Science and the Return to the Moon: 
The Vision for Space Exploration

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What’s the value of exploration?

Humans explore because it conveys an evolutionary advantage
exploration broadens experience and imagination, permitting better prediction of the future, ensuring better odds for survival
curiosity and its satisfaction is intellectually and emotionally satisfying

Exploration improves our ability to solve problems
increased imagination and knowledge base permits recognition of innovative approaches and solutions
helps focus energies on posing the right questions, or, on questions that can be addressed and answered

Exploration excites and inspires the creative, productive segments of society
permits intellectual connections and relations that might not otherwise occur (the ‘ah-ha!’ syndrome)
Frontiers are unknown, mysterious places that stimulate imagination
**Exploration ≠ Science**

*Exploration* is going into the unknown, probing the frontier, looking over the next hill.

- It has structure, but is not directed
- Discoveries sometimes build on each other, sometimes are isolated

*Science* is the process by which we explain nature

- It has a well-defined, directed structure (observation, hypothesis, experiment, verification)
- Scientific knowledge is cumulative and self-correcting

Both are dynamic, not static. Science always follows exploration

*Exploration precedes and enables science*
Exploration and Science

"Exploration without science is tourism" – A NASA official

Exploration is **broader and richer** than science

- Security and asset protection
- Wealth creation
- Settlement and infrastructure development

Exploration **enables** science

- Access to remote locales and exotic environments
- Exploratory infrastructure permits scientific investigation
Why Human Spaceflight?
The rational dimension

People bring unique capabilities to space exploration
  Conduct field science, requiring intense interaction of human with environment
  Repair and maintain complex equipment and installations
Machines do not and will not possess intelligence of necessary magnitude to explore the solar system
  Robots are good for remote, hostile environments to provide first-order reconnaissance
  Robots can be designed to answer focused questions (hypothesis testing) or make precision measurements

But: We don’t always know ahead of time what measurements are significant and which are irrelevant
Why Human Spaceflight?
The emotional dimension

**Inspiration**
- People in space are our surrogates; vicarious exploration
- Cathedral building; scale is too big for one generation
- A human window onto the universe

**Drama**
- Marked upsurge of public interest during crises (e.g., Apollo 13)
- Emotion and curiosity (about past and future)
- A modern gladiatorial contest, without the gore

**Spectacle**
- Invokes our pioneer/frontier origins
- Encourages a communal perspective
- Belief in the future; something bigger than ourselves
Study of Apollo samples taught us key signs of large-body impact. We have since found that large objects collide with Earth on a quasi-regular basis. Not a question of *if*, but *when*. Conclusion: We’re doomed. Solution: Multiple reservoirs of human culture.
Why the Moon?

It’s close
Three days away and easily accessible (as near as GEO)
Transport system to Moon can also access GEO, cislunar, Earth-Sun Lagrangians, and some asteroids

It’s interesting
Moon contains a record of planetary history, evolution and processes unavailable for study on Earth or elsewhere

It’s useful
Retire risk to future planetary missions by re-acquiring experience and testing with lunar missions
Development of lunar resources has potential to be a major advancement in space logistics capability
The Vision for Space Exploration

Conceived in response to loss of Columbia Space Shuttle, Feb. 1 2003

Five steps:
- Return Shuttle to flight
- 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

Proposed by President Bush, endorsed by 109th Congress
VSE is now national policy

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 George W. Bush - January 14, 2004
Founding VSE Policy Documents

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 and a staging area for missions beyond
  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
An Overlooked Key Policy Document

Speech by OSTP Director and President’s Science Advisor John Marburger at Goddard Symposium, March 15, 2006

Critical Points:
- Incorporate Solar System into our economic sphere
- Ultimate goal is *to use* space for benefit of mankind
- Moon is of unique significance -- closest and most accessible source of materials and energy out of Earth’s gravity well
- Development of off-planet resources makes entire Solar System accessible
- Critical architectural consideration: Space exploration budget must grow at low level to be sustainable

http://www.ostp.gov/pdf/jhmgoddardsymp03_15_06release.pdf
The Vision: A Fundamental Premise

Apollo was a politically driven program; we are NOT in a similar situation.

Congress has funded NASA at (more or less) a constant level for the last 30 years (~ 1% of federal budget).

Such spending levels appear to be politically “sustainable”

We must be clever enough to architect a lunar return that fits this budget profile. How?

Small, incremental, cumulative steps

Learn to use what we find in space to create capability

Extend human reach in stages

Free variables: Apollo = funding; VSE = schedule
Deriving the VSE lunar “mission”

Common themes from the 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

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

Arrive
Create transportation system to take humans to and from the Moon
Use this system to access cislunar and translunar space

Survive
Build habitat to safely house human explorers
Protect from environmental hazards
Extract consumables from local materials

Thrive
Create new infrastructure and capabilities by using the material and energy resources of the Moon
Extend this economic zone first to cislunar, then to translunar space
Architectural Implications

Use robotic flights to acquire strategic knowledge and emplace assets
    robotic missions are not just for science

Commonality of hardware, systems, procedures between robotic and human flight elements
    test Altair components on robotic missions

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

Build up infrastructure in a single location to create capability rapidly
    Forget sorties: pick the site and build up an outpost
Science and the Vision

Science is a key part of the Vision

Pure science v. Applied science

Scientific exploration will always be a part of the NASA portfolio

Applied sciences at core of making space “useful”

The Vision makes applied science an important, co-equal part of the space program
Science and the Vision II

If we are successful in using space resources, new scientific opportunities will arise.

Conversely, future scientific opportunities will be limited if we must always bring what we need in space from Earth.
The Vision for Space Exploration

What is the VSE?
A strategic direction
Small, incremental, cumulative steps
Create new space-faring capability
Can humans thrive off-planet?

What isn’t the VSE?
A science entitlement
A rocket-building entitlement
Apollo to Mars
The next “NASA program”
For more information, go to:
http://www.spudislunarresources.com

Spudis Lunar Resources
Using the Moon to learn how to live and work productively in space

What's this web site all about?

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