

**U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY**

HEARING CHARTER

*Options and Issues for NASA's Human Space Flight Program:
Report of "Review of U.S. Human Space Flight Plans" Committee*

Tuesday, September 15, 2009
2:00 p.m. – 4:00 p.m.
2318 Rayburn House Office Building

I. Purpose:

To examine the summary report of the Review of U.S. Human Space Flight Plans Committee that was established by the National Aeronautics and Space Administration (NASA) under the direction of the Office of Science and Technology Policy, and to consider implications and related issues for NASA.

II. Witnesses

Panel I

Mr. Norman R. Augustine, *Chair, Review of U.S. Human Space Flight Plans Committee*

Panel II

Vice Admiral Joseph W. Dyer USN (Ret.), *Chair, Aerospace Safety Advisory Panel, NASA*

Dr. Michael D. Griffin, *Eminent Scholar and Professor, Mechanical and Aerospace Engineering, University of Alabama in Huntsville*

III: Key Issues for the Hearing

- *How was the review committee able to compare options that differ significantly in terms of technical and programmatic maturity, understanding of risk, and fidelity of cost estimates? What are the limitations of the review committee's approach, and how should Congress and the Administration assess the options in light of those limitations?*
- *Given the differing degrees of technical, programmatic, and cost estimation maturity of the various options, what level of confidence can Congress and the Administration have that any of the alternative options can actually fit into the*

- enhanced funding envelope proposed by the review committee in its summary report?*
- *Since the Constellation program is the program for which funds have been authorized and appropriated over the last four years and for which design, development, and test activities have been underway over that same period, did the review committee attempt to develop an option that would maintain the Constellation program development path but that would fit into the enhanced funding envelope proposed by the committee by rephrasing of milestones, initial exploration destinations, etc.? If so, why was it not included in the final set of options contained in the summary report?*
 - *The same historical cost risk factor [1.51] appears to have been applied by the review committee to all of the options regardless of their level of technical and programmatic maturity. Does it make sense to apply the same risk factor to a program that has completed design reviews and hardware testing activities that is applied to options for which no comparable milestones have yet been achieved and for which the fidelity of the original cost estimate is correspondingly low?*
 - *How can Congress and the Administration meaningfully compare the safety implications of the Constellation program of record and the other options in light of the review committee's decision not to attempt to distinguish between the levels of safety of the various options?*
 - *What was the review committee's assessment of the technical maturity, program management, and cost control of the Constellation program? Did it find it to be a well executed program within the resources available or a flawed program?*
 - *How high should the threshold be for a decision to scrap the existing Constellation program that has been under development for four-plus years? What circumstances would justify abandoning the program at this point in its development?*
 - *If the Administration and Congress were to maintain the outyear budget plan that accompanied the FY 2010 NASA budget request and not provide enhanced funding, how should those funds be allocated?*
 - *To what extent do the options presented by the review committee address the goals and objections for exploration that Congress has authorized in the NASA Authorization Acts of 2005 and 2008?*
 - *How would the review committee rank the various options against each other and against the Constellation program?*
 - *What driving assumptions (e.g., cost, programmatic, risk) steered the review committee in determining its final options? How, if at all, are the assumptions that guided the conclusions in the Summary Report different from those discussed during the review committee's last meeting on August 12, 2009?*
 - *How did the review committee develop measures and criteria by which to evaluate the options and their ability to meet the direction set by the Office of Science and Technology Policy for the review?*
 - *How does the sustainability of the workforce and expertise needed to pursue the review committee's human spaceflight options differ under each of the options proposed?*

- *How should the review committee's finding that "interim reliance on international crew services" is "acceptable", be interpreted in terms of the gap in the nation's ability to launch humans into space? What, if any, strategic implications of the gap did the review committee consider? How, if at all, does the gap affect implementation of any of the options presented by the review committee?*
- *When making a decision on an option, how do Congress and the Administration reconcile the review committee's statements that it treated human safety as a "sine qua non" while also stating that it was "unconvinced that enough is known about any of the potential high-reliability launcher-plus-capsule systems to distinguish their levels of safety in a meaningful way"?*
- *What are the implications of the recommended options on NASA's ability to sustain a balanced portfolio of science, aeronautics, human spaceflight and exploration?*
- *How, if at all, do the options presented by the review committee contribute to the development and evolution of international collaboration for human exploration over the long-term? How do the options compare in that regard? How did the review committee assess the international capabilities that could be potentially leveraged for each option?*
- *To what extent do the integrated options require technologies and operational techniques or other research and development that can only be conducted on the International Space Station? How did the review committee assess the time needed to achieve such R&D into its estimates of the timeline for each of the proposed options?*
- *What is the basis for the review committee's estimate that commercially-provided crew service could be available a year earlier than the currently planned Ares/Orion program?*
- *Stimulating a "vigorous and competitive commercial space industry" as the review committee suggests would seem to depend on a robust government-sponsored exploration program. What did the review committee assume about the existence of a commercial market that would allow the government to be a marginal user of commercial services?*
- *To what extent do the options recommended require major technology developments, breakthroughs, or demonstrations of advanced technologies? For example, how critical is the capability to provide in-space refueling to enable the implementation of the options presented by the review committee? Are there vehicles and pathways for achieving technology advancements in place? What level of programmatic risk is introduced if an option is dependent on achieving such advancements in advance?*
- *How did the review committee assess the extent to which each option could engage the public and the younger generations on whom the nation will depend to carry out human exploration plans into the future?*
- *What is the basis of the \$3 billion increase above the FY 2010 budget profile for exploration that the review committee concluded was needed to support a meaningful human spaceflight program? What does that \$3 billion include and*

what is the increase each year that the review committee thought was needed to reach that level of investment?

IV: Overview of Review of U.S. Human Space Flight Plans

On May 7, 2009, the Office of Science and Technology Policy, Executive Office of the President, announced the “*launch of an independent review of planned U.S. human space flight activities with the goal of ensuring that the nation is on a vigorous and sustainable path to achieving its boldest aspirations in space.*” According to the press release, John P. Holdren, Assistant to the President for Science and Technology and Director of the Office of Science and Technology Policy stated: ‘*President Obama recognizes the important role that NASA’s human space flight programs play in advancing scientific discovery, technological innovation, economic strength and international leadership*’. He went on to say that ‘*The President’s goal is to ensure that these programs remain on a strong and stable footing well into the 21st Century, and this review will be crucial to meeting this goal.*’

Charter and Scope of the Review of U.S. Human Space Flight Plans Committee

The National Aeronautics and Space Administration chartered the “Review of U.S. Human Space Flight Plans Committee” as a Federal Advisory Committee Act (FACA) committee, which requires that meetings and information presented to the review committee be accessible to the public.

The Charter for the review committee states the following Scope and Objectives:

“The committee shall conduct an independent review of ongoing U.S. human space flight plans and programs, as well as alternatives, to ensure the Nation is pursuing the best trajectory for the future of human space flight—one that is safe, innovative, affordable, and sustainable. The review committee should aim to identify and characterize a range of options that spans the reasonable possibilities for continuation of U.S. human space flight activities beyond retirement of the Space Shuttle. The identification and characterization of these options should address the following objectives: a) expediting a new U.S. capability to support utilization of the International Space Station (ISS); b) supporting missions to the Moon and other destinations beyond low-Earth orbit (LEO); c) stimulating commercial space flight capability; and d) fitting within the current budget profile for NASA exploration activities.”

“In addition to the objectives described above, the review should examine the appropriate amount of research and development and complementary robotic activities needed to make human space flight activities most productive and affordable over the long term, as well as appropriate opportunities for international collaboration. It should also evaluate what capabilities would be enabled by each of the potential architectures considered. It should evaluate options for extending ISS operations beyond 2016.”

The review committee reports to the NASA Administrator and the Director of the Office of Science and Technology Policy (OSTP), Executive Office of the President. The review committee was given 120 days, following the date of its first meeting, to submit a report.

Members of the Review Committee

The review committee is comprised of ten members, including the chair, with background and expertise in launch and aerospace systems, engineering, space science, human space flight, and management. The review committee is chaired by Mr. Norman Augustine, Chairman and CEO, Lockheed Martin Corporation (retired). Mr. Augustine is also a former member of the President's Council of Advisors on Science and Technology under Presidents Clinton and George W. Bush and chaired the National Academies study, *Rising Above the Gathering Storm*. The full list of review committee members, as presented in a NASA Press Release dated June 1, 2009, is provided in Attachment D.

Review Committee Meetings and Materials

The review committee held six public meetings, beginning with its first meeting held on June 17, 2009 in Washington, D.C. and at locations near NASA Centers involved in human spaceflight, held fact finding meetings, and conducted site visits to facilities that support the human spaceflight and exploration programs. The material presented to the review committee, including statements from Members of Congress and analyses and syntheses prepared by the review committee members, are available to the public at the Review of Human Space Flight Plans committee website.

<<http://www.nasa.gov/offices/hsf/home/index.html>.> The statements provided to the review committee by the Chairman and Ranking Member of the House Committee on Science and Technology are included in Attachment E.

Results and Options Presented by the Review Committee (Excerpts from the Summary Report)

A summary report of the Review of U.S. Human Space Flight Plans Committee was released publicly on September 8, 2009. The review committee is preparing a final report.

In its Summary Report, the review committee stated that “The U.S. human spaceflight program appears to be on an unsustainable trajectory. It is perpetuating the perilous practice of pursuing goals that do not match allocated resources. Space operations are among the most complex and unforgiving pursuits ever undertaken by humans. It really is rocket science. Space operations become all the more difficult when means do not match aspirations. Such is the case today.”

In its direction from OSTP, the review committee was tasked to fit the options for a U.S. human spaceflight program into the existing budget profile for NASA's exploration activities. With respect to that direction, the review committee “*found two executable*

options that comply with the FY 2010 budget. However, neither allows for a viable exploration program. In fact, the committee finds that no plan compatible with the FY 2010 budget profile permits human exploration to continue in any meaningful way.”

The review committee also received approval from OSTP to present options that exceed the FY 2010 budget profile for NASA’s exploration activities. In that regard, the review committee stated that *“The committee further finds that it is possible to conduct a viable exploration program with a budget rising to about \$3 billion annually above the FY 2010 budget profile. At this budget level, both the Moon First strategy and the Flexible Path strategies begin human exploration on a reasonable, though hardly aggressive, timetable. The committee believes an exploration program that will be a source of pride for the nation requires resources at such a level.”*

The review committee’s key findings are as follows:

Summary of Key Findings

“The committee summarizes its key findings below. Additional findings are included in the body of the report.

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.*

International partnerships: *The U.S. 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.*

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.*

The human-spaceflight gap: *Under current conditions, the gap in 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.*

Extending the International Space Station: *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.*

Heavy-lift: *A heavy-lift launch capability to low-Earth orbit, 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 [Evolved Expendable Launch Vehicle] family. Each approach has advantages and disadvantages, trading capability, lifecycle costs, operational complexity and the “way of doing business” within the program and NASA.

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.*

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.*

Pathways to Mars: *Mars is the ultimate destination for human 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.*

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 FY 2010 budget guideline.*
- Meaningful human exploration is possible under a less constrained budget, ramping to approximately \$3 billion per year above the FY 2010 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.”*

Options

In its Summary Report, the review committee presented five integrated options for a human spaceflight program. Those options, along with a summary table of the options as presented in the review committee’s Summary Report, are provided below.

“The committee was asked to provide two options that fit within the FY 2010 budget profile. This funding is essentially flat or decreasing through 2014, then increases at 1.4 percent per year thereafter, which is less than the 2.4 percent per year used to estimate cost inflation. The first two options are constrained to that budget.

Option 1. Program of Record as assessed by the committee, constrained to the FY 2010 budget. This option is the Program of Record, with only two changes the committee deems necessary: providing funds for the Shuttle into FY 2011 and including sufficient funds to de-orbit the ISS in 2016. When constrained to this budget profile, Ares I and Orion are not available until after the ISS has been de-orbited. The heavy-lift vehicle, Ares V, is not available until the late 2020s, and worse, there are insufficient funds to develop the lunar lander and lunar surface systems until well into the 2030s, if ever.

Option 2. ISS and Lunar Exploration, constrained to FY 2010 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 FY 2011, 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. This option does not deliver heavy-lift capability until the late 2020s and does not have funds to develop the systems needed to land on or explore the Moon.

The remaining three alternatives are fit to a different budget profile—one that the committee judged more appropriate for an exploration program designed to carry humans beyond low-Earth orbit. This budget increases to \$3 billion above the FY 2010 guidance by FY 2014, then grows with inflation at a more reasonable 2.4 percent per year.

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. The committee made only two additions it felt essential: budgeting for the fly-out of the Shuttle in 2011 and including additional funds for ISS de-orbit. The committee’s assessment is that, under this funding profile, the option delivers Ares I/Orion in FY 2017, with human lunar return in the mid-2020s.

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. There are two significantly different variants to this option.

Variant 4A is the Ares Lite variant. This retires the Shuttle in FY 2011 and develops the Ares V (Lite) heavy-lift launcher for lunar exploration. Variant 4B is the Shuttle extension variant. This variant includes the only foreseeable way to eliminate the gap in U.S. human-launch capability: it extends the Shuttle to 2015 at a minimum safe-flight rate. It also takes advantage of synergy with the Shuttle by developing a heavy-lift vehicle

that is more directly Shuttle-derived. Both variants of Option 4 permit human lunar return by the mid-2020s.

Option 5. Flexible Path. This option follows the Flexible Path as an exploration strategy. It operates the Shuttle into FY 2011, extends the ISS until 2020, funds technology development and develops commercial crew services to low-Earth orbit. There are three variants within this option; they differ only in the heavy-lift vehicle.

Variant 5A is the Ares Lite variant. It develops the Ares Lite, the most capable of the heavy-lift vehicles in this option. Variant 5B employs an EELV-heritage commercial heavy-lift launcher and assumes a different (and significantly reduced) role for NASA. It has an advantage of potentially lower operational costs, but requires significant restructuring of NASA. Variant 5C uses a directly Shuttle-derived, heavy-lift vehicle, taking maximum advantage of existing infrastructure, facilities and production capabilities.

All variants of Option 5 begin exploration along the flexible path in the early 2020s, with lunar fly-bys, visits to Lagrange points and near-Earth objects and Mars fly-bys occurring at a rate of about one major event per year, and possible rendezvous with Mars's moons or human lunar return by the mid to late 2020s.

The committee has found two executable options that comply with the FY 2010 budget. However, neither allows for a viable exploration program. In fact, the committee finds that no plan compatible with the FY 2010 budget profile permits human exploration to continue in any meaningful way.

The committee further finds that it is possible to conduct a viable exploration program with a budget rising to about \$3 billion annually above the FY 2010 budget profile. At this budget level, both the Moon First strategy and the Flexible Path strategies begin human exploration on a reasonable, though hardly aggressive, timetable. The committee believes an exploration program that will be a source of pride for the nation requires resources at such a level.”

	Budget	Shuttle Life	ISS Life	Heavy Launch	Crew to LEO
Constrained Options					
Option 1: Program of Record (constrained)	FY10 Budget	2011	2015	Ares V	Ares I + Orion
Option 2: ISS + Lunar (constrained)	FY10 Budget	2011	2020	Ares V Lite	Commercial
Moon First Options					
Option 3: Baseline - Program of Record	Less constrained	2011	2015	Ares V	Ares I + Orion
Option 4A: Moon First - Ares Lite	Less constrained	2011	2020	Ares V Lite	Commercial
Option 4B: Moon First - Extend Shuttle	Less constrained	2015	2020	Directly Shuttle Derived + refueling	Commercial
Flexible Path Options					
Option 5A: Flexible Path - Ares Lite	Less constrained	2011	2020	Ares V Lite	Commercial
Option 5B: Flexible Path - EELV Heritage	Less constrained	2011	2020	75mt EELV + refueling	Commercial
Option 5C: Flexible Path - Shuttle Derived	Less constrained	2011	2020	Directly Shuttle Derived + refueling	Commercial

Source: Summary Report of the Review of U.S. Human Space Flight Plans Committee, p. 9

Ground Rules and Assumptions on Affordability

According to its analysis presented during the review committee's last meeting held on August 12, 2009, the review committee articulated the following ground rules and assumptions that were followed in its analyses.

- “Aerospace [Aerospace Corporation was the contractor used by the review committee to perform cost analyses in support of the review committee’s work] used a 1.51 historical risk factor on all element development costs of all scenarios on the cost to go. A lower (1.25) historical risk factor was used on productive/ operations
- An additional \$200 million was added to the COTS [Commercial Orbital Transportation Services] cargo baseline in FY 2011 to incentivize current COTS cargo demonstrations
- Except for international partner agreements already assumed for the ISS, all elements were fully costed (for costing purposes only)
- For all scenarios, except the Program of Record, assume a technology program starting at \$500M in FY2011 and ramping up to \$1.5 billion over five years. Maintain the \$1.5 billion annually thereafter. (Assume double counting in other ISS and ESMD [Exploration Systems Mission Directorate] lines, so funding is one-half of that.)
- For scenarios that assume commercial crew, assume a \$2.5B NASA investment over 4 years beginning in FY 2011
- Use Aerospace contract termination/restart model and actual contract termination costs in Cx [Constellation] programs

- *For all scenarios that include refueling, assume technology line funds development and add a \$1 B one-time cost to flight certify the fuel transfer kit*
- *For all scenarios assuming lunar sorties/outpost, use the Cx estimate for the Altair lander and lunar surface system; for the Deep Space options, assume a commercial lunar lander, but a government furnished ascent stage*
- *For options using EELV heavy lift launch vehicles, cost as if NASA does not build the system and uses NASA infrastructure and workforce only when required to conduct operations*
- *For the Shuttle Derived Systems scenario, assume Side-mount costs (provided by NASA) for the cargo only version*
- *Current program elements (ISS and STS):*
 - *For scenarios with ISS de-orbit in 2016, assume additional \$1.5 B cost beyond current estimate*
 - *For scenarios with existing shuttle manifest, assume fly-out to March, 2011”*

Discussion

There are multiple aspects of the review committee’s assumptions and analyses that Congress will need to understand in order to make an informed judgement about the options presented in the summary report.

Costs of Deviating from the Congressionally-authorized Program

Congress authorized the exploration initiative, including the Constellation Program, in the NASA Authorization Acts of 2005 and 2008 and encompassing a stepping-stone approach to exploration beginning with robotic and human exploration of the Moon in preparation for exploration missions to other destinations in the solar system. In addition, the 2008 Authorization directs the NASA Administrator to ensure that the ISS remain a viable laboratory through at least 2020. The Summary Report did not include an option that accounts for this Congressionally-authorized scenario, and therefore does not present the President with the option and costs of the program that matches what Congress has authorized by law. The absence of this scenario also makes it difficult to compare the program authorized by law against the alternatives presented by the review committee.

In addition, the summary report did not outline the costs and risks associated with terminating the program of record (or various elements of the Program) or how the review committee weighed those termination costs and risks against the costs and risks of undertaking an alternative architecture.

Cost Assumptions

In materials presented at its last meeting held on August 12, 2009, the review committee used cost analyses conducted by the Aerospace Corporation to compare the costs of various options, including the program of record (Constellation). The Aerospace Corporation used a historical risk factor of 1.51 in assessing the costs. NASA has indicated that it already budgeted the Constellation program at a level for which there is a 65 percent confidence that the program will meet its schedule and budget projections. In

addition, the Constellation program has reached a level of maturity that would argue risk uncertainty has been reduced. Congress will need to understand whether or not the costs-to-go for the Constellation program have been essentially double-counted costs required for Constellation given that a risk factor was applied on top of NASA's estimates.

In addition, there are different levels of maturity in the options for human spaceflight systems that the review committee considered, ranging from options that are the concept and viewgraph stage to designs that have been studied in depth. Congress will need to understand how the review committee went about estimating and comparing the costs for designs that have such a wide range of maturity levels.

Safety

On the one hand, the review committee noted that throughout its report, human safety *“is treated as a sine qua non.”* It also notes that *“Ares I was designed to a high standard in order to provide astronauts with access to low-Earth orbit at lower risk and a considerably higher level of reliability than is available today.”* On the other hand, regarding the alternative human spaceflight systems reviewed, the report stated that the review committee *“was unconvinced that enough is known about any of the other potential high-reliability launcher-plus-capsule systems to distinguish their levels of safety in a meaningful way.”* The report also states that *“New human-rated launch vehicles will likely be more reliable once they reach maturity...”* At issue is how the review committee reconciled the emphasis it gave to human safety in its report with the uncertainties the report introduces about how to rate the safety of potential alternative crewed launch systems that exist at very different levels of maturity. Even for a potential human-rated EELV system, which was studied by the Aerospace Corporation, *“Aerospace did not perform estimates of loss of mission (LOM) and loss of crew (LOC) probabilities for the HR Delta IV H options studied.... To allow an equitable comparison of HR Delta IV HR Delta IV H to Ares 1 LOM/LOC a new study....would be needed.”* The review committee's approach to ascertaining the safety of alternative systems also needs explanation, and in particular the relationship assured by the review committee between reliability and safety. There are many uncertainties regarding safety that Congress will need to understand in assessing the review committee's proposed options.

International Cooperation

The review committee's summary report refers to the benefits of an international exploration program, including strengthening of geopolitical relationships, leveraging of resources, and enhancing exploration. However, the report does not discuss the extent to which each option would contribute to or benefit from international cooperation, how international cooperation would evolve over the long-term as part of the options presented, and what international capabilities could potentially be applied to each of the options. In addition, the review committee states, in its summary of key findings, that *“If international partners are actively engaged, including on the “critical path” to success, then there could be substantial benefits to foreign relations....”* Having international partners on the “critical path” would be a significant shift from current approach to partnerships. This leads to questions about the types of risks this new approach would introduce; how, if at all, the review committee assessed those risks; and the extent to

which the review committee found that those risks would be outweighed by the additional benefits from the international collaboration that could be realized.

Crew Access to Low-Earth Orbit

The review committee's summary report states that "*There are two basic approaches [to crew access to low-Earth orbit]: a government-operated system and a commercial crew-delivery service.*" This seems to suggest that the review committee considered crew-access to LEO in an either-or binary fashion, which differs from the congressionally-authorized program to support commercial development of commercial crew services to low-Earth orbit, while also retaining the government capability. The review committee suggests, in its summary report that "*it is an appropriate time to consider turning this transport service over to the commercial sector.*" It is unclear, however, whether the review committee is suggesting that government capability to launch humans into low-Earth orbit be abandoned in favor of as-yet-undeveloped commercial systems—as some of the options suggest—or whether it simply thinks commercial development should be stimulated in parallel to the government program and phased over once the commercial systems have matured. It is also unclear whether or not the review committee considered the strategic implications of not having a government system to launch humans into low-Earth orbit. These issues warrant clarification.

Commercial Services and Potential Cost Savings

The summary report states that providing human access to low-Earth orbit by using commercial crew services "*creates the possibility of lowering operating costs for the system and potentially accelerates the availability of U.S. access to low-Earth orbit by about a year, to 2016.*" If this is the review committee's rationale for a commercially provided service in lieu of a government-provided service to low-Earth orbit, there are several issues that need to be clarified. The Summary Report does not discuss the technical analysis that led the review committee to indicate that commercial services could potentially reduce the gap by about a year or the review committee's level of confidence in that date. In addition, because commercial crew systems are largely conceptual at this stage, it is unclear what assumptions about their potential to meet NASA's human safety requirements that the review committee assumed.

In addition, the summary report states that "*Establishing...commercial opportunities could increase launch volume and potentially lower costs to NASA and all other launch-service customers.*" The Summary Report does not discuss the level of activity that would be needed to lower the costs of crew transport for the government, when would the government would be able to benefit from those savings, and how much the government could expect to save from using commercial crew services in lieu of government-provided services. Congress will need to understand these issues as it evaluates the options presented by the review committee and any decision by the Administration on the future course of the nation's spaceflight program.

\$3 Billion Increase

In establishing scenarios that reflected increases in budget, characterized in the summary report as a "Less Constrained" budget, it is not clear why the \$3 billion figure was

chosen. No factual basis can be ascertained from the summary report for why \$3 billion is the appropriate amount rather than some other amount. Furthermore, to make meaningful comparisons, Congress will need to know whether the \$3 billion is phased similarly across all applicable options, how mission capabilities funded by the increase differ relative to one another, and what the review committee assumed the annual increases would be to reach the \$3 billion level by FY 2014.

V. Background

In January 2004, President George W. Bush introduced a Vision for Space Exploration that would:

- *“Implement a sustained and affordable human and robotic program to explore the solar system and beyond;*
- *Extend 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 U.S. scientific, security, and economic interests.”*

According to the Bush initiative, the goals would be achieved through retiring the Space Shuttle as soon as the International Space Station is completed, using the ISS to support exploration goals, carrying out human and robotic lunar exploration activities to enable science and exploration goals, and developing a new crew exploration vehicle to support missions beyond low-Earth orbit (with an operational capability to be demonstrated no later than 2014).

Congress authorized the space exploration initiative in two authorization laws, the NASA Authorization Act of 2005 (P.L. 109-155) and the NASA Authorization Act of 2008 (P.L. 110-422). (Attachment A provides the Authorization language.) In addition, the 2008 Authorization Act authorized an additional \$1 billion to accelerate development of the Ares I crew launch vehicle and the Orion crew exploration vehicle. Ares I and Orion are part of the Constellation Program, which also includes development an Ares V heavy-lift vehicle needed to carry a lunar lander beyond low-Earth orbit that would dock with Orion and transport the crew and cargo to the Moon and other potential destinations. The 2008 Act also directed that the Administrator *“take all necessary steps to ensure that the International Space Station remains a viable and productive facility capable of potential United States utilization through at least 2020...”*

Although NASA was directed by the President to carry out the plan, the Bush Administration did not request a budget adequate to implement the Vision for Space Exploration while also maintaining a balanced portfolio of science and aeronautics programs, returning the Shuttle to flight following the Columbia accident, and

completing the International Space Station. Attachment B depicts the mismatch between the original budget estimates required for NASA to implement the Vision and the Administration budget requests.

According to information that NASA provided to the Subcommittee on Space and Aeronautics in May 2009, NASA's Exploration Systems Architecture Study (ESAS), which formed the basis of the Constellation Program, assumed a total of about \$34.4 billion would be required for the program through 2013. According to NASA, funding for Constellation from the FY 2007 President's Budget Request through the FY 2009 President's Budget Request covering a period of FY 2006-FY2013 averaged about \$31.8 billion. The FY 2009 President's budget request for Constellation through 2013 is about \$2.6 billion less than what ESAS' funding projection for Constellation, according to NASA. In addition, the budget analyses presented by review committee members at the last meeting held on August 12, 2009, state that the President's FY10 budget submittal "*significantly reduces planned funding available to the Constellation program; More than \$1.5B (FY09) per year starting in FY13.*"

In 2009, President Obama signed into law, the American Recovery and Reinvestment Act of 2009 (P.L.111-5), which appropriated \$1 billion in Recovery Act funds for NASA. Of that total, \$400 million was provided for NASA's exploration activities. In his statement to the Subcommittee on Commerce, Justice, Science and Related Agencies on April 29, 2009, NASA Acting Administrator Scolese testified that NASA has allocated \$250M of the exploration Recovery Act funds to Constellation Systems and the remaining \$150M to Commercial Crew and Cargo. On August 10, 2009, NASA announced a request for proposals and its plans to use \$50 million of Recovery Act funds "*for the development of commercial crew space transportation concepts and enabling activities*".

With its release of the top-line FY 2010 budget request for NASA in February 2009, the Administration, cited several highlights, including "*a robust program of space exploration involving humans and robots*", "*return Americans to the Moon by 2020*", "*safe flight of the Shuttle through the vehicle's retirement at the end of 2010*", "*the development of new space flight systems for carrying American crews and supplies to space*", and the "*continued use of the International Space Station*", among other objectives.

Later, with the release of the full, detailed FY2010 budget request for NASA in May 2009, the Administration "*announced the launch of an independent review of NASA's human space flight activities*" and the summary report of that effort is the focus of today's hearing. The FY 2010 budget proposal reduced outyear projections for the Constellation Program by roughly \$3.7 billion from that projected in the FY 2009 budget proposal for the FY 2011-FY 2013 period. The FY 2010 budget request also stated that "*Following the human spaceflight review, the Administration will provide an updated request for Exploration activities reflecting the review's results.*" The FY 2010 budget request retained the goal of returning humans to the Moon by 2020, despite the fact that the request would reduce funding for work on lunar related activities required to reach that goal. The FY 2010 budget request for the Ares V Cargo Launch Vehicle (\$25

million) and its runout budget for FY 2011 through FY 2014 (\$100 million total) is insufficient to initiate full scale development of the heavy-lift launch vehicle that is designed to support exploration missions beyond low Earth orbit. In addition, the five-year budget plan contains no significant funding for the Altair lunar lander. A summary of the President's FY 2010 request for NASA is provided as Attachment C.

In its appropriation bill for FY 2010, H.R. 2847, as discussed in the House Commerce, Justice, Science, and Related Agencies Appropriations Bill, 2010, Report 111-149, the House Appropriations Committee provided appropriations for NASA's exploration program at a level \$212 million less than that of the FY 2009 enacted budget and \$670 million less than the President's FY2010 request for NASA's exploration programs. In his statement for the House consideration of H.R. 2847, Subcommittee Chairman Mollahan said: *"Funds are provided in this bill to continue investments in human spaceflight at the level of last year. Reductions from the budget request should not be viewed by this body as any diminution of certainly my support or the Committee's support in NASA's human spaceflight activities. Rather, it is a deferral. It is a deferral taken without prejudice. It is a pause. It is a timeout. Call it what you will, it is an opportunity for the President to establish his vision for human space exploration looking at the Augustine report when it becomes available in August, and then for his administration to consider what their vision will be, and then most importantly, certainly for the Committee, Mr. Chairman, to come forward with a realistic future funding scheme for the human space exploration program. We hope it is a vision worthy of the program, and we look forward to realistic funding levels, which we have never had, or haven't had for many, many years, for human spaceflight."*

The Senate Departments of Commerce, Justice, Science, and Related Agencies Appropriations Bill, 2010, Report 111-34, stated the following:

"Review of U.S. Human Space Flight Plans.—The Committee directs that NASA shall not use the operating plan or reprogramming process as the method of implementing the recommendations of the review. The opportunity for directing a well constructed and thoughtful approach to manned space flight should be as a budget amendment to the 2010 budget request that is received in a manner that is timely for consideration by the Committee, or as part of the 2011 budget request.

Ares I and Orion.—The Committee provides the full budget request of \$1,415,400,000 for Ares I, the new Crew Launch Vehicle, and \$1,383,500,000 for Orion, the Crew Exploration Vehicle.

Ares V.—The Committee believes that the Ares V cargo launch vehicle will be a critical national asset for carrying exploration and scientific payloads beyond low-Earth orbit to the Moon and beyond. To facilitate the earliest possible start of the development of the Ares V, the Committee recommends a funding level of \$100,000,000."

Status of Constellation Program

The Constellation Program, including the Ares I crew launch vehicle and the Orion crew exploration vehicle, the Altair Lunar Lander, and the Ares V launch vehicle, has

continued its work during the course of the human space flight review, as directed by the Administration. However, as a result of the review, NASA officials reported that contracts for initial work on the Ares V vehicle—the heavy lift launcher planned to ferry the lunar lander to the Moon—were put on hold pending the results of the Review of U.S. Human Space Flight Plans.

At the time the Administration released the FY 2010 budget request for NASA, the Constellation Program had completed most major procurements, undertaken hardware design, development and test activities, constructed key facilities, completed initial reviews for ground and mission operations, continued preparation for the first flight test of the Ares rocket (Ares I-X), which is scheduled for the end of October 2009, and continued work in preparation for a test of the Orion Pad Abort system. In September 2008, the Ares I rocket passed the preliminary design review, a key milestone that assesses the vehicle's design to ensure its safety, reliability, and alignment with NASA's requirements. In November 2008, the J-2X engine, which is designed to be used as the upper stage of the Ares I and the Earth departure stage of the Ares V launch vehicles passed the critical design review allowing it to proceed to fabrication and full-testing of the engine. On September 10, 2009, the 5-segment rocket motor that will be used on the Ares I rocket was successfully test-fired. In addition, on September 1, 2009, NASA announced the successful completion of the preliminary design review for Orion.

As of early September 2009, NASA reported that \$7.7 billion has been spent on the Constellation Program, of which \$3.1 billion has been spent on Orion and approximately \$3 billion on Ares I. The remainder has been spent on ground and program integration, space suit development, and other activities. According to NASA, the projected budget for Ares I and Orion through 2015 is \$35 billion.

Status of Space Shuttle Program

The Space Shuttle Program is now entering its 28th year of service. Three orbiters are now left to carry out the remaining launch schedule of 6 flights, all to the International Space Station. These flights will be providing the remaining nodes, experiments, and spare parts which will enable the station to be utilized as a U.S. National Laboratory. The Space Shuttle is slated to be retired in 2010, with the last flight currently scheduled for September 2010. The FY 2009 budget for the program is \$2.98 billion and the FY 2010 budget request is \$3.15 billion. The Shuttle program will be completely unfunded by FY 2012, according to the President's FY 2010 request.

International Space Station Program

The International Space Station (ISS)'s partners include the United States, nations of the European Space Agency, Russia, Japan, and Canada. The first module of the Station was developed by Russia and placed into orbit in 1998. Shortly thereafter, in 1998, the U.S. launched its first module, which was attached to the Russian node. Since that time, U.S., Russian, European, and Japanese modules, among many other systems, instruments, and equipment have been delivered and assembled as part of the ISS. The Station has been crewed since the year 2000. During the first eight years of ISS operations, scientific

research has helped lead “*advances in the fight against food poisoning, new methods for delivering medicine to cancer cells, and better materials for future spacecraft*”, according to a September 2009 NASA release, announcing publication of a NASA report, “International Space Station Science Research Accomplishments During the Assembly Years: An Analysis of Results from 200-2008.” In 2009, the size of the crew doubled from three to six persons, enabling additional crew time to be available for research activities. In its current configuration, NASA characterizes the ISS as 83 percent complete. Six Shuttle flights are manifested to complete the assembly of the Station, which is currently planned to be operated and utilized through 2015. According to NASA, the U.S. has invested approximately \$44 billion in the ISS, while combined investment of the U.S. and its partners is valued at over \$54 billion.

Historical Trends of Federal Government Spending on NASA

According to historical budgetary data, NASA’s annual budget authority, on average between FY 1976 and FY 2008, was 0.80 percent of the total federal budgetary authority. For Fiscal Year 2009, NASA’s percent of the total federal budget authority is estimated to be 0.43, its lowest in over three decades. The total federal budgetary authority in FY 2010 is estimated to be \$3.42 trillion. If one applies the average percentage of total annual budgetary authority for NASA through FY 2008 (.80 percent) to the estimated total budgetary authority for Fiscal Year 2010, the NASA funding level would be \$27.5 billion [Versus the FY 2010 request of \$18.7 billion].

In terms of discretionary budget authority, on average between FY1976 and FY2008, NASA’s total budget authority was 2.07 percent of total federal discretionary budget authority. According to the President’s budget request, total federal discretionary budget authority in FY 2010 is estimated to be \$1.24 trillion. Applying the 2.07 percent historical average of discretionary budget authority for NASA to the \$1.24 estimated total federal discretionary budget authority for FY 2010 would result in a NASA funding level of \$25.8 billion.

Previous Studies and Reviews of Human Space Flight and Exploration

There have been numerous studies and reviews of potential directions and goals for the nation’s human and robotic exploration program dating back to the early years of the space program, including the report of a 1969 Space Task Group, *The Post-Apollo Space Program: Directions for the Future*,” chaired by Vice President Spiro Agnew to the 1990 *Report of the Presidential Commission on the Space Shuttle Challenger Accident* (aka the Rogers Commission report), the “90-Day” study that accompanied President George H. W. Bush’s Space Exploration Initiative, and the 1990 Synthesis Group report that studied ideas relevant to accomplishing the Space Exploration Initiative, and the report of the Advisory Committee on the Future of the U.S. Space Program, chaired by Norman Augustine. Those reports appear to be consistent in highlighting the importance of a direction for the nation’s human exploration activities beyond low-Earth orbit. The Columbia Accident Investigation Board (CAIB), which issued its report in 2003, also called attention to the lack of a program for exploration beyond low-Earth orbit when it said: “*Review committees...have suggested that the primary justification for a space*

station is to conduct the research required to plan missions to Mars and/or other distant destinations. However, human travel to destinations beyond Earth orbit has not been adopted as a national objective.” Then, in 2004, President George W. Bush announced the Vision for Space Exploration (VSE) referenced earlier in this charter.

Attachment A

NASA Authorization Acts of 2005 and 2008 Provisions Related to the Exploration Initiative

P.L. 109-155, NASA Authorization Act of 2005

(b) VISION FOR SPACE EXPLORATION.—

(1) IN GENERAL.—The Administrator shall establish a program to develop a sustained human presence on the Moon, including a robust precursor program, to promote exploration, science, commerce, and United States preeminence in space, and as a stepping-stone to future exploration of Mars and other destinations. The Administrator is further authorized to develop and conduct appropriate international collaborations in pursuit of these goals.

(2) MILESTONES.—The Administrator shall manage human space flight programs to strive to achieve the following milestones (in conformity with section 503)—

(A) Returning Americans to the Moon no later than 2020.

(B) Launching the Crew Exploration Vehicle as close to 2010 as possible.

(C) Increasing knowledge of the impacts of long duration stays in space on the human body using the most appropriate facilities available, including the ISS.

(D) Enabling humans to land on and return from Mars and other destinations on a timetable that is technically and fiscally possible.

P.L. 110-422, NASA Authorization Act of 2008

SEC. 2. FINDINGS.

...

(7) Human and robotic exploration of the solar system will be a significant long-term undertaking of humanity in the 21st century and beyond, and it is in the national interest that the United States should assume a leadership role in a cooperative international exploration initiative.

(8) Developing United States human space flight capabilities to allow independent American access to the International Space Station, and to explore beyond low Earth orbit, is a strategically important national imperative, and all prudent steps should thus be taken to bring the Orion Crew Exploration Vehicle and Ares I Crew Launch Vehicle to full operational capability as soon as possible and to ensure the effective development of a United States heavy lift launch capability for missions beyond low Earth orbit.

...

(10) NASA should make a sustained commitment to a robust long-term technology development activity. Such investments represent the critically important “seed corn” on

which NASA's ability to carry out challenging and productive missions in the future will depend.

(11) NASA, through its pursuit of challenging and relevant activities, can provide an important stimulus to the next generation to pursue careers in science, technology, engineering, and mathematics.

(12) Commercial activities have substantially contributed to the strength of both the United States space program and the national economy, and the development of a healthy and robust United States commercial space sector should continue to be encouraged.

SEC. 401. SENSE OF CONGRESS.

It is the sense of Congress that the President of the United States should invite America's friends and allies to participate in a long-term international initiative under the leadership of the United States to expand human and robotic presence into the solar system, including the exploration and utilization of the Moon, near Earth asteroids, Lagrangian points, and eventually Mars and its moons, among other exploration and utilization goals. When appropriate, the United States should lead confidence building measures that advance the long-term initiative for international cooperation.

SEC. 402. REAFFIRMATION OF EXPLORATION POLICY.

Congress hereby affirms its support for—

- (1) the broad goals of the space exploration policy of the United States, including the eventual return to and exploration of the Moon and other destinations in the solar system and the important national imperative of independent access to space;*
- (2) the development of technologies and operational approaches that will enable a sustainable long-term program of human and robotic exploration of the solar system;*
- (3) activity related to Mars exploration, particularly for the development and testing of technologies and mission concepts needed for eventual consideration of optional mission architectures, pursuant to future authority to proceed with the consideration and implementation of such architectures; and*
- (4) international participation and cooperation, as well as commercial involvement in space exploration activities.*

SEC. 403. STEPPING STONE APPROACH TO EXPLORATION.

In order to maximize the cost-effectiveness of the long-term exploration and utilization activities of the United States, the Administrator shall take all necessary steps, including engaging international partners, to ensure that activities in its lunar exploration program shall be designed and implemented in a manner that gives strong consideration to how those activities might also help meet the requirements of future exploration and utilization activities beyond the Moon. The timetable of the lunar phase of the long-term international exploration initiative shall be determined by the availability of funding. However, once an exploration related project enters its development phase, the Administrator shall seek, to the maximum extent practicable, to complete that project without undue delays.

SEC. 404. LUNAR OUTPOST.

(a) *ESTABLISHMENT.*—As NASA works toward the establishment of a lunar outpost, NASA shall make no plans that would require a lunar outpost to be occupied to maintain its viability. Any such outpost shall be operable as a human-tended facility capable of remote or autonomous operation for extended periods.

(b) *DESIGNATION.*—The United States portion of the first human-tended outpost established on the surface of the Moon shall be designated the ‘Neil A. Armstrong Lunar Outpost’. (c) *SENSE OF CONGRESS.*—It is the sense of Congress that NASA should make use of commercial services to the maximum extent practicable in support of its lunar outpost activities.

SEC. 405. EXPLORATION TECHNOLOGY DEVELOPMENT.

(a) *IN GENERAL.*—A robust program of long-term exploration related technology research and development will be essential for the success and sustainability of any enduring initiative of human and robotic exploration of the solar system.

(b) *ESTABLISHMENT.*—The Administrator shall carry out a program of long-term exploration-related technology research and development, including such things as in-space propulsion, power systems, life support, and advanced avionics, that is not tied to specific flight projects. The program shall have the funding goal of ensuring that the technology research and development can be completed in a timely manner in order to support the safe, successful, and sustainable exploration of the solar system. In addition, in order to ensure that the broadest range of innovative concepts and technologies are captured, the long-term technology program shall have the goal of having a significant portion of its funding available for external grants and contracts with universities, research institutions, and industry.

SEC. 406. EXPLORATION RISK MITIGATION PLAN.

(a) *PLAN.*—The Administrator shall prepare a plan that identifies and prioritizes the human and technical risks that will need to be addressed in carrying out human exploration beyond low Earth orbit and the research and development activities required to address those risks. The plan shall address the role of the International Space Station in exploration risk mitigation and include a detailed description of the specific steps being taken to utilize the International Space Station for that purpose.

(b) *REPORT.*—The Administrator shall transmit to the Committee on Science and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate the plan described in subsection (a) not later than one year after the date of enactment of this Act.

SEC. 407. EXPLORATION CREW RESCUE.

In order to maximize the ability to rescue astronauts whose space vehicles have become disabled, the Administrator shall enter into discussions with the appropriate representatives of spacefaring nations who have or plan to have crew transportation systems capable of orbital flight or flight beyond low Earth orbit for the purpose of agreeing on a common docking system standard.

SEC. 408. PARTICIPATORY EXPLORATION.

(a) IN GENERAL.—The Administrator shall develop a technology plan to enable dissemination of information to the public to allow the public to experience missions to the Moon, Mars, or other bodies within our solar system by leveraging advanced exploration technologies. The plan shall identify opportunities to leverage technologies in NASA’s Constellation systems that deliver a rich, multimedia experience to the public, and that facilitate participation by the public, the private sector, nongovernmental organizations, and international partners. Technologies for collecting high-definition video, 3-dimensional images, and scientific data, along with the means to rapidly deliver this content through extended high bandwidth communications networks, shall be considered as part of this plan. It shall include a review of high bandwidth radio and laser communications, high-definition video, stereo imagery, 3-dimensional scene cameras, and Internet routers in space, from orbit, and on the lunar surface. The plan shall also consider secondary cargo capability for technology validation and science mission opportunities. In addition, the plan shall identify opportunities to develop and demonstrate these technologies on the International Space Station and robotic missions to the Moon, Mars, and other solar system bodies. As part of the technology plan, the Administrator shall examine the feasibility of having NASA enter into contracts and other agreements with appropriate public, private sector, and international partners to broadcast electronically, including via the Internet, images and multimedia records delivered from its missions in space to the public, and shall identify issues associated with such contracts and other agreements. In any such contracts and other agreements, NASA shall adhere to a transparent bidding process to award such contracts and other agreements, pursuant to United States law. As part of this plan, the Administrator shall include estimates of associated costs.

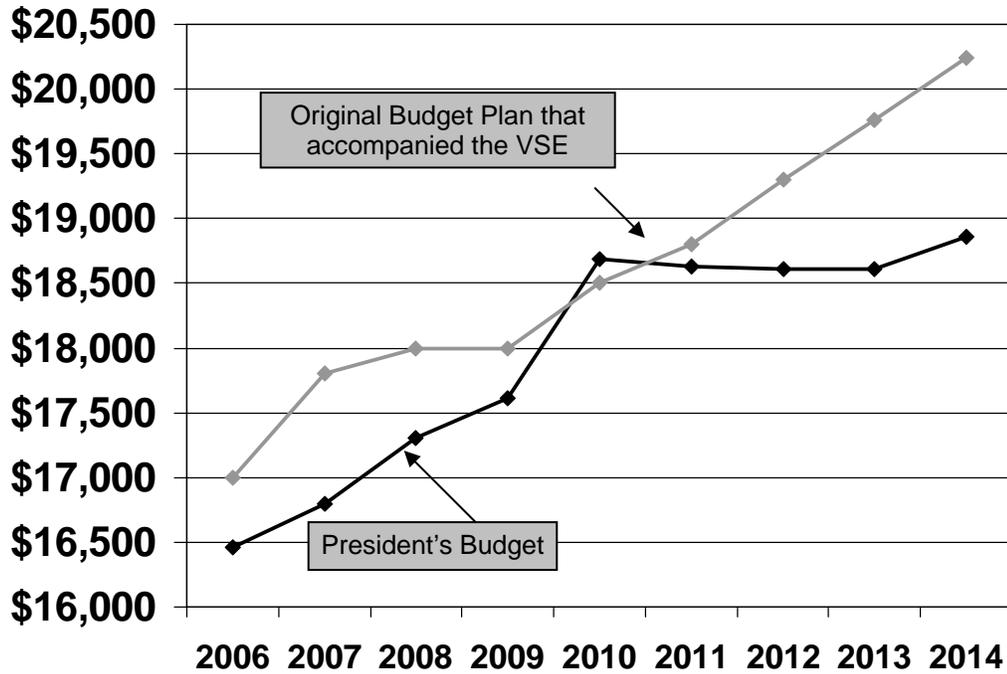
(b) REPORT.—Not later than 270 days after the date of enactment of this Act, the Administrator shall submit the plan to the Committee on Science and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate.

SEC. 409. SCIENCE AND EXPLORATION.

It is the sense of Congress that NASA’s scientific and human exploration activities are synergistic; science enables exploration and human exploration enables science. The Congress encourages the Administrator to coordinate, where practical, NASA’s science and exploration activities with the goal of maximizing the success of human exploration initiatives and furthering our understanding of the Universe that we explore.

Attachment B

Comparison of Budget Plan that accompanied the VSE (Vision for Space Exploration) in 2004
with actual/planned President's Budget Requests for NASA
(in millions of dollars)



Attachment C

NASA's FY 2010 Budget Request

Budget Authority (\$M)	FY 2008	FY 2009	Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
Science	4,733.2	4,503.0	400.0	4,477.2	4,747.4	4,890.9	5,069.0	5,185.4
Earth Science	1,237.4	1,379.6	325.0	1,405.0	1,500.0	1,550.0	1,600.0	1,650.0
Planetary Science	1,312.6	1,325.6		1,346.2	1,500.6	1,577.7	1,600.0	1,633.2
Astrophysics	1,395.6	1,206.2	75.0	1,120.9	1,074.1	1,042.7	1,126.3	1,139.6
Heliophysics	787.6	591.6		605.0	672.6	720.5	742.7	762.6
Aeronautics	511.4	500.0	150.0	507.0	514.0	521.0	529.0	536.0
Exploration	3,299.4	3,505.5	400.0	3,963.1*	6,076.6*	6,028.5*	5,966.5*	6,195.3*
Constellation Systems	2,675.9	3,033.1	400.0	3,505.4	5,543.3	5,472.0	5,407.6	5,602.6
Advanced Capabilities	623.5	472.3		457.7	533.3	556.5	558.9	592.7
Space Operations	5,427.2	5,764.7	0.0	6,175.6	3,663.8	3,485.3	3,318.6	3,154.8
Space Shuttle	3,295.4	2,981.7		3,157.1	382.8	87.8	0.0	0.0
International Space Station	1,685.5	2,060.2		2,267.0	2,548.2	2,651.6	2,568.9	2,405.9
Space and Flight Support (SFS)	446.2	722.8		751.5	732.7	745.9	749.7	748.9
Education	146.8	169.2	0.0	126.1	123.8	123.8	123.8	125.5
Cross-Agency Support	3,251.4	3,306.4	50.0	3,400.6	3,468.4	3,525.7	3,561.4	3,621.4
Center Management and Operations	2,011.7	2,024.0		2,084.0	2,119.2	2,142.5	2,166.1	2,189.9
Agency Management and Operations	834.1	921.2		961.2	956.9	964.5	972.3	981.5
Institutional Investments	325.5	293.7	50.0	355.4	392.3	418.7	423.0	450.0
Congressionally Directed Items	80.0	67.5		0.0	0.0	0.0	0.0	0.0
Inspector General	32.6	33.6	2.0	36.4	37.0	37.8	38.7	39.6
NASA FY 2010	17,401.9	17,782.4	1,002.0	18,686.0	18,631.0	18,613.0	18,607.0	18,858.0
<i>Year to Year Change</i>		2.2%		5.1%	-0.3%	-0.1%	0.0%	1.3%

*Following the human spaceflight review, the Administration will provide an updated request for Exploration activities reflecting the review's results.

Attachment D

Members of the Review of U.S. Human Space Flight Plans Committee

- Norman Augustine (chair), retired chairman and CEO, Lockheed Martin Corp., and former member of the President's Council of Advisors on Science and Technology under Presidents Bill Clinton and George W. Bush
- Dr. Wanda Austin, president and CEO, The Aerospace Corp.
- Bohdan Bejmuk, chair, Constellation program Standing Review Board, and former manager of the Boeing Space Shuttle and Sea Launch programs
- Dr. Leroy Chiao, former astronaut, former International Space Station commander and engineering consultant
- Dr. Christopher Chyba, professor of Astrophysical Sciences and International Affairs, Princeton University, and member, President's Council of Advisors on Science and Technology
- Dr. Edward Crawley, Ford Professor of Engineering at MIT and co-chair, NASA Exploration Technology Development Program Review Committee
- Jeffrey Greason, co-founder and CEO, XCOR Aerospace, and vice-chair, Personal Spaceflight Federation
- Dr. Charles Kennel, chair, National Academies Space Studies Board, and director and professor emeritus, Scripps Institution of Oceanography, University of California, San Diego
- Retired Air Force Gen. Lester Lyles, chair, National Academies Committee on the Rationale and Goals of the U.S. Civil Space Program, former Air Force vice chief of staff and former commander of the Air Force Materiel Command
- Dr. Sally Ride, former astronaut, first American woman in space, CEO of Sally Ride Science and professor emerita at the University of California, San Diego

Attachment E

**Statements to the Review of U.S. Human Space Flight Plans Committee
By Chairman Gordon and Ranking Member Hall
Committee on Science and Technology
U.S. House of Representatives**

Statement to the Review of U.S. Human Space Flight Plans Committee

**Hon. Bart Gordon
Chairman, Committee on Science and Technology
U.S. House of Representatives**

July 17, 2009

Thank you for the opportunity to submit this statement. I regret that I was unable to participate in your June 17th meeting due to prior congressional commitments, and I look forward to meeting with you in person at a later date if you are interested in doing so.

You have asked for a congressional perspective on the human spaceflight-related policies of the NASA Authorization Acts of 2005 and 2008 [P.L. 109-155 and P.L. 110-422, respectively]. I think that the most appropriate way to view the human spaceflight-related provisions of both Acts is in the context of the overall goals of the legislation, namely, to promote a balanced and robust program of space and aeronautics initiatives at the National Aeronautics and Space Administration and to authorize funding levels commensurate with the tasks that NASA is being asked to undertake. It was the consensus of Congress in its consideration of those Acts that human space flight and exploration is an important component of a balanced NASA portfolio, as well as being in the national interest for geopolitical, technological, scientific, and inspirational reasons. In that regard, I would quote Finding #1 of P.L. 110-422: *“NASA is and should remain a multimission agency with a balanced and robust set of core missions in science, aeronautics, and human space flight and exploration.”*

With respect to human space flight and exploration, both the 2005 and 2008 Authorization Acts represent a congressional consensus on the importance of completing the International Space Station [ISS] and ensuring its productive utilization in support of research and development activities required for exploration beyond low Earth orbit, as well as basic and applied R&D that could have terrestrial benefits. With respect to the question of what the operational lifetime of the ISS should be, Congress states the following in Section 601 of the NASA Authorization Act of 2008:

“(a) In General.—The Administrator shall take all necessary steps to ensure that the International Space Station remains a viable and productive facility capable of potential United States utilization through at least 2020 and shall take no steps that would preclude its continued operation and utilization by the United States after 2015.”

In addition, Sec. 601(b) emphasizes the importance of effective utilization of the ISS by directing that the NASA Administrator submit *“...a plan to support the operations and utilization of the International Space Station beyond fiscal year 2015 for*

a period of not less than 5 years.” Thus, while Congress does not explicitly mandate the continuation of the ISS program past 2015 in P.L. 110-422, I believe that the aforementioned provisions reflect a congressional consensus that the productive utilization of the ISS is an important national goal, and the ISS program should not be constrained to an arbitrary termination date.

That said, Congress recognizes that productive operation and utilization of the ISS will be challenging once the Space Shuttle is retired following the completion of its flight manifest. While Congress is very supportive of NASA’s plans to use commercial cargo resupply services once they are developed, Congress also wants NASA to have contingency arrangements in place, including international partner resupply capabilities, so that the nation’s utilization of the ISS is not jeopardized. Thus, Sec. 603 of P.L. 110-422 includes a provision that states:

“The Administrator shall develop a plan and arrangements, including use of International Space Station international partner cargo resupply capabilities, to ensure the continued viability and productivity of the International Space Station in the event that United States commercial cargo resupply services are not available during any extended period after the date that the Space Shuttle is retired.”

One of the great accomplishments—and strengths—of the International Space Station program has been the durable international partnership that has developed over the program’s lifetime, and we believe that anything that can be done by the partnership to increase the post-Shuttle resiliency of the ISS should be encouraged.

It is an unfortunate policy failure that there will be a gap between the retirement of the Space Shuttle and commencement of operations of the follow-on Constellation space transportation system. However, at this point there do not appear to be really good options available that would obviate such a gap. Congress in the NASA Authorization Act of 2008 makes clear that it considers the most appropriate approach to be development of the follow-on Constellation systems as soon as possible with the goal of providing a system that can both service the ISS until other capabilities become available and support human exploration beyond low Earth orbit. As is stated in Finding #8 of P.L. 110-422:

“Developing United States human space flight capabilities to allow independent American access to the International Space Station, and to explore beyond low Earth orbit, is a strategically important national imperative, and all prudent steps should thus be taken to bring the Orion Crew Exploration Vehicle and Ares I Crew Launch Vehicle to full operational capability as soon as possible and to ensure the effective development of a United States heavy lift launch capability for missions beyond low Earth orbit.”

In support of that position, Congress authorizes an additional \$1 billion dollars in P.L. 110-422 above the President’s FY 2009 request to accelerate the initial operating

capability of the Orion Crew Exploration Vehicle and Ares I Crew Launch Vehicle. Congress is committed to the success of those development projects and wants to ensure that they are brought to operational status in an effective and efficient manner. I thus believe that the threshold for any decision to deviate from the projects of record at this point in their development should be high, e.g., major technical feasibility issues, prohibitive cost growth/schedule delays, or unacceptable safety risk.

It is important to note that both the 2005 and 2008 Authorization Acts make clear that Congress does not view the primary objective of the human space flight program to be just having the capability for Americans to access low Earth orbit, or the two pieces of legislation would not place the emphasis that they do on developing systems to support human missions *beyond* low Earth orbit, as referenced in both the above-mentioned sections and in Title IV of P.L. 110-422. Thus, if it is determined that adjustments are required to the Constellation program of record, priority should be given to timely development of a transportation capability for enabling human missions to the Moon and other destinations beyond low Earth orbit and for ensuring NASA's ability to access the ISS as needed.

Furthermore, while Sec. 902 of P.L. 110-422 seeks to stimulate the development of a commercial crew transportation capability in the United States, the congressional motivation for development of such a capability was not elimination of the post-Shuttle "gap" over the near term—there was no consensus on that matter when the legislation was being considered by Congress. In addition, Congress is quite clear in Sec. 902(b) of the Act as to the relative priority to be given to federal support of a commercial crew initiative versus funding for NASA's Constellation program:

“(b) Congressional Intent.—It is the intent of Congress that funding for the program described in subsection (a)(4) [i.e., COTS crewed vehicle demonstration program] shall not come at the expense of full funding of the amounts authorized under section 101(3)(A), and for future fiscal years, for Orion Crew Exploration Vehicle development, Ares I Crew Launch Vehicle development, or International Space Station cargo delivery.”

It is clear from the NASA Authorization Acts of 2005 and 2008 that a durable congressional consensus has been achieved on goals and objectives for the nation's human and robotic exploration of the solar system, as well as on the overall approach to be taken. That is a significant accomplishment, and I would hope that your panel will resist the temptation to propose major departures from that hard-won consensus. It should be noted that Congress's direction for the nation's exploration initiative is consistent with the broad goals and objectives of President Bush's Vision for Space Exploration, a Vision that unfortunately was not accompanied by resources sufficient to realize it as originally articulated without doing damage to other important NASA missions.

The congressional consensus on exploration is summarized by the following provisions from P.L. 110-422:

Finding #7 “Human and robotic exploration of the solar system will be a significant long term undertaking of humanity in the 21st century, and it is in the national interest that the United States should assume a leadership role in a cooperative international exploration initiative.”

The legislation elaborates on that Finding in Sections 401 and 402 of the Act:

Sec. 401: “It is the sense of Congress that the President of the United States should invite America’s friends and allies to participate in a long-term international initiative under the leadership of the United States to expand human and robotic presence into the solar system, including the exploration and utilization of the Moon, near Earth asteroids, Lagrangian points, and eventually Mars and its moons, among other exploration and utilization goals. When appropriate, the United States should lead confidence building measures that advance the long-term initiative for international cooperation.”

Sec. 402: “Congress hereby affirms its support for—

- (1) the broad goals of the space exploration policy of the United States, including the eventual return to and exploration of the Moon and other destinations in the solar system and the important national imperative of independent access to space;*
- (2) the development of technologies and operational approaches that will enable a sustainable long-term program of human and robotic exploration of the solar system;*
- (3) activity related to Mars exploration, particularly for the development and testing of technologies and mission concepts needed for eventual consideration of optimal mission architectures, pursuant to future authority to proceed with the consideration and implementation of such architectures; and*
- (4) international participation and cooperation, as well as commercial involvement in space exploration activities.*

With respect to the implementation of the nation’s exploration initiative, both the 2005 and 2008 NASA Authorization Acts emphasize the importance of the Moon as a stepping stone for exploration as well as a potential venue for utilization activities. In that regard, Section 403 of P.L. 110-422 states:

“In order to maximize the cost-effectiveness of the long-term exploration and utilization activities of the United States, the Administrator shall take all necessary steps, including engaging international partners, to ensure that activities in its lunar exploration program shall be designed and implemented in a manner that gives strong consideration to how those activities might also help meet the requirements of future exploration and utilization activities beyond the Moon. The timetable of the lunar phase of the long-term international exploration initiative shall be determined by the availability of funding. However,

once an exploration-related project enters its development phase, the Administrator shall seek, to the maximum extent practicable, to complete that project without undue delays.”

In addition, while Congress is on record in the 2005 NASA Authorization in support of development of a sustained U.S. human presence on the Moon, Congress wants to maintain flexibility and resiliency with respect to the nation’s lunar activities. Thus Section 404(a) of P.L. 110-422 states:

“As NASA works toward the establishment of a lunar outpost, NASA shall make no plans that would require a lunar outpost to be occupied to maintain its viability. Any such outpost shall be operable as a human-tended facility capable of remote or autonomous operation for extended periods.”

While there are a number of other important provisions related to human space flight and exploration contained in the NASA Authorization Acts of 2005 and 2008, I will not dwell on them here and instead would refer you to those Acts. However, among them are four considerations that I would highlight that Congress believes need attention in the nation’s conduct of its human exploration initiative. First, as Section 405 of the 2008 Act concludes: *“A robust program of long-term exploration-related research and development will be essential for the success and sustainability of any enduring initiative of human and robotic exploration of the solar system.”* Such non-flight project-specific technology development activities have withered at NASA and need to be revitalized. They should be viewed as intrinsic to NASA’s exploration effort and its mission as a cutting-edge R&D agency, and they should be robustly funded.

Second, Congress believes that a well-executed exploration program can have significant inspirational and educational benefits. However, the public needs to become engaged for those benefits to be realized. Section 408 [*“Participatory Exploration”*] of P.L. 110-422 represents an initial attempt by Congress to encourage increased public engagement in the nation’s human and robotic exploration activities by leveraging technologies in the Constellation systems that can deliver a rich multimedia experience to the public. In addition, Congress believes that the ISS can provide additional opportunities for educational outreach.

Third, Congress believes that NASA should coordinate, where practical, its science and exploration activities to capture the synergies between them. The goal of the coordination should be to maximize the success of the human exploration initiative *and* to further our understanding of the universe.

Fourth, one of the broad benefits to the nation of a robust exploration program can be the engagement and encouragement of the commercial sector to the extent practicable. NASA is already undertaking initiatives in that regard in its overall human space flight program, but Congress is encouraging NASA to also look for opportunities to support its planned activities beyond low Earth orbit, such as with respect to the lunar outpost.

In conclusion, there now exists a broad congressional consensus on appropriate goals, objectives, and implementation strategies for NASA's human space flight and exploration activities, as reflected in the NASA Authorization Acts of 2005 and 2008. It is now time to ensure that all appropriate steps are taken to maximize the probability of success in achieving those goals and objectives through the projects that are currently under development. That will require a steadfastness of purpose, and I am encouraged that Congress has achieved a durable consensus that I hope will be matched by the Administration once your review has been completed. It will also require resource commitments commensurate with the tasks that the nation is asking NASA to undertake—we should not pretend that such challenging goals can be achieved “on the cheap”. That approach has already been tried, and it has been proved wanting. I hope that your review will provide a clear understanding of what will be required if America is to retain its leadership in human space flight by undertaking the challenging initiatives called out in the NASA Authorization Acts of 2005 and 2008.

I would be happy to discuss any of these matters in further detail if you would like to do so.

STATEMENT OF
THE HONORABLE RALPH HALL (R-TX)
Ranking Member, U.S. House Committee on Science and Technology
U.S. Human Space Flight Plans Committee
Wednesday, June 17, 2009
Carnegie Institution for Science

I want to thank the members of this Committee for the important work you are doing on behalf of our Nation. I also want to thank you for the opportunity to share my views on the human spaceflight-related policies of the NASA Authorization Acts of 2005 and 2008 (P.L. 109-155 and P.L. 110-422 respectively). The views expressed here are primarily mine but I know they are shared by a number of my colleagues.

America must be the Preeminent Space-faring Nation

I think it is important to note that the first Authorization Act of 2005 (P.L. 109-155) was the product of a Republican-led Congress and the second Authorization Act in 2008 (P.L. 110-422) was the product of a Democratically-led Congress. Yet, in both cases the intent was the same, to enable NASA to succeed on its current path toward completion of the International Space Station, utilize the Station to carry out world-class research, retire the Space Shuttle after completing its remaining flights without the constraint of a predetermined date, and develop a new launch system capable of taking humans beyond low-Earth orbit – a feat the shuttle cannot do – for the first time since the 1970s. In both of our Authorizations we allocated more money than the Administration requested because in our opinion NASA was being asked to do too much with too little. I am concerned that we cannot continue to be the preeminent space-faring nation without adequate Administration support and appropriate funding.

One of the most important issues facing NASA, and indeed our nation, is the impending retirement of the Space Shuttle, and the subsequent five year gap in independent U.S. access to the \$100 billion International Space Station. With the NASA Authorization Act of 2005, Congress endorsed the development of the new spacecraft and launch vehicles (and I stress launch vehicles plural) with the goal of launching the new system “as close to 2010 as possible.”

In the NASA Authorization Act of 2008 Congress established the new system as a priority by stating, “Developing United States human spaceflight capabilities to allow independent American access to the International Space Station, and to explore beyond low-Earth orbit, is a *strategically important national imperative* (emphasis added), and all prudent steps should thus be taken to bring the Orion Crew Exploration Vehicle and Ares 1 Crew Launch Vehicle to full operational capability as soon as possible, and to ensure the effective development of a U.S. heavy-lift launch capability for missions beyond low Earth orbit.” As a result, the Act sought to accelerate the development of the new system by authorizing an additional \$1 billion in FY09.

Looking longer term we are very concerned that the current budget request has eliminated funding for the Ares 5 heavy-lift launcher, and the Altair Lunar Lander, without which America is unable to explore beyond low-Earth orbit.

The NASA Authorization Act of 2008 also recognized the Space Shuttle's critical role in completing and utilizing the International Space Station, and added one additional mission, if it could be done safely, to deliver the Alpha Magnetic Spectrometer (AMS). As Authorizers, we are concerned that NASA may be unable to complete the remaining Shuttle missions, including the AMS flight, before the end of 2010. Unless the Administration and the Congress provide funds commensurate with extension, the Agency could be forced to take resources away from the development of Orion and Ares, adding delays that could further jeopardize the 2015 availability, and contribute to further losses of our highly-skilled aerospace workforce.

I, along with many of my colleagues, am not in favor of excessive government spending. But in this time of economic turmoil and growing international technological competitiveness, many of us are in agreement that America's space program is well-established on a path that, if sustained, will ensure our role as the world leader in space exploration and exploitation for decades to come. By pursuing human spaceflight we challenge our industry and inspire America to dream big and succeed. That is what leadership is all about.

Other countries recognize the strategic importance of the soft power we gained in the world through our audacious leadership in human space flight. The political and technological stature America has earned through our space program is now sought by other nations eager to demonstrate their hard-won capabilities to the world. The International Space Station in orbit today is a remarkable achievement, bringing together the scientific and engineering talents, and resources of many nations. That achievement would not have been possible without American leadership. But such leadership is built on trust that we will keep our commitments to our international partners. If we continue to under-fund our space program we risk losing the international trust and credibility that is vital for long term success.

Today, nearly 70 percent of the world's population was not alive to see Neil Armstrong walk on the Moon. Their opinions will be shaped by what happens in the future, not what happened in the past. We should not be in a race with China or any other country. We are the preeminent leader in space. But leadership is temporary. We should ensure that we take the necessary actions to remain the leader in human space flight.

I want to thank the committee once again for this opportunity to share our minority views.