

# **The Vision and the Mission**

*What are we doing on the Moon?*

Paul D. Spudis

*Applied Physics Laboratory*

paul.spudis@jhuapl.edu

February 2006

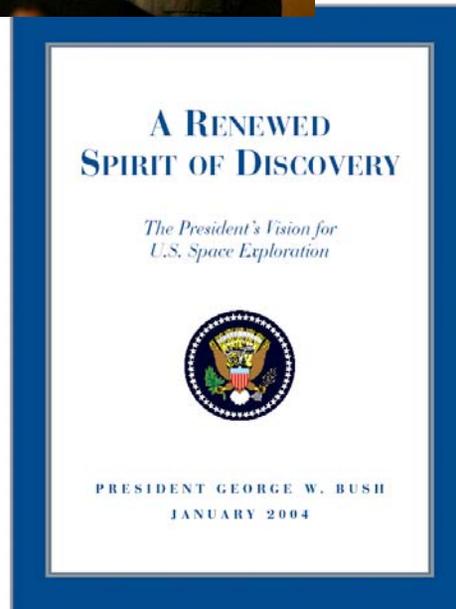
# Outline

- White House sources for Vision for Space Exploration policy
- Analysis of WH statements and intent
- NASA response to WH policy
- Deriving the lunar “mission” from VSE policy statements
- Implications for lunar return architectures
- Backup

# Sources for White House VSE Policy



Presidential speech at  
NASA, January 14,  
2004



*A Renewed Spirit of  
Discovery*, White  
House, January,  
2004

# **The Vision for Space Exploration**

Complete ISS assembly and retire Shuttle

Build new human spacecraft (CEV) for transport  
beyond LEO

Return to the Moon with people and robots to  
explore and prepare for voyages beyond

Human missions to Mars and other destinations

## **President Bush's speech, NASA, Jan. 14, 2004**

Inspired by all that has come before, and guided by clear objectives, today we set a new course for America's space program. We will give NASA a new focus and vision for future exploration. We will build new ships to carry man forward into the universe, to gain a new foothold on the moon, and to prepare for new journeys to worlds beyond our own.

....

America has not developed a new vehicle to advance human exploration in space in nearly a quarter century. It is time for America to take the next steps.

Today I announce a new plan to explore space and extend a human presence across our solar system. We will begin the effort quickly, using existing programs and personnel. We'll make steady progress -- one mission, one voyage, one landing at a time.

# President Bush's speech, NASA, Jan. 14, 2004

Our third goal is to return to the moon by 2020, as the launching point for missions beyond.

Beginning no later than 2008, we will send a series of robotic missions to the lunar surface to research and prepare for future human exploration. Using the Crew Exploration Vehicle, we will undertake extended human missions to the moon as early as 2015, with the goal of living and working there for increasingly extended periods. Eugene Cernan, who is with us today -- the last man to set foot on the lunar surface -- said this as he left: "We leave as we came, and God willing as we shall return, with peace and hope for all mankind." America will make those words come true. (Applause.)

Returning to the moon is an important step for our space program. Establishing an extended human presence on the moon could vastly reduce the costs of further space exploration, making possible ever more ambitious missions. Lifting heavy spacecraft and fuel out of the Earth's gravity is expensive. Spacecraft assembled and provisioned on the moon could escape its far lower gravity using far less energy, and thus, far less cost. Also, the moon is home to abundant resources. Its soil contains raw materials that might be harvested and processed into rocket fuel or breathable air. We can use our time on the moon to develop and test new approaches and technologies and systems that will allow us to function in other, more challenging environments. The moon is a logical step toward further progress and achievement.

## ***A Renewed Spirit of Discovery, White House, January 2004***

The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:

Implement a sustained and affordable human and robotic program to explore the solar system and beyond;

Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and

Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

# ***A Renewed Spirit of Discovery, White House, January 2004***

## **The Moon**

Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system;

Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities; Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020;

Use lunar exploration activities to further science, and to develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration to Mars and other destinations.

# Analysis – VSE Speech

<b>President's speech</b>	<b>Analysis</b>
<p>We will build new ships to carry man forward into the universe, <b>to gain a new foothold on the moon</b>, and to prepare for new journeys to worlds beyond our own.</p>	<p>The new lunar mission will be used to establish a presence off-planet, with the aim of learning the skills we need to voyage farther afield</p>
<p>Beginning no later than 2008, we will send <b>a series of robotic missions</b> to the lunar surface to research and prepare for future human exploration.</p>	<p>The charter for a robotic lunar exploration program, designed to gain new knowledge and to prepare for the human missions and activities to follow</p>
<p>Using the Crew Exploration Vehicle, we will undertake <b>extended human missions</b> to the moon as early as 2015, with <b>the goal of living and working there for increasingly extended periods.</b></p>	<p>Human missions will begin with short stays and evolve into a permanent presence that will allow us to not only survive but live and work productively in space beyond low Earth orbit.</p>

# Analysis – VSE Speech

<b>President's speech</b>	<b>Analysis</b>
Establishing an extended human presence on the moon could <b>vastly reduce the costs of further space exploration</b> , making possible ever more ambitious missions	Introduces the idea that learning to use lunar resources is an important part of the VSE. It also alludes to the concept that our return to the Moon is critical for the creation of new space-faring capability
Also, <b>the moon is home to abundant resources</b> . Its soil contains raw materials that might be harvested and processed into rocket fuel or breathable air.	Implicitly makes harvesting lunar resources part of the lunar mission.
We can use our time on the moon to <b>develop and test new approaches and technologies and systems</b> that will allow us to function in other, more challenging environments.	The Moon as a test bed idea. Use lunar experience to learn how to productively live and work off-planet, including surface systems, operational experience, exploration strategies, and resource utilization

## Analysis – *Renewed Spirit* Document

<b>Document</b>	<b>Analysis</b>
The fundamental goal of this vision is to <b>advance U.S. scientific, security, and economic interests</b> through a robust space exploration program	The three lynchpins of space policy articulated. Of these, all three apply to Moon; only science applies to Mars (see backup 1)
Implement a <b>sustained and affordable</b> human and robotic program to explore the solar system and beyond;	Both descriptors suggest need for milestones and the creation of new capability to make program viable
Extend human presence across the solar system, starting with <b>a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;</b>	Use the Moon to prepare for longer and more challenging voyages later. Note that Mars is only the first of many “other destinations”, not the “ultimate goal” in any sense.
Develop the <b>innovative technologies, knowledge, and infrastructures</b> both to explore and to support decisions about the destinations for human exploration	Moon as a learning laboratory of space flight. The systems we need to go to the Moon will be used to go later to the planets.

## Analysis – *Renewed Spirit* Document

<b>Document</b>	<b>Analysis</b>
Undertake lunar exploration activities to <b>enable sustained human and robotic exploration</b> of Mars and more distant destinations in the solar system;	Lunar activities enable <i>sustained</i> exploration; resource utilization and technical development on the Moon are two of those activities
Starting no later than 2008, initiate <b>a series of robotic missions to the Moon</b> to prepare for and support future human exploration activities	The charter for RLEP. Missions are to both “prepare for and support” future human activities; includes obtaining strategic knowledge and emplacing assets on the Moon.
Conduct <b>the first extended human expedition to the lunar surface as early as 2015</b> , but no later than the year 2020;	First human missions to occur between 2015 and 2020; use of term “extended” means that such missions must exceed Apollo capabilities
Use lunar exploration activities to <b>further science, and to develop and test new approaches</b> , technologies, and systems, <b>including use of lunar and other space resources</b> , to support <b>sustained human space exploration</b> to Mars and other destinations.	The charter for lunar surface activities. Key activities are <i>science</i> and <i>development of new approaches</i> , both with the aim of creating a <i>sustained</i> program. Note that lunar ISRU is specifically highlighted; clearly this is meant to be a key lunar surface activity.

# Synthesis

## **Vision for Space Exploration speech**

Intent is to create both an extended human presence in space and a sustained program.

The Moon plays a key role:

- Our first destination beyond LEO

- Serves as a test bed for development of systems, procedures and techniques

- Use of lunar resources is specifically mentioned

## ***Renewed Spirit of Discovery* document**

Three rationales for U.S. space exploration: science, security, and economy

Goal is a sustained and affordable program

Use the Moon to create new capability; learn how to live and work off-planet

Lead with robotic missions that gather key information *and* emplace assets before the arrival of people

Key activities of human missions to the Moon are *science* and *development of new approaches*, both with the aim of creating a *sustained* program

Learning to use lunar resources is specifically identified as one of these new approaches

## **Moon v. Mars in the VSE**

In speech, Moon is mentioned eleven times; Mars four times  
Specific activities and tasks are identified for lunar surface;  
none for Mars

Dates and program milestones are specifically given for the  
Moon mission, none for Mars

When Mars is mentioned, the VSE is careful to specify “and  
other destinations,” indicating that Mars is not and was  
never intended to be any kind of “ultimate destination”

Goals of space program are defined as science, security, and  
economy; of these, the Moon potentially contributes to all  
three, Mars contributes only to the first (see backup 1)

# NASA and the Vision

Immediately after the VSE was announced, some in NASA attempted to steer the mission away from the Moon by redefining the Vision as a human Mars mission (see backup 2)

This interpretation continues to hold sway among a significant fraction of NASA personnel, despite the clear meaning and intent of the VSE policy documents

Agency continues to battle itself; 1/3 support VSE as articulated, 1/3 anti-Moon (with varying flavors of Mars mania and/or *robots über alles*), and 1/3 apathetic and/or clueless

The continuing confusion and misunderstanding about Vision goals is hindering the agency's ability to execute the Vision and to define a lunar architecture

# Deriving the lunar “mission”

## Common themes from both VSE policy documents:

Sustainable and affordable program

Explore with robots *and* humans

Test bed for systems and procedures on the Moon

Lunar resource utilization

Creation of new space flight capability

### The Mission:

We are going to the Moon to learn the skills we need to live and work productively off-planet

## **Some Corollaries of this Mission**

We're going to the Moon to stay (or at least for an extended period of time)

Learn how to explore planetary surfaces, live on an alien body, and work productively once there.

Learn how to extract what we need (consumables, propellant, power) from local reservoirs of materials and energy

Be flexible and imaginative in the use of people and machines; learn how to use both synergistically (e.g., telepresence explorers)

Commonality of systems, procedures, architectures, and methodologies is highly desirable

# Architectural Implications

Use robotic flights to acquire strategic knowledge *and* emplace assets (RLEP is *not* just for science)

Commonality of hardware, systems, procedures between robotic and human flight elements (e.g., test LSAM components on RLEP)

Locate “high grade” lunar resources and build human habitats nearby (concentrated resources (e.g., polar ice) are easiest to use; focus on them first)

Concentrate infrastructure in a single location to create capability rapidly (Forget sorties: pick the site and build up an outpost)

# Implications for RLEP

Need a program designed to obtain key knowledge early, then build up capability later (reconnaissance followed by infrastructure creation)

Should have as much commonality with human systems as possible (e.g., pinpoint landing algorithms)

Should develop and use systems that can take advantage of lunar resources (e.g., cryogenic propulsion)

Logical sequence of missions (see backup 3):

Orbiters: global mapping, communications relays, navigational system

Landers: Survey outpost sites, environmental characterization, asset emplacement

Rovers: Map sites for civil engineering, resource prospecting, ISRU demos and tests, excavation, infrastructure creation

# Conclusions

Vision for Space Exploration is primarily about creating capability in space; extend human reach beyond LEO

The Moon plays a key role in the VSE

- Explore for scientific purposes

- Learn the techniques and build the systems needed to explore the planets

- Use local resources of material and energy to create a space-faring infrastructure

The VSE is *not* a “manned Mars mission”; ultimate goals are to go everywhere and do everything

Our “mission” on the Moon is to learn how to live and work productively off-planet

RLEP serves a key role in implementing the Vision:

- Early accomplishment and strategic knowledge gathering

- Devise and test systems relevant to human exploration

- Characterize presence and demonstrate extraction of lunar resources

- Poles of the Moon are of extreme interest: permanent sunlight, concentrated volatiles, benign thermal environment, scientific attractions

# Backup

1. The Value of the Moon and Mars
2. The Evolution of a Pernicious Idea
3. Lunar Exploration Strategy – A Strawman

# The Value of the Moon and Mars

- The fundamental goal of the Vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program
- The Moon contributes to all three interests:
  - Scientific: planetary science, observational platform, a natural laboratory for a variety of investigations
  - Security: Situational awareness, cislunar transportation infrastructure and asset protection, protect Earth from impact by monitoring flux of Earth-crossers from telescopes on the Moon
  - Economic: Lunar resources can industrialize cislunar space; propellant and other materials for local consumption and export; energy production and export to earth
- Mars is principally a scientific target
  - Too far to be of significant economic use, except for local consumption
  - Removed from Earth's vicinity, thus irrelevant to security concerns

The evolution of a pernicious idea. My comments (in blue text) after each quotation.

April, 2004

### **President Bush speech at NASA Headquarters, Jan. 14 2004:**

"Using the Crew Exploration Vehicle, we will undertake extended human missions to the moon as early as 2015, with the goal of living and working there for increasingly extended periods."

Speaks for itself.

### **White House – A Renewed Spirit of Discovery Document (Jan. 2004):**

"Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations; "

#### B. Space Exploration Beyond Low Earth Orbit

##### The Moon

- \*Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system;

- \*Starting no later than 2008, initiate a series of robotic missions to the Moon to prepare for and support future human exploration activities;

- \*Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than the year 2020; and

- \*Use lunar exploration activities to further science, and to develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration to Mars and other destinations.

Still there, but subtly different. Now lunar return is linked more directly to Mars support role, although use of resources and lunar science are still prominent.

## **NASA – The Vision of Space Exploration document (Feb. 2004):**

Lunar test beds and missions (p. 7)

“The Moon will provide an operational environment where we can demonstrate human exploration capabilities”

Demonstrate exploration capabilities, NOT “explore”

“The major focus of these lunar activities will be on demonstrating capabilities to conduct sustained research on Mars and increasingly deep and more advanced exploration of our solar system”

Lunar science mentioned after this passage (“additionally...”), but is not major focus. Learning to live on Moon not mentioned at all.

## **NASA – Space Science and the President’s Renewed Spirit of Discovery (OSS brief to Aldridge Commission, Feb. 2004)**

Chart 7 – ORDT Charter and LRO Schedule  
In relation to Lunar Reconnaissance Orbiter:

“Objectives and Requirements Definition Team (ORDT) activity will be guided by the needs associated with future human-based exploration of the Moon as a “proving ground” and “test bed” for eventually sending humans to the surface of Mars and beyond.”

This presentation took the NASA document a step further yet by completely omitting ANY mention of lunar science, resources, or habitation

## **NASA – Integration Team brief (March 2004)**

Chart 8 – “President’s Vision Statement can be articulated into a set of primary Level 0 requirements  
Use the Moon as a test bed for capabilities and systems required to pursue programs of exploration at Mars  
and beyond

OSS’s interpretation of the Vision codified as a NASA working “rule”

Chart 52 – Architecture ground rules and assumptions

- Mars is Discovery driven
- Moon is Mars driven, i.e., feeds forward to Mars

Yet another demotion of the Moon’s importance

## **NASA Red Team brief (March 2004)**

Chart 9 – NASA Exploration Level 0 Requirements

NASA shall conduct extended human lunar expeditions to further science and to develop and test new exploration approaches, technologies, and systems, including the use of lunar and other space resources to enable sustained human exploration of Mars and more distant destinations in the solar system.

Underlined text in passage above was DELETED from Moon Level 0 requirement by Red Team

## **NASA Red Team brief (March 2004)**

### Chart 22 – Findings/Recommendations

Finding: Resources allocated to the lunar component of the program directly affect progress toward Mars

#### Recommendations

Develop absolute minimum robotic and human lunar test bed objectives consistent with Mars exploration activities

Articulate clear exit criteria for lunar ops and ramp up of Mars development

The origin of the “lunar touch-and-go” concept at NASA. The purest distillation of the agency’s Mars mania I’ve ever seen in a single chart.

And so, we arrive at present.....

## **Lunar Exploration Strategy – A Strawman**

P. D. Spudis, Sept. 10, 2004

{Need a mission first; cannot judge whether a flight or widget is relevant to your aims if you don't have any.}

**Mission:** Go to the Moon to learn to live and work productively in space.

### ***Basic principles:***

Small, incremental building blocks

Cumulative – each step builds on previous one

Early accomplishment, early capabilities

Robotic presence first, then people

### ***Principal aims:***

Identify site on Moon to use for first human outpost; do this early (e.g., NOW)

Characterize this site at sufficient level of detail to plan for occupation and utilization

Requirements in priority order:

Safe and relatively easy access

Habitation

Resource utilization

Exploration and science

### ***Some first-order observations:***

No reason **not** to go to the lunar poles: areas of (near) permanent sunlight, benign thermal environment, resources (regardless of whether it's in water or H<sub>2</sub> form), science potential (see whole celestial hemisphere, SPA basin floor at south pole), cold traps for easy cryo-ops

Leave open option to go to both poles at some point (two outposts or a branching architecture)

Water ice is likely, therefore, water production will be an early important goal

Water to support human inhabitants

Crack water to make O<sub>2</sub> and H<sub>2</sub> propellant

Cold traps have a variety of uses (cryo storage, cool astronomical detectors)

Bulk regolith likely to be used early

Build open shelters (pad blast deflectors), pave roads

Cover habs for radiation protection

Needs for outpost: radiation protection, thermal control, solar electric and thermal power, mobility (surface rovers), communications and navigation (flight and surface), instrumentation (scientific and technical), tools and equipment

***Basic strategy:***

Fly robotic missions to collect key data; use data to make key architectural decisions, fly additional robotic missions to get follow-up info (2008-2011)

Emplace robotic infrastructure on Moon (at single site) to build up outpost prior to human arrival (2011-2015)

Make outpost a “turnkey” operation for arriving humans (2015)

Use humans to extend and improve surface operations and ISRU (science and resources) (2015-2020)

***Initial missions – robotic orbiters and landers***

1st mission: (NLT 2008) Lunar Reconnaissance Orbiter or equivalent (ORB)

Improve global geodetic control, map topography and surface properties, map and characterize polar deposits. Conduct cooperative research with other lunar orbiters Chandrayaan-1, SELENE

2<sup>nd</sup> mission: Lunar Outpost Lander (LAND)

Long-lived robotic lander to one of “permanent” sunlit areas (PSA) currently identified near poles. Conduct a precision landing at a pre-determined site. Characterize surface conditions and environment, landing beacon for future landers, comm relay/surface nav system. Demonstrate power generation in PSA

3<sup>rd</sup> mission: Comm/Nav orbital constellation (ORB)

Begin construction of lunar GPS with 2-3 microsats. Carry USO timing reference, comm relay payload. Collect other high priority data as identified in the ORDT (e.g. simple imager for polar light mapping if not already acquired by LRO).

Improve far side gravity knowledge.

4<sup>th</sup> mission: Polar Deposit Mapper (LAND)

Surface rover to examine in situ polar ice for physical, chemical, isotopic properties, characterize environment of polar dark surface, extended traverse (use comm/nav sats GPS for traversing) [Lander stage augments surface landing beacon system]

5<sup>th</sup> mission: ISRU Demo (LAND)

Resource processing experiments, soil moving, excavation, water extraction, waste disposal. Store extracted resources (test long-term cryo storage) to fuel RFC (test RFC technology)

### ***Subsequent robotic missions (examples, in no particular order)***

Long-range surface rover – cargo carrying, demonstrate Earth-based teleoperations on Moon, digging/excavating attachments, soil moving and burial experiments

Advanced ISRU plants – water extraction, cryo plants, solar cell manufacturing experiments, ceramics and brick manufacture, microwave soil products, O<sub>2</sub> generation and storage

Exploration rover – mineral/chem analysis package, sample collection tools, remote sensing package

Expanded and advanced orbital missions – new generation sensors (e.g., low RF sounders, uv-spectrometers, X-ray mappers), replace and extend orbital comm/nav architecture

Astronomical demonstration telescope – small aperture (~ 1 m) IR remote-controlled telescope to demonstrate value of lunar-based astronomy.

Landing pad/ road grader rover – make lunar road and pad infrastructure. Study issues in dust mitigation.

Habitat pre-emplacement – Hab module, emplaced and installed via human-controlled Earth-based teleoperations. Set up hab, cover with regolith, install radiators, solar arrays, electrical power and comm connections

### ***Initial Human Missions (after 2015)***

Need to exceed Apollo total cumulative exploration totals with first mission (political payback)

Suggested strawman: 4 people on surface for one month; with successor missions, increase time first, then people

Activities:

Secure and finalize habitat module emplacement

check out and use pre-emplaced equipment (rovers, loaders, etc)

service ISRU equipment and collect harvested products for use on Moon

Explore vicinity of near outpost

Set up network equipment (ALSEP-like geophysical and astrophysical stations)

Conduct initial geological field explorations of site

### ***Future Manned Missions (post-2020)***

If operations and ISRU make surplus product, export for sale in cislunar space; build additional infrastructure for first outpost or establish second outpost elsewhere on the Moon