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THE MOON AND THE NEW PRESIDENTIAL SPACE VISION

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Abstract. The new US Vision for Space Exploration is briefly described, with particular emphasis on the place of lunar exploration. The value of humans in the exploration of the Moon is discussed, and it is argued that people offer significant advantages over robots for the purposes of scientific exploration. The Vision provides a new rationale for space activities, one aimed at both broadening our knowledge base and, in the longer term, of increasing prosperity by providing access to the material and energy resources of the Solar System.

Keywords: Human spaceflight, lunar exploration, Mars exploration, space policy, Vision for Space Exploration

1. The New Space Vision

On 14 January 2004, US President George W. Bush announced a new direction for US space 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.

This new 'Vision for Space Exploration' stems from an interagency review of US space policy following the Columbia accident in February 2003. During this review process every possible option was put on the table, including termination of the space program. The resulting Vision is supported at the highest levels of the US government, with the final decision having been made by the President himself. The goals and objectives of the Vision (White House, 2004) are to:

- Implement a sustained and affordable human and robotic programme to explore the Solar System and beyond;
- Extend a 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 US scientific, security, and economic interests.

In the furtherance of these objectives, the Vision calls for rapid completion of the International Space Station (ISS) in a manner consistent with US international obligations, followed by the retirement of the Space Shuttle by about 2010. It calls for US research on the ISS to focus on supporting exploration goals (with an emphasis on understanding how the space environment affects astronaut health and capabilities), and for the initiation of a programme of robotic and human exploration of the Moon with a human return to the Moon as soon as 2015, but no later than 2020. The Vision further calls for continued robotic exploration of Mars, and other Solar System destinations, both for scientific purposes and in support of human exploration. This will lead eventually to human expeditions to Mars, after first acquiring adequate knowledge about the planet from robotic missions and demonstrating sustained human exploration on the Moon.

As the President stressed, this Vision should be seen as a journey, not a race, and international participation will be welcomed. It envisages cumulative, incremental, steps to build-up space-faring infrastructure that will expand the sphere of human reach out into the Solar System. Robotic precursors will lead the way, and indeed the whole Vision is predicated on human–robotic partnership and synergy. Crucially, the Vision does not assume large increases in NASA's budget, but is instead predicated on the assumption that the present level of NASA, about 0.7% of the federal budget, is politically sustainable.

2. The Presidential Space Commission

In his January 2004 speech, the President established an independent Commission on Implementation of US Space Exploration Policy to review NASA plans and advise on the implementation of the Vision. The Commission was chaired by Edward C. "Pete" Aldridge, and had nine members drawn from government, the private sector, the military, and the scientific community. Its purpose was to identify possible problems with implementation of the Vision, and to suggest alternative approaches. The Commission also addressed scientific, technology, and management issues related to the Vision.

The Commission arrived at the following findings and recommendations (Aldridge et al., 2004):

- The Vision must be managed as a significant national priority, a shared commitment of the President, Congress, and the American people.
- NASA's organizational structure, and relationship with the private sector, will need to be transformed in order to implement the Vision. NASA's role should be limited to areas where only a government agency can perform the proposed activity.
- The successful development of enabling technologies will be critical to the attainment of the Vision, and the Commission recommended the establishment of special project teams to identify and develop such technologies.
- Sustaining the long-term exploration of the Solar System requires a robust space industry. Such a space industry will contribute to economic growth, produce new products through the creation of new knowledge, and lead the world in invention and innovation.
- International talents and technologies will be of significant value in successfully implementing the Vision. The Commission recommends that NASA pursue international partnerships based upon an architecture that would encourage global investment in and support of the Vision.
- Implementation of the Vision will require scientific knowledge, but will also provide new scientific opportunities for the study of the Earth, the Solar System, and the wider Universe. That is, science *enables* new exploration, and is *enabled* by a human presence at new destinations.
- The Vision offers an extraordinary opportunity to stimulate mathematics, science and engineering excellence for students and teachers, and to engage the public in a journey that will shape the course of human destiny.

3. Back to the Moon

As outlined in previous publications (e.g. Spudis, 1996, 2001), the Moon is a natural laboratory for many aspects of planetary science, especially for the unique record it preserves of early Solar System history. Moreover, the Moon may also act as an astronomical platform from which to observe the Universe, and as a potential source of materials and energy for human civilization. In the wider context of the future of space exploration, the Moon is a place where human beings can learn to live and work in space.

The architecture for a human return to the Moon begins with robotic missions to reconnoiter potential landing sites, locate sources of raw materials for later use and, later, emplace infrastructure. In parallel, a new human-rated Crew Exploration Vehicle (CEV) must be developed, ideally as a modular spacecraft that could support both lunar and cislunar space activities. Initially a single landing site will be identified, probably at a polar location to exploit probable deposits of water and other volatiles. An early priority will be to use lunar materials so that human crews can "live-off the land." Confirming the existence of lunar polar ice deposits will be crucial in this respect, as such deposits can be processed to make hydrogen and oxygen for use on the Moon itself, and for distribution throughout cislunar space. Propellant produced on the Moon would make travel within and through cislunar space routine and thus completely change the spaceflight paradigm. As all commercial and strategic assets are located in cislunar space, such routine access to this region has important economic and strategic implications.

Initial evidence for ice in permanently shadowed lunar craters was provided by the Clementine bistatic radar experiment (Nozette et al., 1996). This was greatly strengthened by the discovery by the *Lunar Prospector* neutron spectrometer of enhanced concentrations of hydrogen at the poles, also correlated with shadowed areas (Feldman et al., 1998). In order to confirm these observations, and obtain a full inventory of lunar polar volatiles, we need to more accurately locate the permanently shadowed areas by high-resolution orbital imaging, measure and map the temperatures in these regions, map the polar ice using imaging radar, and study the hydrogen concentrations at higher spatial resolution. These observations must then be followed by *in situ* measurements of the structure, chemical composition, and geotechnical properties of the ice-bearing regolith.

4. What Humans Bring to Space Exploration

Machines are good at operating in extreme environments, and of dispassionately recording large quantities of data. However, they are not able to think, learn from their mistakes, repair themselves, build upon discoveries in order to re-direct exploration plans, or collect information that they were not specifically designed to obtain in advance. In contrast, humans bring curiosity, adaptability, expert knowledge, and an ability improvise to an exploration program. This is especially true for field sciences, such as geology and biology, which require an expert knowledge base to determine the validity and relevance of an observation. Fieldwork is predominantly a *mental* activity and physical requirements are subordinate (see also the contribution by C. Cockell elsewhere in this volume). A human presence is also often useful for the emplacement and maintenance of advanced scientific instruments, which often requires interactive problem solving skills (Spudis, 2001).

Thus, while robots are valuable explorers to collect data and characterize planetary surfaces, people are needed to do the detailed field work that results in real understanding, and to fix balky equipment with innovative approaches. Telepresence is a promising technology for some applications, but largely unproven and the time-delay factor will always mean that human operators will need to be located nearby. In short, both machines and people will be needed to explore and use the Moon.

5. Conclusion

The Vision for Space Exploration provides a new rationale for space activities. This rationale is based on the need to explore space in order to broaden our knowledge and imagination base. In the longer term, it also holds for the promise increasing human prosperity and security by providing access to the essentially unlimited supplies energy and materials of the Solar System.

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6. Discussion

Mr. Bernhard Hufenbach (ESA): Will early missions to the Moon rely on space resources, and what are the implications for the development of a heavy lift capability?

Dr. Spudis: It is likely that early missions will not use local resources, but will carry out tasks to evaluate their existence, concentrations, accessibility, and utility. We need to understand where resources are available and how to process and use them. Our goals are to answer the question: Can we live off-planet? Ultimately, the use of space resources will lower costs and provide more access to cislunar space.

We will probably develop a heavy-lift capability at some point, but that is an architectural decision that needs to be evaluated on the basis of delivered mass needs and program phasing.

Mr. Tony Bird: On the issue of human versus robotic exploration, and passing over the fact that they do different things in different ways, what is the cost differential? How much more expensive is human exploration, and how has this differential been moving over time?

Dr. Spudis: Obviously, human missions require much more mass in space than do robotic missions, if only because of the need to carry systems and consumables designed to support human life, and are thus significantly more expensive. There is no single number that can characterize a "cost differential" because cost numbers reflect not only mass delivered but also how one implements a given mission. It is possible to fly relatively inexpensive human missions, depending on what levels of risk and crew comfort one is willing to accept. The real goal of the Vision is to make flight by both robots and humans routine. By developing and using the local resources of space, we will be able to lower the costs of both human and advanced robotic exploration.

Dr. John Dudeney (British Antarctic Survey): It will be vital to have an internationally agreed legal framework to govern human exploration and stewardship of the Moon. Is there yet any international action to develop the existing Moon Treaty to provide such a framework?

Dr. Spudis: There is no current effort that I am aware of to define the legal framework of lunar development. However, many people are seriously thinking about these issues. The current treaty regime under which the United States explores space is the 1967 United Nations Treaty on the Peaceful Uses of Outer Space. That legal regime does not permit claims of national sovereignty of extraterrestrial bodies, but says nothing about either public or private development of space resources. It certainly does not prohibit such development. Unless we can undertake such activities and learn how to live off-planet, humanity is likely to be confined to Earth's surface for a very long time to come.

Mr. Nigel Calder: Are the scenarios of 30 years ago for creating habitations for ordinary people in space, such as those envisaged by Gerald K. O'Neill, any part of the long-term picture here?

Dr. Spudis: Not specifically. However, learning and practicing the types of skills needed to colonize space are clearly part of the Vision. Anytime you send humans on long journeys beyond low Earth orbit, and use the local materials and energy resources to create capability and support the missions, you are acquiring valuable knowledge essential to implementing O'Neill's vision of space colonies.

Professor Steve Miller (UCL): In your discussion of how humans will fare on the Moon or – later on Mars, you gave the impression of "living off the land" and of "exploiting the resources". This issue comes increasingly to the fore if we are talking about establishing permanent or semi-permanent bases. There seems to be an implication in what you say that we have some kind of a right to do that on other moons/planets which may extend to a notion of territorial rights, or even some form of ownership. Do you think that the notion of resource-exploitation extends in the way I have suggested, and we – Earth-dwellers – do have "rights" on other planets? And, given that for the time being at least different nations or groups of nations have their own space exploration programs, are we going to need some form of international conventions and/or treaties governing the exploitation of resources on other moons and planets? If so, a suggestion might be that the sort of treaties governing Antarctica might serve as a model?

Dr. Spudis: There are many different models of international cooperation and agreement that we can look to for guidance on these issues. I wouldn't limit it to the Antarctic model, although I will note that use of resources does not imply ownership – McMurdo Base creates drinking and bathing water for the local population of scientists and technicians from the local ice, but that does not imply that the United States "owns" Antarctica, nor should it. Clearly, some legal regime for space resource utilization will emerge that will be acceptable to everyone. There may be disagreement and controversy before we get there, but what field of human endeavor doesn't have this?