49. SPACE POLICY AND THE CONSTITUTION #6

Harrison H. Schmitt
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America's Deep Space Vision: Settlement of the Moon and Mars versus Asteroid Visits

America's eroding geopolitical stature, highlighted by the July 21, 2011, end to flights of the United States Space Shuttle, has reached crisis proportions. Obama Administration officials now spin the nebulous thought of Astronauts flying many months to an undetermined asteroid in 2025 as an actual "National Space Policy". On the other hand, Republican candidates for President have not yet recognized the importance of international civil space competition in the federal government's constitutional function to provide for the nation's "common defence". Candidates appear to be uninterested in having the United States lead deep space exploration, including the establishment of American settlements on the Moon; or may actually consider Obama's unfocused proposals as being credible rather than realizing that those proposals would transfer geopolitical dominance to China and control of American space transport to Russia.

Although the Bush Administration and Congress did not follow through with adequate funding, at least the 2004 *Vision for Space Exploration* put forth by President Bush and approved by Congress was a legitimate formulation of a National Space Policy. It implicitly recognized that America's best security interests would not be served by being dependent on Russia for access to space or by ceding to China both deep space exploration and access to space resources. Unfortunately, with the acquiescence of Congress in 2010, President Obama cancelled what had become known as NASA's *Constellation Program* – a program designed to maintain and expand America's hard-won position as the world's leading space-faring nation. Meanwhile, China is building a major new deep space launch facility in Hainan and developing new rockets and spacecraft to take over the exploration of the Moon from the United States and the free world.

A properly funded *Constellation Program*, would have returned Americans and their partners to the Moon, begun creation of the infrastructure and operational capabilities to settle there and go to Mars and beyond, and provided a timely replacement for the aging Space Shuttle. Assuming that the Obama Administration actually requests authorization and budget authority to implement a human mission to a near-Earth asteroid (NEO), including the required heavy lift rockets, specialized spacecraft, operational infrastructure, and hiring authority, how would such a mission stack up relative to returning to the Moon?

Mars Mission Preparation

Heavy Lift Launch Vehicles & Operational Experience. Both repeated trips to the Moon and an occasional asteroid mission

require an Apollo Saturn V-class, heavy lift rocket to escape the Earth's gravity-well. Lunar exploration and an eventual commercially supported lunar settlement, however, would give a much greater, long-term return on investment of the same taxpayer dollars. Operational experience and multi-generational training gained at a Moon base or settlement is far more relevant to exploration and bases on the gravitationally similar Martian surface (3/8 gravity versus 1/6 gravity) than a mere "rendezvous and docking" with a near zero gravity asteroid.

Physiological Countermeasures. Understanding of the physiological countermeasures to space radiation exposure necessary for travel to Mars can be gained on the Moon sooner and at much lower risk with the added benefit of the future production of lunar water for radiation shielding. Of particular importance is determining whether the Moon's one-sixth Earth's gravity triggers physiological re-adaptation after astronauts experience the adverse effects of prolonged exposure to zero gravity during travel to Mars. This ***cannot*** be determined on a near zero-gravity asteroid. (The complexity and cost of physiological countermeasures on a Mars mission is critically dependent on knowing if this re-adaptation occurs in one-sixth gravity or not.)

Operational Approaches. Operational approaches for Mars landing and exploration, such as communications delays and lander concepts, can be evaluated and simulated realistically during lunar operations but not during an asteroid mission. Similarly, layered engineering defenses related to planetary biological protection and dust mitigation on Mars can be fully tested at a lunar base or settlement but not during a short visit to an asteroid. In addition, Mars atmospheric entry and descent vehicles and proceprocedures can be tested in the low-density upper atmosphere of Earth more logically as an adjunct to a lunar exploration and settlement program than as part of a single purpose mission to an asteroid. Entry, descent and landing by large spacecraft through the thin but operationally significant Martian atmosphere are challenges for which there currently are no known engineering solutions.

Commercialization of He-3 and other Lunar Volatiles. Commercial access to the fusion energy resource of the Moon, Helium-3, also opens the potential of interplanetary fusion rockets that would allow continuous acceleration and deceleration between Earth and Mars, thus lowering travel risk to humans exploring deep space. Further, the Helium-3 production by-products of hydrogen, oxygen, and water can significantly lower the cost and risk of deep space travel and space station re-supply. A one-time visit to an asteroid provides no technically or commercially viable alternatives in this arena.

Reduction of Risk for Mars Missions. Programmatically, the transition from a lunar exploration and commercially supported settlement initiative to one focused on Mars landing and exploration would be more straightforward than a one-shot asteroid visit. Lunar exploration overall imposes much lower risk to explorers and mission success than a brief visit to an asteroid and is far more applicable to the reduction of the risks of Mars transit and exploration.

Science

Solar System History. Far more new science related to the early history of the Earth and other planets can be gained through renewed lunar exploration, sampling and analysis than similar activities related to an asteroid. Most asteroid science has been and can be gained from meteorites

and multi-spectral imaging by the Hubble and future Webb telescopes. Robotic missions to asteroids, like the Dawn spacecraft now at Vesta, can answer most remaining questions about asteroids, particularly if sample returns are implemented in the future. Finally, the history and evolution of the Sun can be investigated extensively by studies of the long-term variations in solar wind composition and effects recorded in over-lapping layers in the lunar regolith (impact-generated rock debris). Such studies would not be productive on an accessible asteroid.

Astrophysical, Earth and Solar Observatories. A far-side lunar observatory shielded from both solar and terrestrial radio noise would be a boon to observational astronomy; however, no synoptic observational science of other parts of the universe, particularly in radio frequencies, can be conducted in a practical way from an asteroid. Also, a multi-spectral polar Earth observatory at a lunar pole, with simultaneous solar observation, would establish long-term, continuous, full sphere monitoring of weather and climate as well as providing a coherent means of synthesizing more detailed but much less synoptic data gathered from near-Earth satellites. Asteroids, of course, provide no such climate, weather and atmospheric physics-related opportunities.

Resources and Commercial Opportunities

Commercialization of He-3 and other Lunar Volatiles. Terrestrially valuable energy resources, that is, Helium-3 fusion fuel and solar energy, exist on the Moon a short distance from the Earth, but are not a practical option for shipment or transmission from an occasional passing asteroid. In this regard, much is known about the commercial parameters of potential lunar resources; however, little is known about the concentrations, physical and chemical form, or ease of access of potential resources on NEO asteroids. Also, gravity can assist in resource extraction and processing on the Moon but not on a near zero gravity NEO asteroid. Due to communication delays, possible resource mining and processing on an asteroid must be autonomous for relatively short intervals with only periodic human command input. This is unlike resource mining and processing on the Moon where it can be continuous either by human crews or by telerobotic operation from Earth.

Economics of Lunar vs. Asteroidal Resources. Unlike the available analyses for the energy resources of the Moon, the required financial envelope for potential commercialization of asteroid resources is completely undefined with major questions as to technical practicality. Once Americans permanently established themselves on the Moon, available lunar resources include readily accessible and relatively low cost consumables necessary for operations in space, including water, hydrogen, oxygen, helium, carbon and nitrogen compounds, and food products. Various solid elements and oxides also could support manufacturing of products for use at a lunar settlement or elsewhere in space.

***Tourism*.** Lunar tourism will eventually become a viable commercial opportunity once launch and support costs are compatible with the heavy lift launch costs required by commercial energy production (about $3000 per 220 pounds); whereas, asteroid tourism, as well as asteroid mining, will remain the stuff of science fiction for the foreseeable future.

Launch Opportunities and Mission Operations

Frequency of Access. For hypothetically possible missions to near-Earth asteroids

(NEOs) that cross the orbit of the Earth, very few asteroid rendezvous opportunities exist over time versus essentially continuous opportunities for the Moon. Time for human asteroid exploration will be short because of increasing energy requirement to return as the asteroid moves away from Earth. On the other hand, stay-times on the Moon have no such constraint.

"Rendezvous and Docking" at an NEO. Because of the near zero gravity of an asteroid, an asteroid mission is a "rendezvous and docking" mission requiring very difficult operational procedures in order for astronauts to explore and sample the materials found there. Asteroids in orbit between Mars and Jupiter, such as Vesta currently being imaged by Dawn, require prohibitively long flight times for human visits until new, much more rapid propulsion technology exists.

Education

Stimulation of Learning and Ambition. An asteroid mission would provide flight opportunities to only a few astronauts and thus limit the interest of children and young people in preparing for careers related to space and technology. In contrast, an indefinite commitment to lunar exploration and commercially supported settlement offers a permanent set of career opportunities as a stimulus to STEM education and economic innovation throughout the country. Importantly, the Moon is a destination children and young people can see with their own eyes in the nighttime sky. That sight would become even more inspiring with the knowledge that men, women and families are living and working on the Moon as those youngsters look up to the sky…and to their futures… while other children look up to see Earth.

Leadership and National Security

Lunar exploration and settlement as a precursor to missions to Mars and beyond would be far more productive and practical than a onetime mission to an asteroid. A return to the Moon also constitutes much less risky national policy in the still risky business of deep space exploration.

All public indications are that our Cold War II adversary, China, includes space in its vision of geopolitical dominance as well as in its plans for technological, educational and energy resource advancement. China's announced long-term space policy is focused on the Moon. The United States stands as the only viable bulwark of freedom on the planet. If the Federal Government ignores this challenge, as well as the commercial energy resources of the Moon and its role as an essential steppingstone to Mars, its constitutional duty to provide for the security of America will be fatally compromised. An asteroid mission constitutes an unacceptable diversion in our broader responsibility to future generations.

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***Harrison H. Schmitt is a former United States Senator from New Mexico as well as a geologist and Apollo Astronaut. He currently is an aerospace and private enterprise consultant, a member of the new Committee of Correspondence, and author of* "Return to the Moon".**