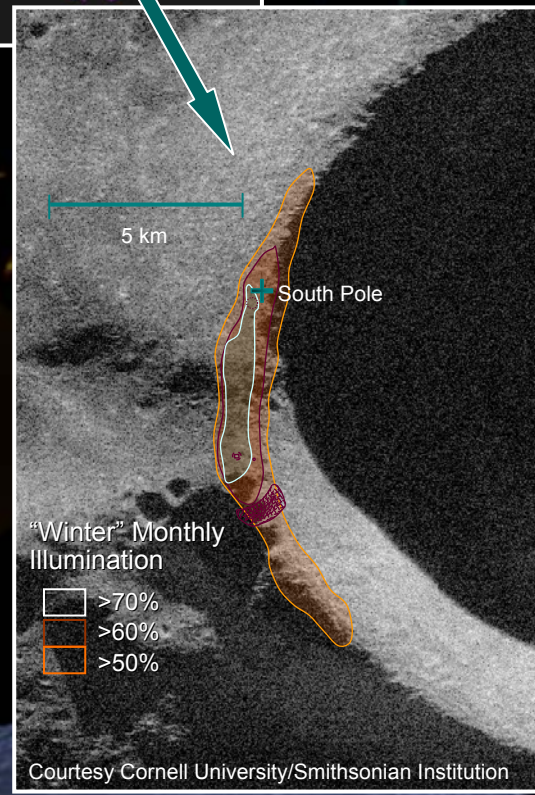
# Lunar Architecture Development Process



# 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



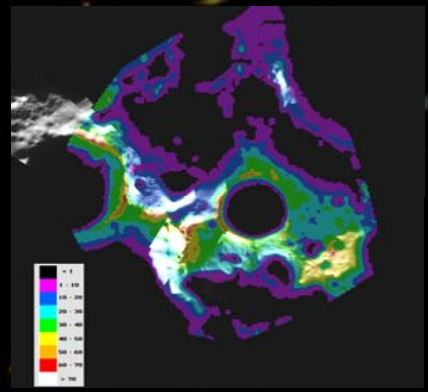




# Outpost Site Location

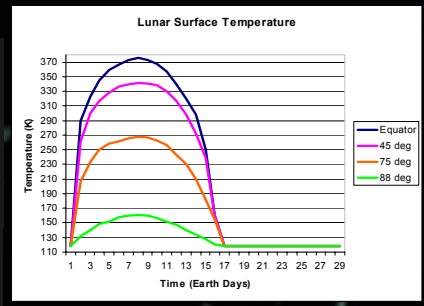
## Outpost Site: Polar

- **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

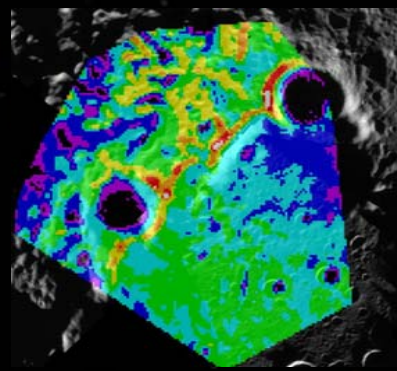
**South Pole**



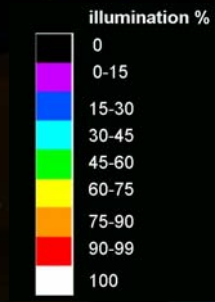
Data obtained during southern winter (maximum darkness)



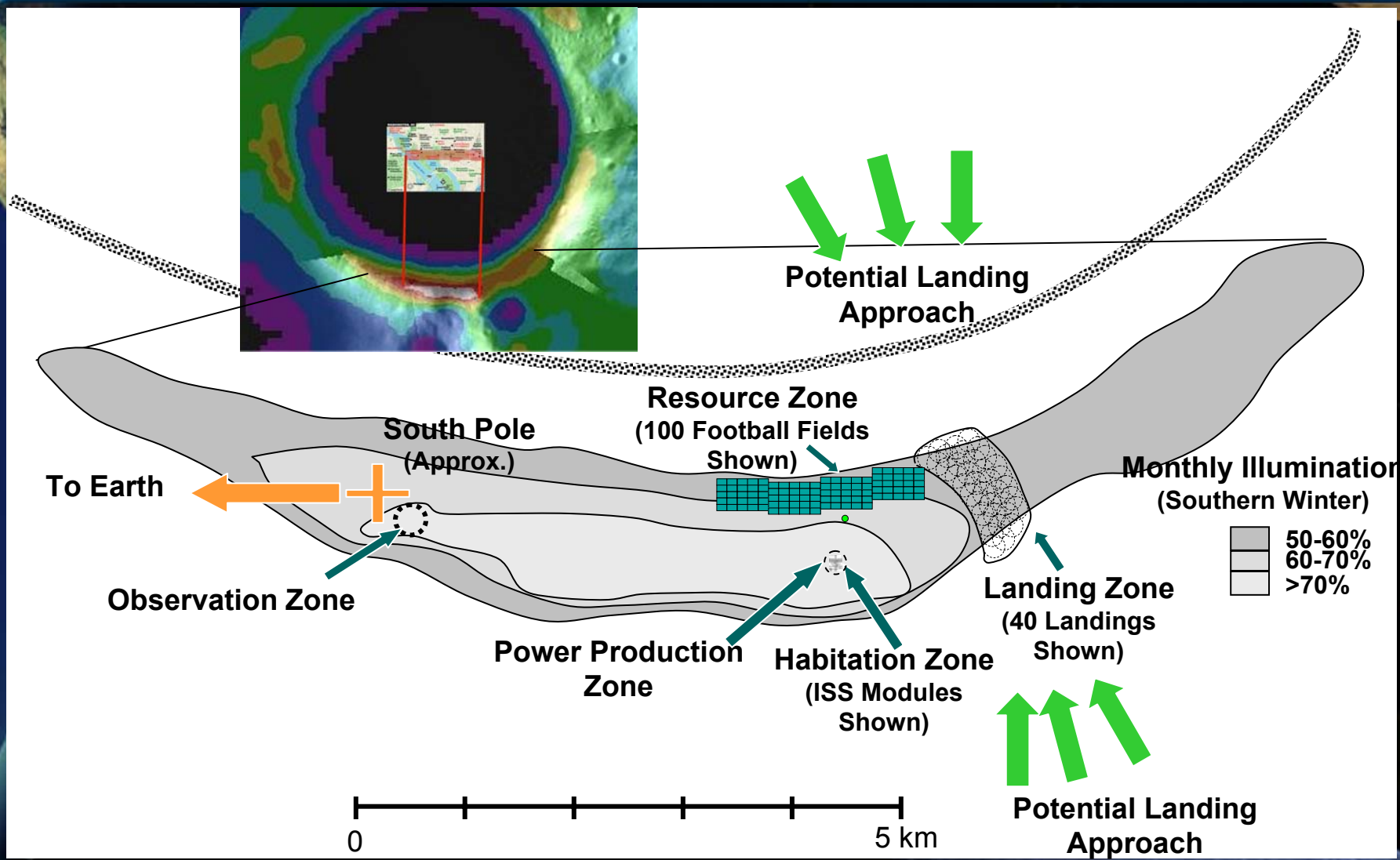

**North Pole**



Data obtained during northern summer (maximum sunlight)

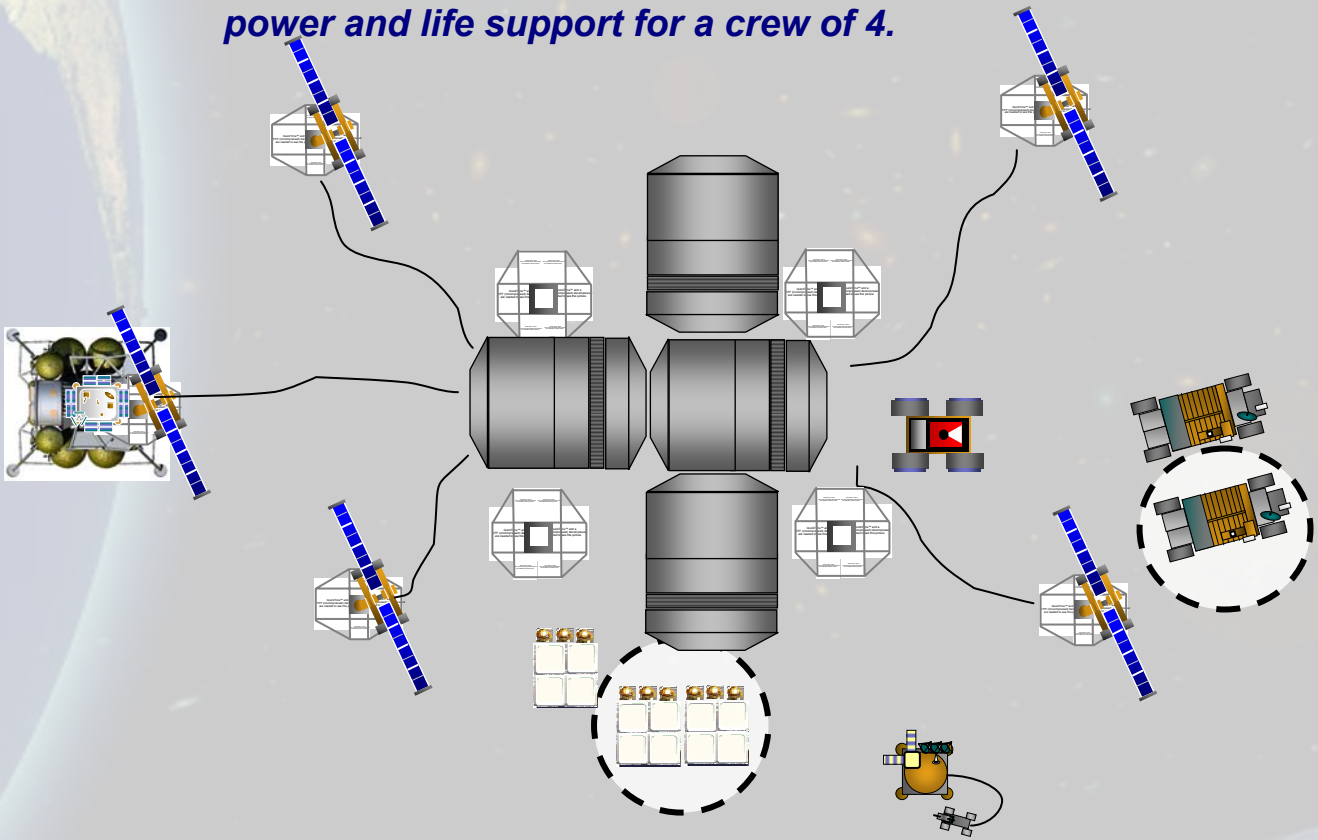


# Shackleton Crater Rim with Notional Activity Zones



# 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)

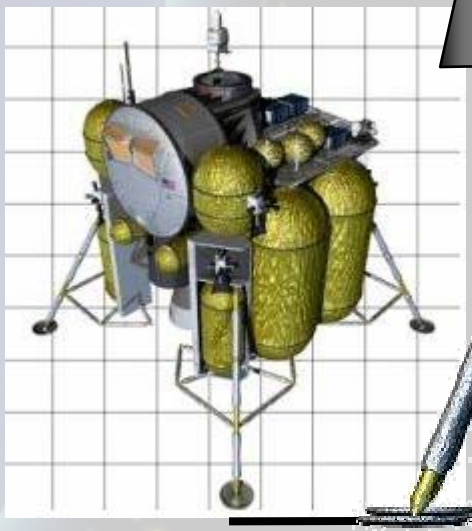


*Point of Departure Only – Not to Scale*

# Key Points: Lander Basic Architecture

Ascent Module (minimized for mass)

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



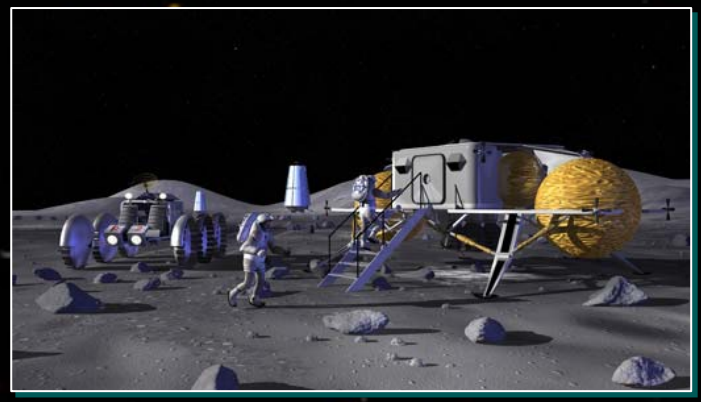


- **Design Goals**
  - Minimize Ascent Module mass
  - Minimize Descent Module mass
  - Maximize landed "payload" mass
  - Simplify interfaces
  - Move functions across interfaces when it makes sense

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)**

**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**

## 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

# 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