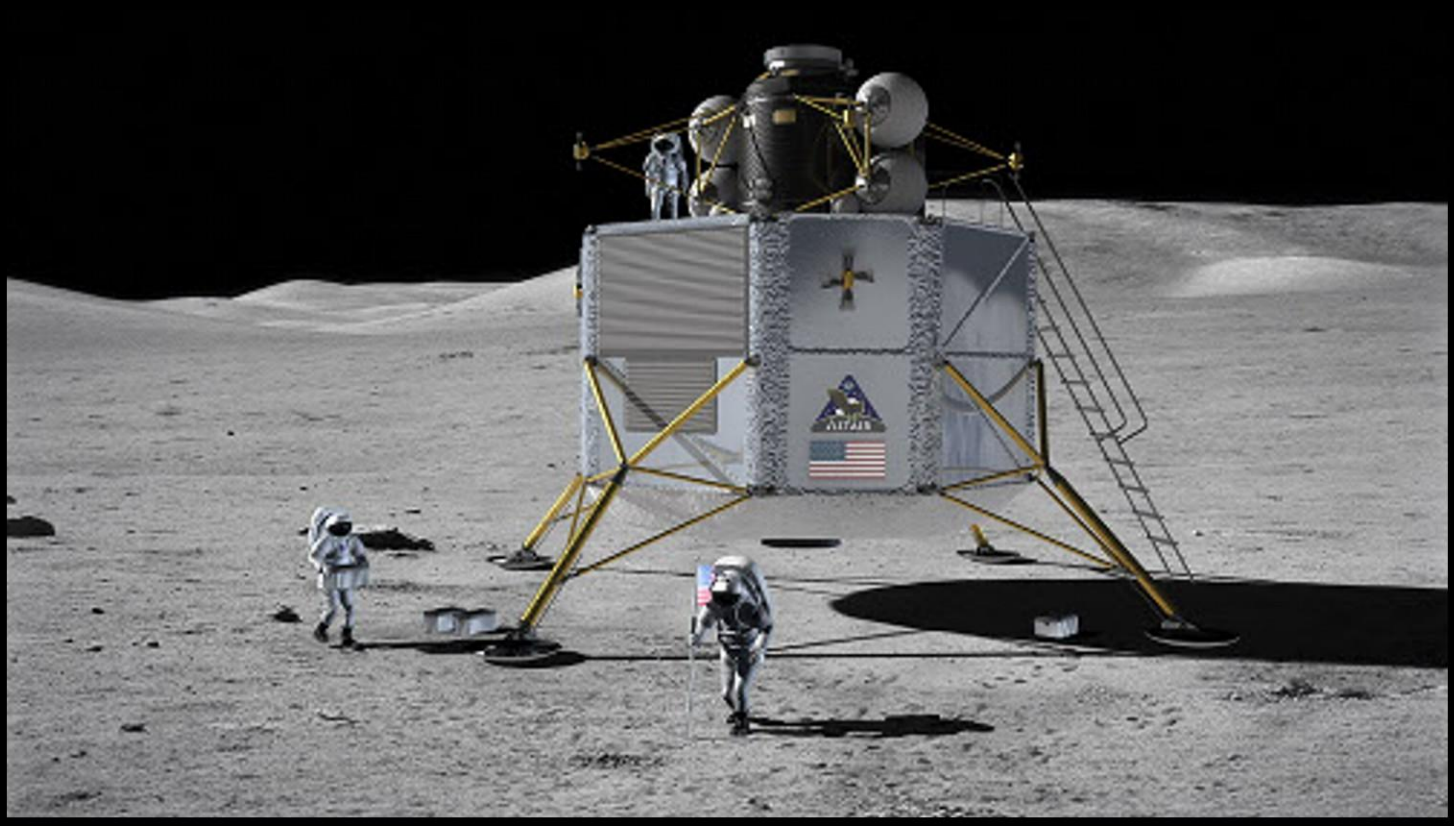
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Subcommittee on Space

"NASA: Past, Present, and Future"

February 16, 2017



Artist's Impression of the Altair Lunar Lander in the Valley of Taurus-Littrow

Panel Member Questions and Answers
by

Honorable Harrison H. Schmitt, Ph.D.
Apollo 17 Lunar Module Pilot,
U.S. Senator

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Questions submitted by **Chairman Lamar Smith**, House Committee on Science, Space, and Technology

1. NASA, in cooperation with Congress, has been able to enhance programmatic continuity by shifting development to focus strongly on capabilities (rather than destinations), particularly in the continued support for the Space Launch System and Orion. Would you recommend further Congressional support for the development of additional systems that would expand or enhance core capabilities? If so, are there particular systems or space-based infra-structure that Congress and NASA may want to prioritize in coming years?

Mr. Chairman, in spite of the Constellation Program being cancelled by the previous President, the Congress and a few leaders in NASA have been able initiate the development of capabilities that allow the United States to choose the Moon and Mars as destinations for a new generation of Americans. I would recommend that choice be made as soon as possible with specific milestones to be accomplished. This choice is as much a geopolitical one as it is for any of many other worthwhile aims. Having said that, I would recommend Congressional support for the development of lunar and planetary landing capabilities and long duration roving systems, building on the work done in Constellation, and for the development of a multinational (not under the UN) claims regime for the Moon that would encourage investors to join with the government in returning to that destination in support of ultimately sending Americans to Mars. (I outline what such a claims regime might look like in Chapter 12 of my book, ***Return to the Moon***, Springer, 2006.)

2. In your opinion, is there room for more cooperation between NASA and other government agencies, such as the Department of Energy? What are some areas you would prioritize for further cooperation?

As was discussed at the hearing, NASA needs to focus on the future of Americans in deep space— its current activities and expertise that support the work of other agencies should be considered for transfer to those agencies as well as spinning off the strategically critical work in aeronautics into a separate, well funded NACA-like agency.

As one of the future economic values of lunar resources is fuel for environmentally benign helium-3 fusion power (nuclear power without nuclear waste), cooperation between NASA and DOE to encourage private sector development of related fusion technology would do a lot to bring private investment into a return to the Moon effort. This cooperative R&D effort in fusion power also is justified on national security grounds as well as feeding into the need for an interplanetary booster to go to Mars.

Unfortunately, my impression for some 20 years or more has been NASA has never believed that DOE was serious about developing fusion power alternatives to deuterium-tritium fusion and DOE never believed that NASA was serious about going back to the Moon. Someone needs to bring them together along with private investors.

3. In the hearing, other witnesses suggested discussing potential lunar efforts as development, enabling, and staging efforts for subsequent missions to Mars and elsewhere in the solar system. Do you think such a framing helps mitigate the persistent difficulties NASA encounters from frequent changes in direction and demands that it keep too many options open?

I do agree that such a framing would help, particularly, if accompanied by specific milestones, adequate management reserves of funding, and the creation of the management system I recommended in my prepared testimony.

4. Based on your experience as a geologist, as an astronaut, and your work on He3, are there other opportunities to make a presence on the Moon a commercially or economically viable?

Once a viable settlement exists on the Moon, with long-term economic stability based on supplying Earth with helium-3 fusion fuel, then the by-products of helium-3 production and settlement operations (H_2O, O, H, He, N, C, and food) will have economic value to other space activities. Also, the existence of a settlement can be marketed internationally to support lunar research stations and exploration. With the attainment of the low launch costs required for the economic viability of helium-3 production (less than $3000/kg[1]), even lunar tourism may become economically viable for some. Of course, once a decision is made to return to the Moon, private capital and management might contribute resources to the creation and implementation of resource production.

[1] Schmitt, H. H., 2006, ***Return to the Moon***, Springer.

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Questions submitted by **Ranking Member Eddie Bernice Johnson**, House Committee on Science, Space, and Technology

1. In your written statement, you suggest that the next major goal for NASA's human exploration program should be returning humans to the surface of the Moon in preparation for the eventual human exploration of Mars. What, in your view, does NASA need to learn from lunar surface activities in preparation for a human mission to Mars that it can't learn in cis-lunar space?

Congresswoman Johnson, I would suggest that renewed deep space exploration and a path to Mars that includes a permanent settlement on the Moon is more than the next major goal for NASA but is one of the next major goals for America. The Moon's role in achieving that goal and providing future generations with a permanent role in deep space is multifaceted. Its resources will be invaluable to both deep space activities and the Earth. Operational experience will prepare future generations of skilled workers, engineers, scientists and managers for the challenges and risks of and indefinite future of deep space flight. Simulations of Mars landings and surface activities on the Moon will feed into future plans for Mars in the face of both the challenges of the thin Martian atmosphere, partial gravity, sampling challenges, and the lack of real-time communications with the Earth. A permanent, self-sustaining lunar settlement also would begin humankind's quest to no longer be a single planet species.

2. How would you ensure that the Moon does not become a costly and time-consuming detour rather than a stepping stone toward sending humans to Mars?

The Congress should require that a return to the Moon be fully integrated in its engineering, scientific, operations and objectives with the long-term goal of Americans reaching and exploring the surface of Mars.

3. Are you proposing that NASA abandon efforts to develop the capabilities needed to send humans to Mars and redirect them towards human exploration of the Moon? Or are you suggesting that NASA's budget be in-creased to support both human exploration of the Moon and Mars?

Human activities on both the Moon and Mars should be the focus of NASA, including robotic lunar and planetary exploration and physiological research on the International Space Station. If NASA is relieved of its many other unrelated responsibilities, its budget may not need to

be increased; however, the annual funding and management reserves required to reach reasonable lunar and Martian program milestones would need to be studied very carefully. If a major deep space program is authorized and appropriated for NASA, then Congress should consider multi-year funding with, of course, close oversight on the progress and efficiency of the program. Once a decision is made to return to the Moon, private capital might contribute resources to the creation of lunar resource production capabilities.

4. If NASA's budget could not be increased to such levels, are you suggesting that resources be provided by moving funding from other NASA programs?

Depending on well-considered costing of the deep space effort, including appropriate management reserves, those unrelated budget resources could be used; however, I also would transfer those programs and expertise, whose national importance warranted it, to other agencies with similar or the same responsibilities, e.g., astronomy to the National Science Foundation (NSF), Earth-sensing to NOAA and the Department of the Interior, and aeronautics to a re-created National Advisory Committee on Aeronautics (NACA). As suggested in my prepared testimony, the Congress also might consider the creation of a National Space Exploration Administration to focus only on the management of deep space exploration with NASA continuing to manage its other activities including our international responsibilities relative to the International Space Station.

5. In your written and oral testimonies, you spoke of the need to maintain an average age workforce of less than 30 years. Do you see a place at NASA for those who have gained the knowledge of human spaceflight over years, if not decades, including both the successes and the tragedies?

There is no question that middle and senior management personnel would provide the relevant knowledge of the past as they would be drawn from those previously younger personnel who have demonstrated the judgment and breadth of experience required to be managers. The agency's core of skilled workers, engineers and scientists, however, should always remain young.

6. NASA scientists recently narrowed down their list of potential landing sites for the Mars 2020 rover to three candidates. As you know, that mission will extract and cache samples of Martian rock and soil for a future mission to collect and return to Earth where they can be further studied. As a field geologist, can you explain the benefits of having humans on Mars to identify and collect science samples?

Humans who are broadly experienced and knowledgeable in their professional fields, no matter what those fields may be, bring that experience and knowledge to bear up on exposure to new domains relevant to their fields. Test pilots are critical to evaluating new aircraft. Surgeons are critical to evaluating new surgical challenges. And so forth. In a similar vein, experienced field geologists evaluate new observations of nature's lunar and planetary handiwork. The instantaneous reprogramming of the experienced human brain when faced with new information is the critical ingredient in all such situations.

There is no question that a robotically collected cache of Martian samples would be scientifically valuable; however, even

more valuable would be a cache of samples collected and documented verbally and photographically by an experienced individual within the three dimensional context of the sample locale being investigated.

7. What challenges do humans bring to the search for extant or past life on Mars?

There is a significant possibility the life began and evolved to a limited extent in the clay, water and organic-rich environment that existed on Mars early in its history, as obviously was the case on Earth. There is little possibility, however, that extant, carbon-based life still is present in the extraordinarily hostile surface environment of Mars today. This surface environment on Mars is nearly as hostile to life as is the Moon's.

On the other hand, simple life forms may have maintained themselves at a geologically stable horizon at depth, where water below and ice above are in stable contact. The depth of that horizon varies with latitude. Until a core through that horizon is studied, it will not be know if life is present. Obtaining that core without exposing humans to possible risks or contaminating the core will require sophisticated equipment and operations. It may well turn out, as we have learned from lunar experiences, that humans, with the facility of instantaneous judgment, can obtain such a core better rather than robots, although *in situ* use of telerobotics may be involved in either circumstance. I am not aware that a definitive study of these coring and analysis activities has been carried out, as it certainly should be prior to an attempt to core to the water-ice horizon.

The search for fossils of extinct life forms will follow traditional field geological practices, including high-resolution visual and chemical studies of samples.

8. What if anything needs to be done now to ensure that NASA's Mars planning takes scientific goals such as sample collection into account?

The definitive study of how to core to the water and ice horizon, discussed above, and to definitively analyze for extant life, needs to be done. It might be wise to have this done by two or three independent engineering and scientific teams.

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Question submitted by **Representative Jim Bridenstine**, House Committee on Science, Space, and Technology

1. With the currently planned low launch cadence we should maximize the utility of each SLS launch. Do you think NASA should also look at sending some sort of robotic lander, particularly one of the several that are being developed by commercial entities, on EM-1?

Congressman Bridenstine, that is an interesting thought. It might be worth NASA issuing a Request for Information (RFI) to the private entities currently working on robotic concepts. This RFI probably should include some broad engineering constraints relevant to Orion and SLS.

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Question submitted by **Representative Charlie Crist**, House Committee on Science, Space, and Technology

1. As a Floridian and former Governor, I understand just how integral the space industry is to the state's culture and economy. As you know, Florida was hit extremely hard by the end of the Shuttle program. We're recovering, but more can surely be done. You mentioned the importance of having a young work-force to help energize deep space exploration. What are your suggestions for attracting a younger workforce to the space industry— and to Florida in particular?

In this regard, Congressman Crist, it is absolutely essential that basic K-12 education emphasize mathematics and critical thinking along with reading, writing, history and basic science. At the same time, vocational training in the skills required for modern manufacturing should be expanded. Far too much K-12 "education" is not relevant to the future needs of the nation, much less the student. The "Sputnik Generation" that accomplished the Apollo Program did not just appear— they were products of a far better K-12 public education system relative to those times than exists today in far more complex times.

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Questions submitted by **Representative Jim Banks**, House Committee on Science, Space, and Technology

1. From my perspective as a veteran and member of the Armed Services Committee— secure, assured access to space should be a priority as we confront growing challenges around the globe. So, while we often hear that civil space activities are important to our national security, how exactly do you think NASA makes our country safer?

Congressman Banks, I believe that a competitive national position in the non-military exploration and utilization of space directly influences the perceptions of Americans and international observers about the overall strength and vitality of the United States. This was demonstrated by President Eisenhower's and Congress' geopolitical rationale for NASA's formation in 1958 and Eisenhower's quiet and Kennedy's public support for the Apollo Program in the early 1960's. One can imagine the adverse consequences in the Cold War if the then Soviet Union had landed men on the Moon first or if the United States had failed. Indeed, it can be legitimately argued that the fact that NASA succeeded in landing on the Moon, and they did not, played a major role in the psychological demise of the Soviet Union when faced with the challenge of President Reagan's Strategic Defense Initiative. Apollo appeared to indicate to Soviet Leadership that we could succeed with SDI and they could not.

In that vein of history, consider a future situation, closer to reality than many would like to believe, where China dominates deep space in what has become a *de facto* Cold War II.

This geopolitical argument is in addition to the stimulus that "civil space activities" have in advancing education, technology, economic health, and American confidence in the future, all of which relate directly to national security. In this context, it is often overlooked that commercial communication satellites are a national defense resource as are weather and Earth-sensing satellites. Commercial comsats have been driving technology development in this arena for decades, particularly with respect to the dispersion of fleets of such assets, as one means of mitigating asymmetric warfare against our national communications assets.

2. What can we do in Congress to capitalize on the important partnerships being fostered between NASA and the private sector?

As is the case for all economic activities, Congress can continue to encourage private investors through creating a more rational tax and regulatory environment than

currently exists for innovation and entrepreneurial risk-taking. In addition, Congress should consider the following more specific actions:

- Require NASA to issue a Request for Information (RFI) on how truly commercial (not subsidized) private investment initiatives could be integrated into a permanent lunar base or settlement plan.

- Require NASA to issue a Request for Information (RFI) on how truly commercial private investment initiatives could utilize the capabilities of the Space Launch System in order to increase launch rates and reduce costs.

- Require the Departments of Commerce and State to propose to Congress the detailed outline of a Lunar Claims Regime[1] that the United States would recognize internationally as the basis for the production of lunar resources. Precedent for this exists in the "Deep Seabed Hard Minerals Act" of 1984 and a subsequent multilateral agreement between the United States and several other nations relative to licensing of seabed mining.

- Unequivocally, express the opposition of Congress to the UN sponsored "Moon Agreement" of 1979 the provisions of which would internationalize the management of lunar space resource development and effectively block private initiatives licensed by the United States. This opposition probably would be best expressed through a Joint Resolution signed by the President. Fortunately, the Senate has never ratified the Moon Agreement.

3. NASA has played a critical role in procuring weather satellites for NOAA to operate. A company (Harris Corp.) in my district in Fort Wayne, IN has been making satellite instruments for NASA for 50 years— including many of the instruments used by the U.S. in space today. What should NASA's role be in weather satellites and what is best way to ensure the US doesn't have a gap in weather satellite coverage?

If NASA were to be re-chartered and enabled to focus on the implementation of a Deep Space Exploration Program, as I have suggested in my prepared testimony, then responsibilities for important but unrelated activities should be transferred to other agencies with comparable responsibilities. In the case of weather and climate-related satellites, NOAA should be able to manage their procurement, particularly if the expertise currently in NASA for procuring such satellites from industry is transferred along with the responsibility. The same can be said of NASA's current responsibilities and expertise in Earth-sensing satellites that could be assumed by the Department of the Interior and astronomy that could be assumed by the National Science Foundation.

[1] Schmitt, H. H., 2006, ***Return to the Moon***, Springer, p. 293-294.