Testimony

Hearing on "NASA Human Space Flight Past, Present, and Future: Where Do We Go From Here?"

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Chairman Hall, Ranking Member Johnson, and Members of the Committee: I am honored to have been asked to appear before you today to discuss the future of the space program, a matter which we all consider to be of strategic interest to our nation. It is also very timely. In this year of Space Shuttle retirement, the direction of our nation's space program has been much in the news. We have witnessed ongoing debate about the details of rocket design, about the supposed utility of fuel depots, about whether and why NASA will conduct a human mission to an asteroid, about whether NASA's human rating requirements are too strict, and about whether new commercial space companies can develop systems to transport cargo and crew to the International Space Station (ISS). It is possible that the Members of this Committee join me in being a bit distracted by all of this, and I think "distracted" is the proper term, because in my opinion the principal issue before us is "none of the above". The issues I outlined above are consequential, but they are not determinative.

The central issue of space policy to be decided by our nation's leaders is simply this: do we want to have a real space program, or not? Based upon our national behavior of late, I believe that most Americans, as well as our partners and competitors abroad, would be forced to conclude that the answer is "not".

What is a "real space program"? Let us return to NASA's chartering legislation, the Space Act of 1958, for guidance. In that seminal work, we find among other things that,

"The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities."

I think this is still true. Does anyone disagree?

Further, “such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States …”

I’ve read the Space Act carefully many times. It creates the agency to which it refers, and calls it “NASA”. The superior wisdom of the Bureau of the Budget, now OMB, was apparently not thought to be required for the purposes of directing our nation’s space program. Somehow, I doubt that this was an oversight on the part of the Act’s creators.

Continuing, “the aeronautical and space activities of the United States shall be conducted so as to contribute materially to … [numerous goals follow, including…] the preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof ...”

Today, the United States is dependent upon a foreign power for the most important of those “applications”, human spaceflight , and our recovery plan, if that is the word for it, is to depend upon certain entrepreneurial companies which have yet to show that they can deliver the laundry to ISS, never mind the crew that would wear it. This behavior does not seem to me to be consistent with preserving our role as a “leader”.

So, as I see it, we today are simply not living up to either the letter or the spirit of the Space Act. To paraphrase my friend and colleague, Boeing Commercial Aircraft CEO Jim Albaugh, the current administration’s view of our nation’s future in space offers “no dream, no vision, no plan, no budget, and no remorse.”

Should the goals enunciated in the Space Act be changed? Are they obsolete in the world of today? I would say “no”; I would say that this nation has been incredibly well served by the vision and goals embodied in that Act, and that we should continue to embrace its vision. But this is the policy discussion we must have, not the details of rocket design or whether our next human spaceflight destination is some asteroid. “We the People” will be here to deal with the consequences of such a decision; this administration will not.

So in that spirit, do we want to have a real space program, or not? I think we must, because there are questions of societal importance that surround the space enterprise. What is the nature and value of a human future in space? What directions will human society take as a result of opening the space frontier? What social and cultural values will evolve and prevail, and how will we influence these developments? How is our stature as a world power affected if we are not active on the human space frontier, when others are? What is the effect on our national security, if we are no longer regarded as the preeminent world power? Can our nation remain open, vital, relevant, competitive and forward-looking in science, technology, culture, and commerce, if it turns back from the frontier of its time?

The resolution of these questions requires a national commitment to a human presence in space to define, occupy, extend, and exploit that frontier. Humans *will* commit themselves to

that purpose. Whether the United States will be a leader in that endeavor is the question which properly confronts us today. All else is detail.

What does a real space program look like, and not look like?

A real space program sets and meets stable national strategic goals for leadership on the space frontier by developing, evolving, and preserving national capabilities to operate on that frontier. It does not allow that capability to be held hostage to the good will of other powers, or to the vagaries of a nascent and fragile marketplace.

A real space program may, and indeed should, offer a stable market to be addressed by commercial providers, but it cannot be dependent upon such providers for strategic capabilities. A real space program recognizes that this nation has interests that rise above the fortunes of individual private contractors, and it protects those interests. The proper role of government is to reward winners, not to pick them, nor to step in as an investor in enterprises which cannot pass the tests that the capital markets impose.

A real space program is grounded in physics, not politics. In stepping outward beyond low Earth orbit and the ISS, a human return the moon is the next logical goal from a host of scientific, engineering, operational, and even commercial perspectives. From there, and with the experience thus gained, we should proceed onward to Mars, and should do so in a timely way, else Mars will always be the destination of the future. With the new systems built for those purposes, it will then be both possible and interesting, as an ancillary mission, to visit one or more near-Earth asteroids, and we should do so when opportunity permits. This is a plan which fits the geography of the Solar System in which we live. A real space program would be built around that fact.

These truths were recognized in the NASA Authorization Act of 2005 and again in 2008, both of which were originated by this Committee. The course for this nation's future in space that was laid out in those Acts does not need to be changed, it needs to be followed. We must stay that course. If we do so, the right rocket designs will emerge. If we cannot, the rocket design doesn't matter. Concerning the larger perspective of this hearing, I can thus offer no better counsel to this Committee than the guidance which it has previously issued.

The remainder of my testimony will address specific issues of narrower scope upon which the Committee has asked me to comment.

1. What are the biggest risks and challenges facing NASA and our industrial base as the agency oversees development of several new human spaceflight systems?

As best I can determine, NASA itself is actually "overseeing" only two new human spaceflight systems: the *Orion* multi-purpose crew vehicle (MPCV) and the 130+ metric ton heavy-lift launch vehicle, the so-called Space Launch System. Both of these are intended for future beyond-LEO human exploration, and should serve that purpose well if funding for those efforts

can be maintained. It would be helpful if they could be developed in integrated fashion, working as a program toward a given destination, rather than as independent capabilities.

Should commercial human spaceflight capability fail to be realized, or should such service be interrupted for any reason, the SLS and MPCV can also provide backup access to the ISS, though with considerable cost inefficiency, as they are substantially and intentionally overdesigned for that purpose.

NASA appropriations are being used to provide funds in advance of product delivery (i.e., front-end government "investment" in private concerns) for several commercial space launch, cargo, and crew vehicle development enterprises. There are numerous risks inherent to this aspect of the overall program.

The most obvious concern is that limited NASA funds are being spread too broadly across a nascent commercial space industrial base. The ISS crew and cargo market is insufficient by itself to support several commercial providers, and quite possibly even one. Other commercial human spaceflight markets are not immediately apparent. Thus, if the several firms selected to receive funds under the CCDEV-2 program (Boeing, SpaceX, Sierra Nevada, and Blue Origin) should all succeed technically, one wonders how they will be supported thereafter, other than via outright government subsidy.

Indeed, the administration's reliance on so-called "commercial" means of acquiring human space flight capabilities does not withstand a conventional business case analysis. Understanding that commerce remains a consequence of exploration, the elimination of the Moon as the next logical exploration goal makes no sense. As I stated earlier, it is unlikely that the ISS market alone can sustain even a single commercial vendor, and yet there is no clear plan to provide even that market beyond ISS. However, a straightforward economic analysis shows that the market for the cargo resupply of a human outpost on the lunar surface could indeed be sustainable over the longer term when sound business practices are assumed. Thus, the administration's present exploration strategy to bypass the Moon as a near term human space flight goal impedes the long-term sustainability of the very commercial sector they are trying to cultivate.

Other concerns exist as well, principally associated with the issue of "oversight" that the Committee has identified in this question. Only one of the companies selected for receipt of funds under CCDEV-2 has any prior experience with human spaceflight, or has yet built a rocket that has entered regular service. But as this Committee knows, the development of these capabilities is not being carried out under direct NASA oversight and control. As befits a commercial model, these firms are carrying out their respective developments largely according to their own standards. This would be expected if these were privately funded activities for the purpose of producing a product to be sold in the market for whatever price that market will bear.

Such is not the case here; public funds have been provided in advance of product delivery to meet a government demand, a fact normally accompanied by the requirement for government oversight and control of product design, development, manufacturing, and operational standards. It is in this fashion that the requirement for public responsibility and accountability for the expenditure of public funds is assured. That requirement is absent in the present plan. I personally expect that this state of affairs can continue only until the first accident happens, the first misuse of public funds is revealed, or some other unseemly event occurs. There will then be a public investigation – quite likely led by this very Committee – which will center on the question "where was NASA's oversight of this effort?" The answer when revealed is not likely to be acceptable.

In summary, and in my judgment, the administration's approach to using the power of the government market to help bring about the development of a robust commercial space flight industry has not been well considered. The resulting turmoil when this is plainly seen by all will, without doubt, further impede progress in human spaceflight, and poses a major risk for this nation.

2. Given current and projected future agency budgets, can NASA develop and maintain a safe and affordable human space flight capability? Will NASA be able to afford missions beyond low Earth orbit?

I am concerned that with presently planned budgets, NASA cannot in fact do these things. Table 1, below, shows the reason for this concern. This table compares the President's Budget Requests for 2007 and 2012. As shown, some $50 billion has been removed from NASA's human exploration program through 2016 alone. In fact, the administration's cumulative request for human exploration through 2016 is only 38% of the 2007 request, the first such request after the completion of the NASA Exploration Systems Architecture Study. With this plan, the administration has failed to heed its own Commission's recommendations in regard to the amount of funding which was needed for NASA and human space exploration.

Table 1. Human Exploration Presidential Budget Requests ($M)

	2009	2010	2011	2012	2013	2014	2015	2016	Cum
2007 Request	**4500**	**5055**	**8775**	**9500**	**11000**	**13000**	**14000**	**14200**	**80030**
2012 Request	3506	3626	3706	3949	3949	3949	3949	3949	30581
Reductions	**-994**	**-1429**	**-5069**	**-5551**	**-7051**	**-9051**	**-10051**	**-10251**	**-49449**

To put the numbers in Table 1 in perspective, the Constellation Program had requested a total of about $110 billion in FY2005 dollars from 2007-2020 to accomplish the first human return to the moon, which would have placed four astronauts on the lunar surface for a week, approximately four times the capability of the final Apollo mission. (The total cost of the Apollo Program from 1959-73 was approximately $163 billion in FY2005 dollars.) Important to note is that this level of investment required no dramatic increase in year-to-year spending for NASA, but was based on the projection of stable funding over that fifteen-year period. Thus, the

Constellation plan represented a reasonable next step in capability beyond Apollo, at a funding level that could be accommodated within a stable NASA budget. The present administration's budget request for human space exploration is enormously reduced. It thus seems clear that the present budget request for NASA is insufficient to accomplish any reasonable program of human exploration.

3. What measures do you recommend to help ensure that the Nation successfully develops safe and cost-effective human space exploration systems and maintains a leadership position in the world?

Our nation's space program and those who execute it cannot return anything of lasting value without the re-establishment of stable, strategically selected long-term goals. As discussed earlier, the NASA Authorization Act of 2008, which originated in this committee, offered just such a vision. The principles of that Act, if re-enacted as the law of the land and funded appropriately, would by themselves result in the restoration of U.S. leadership on the space frontier. Specific recommendations follow below.

1) NASA should begin development of a crew transportation system for the purpose of taking our astronauts and those of our international partners to and from low Earth orbit. It is inconceivable that our government would place this nation in the position of depending solely upon either foreign powers or private entities for human access to space. The new Space Launch System (SLS), while it can accomplish this task, is substantially overdesigned for the purpose. It is nonsensical to require the launch of a heavy-lift vehicle for purposes of ISS resupply or for missions such as Hubble servicing and the like. This nation, through NASA, should pursue a broad range of human spaceflight programs; exploration beyond low Earth orbit is only one of them. When our nation is held hostage to other entities for basic access to space, something is very wrong.

2) Missions to the moon, asteroids, and Mars require a heavy-lift launch vehicle if they are to be conducted with any semblance of efficiency. The new Space Launch System, while not as capable or cost-effective as the Ares V design it replaces, is quite similar and is an effective compromise. The Congress should remain vigilant regarding the conduct of this program, as recent events have made it quite clear that the administration does not actually wish to pursue this development.

In summary, I will close on the point with which I began. This nation needs a real space program. That program is inherently about extending human presence out into the Solar System in which we live. The purposes and benefits of this presence can be seen only dimly today, just as our ancestors had trouble seeing value in the New World beyond Virginia tobacco and the fur trade. But the entire history of human development suggests that those benefits will exceed our wildest imagination, and that they will accrue to the society that takes the gamble.

The current NASA program – development of MPCV and SLS – represents the minimum possible investment in rebuilding the capability needed to begin the establishment of a permanent human presence beyond Earth Orbit. That human presence should begin on the moon, the place with the greatest potential to help bring about a viable commercial space industry, and which can serve as the next strategic destination to keep international partners and competitors focused on the peaceful development of the space frontier.

Thank you. I would be happy to answer any questions you may have.

Postscript: A Comment on Fuel Depots

It is sometimes argued that development of a heavy-lift launch vehicle is unnecessary, that the necessary propellant for beyond-LEO missions can be accumulated in "fuel depots" to be resupplied by smaller commercial launch vehicles. The claims made in support of this architectural approach are difficult to understand. In general, the lowest marginal cost-per-pound for payload to orbit is obtained by using a rocket having the largest possible payload. An architectural approach based upon the use of numerous smaller vehicles to stock a fuel depot is inevitably more expensive on a mission-cost basis than can be obtained by putting the necessary payload up in larger pieces, as with a Saturn 5 class vehicle; i.e., 130 metric tons or larger payload capacity.

When this known inefficiency in the marginal cost of tonnage to orbit delivered by smaller launch vehicles in comparison with larger vehicles is acknowledged, the counterargument is sometimes offered that the use of smaller vehicles and fuel depots obviates the need for a heavy-lift launch vehicle, and that the money thus saved more than offsets that which is spent on the fuel depot and smaller launch vehicles. This may or may not be so, depending upon the economics inherent to any given approach, but the argument in any case ignores a more crucial fact – if NASA does not build a heavy-lifter, then we will not have a heavy-lifter! This matters, because human exploration beyond low Earth orbit imposes requirements of far greater scope than merely lifting propellant to orbit, even if that particular requirement does constitute two-thirds of the burden of raw tonnage to orbit. What is ignored by proponents of propellant depots is that the remaining one-third of the total mass consists of large, complex, heavy, tightly integrated systems whose design and development benefits enormously if they can be launched in one piece, with those pieces as large as possible. This can only be done with a true heavy-lift vehicle, preferably one with the largest possible payload volume as well as payload mass. It is simply the case that in some fields of human endeavor, size does matter. Human space exploration is one of those.

Finally, a fuel depot requires a presently non-existent technology – the ability to maintain cryogenic fuels in the necessary thermodynamic state for very long periods in space without expending excessive amounts of propellant due to heating and subsequent "boil off". This technology is the holy grail of deep-space exploration, because it is necessary for both chemical- and nuclear-powered upper stages. We should by all means pursue it. But to embrace an architectural approach that requires a non-existent technology at the very beginning of beyond-LEO operations is unwise in the extreme.

One has the sense that the primary purpose of fuel depots in some proposed space architectures is to provide a market for companies offering rockets with small- to medium-sized payloads. This approach reverses cause-and-effect. We should be asking how commercial space companies can help accomplish the human exploration program we want to do, rather than asking what kind of human exploration program best suits the needs of commercial space.