

COMMENTARY

Commentary on the Augustine Committee Report on the Future of Human Space Exploration

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Introduction

After many months of speculation, numerous meetings, articles, and suggestions, the Review of U.S. Human Space Flight Plans Committee (aka the Augustine Committee) has released its reports providing options to the administration for consideration in plotting the course of human exploration through the rest of the decade and beyond. The report is, within the bounds of the mission presented in its charter, generally sound and is in broad agreement with CSIS's May 2009 report *Mid- and Long-Term Prospects for Human Spaceflight*. While there are a few overarching conclusions that deserve special attention, before exploring the key findings and integrated options presented in the Augustine Committee report, one thing is clear above all else: a successful or meaningful space program in the United States will require strong presidential leadership. The most ambitious, exciting, and enduring projects in the history of the U.S. space program were all born out of strong presidential leadership: Kennedy for the Apollo program, Reagan and Clinton for the International Space Station. President Obama has a clear opportunity to leave a profound legacy for generations yet to come. Moreover, the critical state of the human space exploration program means that a failure of presidential leadership in this critical period will, in all likelihood, spell the beginning of the end of U.S. leadership in space.

First, space exploration is inescapably a global effort. Other nations now can match, or in some cases, exceed the technological capabilities of the U.S. space program. If the U.S. president is willing to take a strong role in guiding NASA leadership in a global program of exploration (but without a domineering posture), building on shared benefit, mutual interdependence, and creation of a global architecture, exploration could become and remain a healthy, vibrant global enterprise. Well thought out engagement of international partners in a manner appropriate to today's geopolitical realities could yield useful soft-power benefits while ensuring the health of a strong human spaceflight program. Experience throughout the history of the space program – from Kennedy and the Apollo program to Reagan and Clinton support of the International Space Station – demonstrates that healthy civil space programs absolutely require strong presidential leadership.

Second, commercial spaceflight capabilities continue to mature. In the very long term, a human space exploration program will not be viable if the commercial sector is neither able nor relied upon to provide more and more basic services. Without commercial engagement, exploration will continue to push the footprint of human presence further and further outward, continually expanding the scale of government obligations, rather than keeping civil space programs focused on the frontiers of exploration. Expenditure of limited NASA resources on recurrent, repetitive, well-understood operational tasks is and will continue to be an inefficient use of the agency's core competencies and unique skills. Furthermore, failure to make effective use of existing commercial capabilities will not help sustain an industrial base in need of income to sustain vital RDT&E efforts.

Third, should NASA continue to address the exploration challenges of the next century using antiquated Cold War, 1960s-era organizational structures and approaches, it is likely that the fundamental problems that have plagued it over past decades will continue in the future. Unless strong measures are taken to change the way NASA does business, we should expect to see future gaps in space exploration capabilities, a weak sense of mission, and a growing difficulty in

maintaining a lead in space exploration against those countries better adapted to the political, economic, and technological realities of the twenty-first century.

Key Findings

The summary of the committee's key findings and commentary on those findings is given below.

- **The right mission and the right size:** NASA's budget should match its mission and goals. Further, NASA should be given the ability to shape its organization and infrastructure accordingly, while maintaining facilities deemed to be of national importance.

While the inherent difficulty of space exploration does make technology and systems development problematic, NASA's tasks are made even more challenging because, structurally, it is still organized and optimized for a Cold War, Apollo-era mission with 1960s-era technology. We strongly agree with the recommendations of chapter nine ("Concluding Observations") of the Augustine Committee report. Giving NASA headquarters the ability to clean house internally is as or *more* important for long-term U.S. leadership in space exploration as any other policy or legislative guidance that Congress or the White House will be able to provide. NASA must be able to address repetition, redundancy, and needless fragmentation among directorates and mission centers, as well as issues related to acquisitions and procurement. The Department of Defense (DOD) was revitalized after the 1986 Goldwater-Nichols Act allowed reorganization and changes in procurement. It is long past time for NASA to be able to do the same.

- **International partnerships:** The United States can lead a bold new international effort in the human exploration of space. If international partners are actively engaged, including on the "critical path" to success, there could be substantial benefits to foreign relations, and more resources overall could become available.

The rest of the world continues to look to the United States not just to have the most advanced space exploration program, but more importantly, to provide global leadership in space. By effectively engaging all space-faring nations, including on the critical path, our global and therefore national space exploration capabilities stand to be improved significantly. Heretofore, in space exploration, a global program has essentially been a series of multiple bilateral agreements. Going forward, if international cooperation is to provide a significant boost to global or even national exploration capabilities, future international cooperation must move beyond a network of bilateral agreements and be structured as a truly multilateral governance system, far closer in character to NATO or the WTO.

Achievements in space exploration can be a potent smart-power tool if cultivated and employed effectively, consequently increasing the potentially utility of space program expenditures. It is important to note that international engagement does not mean continuing to look only to our long-standing partners and allies, but toward emerging space powers. It is entirely possible that by 2020, Europe and Japan will still have no human spaceflight program, while China and India could have substantial spaceflight experience. Planning for the next decade and beyond, it is critical to recognize this now, not once it has already become more difficult to engage them on mutually beneficial terms.

International partners must be engaged in the development of an open architecture, for the fundamental sustainability of any national exploration program, allowing for:

1. international cooperation on specific programs, including those on the critical path, thereby redistributing technical programmatic risks, sharing costs, and increasing political sustainability;
2. inclusion of discrete national capabilities into an international architecture, allowing use of systems that have not been developed through broad cooperative efforts; and
3. straightforward integration of private support for exploration going forward as commercial capabilities mature.

Ultimately, the goal of broadening a global exploration program would be to increase the number of discrete logistical nodes and options for transport between those nodes, maximizing strategic redundancy, opening up competition to spur innovation and reduce costs, and allowing for effective international engagement at will. Some prior models for international cooperation, including GEOSS and Intelsat may prove useful as examples going forward.

- **Short-term Space Shuttle planning:** The current Shuttle manifest should be flown in a safe and prudent manner. The current manifest will likely extend to the second quarter of FY 2011. It is important to budget for this likelihood.

It may prove difficult to complete the existing Shuttle manifest in the timeframe originally planned. It will be helpful to decouple completion of the manifest from this potentially aggressive timetable, without the possibility of turning any flights in early 2011 a precursor to an unintended Shuttle extension beyond 2011. Given the current state of external tank reproduction, an additional flight beyond the current manifest may be feasible, but should be considered if and only if it makes effective use of the Shuttle's unique up and downmass capabilities – i.e. launching of an additional ISS module and complete utilization of downmass capabilities, without becoming a pretext for a “back-door” extension of the Shuttle program.

- **The human spaceflight gap:** Under current conditions, the gap in the U.S. ability to launch astronauts into space will stretch to at least seven years. The committee did not identify any credible approach employing new capabilities that could shorten the gap to less than six years. The only way to significantly close the gap is to extend the life of the Shuttle program.

At this point, cuts to NASA's budget since 2005 have made the existence of a large human spaceflight gap inevitable and irreparable. There may, however, be some options involving use of existing launchers and simplified or modified capsules that could provide an interim capability and shorten the length of the gap by several years. Extending the Shuttle program by more than a launch or two without a budget increase of several billion dollars per year, switching to a strongly Shuttle-derived heavy lift alternative, and other drastic measures, would be counterproductive and could irreparably damage any future exploration efforts.

NASA's overhead and fixed costs all but ensure that “in order to pursue a major new program, existing programs have had to be terminated, sometimes prematurely” ensuring that future gaps in capability will be the rule, rather than the exception. The broader use of commercial capabilities to reduce or eliminate gaps in years and decades to come should be an integral part of NASA's exploration strategy. For example, cooperating with the DOD and intelligence community on human-rating EELVs could allow for the nation to retain a launch vehicle for a capsule-based human spaceflight capability indefinitely while increasing mission assurance for national security payloads.

- **Extending the International Space Station (ISS):** The return on investment to both the United States and our international partners would be significantly enhanced by an extension of ISS life. *Not* to extend its operation would significantly impair U.S. ability to develop and lead future international spaceflight partnerships.

Unilateral withdrawal from the ISS only five years after completion of a quarter century of deliberation, discussion, and assembly is not only a pointless retreat in the face of success, it would be a strong signal that the United States cannot be counted on as a reliable partner and that long-term commitments by NASA should be taken only as being notional and tentative. Termination of the ISS in 2016 without prior political discussion and agreement by the members of the Intergovernmental Agreement (IGA) on the ISS will drastically limit the ability of the United States to maintain a true global leadership role in exploration, ultimately making international cooperation on future efforts vastly more difficult. It may very well be that the members of the IGA will want to continue operating the station far past 2016, in which case NASA must continue its support of the ISS. However, it is also possible that the ISS partners may want to decommission the ISS in 2016, so the United States must not arbitrarily lock other nations into indefinite use of the ISS. In either case, the essential requirement is that the United States not act unilaterally and only makes a decision after full discussion and agreement with all the station partners.

The broader, more important lesson to take away from this and the previous key finding is that NASA's mandates and funding have historically *always* created gaps in destinations, transportation, or both. The gap between Apollo 17 and the launch of Skylab meant that the United States had a transportation system and no place to go. The gap between Apollo and the Shuttle meant that we did not even have a means to go anywhere even if we had a destination. The current gap is one more in a long string of gaps in the human spaceflight program. Going forward, we as a nation cannot continue building gaps in either transport or destination in future spaceflight programs. It is for this reason that we strongly recommend keeping the original 2020 deadline for a return to the Moon, so we do not introduce a new gap between the end of the ISS and the beginning of the next phase of exploration. Alternately, the establishment of some sort of human presence on the Moon could be seen as a fundamental requirement for decommissioning of the ISS.

- **Heavy lift:** A heavy-lift launch capability to low-Earth orbit (LEO), combined with the ability to inject heavy payloads away from the Earth, is beneficial to exploration, and it also will be useful to the national security space and scientific communities. The committee reviewed the Ares family of launchers, more directly Shuttle-derived vehicles, and launchers derived from the EELV family. Each approach has advantages and disadvantages, trading capability, lifecycle costs, operational complexity, and the “way of doing business” within the program and NASA.

A heavy-lift launcher is a fundamental requirement for sustained exploration beyond low-Earth orbit. While it may be possible, in theory, to conduct some type of lunar exploration program using existing launchers, any sort of flexible-path option, let alone future exploration of Mars, will absolutely require a heavy-lift capability. The underlying problem with this situation is that launchers in the 25-ton-to-LEO range do exist and will continue to be developed for use by existing commercial entities. However, a heavy-lift capability of the type mentioned here is exceedingly unlikely to come about on its own without significant government support. Even if undertaken by a single space agency, the inevitable technical, schedule, and cost problems will make maintaining continued support for a heavy launcher difficult at best. For this kind of vehicle, international cooperation will most likely be essential. The ability to redistribute technical, budgetary, and political risk; greater program sustainability; and broad global buy-in will all contribute significantly to seeing the development of such a vehicle through to completion and maintaining the longevity of the program over the long term.

As can be inferred from other key findings, the important aspect of any heavy-lift capability is that it be fielded quickly and cost effectively, minimizing overhead and fixed costs. In particular, international engagement, structural and procurement changes in NASA, and engagement of the commercial sector should all be considered vital components of any program to deliver a heavy-lift capability. Ultimately, a heavy-lift vehicle is essential to an exploration strategy, and implementation of the key findings is essential to completion and use of such a vehicle.

- **Commercial crew launch to low-Earth orbit:** Commercial services to deliver crew to low-Earth orbit are within reach. While this presents some risk, it could provide an earlier capability at lower initial and lifecycle costs than government could achieve. A new competition with adequate incentives should be open to all U.S. aerospace companies. This would allow NASA to focus on more challenging roles, including human exploration *beyond* low-Earth orbit, based on the continued development of the current or modified Orion spacecraft.

NASA's great strength is as an exploration agency, pushing technological boundaries to explore new places using new capabilities. Continued investment of talent and resources in well-understood technologies does not effectively leverage NASA's key strengths. In order to maximize use of its unique capabilities, NASA must be able to make better use of private-sector capabilities in well-understood areas, both through use of commercial capabilities as well as broader utilization of public-private partnerships. It is also vital to remember that if the government is paying for the development and operation of a system, it is not a truly commercial effort. For private-sector engagement to be worthwhile, it must be more than a novel form of government procurement—for the purposes of space exploration, a commercial program can only be considered commercial if it makes relies on private-sector investment and then sells a service to the government as a customer.

In the particular area of commercial crew and cargo transport to low-Earth orbit, any competition should be open to bidders large and small, old and new, and teams with domestic and foreign partners. For example, launch of European and Japanese cargo vehicles on U.S. commercial rockets could provide an effective near-term solution for cargo transport that

is both more cost effective and enhances international cooperation. Additionally, given the U.S. government investment to date, it is our view that the Ares I project should not be cancelled, but rather turned over, in its entirety, to the commercial sector and be allowed to compete against other existing and planned commercial solutions for launch of crew and cargo capsules to low-Earth orbit. This, combined with the proposal for human-rating EELVs would give the nation a menu of launch options for civil, commercial, and national security payloads independent of any broader exploration architecture. Even in the event that a human-rated EELV is not used as part of an exploration architecture, the DOD model used with the development of the EELV (private-sector funding for program development for many customers including government payloads) should be employed for all transportation to LEO that does not require a heavy-launch vehicle. This arrangement could be used with the entire range of existing and planned launchers, such as the Ariane 5, Long March 5, H-IIB, GSLV Mk III, Angara, Taurus II, and Falcon 9 and other launch vehicles, yielding a fleet capable of sustaining a broad, global exploration effort.

- **Technology development for exploration and commercial space:** Investment in a well-designed and adequately funded space technology program is critical to enable progress in exploration. Exploration strategies can proceed more readily and economically if the requisite technology has been developed in advance. This investment will also benefit robotic exploration, the U.S. commercial space industry, and other U.S. government users.

Development of key enabling technologies for improving the broad set of space exploration capabilities is an area in which increased NASA investment is of extraordinary importance. For example, problems with foam shedding from the Space Shuttle's external tank have been known for decades. However, no ability was developed for the Space Shuttle to check or repair tile damage in orbit until after the Columbia accident in 2003. Conversely, the Gemini program of the 1960s was a technology test bed explicitly intended for the development of new space exploration technologies, which delivered significant increases in capabilities, without which the Apollo program would have been impossible. NASA must return to aggressive technology development of enabling capabilities for future space exploration in areas including on-orbit refueling, extra-vehicular activities, on-orbit assembly, automated docking, rendezvous, and refueling. An aggressive technology development program could also provide for the development of technological solutions to ongoing problems, without tying such development to the success or cancellation of any one program.

- **Pathways to Mars:** Mars is the ultimate destination for exploration, but it is not the best first destination. Both visiting the Moon first and following the "Flexible Path" are viable exploration strategies. The two are not necessarily mutually exclusive; before traveling to Mars, we might be well served to both extend our presence in free space and gain experience working on the lunar surface.

Given the policy and technology realities of exploration, the Moon is not and cannot be the ultimate destination, but it is the best first destination for exploration. The simple fact is that the United States has already invested a significant amount of political and fiscal capital in returning to the Moon. The results of this are apparent when one looks at the wide array of lunar exploration programs initiated by countries around the globe. To abandon this, particularly in favor of a "Flexible Path" to nowhere that bypasses the Moon for more than a decade would damage our global leadership role in space exploration.

Clearly, any reasonable plan for human exploration of Mars would be a multi-decade endeavor and would rival the Apollo program in terms of relative increase in technology and capability needed for success. A more circumspect approach, featuring continuous incremental evolution of capabilities is a much better option for the near future in any foreseeable exploration scenario. Both the Flexible Path and Moon first options satisfy this criteria, as both options are, at least in terms of technology development, essentially subsets of any future human expedition to Mars. Successful pursuit of the Moon-return option needs little further technology development to allow the Flexible Path option, which requires additional funding for deep space exploration missions. But pursuit of Flexible Path at the expense of a Moon return could easily turn into a long series of "flag-planting" missions, ultimately replicating the fate of the Apollo program, but on a much larger scale.

- **Options for the human spaceflight program:** The committee developed five alternatives for the human spaceflight program. It found:

- Human exploration beyond low-Earth orbit is not viable under the FY2010 budget guideline.
- Meaningful human exploration is possible under a less-constrained budget, ramping to approximately \$3 billion per year above the FY2010 guidance in total resources.
- Funding at the increased level would allow either an exploration program to explore Moon first or one that follows a Flexible Path of exploration. Either could produce results in a reasonable timeframe.

Meaningful exploration under the FY2010 budget, if possible at all, will necessitate extensive NASA administrative, legal, and budgetary reorganization, shifting of certain operational missions to other agencies, heavy reliance on international cooperation, and extensive changes in NASA's relationship with the commercial sector. Some combination of increased funding along with changes of the sort mentioned above will likely be the only reliable way for NASA to move forward once again.

One critical point that has not been fully explored is that the requirement for \$3 billion dollars of funding in the "less constrained" budgetary scenarios assumes that the only way to make good shortfalls is by increasing the NASA budget. Addressing the problem from this perspective obscures the fact that NASA needs goods and services worth \$3 billion annually. It is entirely possible to address some or all of this shortfall through international cooperation and expanded public-private partnerships. However, addressing this shortfall by using such tools requires expenditure of political, rather than monetary capital. Moreover, given the current state of civil space exploration in the U.S., if there is no strong action by the President now, the U.S. may well lose its position as global leader, and simply become one of many spacefaring nations.

Integrated Program Options

The committee has identified five principal alternatives for the human spaceflight program. They include one baseline case, which the committee believes to be an executable version of the current program of record, funded to achieve its stated exploration goals, a modified baseline case, and three alternatives based on a slight increase in budget. In the interests of space, detailed explanations of each program option will not be repeated in full here.

- **Option 1. Program of Record as assessed by the committee, constrained by the FY2010 budget:** This option is the Program of Record, with only two changes the committee deems necessary: providing funds for the Shuttle into FY2011 and including sufficient funds to de-orbit the ISS in 2016.

Should the nation move forward with this option without inclusion of any of the measures suggested in the discussion of key findings above, it will be necessary to dramatically reframe NASA's role in coming decades. Execution of this option without NASA reorganization, much more effective use of commercial or international capabilities, and withdrawal from the ISS in 2016 will cause the United States to relinquish its leadership role in human spaceflight, placing it in a tier below Russia and China and equal to or slightly behind Europe and Japan. Although theoretically Orion/Ares I development could be continued, neither system would be operational in time for there to be any point in building such a system. If the Ares V is not deployed for at least another two decades, it is unlikely that sufficient funding and interest can be sustained to see the project through to conclusion. Therefore, strict implementation of this option effectively necessitates the end of any U.S. human spaceflight ambitions. Should the administration decide to execute such a plan, the outcome over the long term would be the phase-out of any independent U.S. human spaceflight capability.

- **Option 2. ISS and lunar exploration, constrained to FY2010 budget:** This option extends the ISS to 2020, and it begins a program of lunar exploration using Ares V (Lite). The option assumes Shuttle fly-out in FY2011, and it includes a technology-development program, a program to develop commercial crew services to low-Earth orbit, and funds for enhanced utilization of ISS.

Much like Option 1, implementation of this option without aggressive implementation of the report's key findings will result in the functional end of the U.S. human spaceflight program. Also, much like the first option, if all key recommendations are fully adopted but no budget cuts are restored, successful completion of this option in a meaningful timeframe is still unlikely.

- **Option 3. Baseline case—implementable Program of Record:** This is an executable version of the Program of Record. It consists of the content and sequence of that program—de-orbiting the ISS in 2016, developing Orion, Ares I and Ares V, and beginning exploration of the Moon.

While execution of this option does provide for a human space exploration program of some consequence, it does not encourage adoption of the report's key findings. In particular, it places little emphasis on international cooperation, effective use of commercial capabilities, technology development to enhance exploration capabilities, and NASA reorganization. Withdrawal from the ISS in 2016 makes it quite unlikely that the United States would be able to garner sufficient partner support to permit a return to the Moon. Essentially, the 2016 decommissioning of the ISS means that this option is not viable if the nation wishes to pursue a worthwhile human spaceflight program.

- **Option 4. Moon first:** This option preserves the Moon as the first destination for human exploration beyond low-Earth orbit. It also extends the ISS to 2020, funds technology advancement, and uses commercial vehicles to carry crew to low-Earth orbit.

This option allows for the fullest implementation of critical key findings, in particular international engagement and private-sector partnership, regardless of which specific architecture variant is chosen. Having already placed a lunar return at the top of the U.S. exploration agenda since 2004, scrapping the Moon as the near-term objective would signal a lack of seriousness and determination about our exploration goals, particularly in light of the many other nations that have now initiated extensive lunar exploration programs. Past experience in international cooperation also suggests that it is easier by far to develop cooperation and international governance structures for cooperation around a specific, concrete project (e.g., a lunar base) rather than a loosely structured set of ill-defined objectives (e.g., the Flexible Path option).

Extension of the ISS to 2020 will not just demonstrate U.S. reliability as a partner in exploration and make it politically feasible for our partners to participate in lunar exploration, it will allow them to mature their already demonstrated capabilities, permitting them to make a larger contribution to exploration beyond low-Earth orbit. A return to the Moon and establishment of a permanent or human-tended base there also permits the somewhat better planning certainty necessary to discuss engagement with the private sector and our international partners over the longer term, avoiding the need to readapt governance structures for each new class of mission.

- **Option 5. Flexible Path:** This option follows the Flexible Path as an exploration strategy. It operates the Shuttle into FY2011, extends the ISS until 2020, funds technology development, and develops commercial crew services to low-Earth orbit.

As with Option 4, the Flexible Path allows for better implementation of critical key findings. However, from a broader perspective there are a few shortfalls inherent in this approach, which limit the conditions in which this option can be successfully executed. The lack of specific, concrete goals toward which efforts can be clearly oriented will clearly hinder international cooperation in exploration and, by extension, the creation of a meaningful human exploration program. However, it should also be noted that the Flexible Path can be pursued in conjunction with a Moon-first Path, particularly if broad inclusion of international partners and commercial capabilities is leveraged effectively. For instance, a Flexible Path option with an international lunar lander and base would yield a Moon-first-flavored variant of the Flexible Path. However, the experience with the Constellation program indicates that international partners still might be reluctant to participate in such a program, as it would isolate them from critical path cooperation in the transportation segment of the architecture. Therefore, use of the Flexible Path as a means to Moon first will require significant international engagement along the entire path, ultimately yielding an international Moon-first program, with an option for further deep space missions. Thus, useful implementation of the Flexible Path along with the realities of international engagement essentially turns this option into a Moon-first Path under a different name.

Conclusion

Overall, the key findings of the Augustine Committee and our recommendations on those findings should not be taken as a list of 10 separate items, but rather 10 facets of the entire effort that will be needed to secure global leadership for U.S. space exploration in years and decades to come. Of the programmatic options presented by the Review of U.S. Human Spaceflight Plans Committee (aka the Augustine Committee), the Flexible Path and Moon-first options allow for the best implementation of critical committee findings and therefore are the only options that provide for any meaningful continued human spaceflight program in the medium to long term. While both the Flexible Path and Moon-first options are viable, the increased ease of international cooperation associated with the Moon-first option is expected to produce a more politically survivable, economically sustainable, and technologically achievable program than the Flexible Path. Therefore, if the Flexible Path is chosen, it should be done only as a part of a global Moon-first program.

Regardless of which path the nation chooses for its future human exploration program, it should make a decision soon. Deferring the decision for several years until, for instance, the ISS must be decommissioned from lack of any program to extend its operational life, will not only leave NASA ill-equipped to sustain any exploration effort, it will mark the effective end of U.S. leadership in space. However, thoughtful decisive action in the very near future can fundamentally reshape our space program for years and decades to come, restoring it as a source of pride in the United States and around the world.

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