

CHALLENGES AND OPPORTUNITIES IN THE NASA FISCAL YEAR 2011 BUDGET PROPOSAL

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION

UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

FEBRUARY 24, 2010

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ONE HUNDRED ELEVENTH CONGRESS

SECOND SESSION

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CHALLENGES AND OPPORTUNITIES IN THE NASA FISCAL YEAR 2011 BUDGET PROPOSAL

WEDNESDAY, FEBRUARY 24, 2010

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 2:36 p.m. in room SR-253, Russell Senate Office Building, Hon. Bill Nelson, Chairman of the Subcommittee, presiding.

OPENING STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Senator NELSON. The meeting will come to order.

Thank you all for being here. We have an important subject to discuss this afternoon.

Senator Vitter, thanks. Thanks for being here.

I'm going to make some opening comments. Senator Vitter will, as well. And then we'll hear from the first panel, which is General Bolden, and then we will invite up our second panel.

We have had quite a discussion about the future of our Nation's space program, and it all started with the new Administration impaneling a very prestigious blue ribbon panel, the Augustine Commission, headed by a former space expert and former CEO, Norm Augustine. And after that—it was such a comprehensive report—many of us urged the White House, as they started to develop their budget, to fund NASA at the level that the Augustine Commission said. Essentially, if you wanted to have a robust space program, other than the existing budget, you would have to have a fairly significant increase in funding.

Well, the White House decided a significant increase in funding, that they would recommend to the Congress—\$6 billion over 5 years—and that, in this budgetary environment, is no small matter. But, it was only half of what the Augustine Commission was recommending. And over and over, as I shared with the White House staff and with the President as well, that there's only one person that can lead the space program, and that is the President, and that the President—who I know, personally, to be a space fan, a space aficionado—would have to make that declaration of support.

And what happened was that, instead of a declaration of support, the NASA budget, which has a lot of very forward-thinking and cutting-edge ideas were rolled out just as part of the regular budgetary message. In the process, it ended up, in some cases, being

misinterpreted, in other cases, giving a false impression, and in other cases, became overlooked as part of the President's budget.

Now, there's a lot that's good in this budget, from this Senator's perspective. We're seeing increases in aeronautics and science and Earth observation. The extension of the International Space Station at least to the year 2020 was an obvious one, but, heretofore, NASA budgets said that the funding for the ISS was going to cutoff in 2015. And there is, in this budget, an emphasis on encouraging science and technology, engineering and math, and that is especially important.

But, here's the problem. Because the President did not make the declaration himself, and with the declaration that the Constellation program was going to be terminated, and with the angst that is already out there among the NASA family because of the layoffs that are anticipated—anticipated because of budgetary decisions that were made 6 and 7 years ago so that a new rocket was not ready by the time that the Space Shuttle was shut down and, therefore, there were going to be layoffs—you add the angst to a statement that the Constellation program is going to be killed, and add to that that it was rolled out in a budget message without the President declaring it, and what did it give? It gave the perception that the President was killing the manned space program.

Now, the problem is that we live in the world of perception, and if the substance is different from the perception, then we've got to straighten it out. And where the perception is substance, if we disagree with the substance, then we have to change it.

And so, I remind you that the President proposes and the Congress disposes. And so, what we're going to start, in the process of understanding the NASA budget that is presented by the Administration—and, in the process, we hope—and this is just a first step—to clear up the perception so that the clear declaration of the President's vision for space is there, and that the American people understand it. And the President, either himself or through his Administration—through his Administrator—needs to clearly state what the goal is.

Now, it's pretty obvious that the goal that we all have talked about for some period of time, since we went to the Moon over 40 years ago, is to go to Mars. The question is, "How do we do that? How do we develop the architecture, the technology, the way stations, the benchmarks? How do we do that?"

And so, we should develop the technology in pursuit of that goal, not the other way around, that you develop technology and then you set a goal. As the saying goes, "No wind is a good wind unless you know where the harbor is." Or, as that great American philosopher stated—Yogi Berra—"You've got to be very careful if you don't know where you're going, because you might not get there."

The hope is that we could provide more efficient access to low-Earth orbit while freeing NASA to explore the heavens—the Moon, the asteroids, Mars. But, this budget doesn't hold up the second half of that bargain, because by eliminating the plans for a heavy lift vehicle and a spacecraft capable of excursions below low-Earth orbit, the U.S., this Senator fears, is going to be on the sidelines while other countries continue to make incremental progress toward destinations like the Moon.

So, what I am hopeful for is—from the President, the White House, or someone—that we are going to get a bold statement of vision and a declaration of the ultimate destination of our space program, and that is Mars. And that vision should support manned spaceflight beyond low-Earth orbit, and that destination should be on the horizon. And then we can develop the technology for getting to that destination.

And once the President has made his vision abundantly clear, it should then be left to the NASA Administrator, working with the Congress, to make the detailed and technical decisions with the funding that we would assist NASA by authorizing and appropriating, in order to achieve that vision. And it's in that spirit that this Senator thinks that we need the continued testing of a booster as a technology testbed, a robust heavy-lift vehicle program and the continued development of spacecraft for the missions beyond low-Earth orbit. And we should accomplish these things in concert with some of the other more positive items that are in this proposed Administration's budget.

Technology research and development is well supported in this budget by advancing technologies such as the on-orbit refueling, the aerocapture techniques, the energy from space, and in-space propulsion. It will enable more efficient, safer, and faster missions throughout the solar system. But, the effort should focus on technologies which make simply getting off the pad easier.

And one of the concerns I have, Mr. Administrator, that I will ask you about, is, as you break down your budget, you've got about \$7.8 billion over 5 years for developing technologies, and you've got 3.1—less than half that amount—\$3.1 billion over 5 years for the development of heavy lift. And in your remarks, I would appreciate it if you would explain that, because we ought to be doing both at the same time, and we have to get lift to get up and do these technology developments like on-orbit refueling.

If you recall the giant Saturn V rocket that carried the folks to the Moon, it was powered by those massive F-1 engines capable of producing over a million and a half pounds of thrust. Well, we've not had an engine of its capability in nearly four decades, and it's time that we initiate a program to develop a new, modern, liquid hydrocarbon engine that can power future launch vehicles. And we're going to have testimony from someone who knows something about propulsion technology—Captain Gibson—in a few minutes.

This effort will serve to mature technologies, which will benefit not only our civil space program, but our national security space enterprise, and the commercial sector, as well.

Now, on the commercial sector, I clearly support the vision of eventually passing to them the responsibility of going to and from LEO, but, until that time, there are a bunch of us that have three concerns:

First, we need to ensure that we're not putting all of our eggs in one basket. And we can avoid this by ensuring that we have multiple competitors from both established and entrepreneurial companies competing with not only new, innovative designs, but with proven vehicles, as well. And so, that competition will ensure, as it moves forward—and some of the inevitable problems arise—that we will have some solid winners.

And my second concern is that the shift to commercial spaceflight cannot come at the expense of astronaut safety. I bring to this committee today the shared concerns of Senator Mikulski and Senator Shelby, our two counterparts on the Appropriations Subcommittee, particularly with regard to safety. And the three of us have talked about this. And so, as these companies compete, they should expect to be held to the standards equal to those of existing government programs for human safety. And I also urge NASA to do its part by providing the commercial sector with the human rating standards to which the commercial sector must adhere, and to give them those standards as soon as possible.

And third, we simply must do right by the men and women who have made this space program great. We're entering a period of transition. There's a great deal of angst out there. We're at risk of losing skills and the corporate knowledge of those workers, and that knowledge having been acquired over five decades. And if the entrepreneurial endeavors are to receive billions of dollars in the years ahead, I encourage them to remember the responsibility that comes with that funding when they're making workforce decisions.

And so, Mr. Commercial Operators, I'm putting you on notice that, as you start to ramp up, you've got to look at this incredible talented workforce that may be out of a job. This is a time of great change and challenge for our existing workforce, and the commercial sector ought to be aware of this.

Now, it is clear that this budget carries forward the decision to retire the Shuttle fleet by the end of this year, a decision that was made in the previous administration. A significant upheaval in this workforce related to the Shuttle retirement is going to occur. But, the massive loss of jobs is now exacerbated by the perception of the cancellation of Constellation and all the programs under it. And so, by continuing with certain R&D elements, such as testing of a test vehicle, of R&D for heavy lift, and the development of vehicles for deep space travel, we can put the workforce to greater use during this time of transition.

And so, today's hearing is going to allow us to start a critical examination of this budget request and to formulating an appropriate congressional response. Again, I can tell you that I have never seen the appropriators and the authorizers unified, as we are.

And with that, let me stop, and let me turn to my Ranking Member, Senator Vitter.

**STATEMENT OF HON. DAVID VITTER,
U.S. SENATOR FROM LOUISIANA**

Senator VITTER. Thank you very much, Mr. Chairman.

And thanks, to all our witnesses, starting with Administrator Bolden.

I'm just sorry, quite frankly, in terms of this hearing, that we're not going to hear from those who I suspect are the true lead architects of this very radical budget proposal, including Deputy Administrator Garver, and I'd ask, Mr. Chairman, that we continue this discussion and specifically hear from her and/or others who claim true original authorship of this, so we can question them directly.

Let me say, as a sidenote, there has been wide speculation that, at some point in this Administration, the Deputy Administrator

would be up for the Administrator's leadership position, and I can tell you, based on this budget, I will be a strong, fierce, and active opponent of that, should that be proposed.

You can tell I'm a little bit concerned about this budget, so let me explain why by focusing on five points:

First, I absolutely believe that this budget and the vision it represents would end our human spaceflight program as we know it and would surrender, at least for our lifetime, perhaps forever, our world leadership in the area. In so doing, I believe we would lose all of the enormous benefits of the technological advances that go along with all of that.

Second, I believe it does this because it cancels all major existing human spaceflight programs, not only ending Shuttle, but completely canceling its replacement, the Constellation program, and replaces it with little more than a hope and a prayer that commercial providers will eventually pick up the slack. I don't think there is any realistic hope that can be done on a reasonable timeline. I'd also point out that this radical vision, this radical departure from all previous NASA plans under any administration, bears no relation to anything laid out clearly in the Augustine Commission reports, so I'm not really sure why we went through that whole exercise.

Third, I believe this budget, as the Chairman very correctly noted, is a budget without a mission. Our greatest accomplishments in human spaceflight were gained because President Kennedy said, "We will land a man on the Moon and return him safely to Earth by the end of this decade." President Kennedy didn't say, "We're going to spend several billion dollars and do some really neat R&D." He said, "We're going to land a man on the Moon. We're going to return him safely to Earth within this decade." It's a big difference. And the mission this budget lays out is more like my second statement, which is no mission at all. You don't accomplish great things without a clearly defined mission, and this budget has no clearly defined mission.

Fourth, what does this do to the employment gap that we've all said we're very concerned about, including you, Mr. Administrator? I'll tell you what it does to it. In terms of employment within the entire industry, in my opinion, it absolutely expands the gap. I don't believe there's any possibility that we will be able to ramp up, depending on the commercial sector alone, in less time than our previous Constellation plans laid out. So, it increases that gap. I can't tell you how many years, but it increases it.

In terms of the gap, regarding the NASA family—the folks within NASA, within NASA programs like Constellation—it increases the gap. It increases the gap to infinity. It says, "There's no gap anymore; we just fall off a cliff." And I think that is enormously detrimental to the NASA family and the long-term capability of NASA.

Fifth, I want to focus on that wonderful workforce. Those folks have been very, very patient, waiting for the signal from this Administration, particularly concerning the next generation and the gap. Well, I'm afraid they just got it, and the message they have heard—not because of perception, but because of reality—the message they have heard loud and clear is what I just said. Their gap

didn't just expand, their gap expanded to infinity if this budget were passed.

And all I say to that is, I certainly want to offer a completely different message. I will fight, with every ounce of energy I have, to defeat this budget or anything like it, to fundamentally change it. I want to give the NASA family out there some hope of doing that. I believe there is great bipartisan support for that effort, as Senator Nelson laid out, including folks on this committee and including folks on the appropriate appropriations subcommittee.

So, those are my comments. I look forward to our discussion.

[The prepared statement of Senator Vitter follows:]

PREPARED STATEMENT OF HON. DAVID B. VITTER, U.S. SENATOR FROM LOUISIANA

I want to thank the Chairman for scheduling this important hearing. NASA is at a critical stage in its history and I believe that, because of the Administration's proposed radical new direction for NASA contained in this budget, the very lifeblood and continued relevance of our Nation's proud and pioneering space program hangs in the balance.

Mr. Bolden, I join my colleagues in welcoming you here today. I realize that upon becoming NASA Administrator, you inherited an agency and space program in flux and fraught with uncertainties about its future role, missions, and goals. And while I disagree wholeheartedly with the new direction you wish to take NASA in with this budget, I realize the difficulty of the position you were put in and the decisions you have to make and have no doubt that you want the best for our space program, and I thank you again for your service.

I would also like to welcome our other witnesses, Capt. Gibson, Mr. Snyder, Mr. O'Brien, and Mr. Young. I look forward to hearing your testimony and to you sharing your valuable experience and expertise on the subject of human spaceflight, and I thank all of you for taking the time to appear here before this committee today.

I continue to believe that the space program represents one of the best uses of taxpayer's dollars, because it is an investment that we can expect will return even greater value to our economy and bring scientific, medical and other benefits that can improve the lives of everyone. However, the FY 2011 Budget Request represents a radical and I believe misguided departure in the way NASA conducts space exploration, specifically in the area of human spaceflight.

The Administration's proposal to cancel the Constellation Program—after more than \$10 billion invested in its development and so soon after the recent successful test flight of the first Ares I rocket—and to rely instead solely on untested and unproven "commercial" providers with no firm timetable on when they could deliver a safe, reliable launch vehicle and crew vehicle is a most troubling development. I believe this proposed new path is both irresponsible and far too risky, and places our astronauts, our space program, and our Nation's role as the world's leader in space exploration and technological development in serious jeopardy.

I also believe that investing billions of dollars in technology development, as this budget proposes, without any clear vision, mission, or target date for achieving them is counterproductive and contrary to the way NASA has done business and been driven to reach the monumental and awe-inspiring achievements it has over the past 50 years. Furthermore, I believe that the lack of a clear mission and vision, which the Constellation Program provided, renders the proposed increase for science education funding ineffective, as I firmly believe that this proposed new path for NASA's human spaceflight program will not and cannot inspire America's youth to study and choose careers in math, engineering, and other sciences. Only a clearly defined mission and vision for our space program can provide our children with the necessary inspiration and enthusiasm to themselves reach for the stars.

The proposed new path for NASA contained in this budget also troubles me because we have a highly skilled and dedicated workforce that makes U.S. human spaceflight happen, and we must not risk losing that workforce, and seeing them forced to permanently leave the very kinds of jobs that can most directly serve to benefit the country and our economy, especially in these troubled economic times. Literally tens of thousands of jobs are on the line here, and with the impending retirement of the space shuttle, the last thing this valuable workforce could afford is the cancellation of the system designed to replace it, and the uncertainty, confusion, and frustration these hardworking Americans and their families are now enduring saddens me greatly.

We must find a better way, a better solution, a better vision with clearly defined missions and goals for our space program than the one proposed in this budget. I believe continuation and acceleration of the Constellation Program or some variant of it is one way to achieve that, along with examining additional ways we might more quickly obtain the capability to explore beyond low earth orbit, such as with the development of a shuttle-derived heavy launch vehicle. If, however, we instead accept the Administration's proposal laid out in this budget request, I have no doubt that it will lead to no less than the ruin of our proud space program that the rest of the world has admired and envied for so long.

I will have questions for the record to focus on some of these issues and concerns, and I look forward to the chance to discuss some of them, and some of the answers, with you today, Mr. Bolden, as well as with the rest of our esteemed panelists.

Thank you all again in advance for your testimony.

Senator NELSON. Well, we're going to have a chance, Senator Vitter, to perfect this budget. And that's what this process is all about.

General Bolden, you may have bit off a little more than you wanted to chew with these opening comments.

Let me just say that most everybody in this room knows Charlie Bolden and knows the extraordinary kind of leader that he is. A retired Marine major general. I shared this during the confirmation hearing, but another astronaut had said to me that Charlie Bolden was the best leader that he had ever run into and had taught him more about leadership than any other person, and that included that astronaut's experience in the Astronaut Office and his 20 years as an Air Force officer.

General Bolden is a veteran of four spaceflights. He is a graduate of the Naval Academy. He has had assignments in the Marine Corps, up until the time that he retired, that have been extraordinary assignments.

And you come well prepared to a very tough job during a very challenging time and overlaid with a very difficult budgetary environment. General Bolden, welcome to the Committee. It's an honor to have you here.

**STATEMENT OF HON. CHARLES F. BOLDEN, JR.,
ADMINISTRATOR, NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION**

General BOLDEN. Mr. Chairman, thank you very much, and members of the Subcommittee. I want to thank you for the opportunity to discuss the President's Fiscal Year 2011 budget request for NASA.

I'm grateful for the support and guidance of this subcommittee, and I look forward to working with you on enactment of the President's bold new direction for our agency.

Before I continue with my statement, let me add one thing noted as not in my prepared statement. And I do—because my deputy was, I feel, unfairly represented, I hope that we have an opportunity to go back to that discussion. And I also would like to go back to the discussion on the NASA family, because I'm a member of the NASA family, and I have been for—since 1980. So, I, too, share the passion that you express, Senator Vitter, about the NASA family and their welfare.

I want to say right upfront that I understand the Committee's concerns that details such as our justification documents have been slow to reach you. I apologize and ask your continued patience as we finalize the details of this historic change in NASA's direction.

Since the introduction of the budget, many have asked what the destination is for human spaceflight, beyond low-Earth orbit, under the President's plan. The answer, as Senator Nelson has expressed, is that our program seeks to enable the capabilities we will need for astronauts to meaningfully explore the Moon, asteroids, and eventually Mars. And Mars is which—what I believe to be the ultimate destination for human exploration in our solar system, at least under my administration.

The right investments in technology will allow us to map out a realist path to this destination that continues to inspire generations of schoolchildren, just as it inspired me many years ago, when I was growing up in Columbia, South Carolina, watching Buck Rogers go to Mars with ease each week, from my seat in the balcony of the Carolina Theater, there in Columbia.

The President's Fiscal Year 2011 budget request for NASA is \$19-point—\$19 billion, including an increase of \$276 million over the enacted 2010 level. Longer term, I am pleased that the budget commits an increased investment of \$6 billion in NASA science, aeronautics, and enabling technologies, over the next 5 years, compared with last year's plan.

All of us at NASA appreciate the President making NASA such a high priority at a time when budget realities dictate reductions and freezes for other worthwhile programs. At a time when we all worry about the economy, NASA's bold new direction will assist economic growth in the United States, particularly in the aerospace industry. One lesson from decades of technology investment by the Federal Government is that funding for research and development leads to innovative capabilities and breakthroughs which, in turn, lead to sustained private-sector job creation. Such R&D investments are a cornerstone of the public-private partnership between our government and American industry.

With the President's new vision, the NASA budget will invest much more heavily on technology research and development than recent NASA budgets. This will foster new technological approaches, standards, and capabilities that are critical to enable next-generation spaceflight, Earth-sensing and aeronautics capabilities. These investments will produce additional opportunities for U.S. industry to spur new businesses, such as recently announced partnership between NASA and General Motors, to build an advanced dexterous humanoid robot, commonly called "R2."

I want to share a few highlights about NASA's bold new path to become an engine of innovation with an ambitious new space program that includes and inspires people around the world. Under this program, the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems. We will encourage the development of commercial human spaceflight vehicles to access low-Earth orbit. We will develop new technologies that will enable more efficient U.S. human exploration into the solar system than is currently conceived.

As the Constellation program is ended in an orderly manner, I want to thank all of the NASA employees and contractors who have worked so hard on this program and given so much of their time and their heart. Their commitment has brought great value

to the agency and to our Nation, and they will continue to play a pivotal role in NASA's future path. Many of the things NASA has learned from the Constellation program will be critical as the agency moves forward.

More specifically, in Fiscal Year 2011 NASA will undertake a flagship technology development and demonstration program with our international partners, commercial, and other government entities to demonstrate critical technologies, such as in-orbit propellant transfer and storage, inflatable modules, automated/autonomous rendezvous and docking, and closed-loop life-support systems; heavy-lift research and development that will investigate a broad scope of research and development activities to support new space-launch propulsion technologies; robotic precursor missions to multiple destinations in the solar system in support of future human exploration, including missions to the Moon, Mars and its moons, Lagrange points, and nearby asteroids; significant investments for the development of commercial crew and further cargo capabilities; extension of the lifetime of the International Space Station to 2020 or beyond, in concert with our international partners; pursuit of crosscutting space technology capabilities, led by the newly established Office of the Chief Technologist, to spawn game-changing innovations to make space travel more affordable and more sustainable; climate change research and observations which will enable NASA to substantially accelerate and expand its Earth science capabilities, including a replacement for orbiting—for the Orbiting Carbon Observatory; aeronautics R&D, including critical areas of Next-Generation Air Transportation System, or NextGen; green aviation and safe integration of unmanned aircraft systems into the national aerospace system; education initiatives, including the recently announced Summer of Innovation pilot program to inspire middle school students.

Americans and people worldwide have turned to NASA for inspiration throughout our history. Our work gives people an opportunity to imagine what is barely possible. And we at NASA get, in turn—get to turn those dreams into real achievements, for all humankind, through missions we execute.

This budget gives NASA a roadmap to even more historic achievements as it spurs innovation, employs Americans in exciting jobs, and engages people around the world.

Mr. Chairman, thank you, again, for your support and that of this subcommittee. I would be pleased to respond to any questions you or the members may have.

[The prepared statement of General Bolden follows:]

PREPARED STATEMENT OF HON. CHARLES F. BOLDEN, JR., ADMINISTRATOR,
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and members of the Subcommittee, thank you for the opportunity to appear today to discuss the President's FY 2011 budget request for NASA. NASA is grateful for the support and guidance received from this committee through the years and looks forward to working with you on enactment of the President's bold new direction.

The President's FY 2011 budget request for NASA is \$19.0 billion, which represents an increase of \$276.0 million above the amount provided for the Agency in the FY 2010 Consolidated Appropriations Act (P.L. 111-117), and an increased investment of \$6.0 billion in NASA science, aeronautics, human spaceflight and enabling space technologies over the next five-years compared with last year's budget

plan. Enclosure 1 displays the details of the President's FY 2011 budget request for NASA.

Before I discuss the details of the NASA budget request, I would like to talk about the importance of NASA's direction for economic growth in the United States, particularly in the aerospace industry. One general lesson from decades of technology investment by the Federal Government is that funding for research and development leads to innovative capabilities and breakthroughs, which in turn lead to sustained private-sector job creation. Such R&D investments are a cornerstone of the public-private partnership between the Federal Government and American industry.

With the President's new direction, the NASA budget will invest much more heavily on technology R&D than recent NASA budgets, which will in turn foster new technological approaches, standards, and capabilities that are critical to enable next-generation spaceflight, Earth-sensing and aeronautics capabilities. These investments will produce additional opportunities for U.S. industry and spur new businesses. Take the case of the recently announced partnership between NASA and General Motors to build an advanced dextrous humanoid robot. This robot will help GM in its manufacturing plants and assist in NASA efforts, such as robotic assembly and repair missions.

The President's FY 2011 budget for NASA also supports critical investments in launch infrastructure and capabilities. The budget provides funds to support NASA and Air Force upgrades to the KSC/CCAFS launch complex enabling us to make the Kennedy Space Center area a 21st Century launch complex. This in time will allow us to improve launch and processing throughput and will support the flagship demonstration projects, robotic precursor missions, smaller scale demonstrations, and commercial crew vehicles that are also funded in this budget at unprecedented levels. This increased pace and diversity of launch activity should lead to future opportunities for the launch vehicle-related workforce, while also helping to enhance industry robustness over the long term.

Finally, NASA's FY 2011 budget furthers the Nation's efforts to inspire the next generation of scientists, engineers, and mathematicians. NASA's missions will seek the involvement of students, educators, and the public across the United States to inspire their interest and proficiency in science, technology, engineering and mathematics (STEM). In this way, NASA plans to help to build America's next STEM workforce.

Thus overall, I am very excited about the beneficial effect that NASA's planned activities will have on economic growth in the United States, especially in aerospace-related industries. Now let me turn to describe our budget request in some detail.

Highlights of the FY 2011 Budget Request

The President has laid out a bold new path for NASA to become an engine of innovation, with an ambitious new space program that includes and inspires people around the world. Beginning in FY 2011, the United States will pursue a more sustainable and affordable approach to human space exploration through the development of transformative technologies and systems. As the Constellation Program is ended in an orderly manner, NASA will encourage the development of commercial human spaceflight vehicles to safely access low-Earth orbit and will develop new technologies that will lay the foundation for a more exciting, efficient and robust U.S. human exploration of the solar system than we are currently capable of, while further strengthening the skills of our workforce and our Nation in challenging technology areas. NASA will also invest increased resources in climate change research and observations; aeronautics research and development (R&D), including green aviation; space technology development of benefit across the entire space sector; and education with an emphasis on Science, Technology, Engineering and Mathematics (STEM) learning.

Here is a broad outline of the FY 2011 budget plan followed by more details. In FY 2011, NASA will undertake:

- Transformative technology development and demonstrations to pursue new approaches to human spaceflight exploration with more sustainable and advanced capabilities that will allow Americans to explore the Moon, Mars and other destinations. This effort will include a flagship demonstration program, with international partners, commercial and other government entities, to demonstrate critical technologies, such as in-orbit propellant transfer and storage, inflatable modules, automated/autonomous rendezvous and docking, closed-loop life support systems, and other next-generation capabilities. It will also include projects that are smaller and shorter-duration, which will demonstrate a broad range of key technologies, including in-situ resource utilization and advanced in-space propulsion.

- Heavy-lift propulsion research and development that will investigate a broad scope of R&D activities to support next-generation space launch propulsion technologies, with the aim of reducing costs and shortening development timeframes for future heavy-lift systems for human exploration.
- Robotic precursor missions to multiple destinations in the solar system in support of future human exploration, including missions to the Moon, Mars and its moons, Lagrange points, and nearby asteroids.
- Significant investments for the development of commercial crew and further cargo capabilities, building on the successful progress in the development of commercial cargo capabilities to-date. NASA will allocate these funds through competitive solicitations that support a range of higher- and lower-programmatic risk systems and system components, such as human-rating of existing launch vehicles and development of new spacecraft that can ride on multiple launch vehicles.
- Extension of the lifetime of the International Space Station (ISS), likely to 2020 or beyond, in concert with our international partners, with investments in expanded ISS utilization through upgrades to both ground support and onboard systems and use of the ISS as a National Laboratory.
- Pursuit of cross-cutting Space Technology capabilities, led by the newly established Office of the Chief Technologist, which will fund advancements in next-generation technologies, to help improve the Nation's leadership in key research areas, enable far-term capabilities, and spawn game-changing innovations that can unlock new possibilities and make space activities more affordable and sustainable. A NASA focus on innovation and technology will enable new approaches to our current mission set and allow us to pursue entirely new missions for the Nation.
- Climate change research and observations, which will enable NASA to substantially accelerate and expand its Earth Science capabilities, including a replacement for the Orbiting Carbon Observatory, development of new satellites recommended by the National Academy of Sciences Decadal Survey, and development of smaller Venture class missions. This investment will ensure the critically important continuity of certain key climate measurements and enable new measurements to address unknowns in the climate system, yielding expanded understanding of our home planet and improved understanding of climate change.
- Aeronautics research and development, including critical areas of the Next Generation Air Transportation System, environmentally responsible aviation, and safe integration of unmanned aircraft systems into the national airspace.
- Education initiatives, including the recently announced Summer of Innovation pilot program involving NASA scientist and curricula to inspire middle-school students and their teachers with exciting experiences that spur those students to continue in STEM careers.

I wish to emphasize that NASA intends to work closely with the Congress, including this subcommittee, to make a smooth transition to the new Exploration program, called for in the President's request, working responsibly on behalf of the taxpayers. With my deepest gratitude, I commend the hard work and dedication that thousands of NASA and contractor workers have devoted to Constellation over the last several years. Their commitment has brought great value to the Agency and to our Nation, and they will continue to play a pivotal role in NASA's future path. Many of the things NASA has learned from the Constellation program will be critical as the Agency moves forward.

The following contains more detail on the summary points made above, in the standard budget order for NASA's appropriation accounts.

Science

The President's FY 2011 request for NASA includes \$5,005.6 million for Science. The NASA Science Mission Directorate (SMD) continues to expand humanity's understanding of our Earth, our Sun, the solar system and the universe with 59 science missions in operation and 30 more in various stages of development. The Science budget funds these missions as well as the research of over 3,000 scientists and their students across our Nation. The recommendations of the National Academies/National Research Council (NRC) decadal surveys help to guide SMD in setting its priorities for strategic science missions; and SMD selects competed missions and research proposals based on open competition and peer review.

The FY 2011 budget request for Science includes \$1,801.7 million for *Earth Science*. This request increases investment in Earth Science by \$1.8 billion from FY

2011 to FY 2014 compared to the FY 2010 budget, for a more aggressive response to the challenge of climate change. NASA will rapidly develop an Orbiting Carbon Observatory-2 mission for launch early in 2013 and a GRACE Follow-On mission for launch in late 2015, respectively, to initiate and extend key global climate data sets. This request accelerates several high-priority Decadal Survey missions that will advance climate research and monitoring. The increased funding accelerates launch of the Soil Moisture Active/Passive (SMAP) mission by 6 months from its estimated date at the recent Agency Key Decision Point (KDP)-B review, to November 2014. ICESAT-2 is advanced by 5 months relative to the estimated date at its recent Agency KDP-A review, to October 2015. The Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission and the Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) mission are each accelerated by 2 years, with both launching in late 2017. Thus, the budget request allows all four Tier-1 Decadal Survey missions to be launched between 2014 and 2017. In addition, NASA—working with the U.S. Global Change Research Program—will be able to identify and begin development for accelerated launch of selected Tier-2 Decadal Survey missions focused on climate change. The budget supports critical continuity of climate observations, including a Stratospheric Aerosol and Gas Experiment III (SAGE III) instrument to be developed for deployment on the ISS, while also supporting an accelerated pace of smaller “Venture class” missions. Finally, increased resources for Earth Science will allow NASA to expand key mission-enabling activities, including carbon monitoring, technology development, modeling, geodetic ground network observations, and applications development including the highly successful SERVIR program.

At present, NASA Earth-observing satellites provide the bulk of the global environmental observations used for climate change research in the United States and abroad. This year, analyses of NASA satellite measurements quantified the rates of ground water depletion since 2003 in California and in India’s Indus River valley—rates that are unsustainable for the future. NASA conducted the first ICEBridge airborne campaigns in both Arctic and the Antarctic, to maintain the critical ice measurements during the gap in time between the ICESAT-1 and -2 satellites.

In FY 2011, the Glory and Aquarius missions will launch; and FY 2011 should close with the launch of the NPOESS Preparatory Project. The Landsat Data Continuity Mission will complete spacecraft integration and test, the Operational Land Imager will be delivered, and the Thermal Infrared Sensor will continue development. The Global Precipitation Mission will complete its System Integration Review in preparation for the beginning of assembly, integration and testing. During FY 2011, the SMAP mission will transition from formulation to development, and ICESAT-2 will begin design. Also in FY 2011, instrument development and observations initiated under the first Venture class solicitation for sustained airborne missions will reach full funding, and the next Venture class solicitations will be released—this time for space-based mission instrument, and complete mission, developments. Engineering studies and focused, actively-managed technology investments—instruments, components, and information systems—continue for the suite of future missions recommended by the National Research Council (NRC) Decadal Survey. In FY 2011, the Earth Science Technology Program will make additional, competitively-selected, instrument technology investments to meet decadal survey measurement goals. Earth Science Research and Applied Sciences Programs will continue to employ satellite observations to advance the science of climate and environmental change, mitigation, and adaptation. NASA will demonstrate the use of Uninhabited Aerial Systems in field campaigns addressing atmospheric trace gas composition and hurricane genesis, and NASA’s modeling and data analysis efforts will contribute to assessment activities of the Intergovernmental Panel in Climate Change and the U.S. Global Change Research Program.

The FY 2011 budget request for Science includes \$1,485.8 million for *Planetary Science*. The current NASA planetary missions continue to make new discoveries and return fascinating images, including a previously unknown large and askew ring of Saturn and a near-complete map of the surface of Mercury. Mars continues to intrigue with signs of water ice just below the surface at mid-latitudes. The Mars rover Spirit is now an in situ science prospector, while Opportunity continues to roll toward the crater Endeavor. The Moon Mineralogy Mapper instrument on India’s Chandrayaan-1 mission detected small amounts of water and hydroxyl molecules at unexpectedly low latitudes on the lunar surface. NASA selected three new candidate mission concepts for further study under the New Frontiers program, and will select the winning concept in FY 2011 to proceed to development. NASA will issue its next Discovery Announcement of Opportunity this year, and will select mission concepts and fund concept studies in FY 2011. NASA will also begin Advanced Stirling Radioisotope Generator development in FY 2011 to be available as an option to improve

the performance of the radioisotope-fueled power sources for use in the next Discovery mission. The Mars Science Laboratory will complete development in FY 2011 for launch in fall 2011, beginning the most comprehensive astrobiology mission to the Red Planet to date. The MAVEN Mars aeronomy mission will continue development for launch in late 2013. NASA will establish a joint Mars Exploration Program with the European Space Agency (ESA) with a trace gas orbiter mission, including a European technology demonstration lander. In FY 2011, NASA plans to select instruments for the mission via a joint Announcement of Opportunity. To advance scientific exploration of the Moon, NASA will launch the GRAIL mission in late 2011 and continue development of LADEE for launch in 2013. Continuing its exploration of the outer planets, NASA will launch the Juno mission to Jupiter in August 2011. NASA will continue studies that support the possibility of a new major Outer Planets Mission concept pending the outcome of the NRC decadal survey now in progress, and will coordinate with ESA on a solicitation for science instruments. The new NRC Decadal Survey in Planetary Science should be complete in FY 2011. The FY 2011 budget request increases NASA's investment in identification and cataloging of Near Earth Objects and, with the Department of Energy, begins funding the capability to restart Plutonium-238 production here in the United States.

The FY 2011 budget request for Science includes \$1.076.3 million for *Astrophysics*. The golden age of Astrophysics from space continues, with 14 observatories in operation. Astrophysics research, technology investments, and missions aim to understand how the universe works, how galaxies, stars and planets originated and developed over cosmic time, and whether Earth-like planets—and possibly life—exist elsewhere in the cosmos. The NASA Kepler telescope has discovered five exoplanets, ranging in size from Neptune to larger than Jupiter, demonstrating that the telescope is functioning as intended; additional discoveries are anticipated in the coming months and years. NASA's newest space observatory, WISE (Wide-Field Infrared Explorer), has captured its first look at the starry sky and its sky survey in infrared light has begun. Radio astronomers have uncovered 17 millisecond pulsars in our galaxy by studying unknown high-energy sources detected by the Fermi Gamma-ray Space Telescope.

The Hubble Space Telescope is operating at its peak performance thanks to the very successful servicing mission last year by the STS-125 crew. The Herschel and Planck missions, led by the European Space Agency with NASA as a partner, launched in 2009 and are returning remarkable scientific results. In FY 2011, NASA will complete most of the development of the NuSTAR mission and prepare it for launch. NASA will also begin developing the Gravity and Extreme Magnetism (GEMS) mission recently selected in the Explorer small satellite program. The James Webb Space Telescope (JWST) continues to make good progress in development toward a 2014 launch. Flight hardware for the many JWST subsystems is being designed, manufactured and tested, including the 18 segments of its 6.5-meter primary mirror; and the mission-level Critical Design Review for JWST will occur this spring. The SOFIA airborne observatory successfully conducted its first open-door flight test in December 2009—a major milestone toward the beginning of early science operations this year. The NRC is conducting a new Decadal Survey in astronomy and astrophysics, which will set priorities among future mission concepts across the full spectrum of Astrophysics, including dark energy, gravity wave, and planet-finding missions; the “Astro2010” Decadal Survey is expected in September.

The FY 2011 budget request for Science includes \$641.9 million for *Heliophysics*. The Heliophysics operating satellites provide not only a steady stream of scientific data for the NASA research program, but also supply a significant fraction of critical space weather data used by other government agencies for support of commercial and defense activities in space. These data are used for operating satellites, optimization of power transmission networks, and supporting communications, aviation and navigation systems. The NASA Aeronomy of Ice in Mesosphere (AIM) satellite has provided the first comprehensive, global-scale view of the complex life cycle of Earth's highest clouds, Polar Mesospheric Clouds, finding clues to why they appear to be occurring at lower latitudes than ever before. The STEREO B spacecraft recently observed a sunspot behind the Sun's southeastern limb—before it could be seen from Earth. In a few days, this sunspot produced five Class M solar flares of the kind that disturb radio signals on Earth, signaling the end of the Sun's extended quiet period of recent years. The Solar Dynamic Observatory (SDO), launched on February 11, will provide images of the Sun of unprecedented resolution, yielding new understanding of the causes of solar variability and its impact on Earth. In FY 2011, the Radiation Belt Storm Probes mission will complete hardware manufacturing and begin integration and testing. The Solar Orbiter Collaboration with the European Space Agency will continue in formulation, and the Solar Probe Plus mission will undergo an initial confirmation review at the end of FY

2011. The Magnetospheric Multi-scale mission will continue development toward a Critical Design Review. IRIS, a recently selected small Explorer mission, will hold its Critical Design Review in FY 2011. The next Explorer Announcement of Opportunity will be released in 2010, with selection for Phase A studies in FY 2011. NASA is working with the NRC to arrange for the next decadal survey in Heliophysics.

Aeronautics Research

The U.S. commercial aviation enterprise is vital to the Nation's economic well-being, directly or indirectly providing nearly one million Americans with jobs. In 2008 aerospace manufacturing provided the Nation with a trade surplus of over \$57 billion. In the United States, more than 60 certified domestic carriers operate more than 28,000 flights daily, moving nearly one million travelers each day. We expect these flights to be safe, affordable, and convenient. We expect airlines to offer flights when and where we want to travel. In business and in our personal lives, the aviation industry is a key enabler to our way of life and the smooth functioning of our economy. However, the air transport system is near maximum capacity given today's procedures and equipment. Rising concerns about the environmental and noise impacts of aviation further limit future growth.

The FY 2011 budget request for Aeronautics is \$579.6 million, an increase of \$72.6 million, which will strongly support our existing portfolio of research and development to directly address these most critical needs of the Nation and enable timely development of the Next Generation Air Transportation System (NextGen). Through a balanced research and development portfolio, NASA's Aeronautics Research Mission Directorate (ARMD) is exploring early-stage innovative ideas, developing new technologies and operational procedures through foundational research, and demonstrating the potential of promising new vehicles, operations, and safety technology in relevant environments. Our goals are to expand capacity, enable fuel-efficient flight planning, reduce the overall environmental footprint of airplanes today and, in the future, reduce delays on the ground and in the sky, and improve the ability to operate in all weather conditions while maintaining the current high safety standards we demand.

The FY 2011 budget request for Aeronautics includes \$228.5 million for the *Fundamental Aeronautics Program*, which seeks to continually improve technology that can be integrated into today's state-of-the-art aircraft, while enabling game-changing new concepts such as Hybrid Wing Body (HWB) airframes which promise reduced drag (thus improving fuel burn) and open-rotor engines which offer the promise of 20 percent fuel burn reduction compared to today's best jet engines. In partnership with Boeing and the Air Force, NASA has completed over 75 flights of the X48B sub-scale HWB aircraft at Dryden Flight Research Center in the last 2 years to explore handling and control issues. NASA is partnering with General Electric and Boeing to evaluate performance and integration of new open-rotor engine concepts in propulsion wind tunnels at the Glenn Research Center. NASA is also addressing key challenges to enable new rotorcraft and supersonic aircraft, and conducting foundational research on flight at seven times the speed of sound. American Recovery and Reinvestment Act funds have enabled NASA to recommission a full-scale airframe structural test facility and to improve wind tunnels at the Langley, Ames, and Glenn Research Centers that are needed to assess new concepts that hold the promise of significant reductions in aircraft weight and fuel consumption. In partnership with industry, NASA has just initiated the first new government-funded effort on low NO_x combustors in 15 years. In FY 2011, NASA will invest \$30.0 million to design, build, and demonstrate a new generation of aircraft engine combustors that will lower the emission of harmful nitrogen oxides by 50 percent compared with current combustors while ensuring compatibility with current and future alternative aviation fuels.

A key research goal is to develop synthetic and bio-derived alternatives to the petroleum-derived fuel that all jet aircraft have used for the last 60 years, but little is known about the emissions characteristics of these alternative fuels. In 2009, NASA led a team of eight partners from government agencies, industry, and academia in measuring emissions from an aircraft parked on the ground operating on various blends of synthetic and standard jet fuel. This team discovered that synthetic fuel blends can reduce particulate emissions by as much as 75 percent compared to conventional jet fuels, which would offer a major improvement in local air quality around airports. Using results from this and other research efforts, NASA has established a publicly-available database of fuel and emissions properties for 19 different fuels and will perform similar tests on biofuels as they become available.

The FY 2011 budget request for Aeronautics includes \$82.2 million for *Airspace Systems*. The focus of this program is to achieve reductions in environmental impact

not only through new aircraft, engines, and fuels, but also through improved air traffic management procedures. Using flight data from just the top 27 airports in the country, NASA systems analysis results indicate that nearly 400 million gallons of fuel could be saved each year if aircraft could climb to and descend from their cruising altitude without interruption. Another 200 million gallons could be saved from improved routing during the cruise phase of flight. Achievement of such operations requires that aircraft spacing in the air and on-time arrival and departure from the regions around our major airports be greatly improved. New satellite-based navigation aids such as the ADS-B system that the Federal Aviation Administration (FAA) is installing throughout the country can enable these improvements, but safe and efficient operational procedures must first be developed, validated, and certified for operational use. In 2009, NASA partnered with FAA, United Airlines, and Air Services Australia to validate pilot and controller procedures for a new concept originally developed by NASA that enables aircraft to safely conduct climbs and descents outside radar coverage in close proximity to nearby traffic. NASA also provided safety analyses needed for regulatory approval. The procedures benefit both airlines and the traveling public by providing long-haul oceanic flight with easier access to fuel-efficient, turbulence-free altitudes. United Airlines is expected to begin flying the oceanic in-trail procedures on revenue flights in May 2011.

The FY 2011 budget request for Aeronautics includes \$113.1 million for the *Integrated Systems Research Program*. Begun in FY 2010, this program evaluates and selects the most promising “environmentally friendly” engine and airframe concepts emerging from our foundational research programs for integration at the systems level. In FY 2011, the program will test integrated systems in relevant environments to demonstrate that the combined benefits of these new concepts are in fact greater than the sum of their individual parts. Similarly, we are integrating and evaluating new operational concepts through real-world tests and virtual simulations. These efforts will facilitate the transition of new capabilities to manufacturers, airlines and the FAA, for the ultimate benefit of the flying public. In addition to strongly supporting our ongoing research portfolio, the FY 2011 budget request includes increased funding to expand our research in new priority areas identified through close consultation with industry, academia and other Federal agencies. In FY 2011, NASA will initiate a \$30 million targeted effort to address operational and safety issues related to the integration of unmanned aircraft systems into the National Airspace System and augment research and technology development efforts by \$20 million, including grants and cooperative agreements, to support NASA’s environmentally responsible aviation research.

The FY 2011 budget request for Aeronautics includes \$79.3 million for the *Aviation Safety Program*. This program conducts research to insure that aircraft and operational procedures maintain the high level of safety which the American public has come to count on. Safety issues span aircraft operations, air traffic procedures, and environmental hazards and this program is supporting research and delivering results in all three areas. American carriers operate 6,500 aircraft on more than 28,000 flights daily. For most of the day the FAA is controlling more than 4,000 aircraft in the sky at the same time. Further increases in capacity will require increased levels of automation for command and control functions and to analyze vast amounts of data, as well as increased complexity of the overall system. It now costs more to prove today’s flight-critical systems are safe than it does to design and build them. The Joint Planning and Development Office has identified Verification and Validation (V&V) of aviation flight-critical hardware and software systems as one of the major capability gaps in NextGen. Therefore in FY 2011, NASA is initiating a new \$20 million research activity in V&V of aviation flight-critical systems to develop methodologies and concepts to effectively test, validate and certify software-based systems that will perform reliably, securely, and safely as intended.

NASA will continue to tackle difficult issues that threaten the safety of commercial flight, ranging from human/machine interaction to external hazards such as weather and icing, as the aircraft industry has come to rely on NASA expertise in predicting the effects of icing on aircraft performance at low and intermediate altitudes. However, over the last 10 years a new form of icing problem has surfaced, occurring primarily in equatorial regions at high cruise altitudes and causing engine power loss or flameout. These conditions cannot be duplicated in any existing ground test facility. To study this problem, in 2009 NASA initiated an effort to modify the Propulsion Systems Laboratory at the Glenn Research Center to enable research on ways to mitigate the effects of high-altitude icing and development of new engine certification procedures.

The FY 2011 budget request for Aeronautics includes \$76.4 million for the *Aeronautics Test Program (ATP)*, which makes strategic investments to ensure availability of national ground facilities and flight assets to meet the testing needs of

NASA and the Nation. The program also invests in the development of new test instrumentation and test technologies. One such example is ATP's collaboration with the Aviation Safety Program to provide a new testing capability in the NASA-Glenn PSL facility to address the threat of high-altitude ice crystals to jet engine operability. The program recently demonstrated for the first time the ability to generate ice crystals at the very cold temperatures (-60°F) encountered at commercial aircraft cruise altitudes. The PSL high-altitude ice crystal capability will become operational in FY 2011. The program also completed the development of a new Strategic Plan to provide the vision and leadership required to meet national goals; provide sustained support for workforce, capability improvements, and test technology development; and provide strategic planning, management, and coordination with NASA, government, and industry stakeholders. This plan will provide informed guidance as ATP develops a critical decision tool for building well-coordinated national testing capabilities in collaboration with the Department of Defense through the National Partnership for Aeronautical Testing (NPAT).

Partnerships with industry, academia, and other Federal agencies are critical to the success and relevance of NASA research. Through close collaboration, NASA ensures that it works on the right challenges and improving the transition of research results to users. NASA is using NASA/FAA Research Transition Teams (RTTs) to conduct joint research and field-trials to speed acceptance of new air traffic management procedures. The Agency is also coordinating management and operation of the Federal Government's large aeronautics ground test infrastructure through the NPAT. Through NASA Research Announcements (NRAs), NASA solicits new and innovative ideas from industry and academia while providing support for Science, Technology, Engineering, and Math departments. The Agency also funds undergraduate and graduate scholarships, Innovation in Aeronautics Instruction grants to improve teaching programs at the university level, and sponsor student design competitions at undergraduate and graduate levels for both U.S. and international entrants. By directly connecting students with NASA researchers and our industrial partners we become a stronger research organization while inspiring students to choose a career in the aerospace industry.

Exploration

The FY 2011 budget request for Exploration is \$4,263.4 million, an increase of \$483.6 million above the FY 2010 enacted level. Included in this budget request is funding for three new, robust programs that will expand the capabilities of future space explorers far beyond those we have today. NASA will embark on these transformative initiatives by partnering with the best in industry, academia and other government agencies, as well as with our international partners. These partners have been integral to much of NASA's previous success and are vital to our bold new vision.

NASA will encourage active public participation in our new exploration missions via a new participatory exploration initiative. Additionally, the FY 2011 budget request builds upon NASA's commercial cargo efforts by providing significant funding for the development of commercial human spaceflight vehicles, freeing NASA to focus on the forward-leaning work we need to accomplish for beyond-LEO missions. The FY 2011 budget request is a 40 percent increase over last year's investment in the Human Research Program, to help prepare for future human spaceflight exploration beyond low-Earth orbit. Last, the Exploration FY 2011 budget request includes funding for the Constellation Program close-out activities spread across FY 2011 and FY 2012.

In the near term, NASA is continuing Constellation work to ensure an orderly closeout of the program in FY 2011 and to capture of all of the knowledge learned through its key efforts. The Constellation Program is focusing on completing its Preliminary Design Review (PDR), which will conclude this year. NASA believes that completing the Constellation PDR will support not only the close-out process for Constellation, but also will ensure that historical data from Constellation work is documented, preserved and made accessible to future designers of other next-generation U.S. human spaceflight systems.

The Exploration FY 2011 budget request includes three new robust research and development programs that will enable a renewed and reinvigorated effort for future crewed missions beyond low-Earth orbit:

- *Technology Development and Demonstration Program:* \$652.4 million is requested in FY 2011, and a total of \$7,800.0 million is included in the 5-year budget plan, to invent and demonstrate large-scale technologies and capabilities that are critical to future space exploration, including cryofluid management and transfer technologies; rendezvous and docking technologies; and closed-loop

life support systems. These technologies are essential to making future exploration missions more capable, flexible, and affordable.

- *Heavy-Lift and Propulsion Research and Development Program*: \$559.0 million is requested in FY 2011, and a total of \$3,100.0 million is included in the five-year budget plan, for an aggressive, new heavy-lift and propulsion R&D program that will focus on development of new engines, propellants, materials and combustion processes that would increase our heavy-lift and other space propulsion capabilities and significantly lower operations costs—with the clear goal of taking us farther and faster into space consistent with safety and mission success.
- *Robotic Exploration Precursor Program*: \$125.0 million is requested in FY 2011, and \$3,000.0 million is included in the five-year budget plan, for robotic missions that will pave the way for later human exploration of the Moon, Mars and nearby asteroids. Like the highly successful Lunar Reconnaissance Orbiter and Lunar Crater Observation and Sensing Satellite missions that captured our attention last fall, future exploration precursor missions will scout locations and demonstrate technologies to locate the most interesting places to explore with humans and validate potential approaches to get them there safely and sustainably.

Cross-agency teams for each of these three areas are working to develop plans that delineate key areas for research and development, specify milestones for progress and set launch dates for relevant missions. They will report to the Administrator over the coming months, and the results of their efforts will be shared with the Congress when they are complete.

The Exploration FY 2011 budget request for *Commercial Spaceflight* is \$812.0 million, which includes \$500.0 million to spur the development of U.S. commercial human spaceflight vehicles, and a total of \$6 billion in the five-year budget plan. This investment funds NASA to contract with industry to provide astronaut transportation to the International Space Station as soon as possible, reducing the risk of relying solely on foreign crew transports, and frees up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration. We also believe it will help to make space travel more accessible and more affordable. An enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities and energy in this area, and spawn other businesses and commercial opportunities, which will spur growth in our Nation's economy. And, a new generation of Americans will be inspired by these commercial ventures and the opportunities they will provide for additional visits to space. NASA plans to allocate this FY 2011 funding via competitive solicitations that support a range of activities such as human-rating existing launch vehicles and developing new crew spacecraft that can ride on multiple launch vehicles. NASA will ensure that all commercial systems meet stringent human-rating and safety requirements before we allow any NASA crew member (including NASA contractors and NASA-sponsored International partners) to travel aboard a commercial vehicle on a NASA mission. Safety is, and always will be, NASA's first core value.

In addition to the \$500 million identified for crew transportation development efforts, the budget also includes \$312.0 million in FY 2011 for incentivizing NASA's current commercial cargo program. These funds—by adding or accelerating the achievement of already-planned milestones, and adding capabilities or tests—aim to expedite the pace of development of cargo flights to the ISS and improve program robustness.

Today, NASA is using \$50.0 million from the American Recovery and Reinvestment Act of 2009 to help drive the beginnings of a commercial crew transportation industry. Through an open competition, in early February, NASA awarded Space Act Agreements to five companies who proposed ideas and concepts intended to make commercial crew services a reality. While there are many vibrant companies out there that we hope to partner with in the future, these five companies, along with our two currently funded Commercial Orbital Transportation Services partners (Space Exploration Technologies and Orbital Sciences Corporation) are at the forefront of a grand new era in space exploration.

The Exploration FY 2011 budget request includes \$215.0 million for the *Human Research Program*, an increase of more than 40 percent over the FY 2010 enacted level, and an investment of \$1,075 million over the five-year budget plan. The Human Research Program is a critical element of the NASA human spaceflight program in that it develops and validates technologies that serve to reduce medical risks associated for crew members.

The Exploration FY 2011 budget request includes \$1,900.0 million for *Constellation Closeout* requirements, and a total of \$2,500.0 million over the FY 2011–2012

timeframe. These funds will be used for related facility and close-out costs, potentially including increased costs for Shuttle transition and retirement due to Constellation cancellation. The Agency has established senior planning teams to outline options for Constellation close out expeditiously and thoughtfully and to assess workforce, procurement and other issues, which will report to the Administrator over the coming months, to ensure that people and facilities are best utilized to meet the needs of NASA's new missions. NASA will work closely with the Congress as these activities progress.

NASA recognizes that this change will personally affect thousands of NASA civil servants and contractors who have worked countless hours, often under difficult circumstances, to make the Constellation Program successful. I commend the investment that these dedicated Americans have made and will continue to make in our Nation's human spaceflight program. Civil servants who support Constellation should feel secure that NASA has exciting and meaningful work for them to accomplish after Constellation, and our contractor colleagues should know that NASA is working expeditiously to identify new opportunities for them to partner with the Agency on the new Exploration portfolio.

Space Technology

Through the new Space Technology Program, led by the recently established Office of the Chief Technologist, NASA will increase its support for research in advanced space systems concepts and game-changing technologies, enabling new approaches to our current mission set and allowing the pursuit of entirely new missions. Using a wide array of management, funding, and partnership mechanisms, this program will engage the brightest minds in private industry, across the NASA Centers, and throughout academia. This new program builds upon the success of NASA's Innovative Partnerships Program and directly responds to input from multiple NRC reports, as well as the Augustine Committee. The Space Technology program will meet NASA's needs for new technologies to support future NASA missions in science and exploration, as well as the needs of other government agencies and the Nation's space industry in a manner similar to the way NACA aided the early aeronautics industry. Many positive outcomes are likely from a long-term NASA advanced space systems concepts and technology development program, including a more vital and productive space future than our country has today, a means to focus NASA intellectual capital on significant national challenges and needs, a spark to renew the Nation's technology-based economy, an international symbol of our country's scientific and technological leadership, and a motivation for many of the country's best young minds to enter into educational programs and careers in engineering and science.

The FY 2011 budget request for Space Technology is \$572.2 million, and \$4,925.9 million is included in the five-year budget plan. With this initiative, NASA will expand its Technology and Innovation portfolio to include: open competitions to stimulate highly innovative, early-stage space system concepts and ideas; development of technologies that can provide game-changing innovations to address NASA and national needs; and development and infusion of cross-cutting capabilities into missions that address needs from multiple NASA Mission Directorates, other government agencies, and commercial activities in space, while fostering and stimulating a research and development culture at NASA Centers. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are transferred to Space Technology.

The need for advanced capabilities is increasing as NASA envisions missions of increasing complexity to explore and understand the Earth, our solar system, and the universe. Technology and innovation are critical to successfully accomplishing these missions in an affordable manner. The Space Technology program will enhance NASA's efforts to nurture new technologies and novel ideas that can revolutionize our aerospace industrial base, as well as to address national and global challenges and enable whole new capabilities in science and exploration that will be of benefit to the Nation. Key focus areas include communications, sensors, robotics, materials, and propulsion. The Space Technology program will use open competitions such as NASA Research Announcements and Announcements of Opportunity, targeted competitions such as those for small business (SBIR), universities (STTR), and engage early career scientists and engineers. NASA will also continue to use challenges and prizes to stimulate innovative new approaches to technology development and will encourage partnerships with both established and emerging commercial space industries. Through the three major elements of this program—Early-Stage Innovation, Game-Changing Innovation, and Crosscutting Capabilities—a broad suite of management, funding and partnership mechanisms are employed to stimulate innovation across NASA, industry and academia.

The Early-Stage Innovation program element sponsors a wide range of advanced space system concept and initial technology development efforts across academia, industry and the NASA Centers. This program element includes: (a) the Space Technology Research Grant program (analogous to the Fundamental Aeronautics program within NASA's Aeronautics Research Mission Directorate) that focuses on foundational research in advanced space systems and space technology, (b) re-establishment of a NIAC-like Program to engage innovators within and external to the Agency in accordance with the recommendations of the NRC's *Fostering Visions of the Future* report, (c) enhancement of the Innovative Partnership Programs Seed Fund into a Center Innovations Fund to stimulate aerospace creativity and innovation at the NASA field Centers, (d) NASA's SBIR/STTR program to engage small businesses, and (e) the Centennial Challenges Prize Program to address key technology needs with new sources of innovation outside the traditional aerospace community. Competitive selection is a major tenet of all the activities within this low technology readiness level (TRL) program element.

The Game Changing Innovation program element focuses on maturing advanced technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs. Responsive to the NRC report, *America's Future in Space: Aligning the Civil Space Program with National Needs*, this program element demonstrates the feasibility of early-stage ideas that have the potential to revolutionize future space missions. Fixed-duration awards are made to PI-led teams comprised of government, academia and industry partners. These awards are evaluated annually for progress against baseline milestones with the objective of maturing technologies through ground-based testing and laboratory experimentation. NASA intends to draw from DARPA's experience to create and implement collaborative game-changing space technology initiatives. New technologies considered may include advanced lightweight structures and materials, advanced propulsion, power generation, energy storage and high bandwidth communications. With a focus on such potentially revolutionary technologies, success is not expected with each investment; however, on the whole, and over time, dramatic advances in space technology enabling entirely new NASA missions and potential solutions to a wide variety of our society's grand technological challenges are anticipated.

A Crosscutting Capabilities program element matures a small number of technologies that are of benefit to multiple customers to flight readiness status. Technical risk, technology maturity, mission risk, customer interest, and proposed cost are discriminators planned for use in the selection process. For infusion purposes, proposing teams are required to have a sponsor willing to cost share a minimum of 25 percent of the planned development effort. With objectives analogous to the former New Millennium program, NASA will pursue flight demonstrations not only as standalone missions, but also as missions of opportunity on planned NASA missions as well as international and commercial space platforms. The Commercial Reusable Suborbital Research Program (which provides suborbital flight opportunities for technology demonstrations, scientific research and education), the Facilitated Access to the Space environment for Technology (FAST) project (which focuses on testing technologies on parabolic aircraft flights that can simulate microgravity and reduced gravity environments) and the Edison Small Satellite Demonstration Missions project (which develops and operates small satellite missions in partnership with academia), are also included in this program element.

NASA has had past success in the development of game-changing technologies and the transfer of its products and intellectual capital to industry. As an example, consider the Mars Pathfinder mission of the early 1990s. In addition to accomplishing its science and technology objectives, Mars Pathfinder established surface mobility and ground truth as important exploration principles, created a groundswell of interest and a foundational experience for a new generation of Mars scientists and engineers, re-engaged the public with Mars as a destination worthy of exploration, led to the creation of NASA's Mars program and establishment of a Mars program budget line, and led to a wide spectrum of small missions to Mars, the asteroids, comets and other bodies in our solar system. For NASA's robotic exploration program, Mars Pathfinder was clearly a game-changer. In a more recent example, consider NASA's recent improvements to thermal protection system (TPS) materials through an Advanced Capabilities development project. Over 3 years, a NASA-industry team raised the TRL of 8 different TPS materials from 5 different commercial vendors, eventually selecting the best as the system for the Orion heat shield. In addition to providing a heat shield material and design for Orion on time and on budget, this Advanced Capabilities development project re-invigorated a niche space industry that was in danger of collapse, re-established a NASA competency able to respond to future TPS needs. For example, the team identified a potentially catastrophic problem with the planned MSL heat shield and remedied the

problem by providing a viable alternate heat shield material and design within stringent schedule constraints. The mature heat shield material and designs have been successfully transferred to the commercial space industry, including the TPS solution for the SpaceX Dragon capsule. Beginning in FY 2011, the new NASA Space Technology program aims to strengthen and broaden these successful innovation examples across a wide range of NASA enterprises and significant national needs.

Space Operations

The FY 2011 budget request includes \$4,887.8 million for Space Operations, funding the Space Shuttle program, the International Space Station Program, and the Space and Flight Support program.

The FY 2011 budget request for the *Space Shuttle* program is \$989.1 million. In 2009, the Space Shuttle flew five times, delivering to the ISS its final set of solar arrays and the equipment needed to support a six-person permanent crew; servicing the Hubble Space Telescope; completing the assembly of the three-module Japanese Kibo science laboratory; outfitting the Station with two external payload and logistics carriers, the Materials Science Research Rack-1, the Fluid Integrated Rack, the Minus Eighty-Degree Laboratory Freezer, a treadmill, and air revitalization equipment; and, delivering key supplies.

In 2010, the Shuttle is slated to fly out its remaining four missions, including the recently completed STS-130 mission. In April, Shuttle Discovery will carry up critical supplies for the ISS using a Multi-Purpose Logistics Module (MPLM) and the Lightweight Multi-Purpose Experiment Support Structure Carrier (LMC). Atlantis will launch in May with the Russian Mini-Research Module-1, as well as the Integrated Cargo Carrier—Vertical Light Deployment (ICC-VLD). This summer, Endeavour will carry the Alpha Magnetic Spectrometer (AMS) and attach it to the Station's truss structure. The AMS is a particle physics experiment, which will use the unique environment of space to advance knowledge of the universe and contribute to understanding the universe's origin. AMS is presently undergoing critical thermal and electrical testing at the European test facilities in the Netherlands. If these tests are successful, AMS will ship to KSC in May for the July launch. The final Shuttle mission, STS-133, is targeted for September of this year. Discovery will carry supplies to ISS, as well as an MPLM that will be installed on ISS as a permanent module, expanding the Station's storage volume. This flight will mark the completion of ISS assembly.

For almost 30 years, the Space Shuttle has carried U.S. and international astronauts into orbit; played a key role in the construction, outfitting, and resupply of the ISS; serviced the Hubble Space Telescope five times; served as an Earth-orbiting laboratory through the Spacelab and SpaceHab missions; and deployed a diverse array of payloads, including science probes and research experiments (such as the Magellan mission to Venus and Earth-orbiting tether experiments), communications satellites; and even student projects. NASA recognizes the role the Space Shuttle vehicles and personnel have played in the history of space activity, and looks forward to transitioning key workforce, technology, facilities, and operational experience to a new generation of human spaceflight exploration activities.

FY 2011 will be the first full year of major Space Shuttle Program (SSP) transition and retirement (T&R) activities. T&R is focused on the retirement of the SSP and the efficient transition of assets to other uses once they are no longer needed for safe mission execution. These activities include identifying, processing, and safing hazardous materials, and the transfer or disposal of SSP assets, including the preparation of Orbiters and other flight hardware for public display. T&R also covers severance and retention costs associated with managing the drawdown of the SSP workforce.

A key element of America's future in space is the *International Space Station*. The FY 2011 budget request for the International Space Station Program is \$2,779.9 million. As of May 2009, the ISS has been able to support a six-person permanent crew, and during the STS-127 mission last July, the Station hosted 13 astronauts representing the five space agencies in the ISS partnership, including those of the United States, Russia, Japan, Europe and Canada. The three major science labs aboard ISS were completed in 2009 with the delivery of the Exposed Facility of the Japanese Kibo module. In addition, the first flight of Japan's H-II Transfer Vehicle (HTV) was successfully carried out last fall, adding a new cargo-carrying spacecraft to the fleet.

This year will mark the completion of assembly of the ISS—the largest crewed spacecraft ever assembled, measuring 243 by 356 feet, with a habitable volume of over 30,000 cubic feet and a mass of 846,000 pounds, and powered by arrays which generate over 700,000 kilowatt-hours per year. The ISS represents a unique re-

search capability aboard which the United States and its partner nations can conduct a wide variety of research in biology, chemistry, physics and engineering fields which will help us better understand how to keep astronauts healthy and productive on long-duration space missions. Funding for ISS research is also reflected in the Exploration budget request and in the Space Technology budget request.

The FY 2011 budget request includes a dramatic increase in the Nation's investment in the research and capabilities of the ISS. With this investment, NASA will be able to fully utilize the ISS and increase those capabilities through upgrades to both ground support and onboard systems. Importantly, this budget extends operations of the ISS, likely to 2020 or beyond. This budget makes a strong commitment to continued and expanded operation of the ISS. The United States as leader in space made this first step and will now work with the other ISS international partners to continue International operation of the ISS. ISS can inspire and provide a unique research platform for people worldwide.

ISS research is anticipated to have terrestrial applications in areas such as biotechnology, bioengineering, medicine and therapeutic treatment. The FY 2011 budget request for ISS reflects increased funding to support the ISS as a National Laboratory in which this latter type of research can be conducted. NASA has two MOUs with other U.S. Government agencies, and five agreements with non-government organizations to conduct research aboard the ISS. NASA intends to continue to expand the community of National Laboratory users of the ISS. This budget request supports both an increase in research and funding for cargo transportation services to deliver experiments to the Station.

ISS can also play a key role in the demonstrations and engineering research associated with exploration. Propellant storage and transfer, life support systems, and inflatable technology can all benefit by using the unique research capabilities of ISS.

In addition to supporting a variety of research and development efforts, the ISS will serve as an incubator for the growth of the low-Earth orbit space economy. NASA is counting on its Commercial Resupply Services (CRS) suppliers to carry cargo to maintain the Station. The first CRS cargo flights will begin as early as 2011. It is hoped that these capabilities, initially developed to serve Station, may find other customers as well, and encourage the development of further space capabilities and applications. The suppliers involved will gain valuable experience in the development and operation of vehicles that can: (1) fly to the ISS orbit; (2) operate in close proximity to the ISS and other docked vehicles; (3) dock to ISS; and, (4) remain docked for extended periods of time.

As a tool for expanding knowledge of the world around us; advancing technology; serving as an impetus for the development of the commercial space sector; demonstrating the feasibility of a complex, long-term, international effort; and, perhaps most importantly, inspiring the next generation to pursue careers in science, technology, engineering, and mathematics, the ISS is without equal.

The FY 2011 budget request for *Space and Flight Support* (SFS) is \$1,119.0 million. The budget request provided for critical infrastructure indispensable to the Nation's access and use of space, including Space Communications and Navigation (SCaN), the Launch Services Program (LSP), Rocket Propulsion Testing (RPT), and Human Space Flight Operations (HSFO). The SFS budget also includes a new and significant investment in the 21st Century Space Launch Complex, intended to increase operational efficiency and reduce launch costs by modernizing the Florida launch capabilities for a variety of NASA missions, which will also benefit non-NASA users.

In FY 2011, the SCaN Program will begin efforts to improve the robustness of the Deep Space Network (DSN) by initializing the replacement of the aging 70m antenna capability with the procurement of a 34m antenna. The NASA DSN is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The DSN also supports selected Earth-orbiting missions. In the third quarter, a System Requirements Review (SRR) of the Space Network Ground Segment Sustainment (SGSS) Project will be conducted, and the Program will have begun integration and testing of the Tracking and Data Relay Satellites (TDRS) K&L. In the area of technology, the Communication Navigation and Networking Reconfigurable Testbed (CoNNeCT) will be installed on ISS. This test bed will become NASA's orbiting SCaN laboratory on the ISS and will validate new flexible technology to enable greater spacecraft productivity. NASA will also have its first optical communication system ready for integration into the Lunar Atmosphere and Dust Environment Explorer (LADEE) spacecraft. In addition, the Disruption Tolerant Networking (DTN) protocols will complete their development at the end of FY 2011 and should be ready for operations throughout the solar system. The SCaN operational networks will continue to provide an unprecedented level of communica-

tions and tracking services to over 75 spacecraft and launch vehicles during FY 2011.

The LSP has six planned NASA launches in FY 2011 including Glory, Aquarius, Juno, Nuclear Spectroscopic Telescope Array (NuSTAR), NPOESS Preparatory Project (NPP) and the Gravity Recovery and Interior Laboratory (GRAIL) mission. In addition to processing, mission analysis, spacecraft integration and launch services, LSP will continue to provide support for the development and certification of emerging launch services.

The RPT Program will continue to provide test facility management, and provide maintenance, sustaining engineering, operations, and facility modernization projects necessary to keep the test-related facilities in the appropriate state of operational readiness. These facilities will support many of the tests planned under ESMD's propulsion research program.

HSFO includes Crew Health and Safety (CHS) and Space Flight Crew Operations (SFCO). SFCO will continue to provide trained crew for the manifested Space Shuttle requirements, four ISS long-duration crew rotation missions. CHS will identify and deliver necessary core medical capabilities for astronauts. In addition, CHS will gather astronaut medical data critical for determining medical risk as a result of space flight and how best to mitigate that risk.

The 21 st Century Launch Complex initiative will primarily benefit NASA's current and future operations at the Kennedy Space Center (KSC), but will also help to improve KSC launch operations for future and current non-NASA users of the range, with the goal of transforming KSC into a modern facility. This new initiative focuses on upgrades to the Florida launch range, expanding capabilities to support commercial launch providers, such as commercial cargo flights and future commercial crew flights in support of ISS, and expendable launch vehicles in support of the Science mission directorate payloads and robotic precursor missions. Additional areas under consideration include modernization activities to support safer and more efficient launch operations; enhancing payload processing capabilities through capacity increases, improvement, and modernization, in addition to potentially relocating the KSC perimeter where appropriate and feasible, to enable certain existing private sector facilities to lie outside the security perimeter, thus making it far more convenient to use those facilities; environmental remediation to reduce the impact on the surrounding areas; and supporting the modernization of the launch range capabilities. We will fully coordinate this activity with all users of the range.

Education

The FY 2011 budget request for education is \$145.8 million. This budget request furthers NASA's commitment to inspiring the next generation of explorers in the STEM disciplines. In FY 2011, NASA will continue to strongly support the Administration's STEM priorities and will continue to capitalize on the excitement of NASA's mission to stimulate innovative solutions, approaches, and tools that inspire student and educator interest and proficiency in STEM disciplines. This strategy will increase the distribution and impact of NASA progressive opportunities for elementary and secondary teachers, university faculty, students of all ages, and the public.

In FY 2011, NASA will support the Administration's STEM education teaching and learning improvement efforts, including Race to the Top and Educate to Innovate, while continuing efforts to incorporate NASA content into the STEM education initiatives of other Federal agencies. This summer, NASA will launch *Summer of Innovation*, an intensive STEM teaching and learning program targeted at the middle school level that includes follow-on activities during the school year. NASA content and products will be incorporated into evidence-based summer learning programs across participating states with the goal of improving student academic performance and motivating them to pursue further education and successful careers. The FY 2011 request includes funding for *Summer of Innovation* over a three-year period.

NASA will also continue to partner with academic institutions, professional education associations, industry, and other Government agencies to provide K-12 teachers and university faculty with the experiences that capitalize on the excitement of NASA discoveries to spark their student's interest and involvement. Examples of such experiences are the NASA student launch initiatives and other hands-on payload development and engineering opportunities. The FY 2011 budget request also places increased emphasis on Education and cyber-learning opportunities and expands teacher pre-service, professional development and training programs. Additionally, NASA seeks to prepare high school students for undergraduate STEM study through experiences that blend NASA research and engineering experiences with classroom study and mentoring. Another Agency education goal is to broaden

community college participation in NASA research and STEM workforce development.

In FY 2011, the Agency aims to increase both the use of NASA resources and the availability of opportunities to a diverse audience of educators and students, including women, minorities, and persons with disabilities. An example is the Innovations in Global Climate Change Education project that will be implemented within the Minority University Research and Education Program. The project will seek innovative approaches to providing opportunities for students and teachers to conduct research using NASA data sets to inspire achievement and improve teaching and learning in the area of global climate change.

Cross-Agency Support

NASA Cross-Agency Support provides critical mission support activities that are necessary to ensure the efficient and effective operation and administration of the Agency. These important functions align and sustain institutional and program capabilities to support NASA missions by leveraging resources to meet mission needs, establishing Agency-wide capabilities, and providing institutional checks and balances. Cross-Agency Support includes two themes: *Center Management and Operations* and *Agency Management and Operations*. The FY 2011 budget request includes \$3,310.2 million for Cross Agency Support.

NASA's FY 2011 budget request includes \$2,269.9 million for *Center Management and Operations*, which funds the critical ongoing management, operations, and maintenance of nine NASA Centers and major component facilities. NASA Centers continue to provide high-quality support and the technical talent for the execution of programs and projects.

NASA's FY 2011 budget request includes \$1,040.3 million for *Agency Management and Operations*, which funds the critical management and oversight of Agency missions, programs and functions, and performance of NASA-wide activities, including five programs: Agency Management, Safety and Mission Success, Agency Information Technology Services, and Strategic Capabilities Assets Program. Beginning in FY 2011, activities associated with the Innovative Partnerships Program are transferred to the Space Technology program. The FY 2011 budget request provides:

- \$428.1 million for *Agency Management*, which supports executive-based, Agency-level functional and administrative management requirements. Agency Management provides for the operational costs of Headquarters as an installation; institutional and management requirements for multiple Agency functions; assessment and evaluation of NASA program and mission performance; strategic planning; and independent technical assessments of Agency programs.
- \$201.6 million for *Safety and Mission Success* activities required to continue strengthening the workforce, training, and strengthening the fundamental and robust checks and balances applied on the execution of NASA's mission, and to improve the likelihood for safety and mission success for NASA's programs, projects, and operations. The engineering, safety and mission assurance, health and medical independent oversight, and technical authority components are essential to NASA's success and were established or modified in direct response to many of the key *Challenger* and *Columbia* accident board recommendations for reducing the likelihood for future accidents. Included under Safety and Mission Success is the Software Independent Verification and Validation program.
- \$177.8 million for *Agency Information Technology Services*, which encompasses cross-cutting services and initiatives in IT management, applications, and infrastructure necessary to enable the NASA Mission and improve security, integration and efficiency of Agency operations. NASA plans significant emphasis on continued implementation of five major Agency-wide procurements to achieve the following: (1) consolidation of IT networks leading to improved network management, (2) consolidation of desktop/laptop computer services and mobile devices to improve end-user services, (3) data center consolidation to provide more cost-effective services, (4) Agency public website management to improve access to NASA data and information by the public, and (5) Agency business systems development and maintenance to provide more efficient and effective business systems. NASA will also continue to improve security incident detection, response, and management through the Security Operations Center.
- \$29.8 million for the *Strategic Capabilities Assets Program* (SCAP). This program funds the costs required to sustain key Agency test capabilities and assets, such as an array of flight simulators, thermal vacuum chambers, and arc jets, to ensure mission success. SCAP ensures that assets and capabilities deemed vital to NASA's current and future success are sustained in order to serve Agency and national needs. All assets and capabilities identified for

sustainment either have validated mission requirements or have been identified as potentially required for future missions.

Construction and Environmental Compliance and Restoration

NASA Construction and Environmental Compliance and Restoration provides for the design and execution of all facilities construction projects, including discrete and minor revitalization projects, demolition for closed facilities, and environmental compliance and restoration. The FY 2011 budget request includes \$397.4 million for Construction and Environmental Restoration, made up of:

- \$335.3 million for the *Construction of Facilities* (CoF) Program, which funds capital repairs and improvements to ensure that facilities critical to achieving NASA's space and aeronautics program are safe, secure, environmentally sound, and operate efficiently. The Agency continues to place emphasis on achieving a sustainable and energy-efficient infrastructure by replacing old, inefficient, deteriorated building with new, efficient, high performance buildings that will meet NASA's mission needs while reducing future operating costs.
- \$62.1 million for *Environmental Compliance and Restoration* (ECR) Program, which supports the ongoing cleanup of current or former sites where NASA operations have contributed to environmental problems. The ECR Program prioritizes these efforts to ensure that human health and the environment are protected for future missions. This program also supports strategic investments in environmental methods and practices aimed at reducing NASA's environmental footprint and lowering the risks of future cleanups.

Conclusion

Americans and people worldwide have turned to NASA for inspiration throughout our history—our work gives people an opportunity to imagine what is barely possible, and we at NASA get to turn those dreams into real achievements for all humankind. This budget gives NASA a roadmap to even more historic achievements as it spurs innovation, employs Americans in fulfilling jobs, and engages people around the world as we enter an exciting new era in space. NASA looks forward to working with the Subcommittee on implementation of the FY 2011 budget request.

Mr. Chairman, thank you for your support and that of this subcommittee. I would be pleased to respond to any questions you or the other Members of the Subcommittee may have.

Senator NELSON. And we will enter into the record the opening statement of the Ranking Member of the full Committee, Senator Hutchison.

General Bolden, you've just made some news, because you have stated that the destination is Mars; that's the goal. Do you have, in what you have just stated, do you have the approval of your superiors?

General BOLDEN. Sir, the words I used have been through every wicket I can think of, so it—I assume that that means I have approval to say that.

Senator NELSON. All the way up through the wickets of the White House, as well.

General BOLDEN. All the way up through the wickets of the White House, as well.

And I would comment, Senator, that when we went to the Moon, we didn't know what we were doing, but the Moon's a couple days away, and so we felt confident that that would not be a problem. When we take on Mars, it's radically different, and it offers radically different challenges. So, I cannot give you, unfortunately—whereas, President Kennedy said he wanted us to go to the Moon and safely return humans in this decade, I wish that I could ask President Obama to do that. He could issue that challenge, but I can't tell him we can do that, because, at this particular time, I can't provide a date certain for the first human mission to Mars,

because there are too many capabilities that we don't have in our kitbag. And so, I'm hopeful that, through the technology demonstrations and technology development that we will undertake with Mars as the focus of our design reference mission, that we'll be able to get there, hopefully, quicker than we would have before.

Senator NELSON. Well, how will NASA determine the research priorities for a destination of Mars?

General BOLDEN. Senator, over probably the last 20 years—and I refrained from bringing in a stack of studies, that I'm certain you and your subcommittee members are very familiar with, that have been—that have come out over at least the last 20 years. If you look at those studies and the technologies and capabilities that have been listed in all of them, they've been pretty consistent. And they have all been focused on getting humans to Mars. So, the big difference that we have today is that the President has decided that he wants to fund the research and development that's necessary to bring about those technologies and to give us those capabilities. So, I am confident that the budget that I've been given will allow us to do that.

You commented about the difference between technology and heavy lift, the fact that there was more in technology than there was in heavy lift. I can use any vehicle to get things to orbit—to low-Earth orbit—to develop the kinds of technologies that we need. I don't need a heavy-lift launch vehicle, nor would I want to use a heavy-lift launch vehicle, to put a propellant storage demonstration in orbit; that would be a waste of the taxpayers money. I can use a Falcon, I can use a Taurus, I can use a Delta, an Atlas. I can use anything that can successfully get me to low-Earth orbit to get the technology demonstrators that I want to get there. So, that's why I think it's important to have more that we spend on technology development today than we do on the actual heavy lift itself. There will come a time that I will ask for more money on heavy lift.

Senator NELSON. Well, I found some additional money that you can use, General Bolden. We've spent \$9 billion on Constellation thus far, and in this budget is another \$2.5 billion to shut it down. If the Constellation program is canceled, how do we make sure that those valuable assets are integrated into the new program? And if the Constellation program is not shut down, how can we use that \$2.5 billion that otherwise would have shut it down?

General BOLDEN. Senator, no matter what happens to the Constellation program, what cannot be forgotten is the work of the dedicated men and women who made that program possible. And already, although I have asked that we take a really hard look inside—deep into the Constellation program to determine what technologies and capabilities may be there that we want to retain, I can give you examples of things that have already come out of the Constellation program that are going to transfer directly to commercial space.

We had a thermal protection system study that was done under the Constellation Technology Development Program. The SpaceX Corporation, that is going to fly the Falcon 9, saw that technology and has adopted it. And so, they will actually use the thermal pro-

tection system, or a hybrid of it, on their vehicle. That came out of the Constellation program.

When I had an opportunity to tour Launch Complex 40 and talk to the people who actually work on Falcon 9 from SpaceX, I discovered that they intend to use a pusher type of launch abort system. I asked them if they had had any information or had had an opportunity to discuss MLAS—the Max Launch Abort System that our folks at NASA had developed and tested—successfully tested out of Langley, at the Wallops Flight Center. They told me they did not know about it. So, I encouraged them to go talk to the people at Langley, because that is a technology—that is a capability that was developed out of the Constellation program that might be directly applicable to them. So, it was \$9 billion, if that's the right figure, that has been very well invested, and it has already brought great returns to the American public, as well as to industry.

Senator NELSON. And part of those returns, as you ultimately want to develop a heavy-lift vehicle, are the testing that's ongoing on the existing rocket—we don't have to call it what its name is; let's call it Rocket X. So, what's the value of the testing of a Rocket X in the R&D development of a heavy-lift vehicle?

General BOLDEN. Senator, the—anytime you can—you know, there are some people who say you can never test enough. I happen to be one of those, but I am also quite aware of fiscal constraints to testing. In my past life, as a tester, you know, in—when I looked at—Hoot Gibson, who's sitting behind me, will tell—we both, during our time as test pilots—you know, you look at your test plan, and you always wanted to add one more flight so that you could say with a great degree of certainty that it was OK for some—for a normal pilot to go fly what you just finished testing. There's not enough money to do that. So, we need to look at prudent ways to test as much as we can, but not too much. And so, any testing that I would be allowed to do in development of a new heavy-lift launch system would be fantastic—within fiscal constraints.

Senator NELSON. Senator Vitter?

Senator VITTER. Thanks, Mr. Chairman.

Mr. Administrator, you took exception to my statement about the Deputy Administrator; you said you wanted to explore that. So, let's explore that. By the way, I agree completely with the Chairman's very strong positive comments about you, and it's for that reason that I don't think you were the original or prime architect of this budget at all.

So, let's explore the question. Who, within NASA or the Administration, was the original prime architect of this radical new budget?

General BOLDEN. Sir, without going into predecisional discussions or predecisional information, I can tell you that I participated in the construction of the budget. That's part of my responsibility as the NASA Administrator. So, I have to take—you know, if you want look at somebody to blame—if that's what you want to call it—as the NASA Administrator, I represent the inputs that we made to the budget. But—

Senator VITTER. Mr. Administrator, you're confirming everything I just said. Let me ask the question again. Who is the prime, original author of this radical budget vision?

General BOLDEN. You know, Senator, I was a contributor to this “radical budget,” as you—

Senator VITTER. Mr. Administrator—

General BOLDEN.—want to call it.

Senator VITTER.—you took umbrage—

General BOLDEN. Oh, sir, my comment—

Senator VITTER.—when I said—

General BOLDEN.—and if—yes, sir.

Senator VITTER.—about my comment about Deputy Administrator Garver.

General BOLDEN. Yes, sir.

Senator VITTER. Are you prepared to completely refute what I think is the fact there?

General BOLDEN. What I—and I’m not refuting anything, Senator. I just wanted to say that I think—

Senator VITTER. I didn’t think you were.

General BOLDEN.—I think Mrs. Garver was misrepresented in leaving the impression that she is an enemy of human spaceflight or she is an enemy of NASA or anything of that nature. I have found her to be a very competent, capable deputy. We have—we come from different backgrounds.

I think when I met with you earlier, I described two radical groups, one group being those who are radically in favor of Constellation, those who are radically in favor of commercial spaceflight. And if you ask anybody out of either of those two groups, they will tell you, “Don’t listen to those guys over there, because they’re stupid. You can’t go that way.” I’m trying to get somewhere in the middle.

And, you know, we both come from different backgrounds, and I appreciate that. I tell people in my meetings every day, “I don’t ever want to walk away from a meeting when I have a unanimous opinion about a decision we’ve made,” because it means either everybody’s been intimidated by something I said, or they’ve given up that they can reason with me, and they’ve sided with me for some unknown reason. I always want there to be difference of opinion among my leaders, because it means that we’re at least keeping an open mind and we’re looking for the optimal solution for the Nation. And Lori is tremendous in providing me insights that I don’t have about commercial space.

Senator VITTER. OK, so just to be clear, are you refuting, or not, my conclusion that she was a prime leading architect of this?

General BOLDEN. Senator, I can’t refute that, because I don’t—you know, there are—there’s OMB, OSTP—

Senator VITTER. OK.

General BOLDEN.—the Executive Office of the President; we all contributed to the budget.

Senator VITTER. Mr. Administrator, you highlighted a top goal of this budget, to inspire schoolchildren.

General BOLDEN. Yes, sir.

Senator VITTER. Talked about middle school kids. And I’m looking for that inspiring nugget. I haven’t found it yet.

General BOLDEN. Senator, I can give you the—

Senator VITTER. What is the quote?

General BOLDEN.—inspiring—

Senator VITTER. Quote——

General BOLDEN. Yes, sir.

Senator VITTER. Quote, “Mars is the focus of our design reference mission,” close quote. I can tell you, I have two seventh-graders at home; that’s not going to inspire them. So, what——

General BOLDEN. Senator, I don’t want——

Senator VITTER. What is the quote?

General BOLDEN. Senator, I don’t want a seventh-grader to think about Mars. I want a seventh-grader to get excited when, in his or her classroom, they have an opportunity to talk, personally, with astronauts on the International Space Station, as we frequently have them do almost every month.

When the President communicated with Expedition 22 increment astronauts and the STS-130 crew last week, and was surrounded by school students who had an opportunity to communicate with them, they were inspired. I can—trust me—I could look at their eyes. The President is inspired, when he has a opportunity to do that. We are going to inspire children by having an opportunity for them to interface and interact with astronauts on the International Space Station now, thanks to this budget, until 2020. We would not have been able to do that before.

And it doesn’t make any difference how an astronaut gets to orbit. There are two things. There’s access and there’s exploration. I need a heavy-lift launch vehicle so I can go do exploration. I don’t—you know, I want redundant, reliable access to space. I don’t think there is any difference of opinion in this room in that regard. You know, whether I get to space on an Ares or an Atlas or a Delta or a Falcon or a Taurus, that’s immaterial. What is important is that we have an American-made capability to get astronauts to low-Earth orbit so that they can do developmental work on the International Space Station that, one of these days, is going to make it possible for us to go to Mars, because we’ll understand a little bit more about bone loss, we’ll understand a little more about muscle mass loss, we’ll understand a little bit more about what disturbs the neural vestibular system. That’s what I need. It doesn’t matter—no one will know how an astronaut got to the International Space Station, 10 years from now. They won’t know what vehicle they went on, nor will they care.

Senator VITTER. Well, Mr. Administrator, we—I think we just have a disagreement here. You said, you don’t want seventh-graders to think about Mars. I absolutely want seventh-graders to think about Mars, because that is the sort of thing that will inspire them. And, you know, the Shuttle, the International Space Station—those are great things, and those people and those astronauts are heroes—don’t get me wrong.

General BOLDEN. Yes, sir.

Senator VITTER. But, to my seventh-graders, that is, to use their language, “so last week.” That is not——

[Laughter.]

General BOLDEN. Senator, I—you know——

Senator VITTER.—going to inspire them. That is not going to inspire them.

General BOLDEN. Senator, with all due respect, I think you underestimate your kids. They—you know, when I talk to school kids

and they tell me they want to be an astronaut, “What do I need to do to be an astronaut?” I tell them—the first thing I say is, “Forget it.” And then they look at me real strange. I said, “Forget it, because, unless you study and work and get a technical background, a technical undergraduate degree, you have no hope of becoming an astronaut. So, I want you to go to school, I want you to be in class, I want you to study really hard, I want you to do the absolute best you can do, and I want you to go to college, and I want you to get an undergraduate technical degree. And if you want to be a pilot and you want to be like me, and that’s all you can do, then go to the military. If you want to be a scientist or an engineer or somebody who’s going to do the hard stuff in space, get a Ph.D. or a master’s, and then think about being an astronaut.”

So, I think your kids understand that. And as long as I can keep them interested in staying in school and learning a lot of science and math, they’re going to go to Mars; they’re going to enable us to go to Mars.

Senator VITTER. Well, I’ll be honest with you, I’m afraid they’re going to look at the messages of this budget, and if they want to be an astronaut, they’re going to conclude, “Forget it.” That’s my concern.

General BOLDEN. Yes, sir.

Senator VITTER. Mr. Administrator, what relation does this very dramatic change of vision have with anything laid out in the Augustine Commission? I mean, point us to a page of the Augustine Commission report that really suggests anything like this.

General BOLDEN. Senator, with all due respect, you know, I don’t really think that this is a radical departure from—it’s not a radical departure from the vision for space exploration, if I can say, and it’s not a radical departure from any other visions or dreams that people have had about going to space. What is different is, it funds what is necessary to realize that vision. I—somebody once told me a vision without resources is a hallucination. If you look at where we were prior to the 2011 budget, we were living a hallucination. We had a great—I won’t use the term “great”—we had a vision for getting to—back to the Moon, getting to Mars and other places in our solar system, but we did not have the funding to do it; we didn’t have the assets to do it. We now have the assets to make an orderly progression to getting humans to a place like Mars, and I’m confident that we can do that.

Senator VITTER. Again, I just disagree. I believe the consensus opinion reaction to this budget is that it is a radical departure. And if vision without resources is a hallucination, resources without vision is a waste of time and money. And that’s what I think this budget represents.

Mr. Administrator, a final question. You said you’re a member of the NASA family, and you are. And I absolutely know that you want all the best for those folks, and feel for them and are supportive of them, but this budget, canceling every major internal human spaceflight program in sight—most obviously, Constellation—extends their gap, as I said, to infinity. So, what do you tell those people in the NASA family?

General BOLDEN. Senator, as I have told them in the last 2 weeks or so since the budget came out, I tell them I don't know how they feel.

My kids are 38 and 33, and they're out of school. So, I don't know what a young engineer with a 15-year-old kid feels like, right now. I know they're hurting. And if they happen to be a civil servant, I can tell them that they're going to be OK, because they're going to have a job. But then, as a young lady told me at Johnson Space Center, "I don't want a job. I want to be able to come to work every day and feel that I'm making a difference."

And so, I can tell them, as I have, that I'm going to do everything in my power to try to make sure that we develop some programs that are going to help us get to where they all—where we all want to go, as soon as possible.

I don't think we would have ever gotten there with the Constellation program set up and funded the way it was. I don't think anyone said Constellation was a bad program; I haven't read that anywhere. But, I think that we can develop capabilities that will allow—potentially allow us to get back to the Moon and—because we are going to go back to the Moon—and will enable us to get to Mars much quicker than we would have under the "program of record." The program of record would have ended the Space Station in 2015. And if we had developed Ares, Ares would have had nowhere to go, because the Space Station would have been defunct.

The President has given us authorization to go and talk to our international partners and get their concurrence in extending the International Space Station to 2020. That at least gives us hope that we will have someplace for our researchers to go for another 5 years to help us try as hard as we can to fill the gap on some of these capabilities that keep us from being able to go to Mars right now.

If you gave me an infinite pocket of money—pot of money, I could not get a human to Mars within the next 10 years, because there are just some things that we don't know. We don't understand the radiation environment. We don't understand fully what happens to the human body in transiting for 8 months. What I would like to do is develop an in-space technology that allows us to go to Mars in days instead of months. And I am told by very good friends of mine, people that Senator—you know, Senator Nelson has had an opportunity to live with for a while, who think that we can go to Mars in days, at least half the time that it would take us right now. But, we've got to invest in that technology. And we're, oh, so close, but we're just not there yet. So, there are things that we have to do and there are technologies that we have to develop if we want to be able to realize any of these dreams.

And that—you know, I—that's not a radical departure from anything. It's just a departure from the way that we were trying to get there. And the way we were trying to get there, I'm just not confident was going to get us there anytime soon, if ever, in today's fiscal environment.

Senator VITTER. Well, let me say that I'm not sitting here defending the previous vision and the budget that was attached to it; it was inadequate. But, I believe this new budget is a big step back-

ward, because of the, you know, fundamental problems I've tried to underscore.

General BOLDEN. Yes, sir.

Senator VITTER. Thank you.

General BOLDEN. Yes, sir.

Senator NELSON. Senator Vitter, you and I had a private conversation over this issue of who developed the budget, and I shared with you my private concern. And since you've shared, publicly, your private concern, I'll just share mine.

[Laughter.]

Senator NELSON. I don't think it's any different than the George Bush Administration. I think OMB is running the space program, because it designs the budget. And this is where I think that the President has to step out and take control and exert and offer the leadership on the goal that has now been articulated by the Administrator of NASA, of which he had White House approval to say, today, which is Mars. If you leave it to OMB, if we get there, it's going to be a long time coming. But, if you have a Presidential decision that that's what we're going to do, and then he turns to his Marine general and says, "General Bolden, make it happen," then things can start popping. And that's where I think the genesis of this budget is.

Senator VITTER. Well, I certainly hope that we have a change and a new direction as you're working toward, so I certainly hope that. I guess I don't think it's primarily from OMB, because this budget has some significant amount of new money. So, if the goal is just to stay status quo on money or cut money, they could have done that a lot more dramatically. There is some significant new money here, but it's accompanied by a dramatic—radical, in my opinion—change of vision and approach, which I don't think suggests OMB simply counting beans. But—that's my honest reaction—but, I certainly hope we get the change and the new direction you're describing.

Senator NELSON. And that's in the context of, they were making decisions with the backdrop of the Augustine Commission.

So, since there is new money here, that gives us the opportunity to perfect this budget.

Senator LeMieux?

**STATEMENT OF HON. GEORGE S. LEMIEUX,
U.S. SENATOR FROM FLORIDA**

Senator LEMIEUX. Thank you, Mr. Chairman.

General thank you for being here today, and thank you for your service to our country.

I want to join my colleagues in my disappointment about this budget. And I can tell from listening to you that this is difficult for you, especially as it affects the NASA family and, as my colleague Senator Nelson knows better than anyone, what impact this is going to have on our home State of Florida.

I want to go back to something that the President of the United States said when he was seeking the office of the presidency. He was in Florida as candidate Obama, and he spoke about the space program. He said, America will need to lead the world to long-term exploration of the Moon and Mars. Even though I think you have

done your best to give us some assurances that we eventually will go to Mars someday, I have great concern about not having a goal for NASA and canceling existing programs that would put us on a path to get us beyond lower Earth orbit further, without a destination and goal for NASA, I am concerned that the agency will simply revert to directionless spending, making the budget situation and justification even worse next year."

A lot has already been said about the frustration of the members of this committee, and we certainly are going to look more at this budget, and we're going to look more at our priorities.

It is not as if this Administration doesn't know how to spend money. The last 2 years, the combined deficit exceeded the deficit of the past 8 years, combined. This year, for 2011, the Administration is proposing a \$3.8-trillion budget. We're going to have \$2.2 trillion in revenues. So, for this Administration with respect to NASA, it's not a question of money; it's a question of priorities. And if we are going to still be the world's leader in space exploration and not abdicate that role to others who would certainly like to fulfill that mandate, we have to have a goal, as Senators Nelson and Senator Vitter said, we have to have a target, we have to have a plan. And I have great concern about saying, "We will get there someday," and not knowing when that's going to be.

But, let me ask you some specific questions about the cancellation of the Constellation program. Whose idea was it or who made that recommendation to cancel Constellation?

General BOLDEN. Senator, the decision and the discussion that went on is predecisional, and I think, as you know, I am not at liberty to discuss predecisional information.

Senator LEMIEUX. So, was there a consensus, then, of all those on the Committee, that this was the right thing to do?

General BOLDEN. I'm not clear as to which committee—

Senator LEMIEUX. In this decisionmaking process, was it unanimous that Constellation be canceled?

General BOLDEN. Senator, I—as I said before, I am one component of the discussion that goes into any Presidential decision, and that information, or that predecisional discussion that I have with the President, I'm not at liberty to share with anyone. I don't know what the input was from others that I may never have talked to.

Senator LEMIEUX. When you talk about a plan of getting to the Moon or Mars someday, what is your view of what the steps are going to be to get there?

General BOLDEN. Sir, the steps are pretty complex and complicated. We've got to, first of all, sit down and look at where we are, in terms of the Constellation program and what was in it. We need to make sure that we don't throw away the baby with the bathwater. We need to determine what technologies and what smaller projects are worthy of retaining, because that will tell us how much we actually have to expend, in terms of brand new technology or brand new assets. So, that's the first step.

The next step is actually to sit down and say, "OK, the way that we generally start is, if we're trying to get to Mars—and it's—I will use Mars, since that is the ultimate destination—what do we need—from what we have, what we know exists today, what do we need to enable us to get there as soon as possible?

Senator LEMIEUX. Are we going to go to the Moon first, before we go to Mars?

General BOLDEN. You will—my thought is that you will inevitably have to go to the Moon, but you'll spend a lot of time on the International Space Station, now that we're going to have it there until 2020, developing some of the technologies. You know, whether humans need to go on—I will tell you, I don't think humans need to go and live on the Moon to do anything anymore. We have rovers that have come out of the Constellation program that enable us to put astronauts on the surface of the Moon for a month at a time, completely self-sustained, and we don't have to build habitats. That in itself is a saving, and—savings—and that came from the Constellation program. But, this is one person's thinking, and I happen—

Senator LEMIEUX. Yes, but you're the Administrator.

General BOLDEN. Yes, but, sir, I don't—

Senator LEMIEUX. I am sure it is up to you for some guidance.

General BOLDEN. I'm giving you at least, you know, a beginning of an idea. But, I—you know, there's a lot of work that has to be done by our team to determine what the steps are that eventually get us to Mars, or get you to any destination.

There are other things that we have to do, and that's the study of asteroids. And you may say, "Well, why?" Well, it's because they can do really bad things to Earth, and if one of them happens to head this way and we don't—either don't understand it or don't have a way to deflect it or something else, that's—part of my job is defense of the planet against things—not people, but things. We—all we needed to do was look at the Hubble image of Jupiter after it was impacted by an asteroid that left a scar that's several Earths in diameter; that's a very serious potential impact to Earth, or—no pun intended—but, a danger to all of us on the planet. So, we need to study asteroids a little bit better. Some people say that that would be one of the earlier missions. One of the earlier human missions would be to put an astronaut on an asteroid. You know, how we get there, I don't know yet, because these are things that, when I was in the Astronaut Office, and before coming back to NASA, people weren't talking about. So, these are new—

Senator LEMIEUX. When do you think—

General BOLDEN.—challenges that—

Senator LEMIEUX.—you might have a plan, Administrator, for where we're going, when we're going to get there, and what the steps along the way will be?

General BOLDEN. —Senator, I can tell you that, over the coming months, and not years, we'll develop a plan, and we will do that in conjunction with the Congress, with members of this committee and others that—for whom—to whom we're responsible, and we'll develop a plan over the coming months. But, you know, 2 weeks after the budget rollout, I just—you know, I—I'm not capable of giving you a complete plan on something as important as how we get to an—get deeper into the solar system.

Senator LEMIEUX. Well, I think the concern that we all have is that plans and money go together.

General BOLDEN. Yes, sir.

Senator LEMIEUX. So, when we're talking about \$6 billion, or whatever sum it's going to be, the funding without a plan gives me concern.

General BOLDEN. Yes, sir.

Senator LEMIEUX. And the funding needs to drive the plan, and vice versa.

General BOLDEN. Senator, I—you know, if I can use—let me use Constellation as an example and tell you where I was when I came into this office. You know, Constellation, at the time that I came into this office, was a lunar-centric program. And it was because, I think, there was not sufficient funding for NASA to go off and plan a way to go to Mars, so we kind of drifted toward the Moon again.

Constellation, when I came into this office, did—while it—while landers and those types of things were an important part of the program, they weren't funded, so there was nothing there. You know, there was thought about how we were going to do it, but it wasn't there, because we didn't have the assets to do it.

So, we were planning to send humans back to the lunar surface, and when I came in, we were talking about habitats and the like. I'm not sure we need—as I mentioned earlier—I'm not sure you need habitats on the lunar surface. I do know that you don't have to send humans to Mars to make it habitable, or least to begin to make it habitable for humans. We now have robots that can go do that. I would never send a human to do something in space that I had been—become confident a robot could go do.

I served on the National Academy board to study saving Hubble, back in 2004, when one of my predecessors canceled the last servicing mission to the Hubble Space Telescope. And one of the witnesses who's going to come in the next panel, behind me, will—can probably share the same story. When we began our meeting, we all determined that, you know, the risk was too great to send humans, and we wanted to send a robotic mission to service Hubble. We talked to every expert we could find in this country and in some other countries, and we were told, "We'd love to help you, but the technology is just not there yet." And we finally convinced ourselves that the right thing to do was a human servicing mission, which we did incredibly well, at the end of last year, with STS-125. If we were to ask a panel today if they could do a human—a robotic servicing mission to Hubble, they would tell you, "Yes, we can." I can take you to the Johnson Space Center today, and let—introduce you to R2—that's a dexterous robot that, you know, can do things with its fingers that I can do with mine, that, in our work with General Motors, can now take a waterproof panel and put it on an automobile door and seal that panel in place using the same motions that we saw astronauts on 125 do putting the thermal shields on the outside of the telescope. We couldn't do that in 2004, when we—when that panel met and made the determination that it was worth risking humans; we're not there anymore.

You know, technology develops out of need. As all of you have said, we do have to know where we're going. We want to go to Mars. We can't get there right now, because we don't have the technology to do it. We're sort of in the same conundrum that I and my panel members were with Hubble.

Senator LEMIEUX. Respectfully, when President Kennedy challenged us to go to the Moon, we didn't have the technology, in that year, to go to the Moon. When we decided that we needed to build an atomic bomb, we didn't have the technology when we made that decision, but we pushed forward because we had a goal. And if we don't have a goal to go there by a specific time, it seems to me that the drive, both funding and purposefully, will be lacking. So, I think that's the concern that the folks have here on this committee and others.

And let me ask you one more question if I may. You talked about getting to the Space Station, how are we going to get there?

General BOLDEN. Sir, we're going to get there, for the next 3 years, on *Soyuz*, the same way we did after the *Columbia* accident. That was the only way we had to get to the Space Station following the unfortunate loss of *Columbia* and seven crew members. We used *Soyuz*, we used our partners, the Russians. They have been reliable partners with us now for a number of years. We understand their system, we send astronauts there to train, who are able to fly their system. When we get—we are going to make commercial——

Senator LEMIEUX. This is the Russian system, right?

General BOLDEN. This is the Russian system. And that—we are stuck where we are because we don't have an alternative American-made system. It is my hope that by 2015, 2016, we will have successfully enabled American industry to produce launch vehicles that can provide us routine, reliable access to low-Earth orbit.

Senator LEMIEUX. What about extending the Shuttle for that period?

General BOLDEN. Sir, that is something that I would not recommend to the President and I could not honestly recommend to you. There is little value in trying to stretch the Shuttle, you know, until we have the capability—a commercial capability to get to low-Earth orbit.

Again, funding is something—you know, it costs us 2-point-some-odd-billion dollars a year to operate Shuttle. I would like to get out of the responsibility—the cost of the operation and the infrastructure that is costs us with Shuttle right now. There would be, potentially, recertification of the vehicle. It would be starting up production lines. There are a lot of things that make extension of the Shuttle not a very good idea, in my mind.

Senator LEMIEUX. Well, you talked about these employees, these members of the NASA family, these rocket scientists, who are going to lose their jobs. I have a great concern, as do my colleagues, about reassembling those folks once they disperse. And those 7,000 folks, directly in Florida, and maybe 14,000 others who are impacted, what are we going to say to them?

General BOLDEN. Senator, it is my hope—you know, I will never be able to save all the jobs. We knew that we were going to have a bathtub, if you will, where we were going to lose people when the Shuttle program came to an end in 2010—decided a long time ago—and we were looking for ways to keep as many of them employed as we could. And that method, at the time, was going to be transitioning a portion of the workforce to the Constellation program, but we were never going to be able to retain the entire work-

force. I'm hopeful that we'll be able to transfer some of them to the commercial sector.

Senator Nelson mentioned, and I have talked to the people in the commercial sector, and I've told them I'm going to hold their feet to the fire. They have provided certain numbers for employment that they say commercial space will bring a minimum of this, a maximum of that. I can't make that happen, and they must. And I'll hold them—I will hold them responsible for that. So, when they promise jobs, they ought to be there. You know, I would say a question that you could ask, as a member of the Florida delegation, is, "OK, tell me how many people are working right now from the State of Florida?" That's the question I asked. And when they told me, "None," I said, "That's unsatisfactory." And I got a note, you know, the next week that said, "OK, we now have some Florida technical people working here, and we intend to convert it to 100-percent Florida by the time we're well into this program." I think those are the kinds of things that are important. You know, moving workers from one State to another does not help your State. And that's what I'm trying to do to help our workforce, is to make sure that someone speaks for them when we talk to the commercial entities.

Now, again, I can't make them do anything. I'm—the President didn't empower me to order a commercial company to hire people from anywhere. But, I can sure encourage them to do all that they can to take advantage of the workforce that I have, take advantage of the infrastructure that we have at the Kennedy Space Center and at Cape Canaveral Air Force Station, and that's what I'm dedicated to do over the coming years.

Senator LEMIEUX. Well, General, I appreciate your testimony.

Mr. Chairman, thank you for holding this hearing.

Senator NELSON. We're going to move to the second panel. Do you have any further comments?

I just want to say, Senator LeMieux, one of the things that we pride ourselves on this panel—and I think it's applicable to the similar panel in the House of Representatives—is that space is a nonpartisan issue, and we always run this committee in a bipartisan way. And as we analyze all of these things that are going on, as you can hear by the comments of the three of us, there have been sharp differences that we have with the Administration's budget. But, we've got to put it in the proper context, also, of the circumstance that this Administration came into in which NASA had been starved, for the last half dozen years, of money, and it didn't have a rocket ready to go when the Space Shuttle was being shut down, so that there was this hiatus of a number of years that we were not going to have an American vehicle.

So, we've aired our differences and our grievances with what has been proposed by the President. And I want this committee to be very active, along with our colleagues on the Appropriations Committee, as—to use a nice word—as we perfect this budget, because there is a great deal at stake here, and it's not only for our employees in our respective states, but it clearly is for this Nation being the leader in technology through its space exploration program. And we've got to make sure that it's right.

So, with that, General Bolden, thank you very much for coming and being with us.

And may I invite the second panel to please come up.

General BOLDEN. Senator, thank you and your colleagues very much for allowing us to come before you today. And I really do look forward to continuing to work with you all. We'll get it right.

[Pause.]

Senator NELSON. Good afternoon.

Well, we have a distinguished panel. I assure you, there won't be nearly as many fireworks as there were on the previous panel. But, each of you brings to the table exceptional depth of experience, each in your own way. And let me introduce this distinguished panel.

Captain Robert Gibson, United States Navy, Retired, was known, in the Astronaut Office, as the best of the best. He's flown five times. He came by way of flying off of a carrier over Vietnam; went to Top Gun. He graduated first in the class in Top Gun. He was chosen for extraordinary missions and the first docking of an American spacecraft, the Space Shuttle, with the Russian Space Station Mir. And Captain Gibson—Hoot Gibson—was chosen to be the commander of that flight.

Miles O'Brien is a 30-year broadcast news veteran, and he was, by good fortune and because of his expertise, chosen to be the first journalist in space, and then, by the misfortune of the *Columbia* disaster, never got to fly. He has worked for years and years as a correspondent, anchor, and producer. And one of the major flights—I think it was John Glenn's flight—Miles co-anchored with Mr. Space, Walter Cronkite, on that historic achievement of a 77-year-old—the original space hero—being able to go back into space. And maybe space does turn back time, because if you see John Glenn now, who is closing in on 88 years of age, he looks as good as many people in their 60s.

And then we have Michael Snyder. And Mike has been in NASA for years and years. He started at the Kennedy Space Center. He has been in the Orbiter Element Division at the Johnson Space Center. He has been an engineer in all kinds of subsystems and orbiter propulsion and power systems. For those propulsion and power systems, Mike has been one of the managers responsible for technical management of those systems. And we wanted somebody to testify today who has his on-the-line experience which is so valuable for us to constantly remind ourselves that we hear not just from the guys at the top; we want to hear from the guys on the line, as well.

And then, Tom Young brings the gray hair to the panel, and we need that, because here's one of the most accomplished people in America, with regard to aerospace, defense, and space, and space applications. He is a member of the National Academy of Engineering. He is the former Director of the Goddard Space Center. He is a former President and Chief Operating Officer at Martin Marietta, and he has been a member of several other aerospace boards of directors.

So, we couldn't have a better panel. And I'm going to go by alphabetical order, so we will start with Captain Hoot Gibson.

**STATEMENT OF CAPTAIN ROBERT "HOOT" GIBSON, USN (RET.)
AND FORMER NASA ASTRONAUT**

Captain Gibson: Mr. Chairman, good afternoon.

Thank you for inviting me to address this distinguished committee, and I'm going to say it's amazing how we have somewhat all focused on the same points.

I was asked to talk about the Administration's new proposal, and specifically a few items: the proposal to cancel the Constellation program; the reliance on commercial spacecraft for low-Earth orbit; testing of Rocket X in support of a heavy-lift vehicle; and astronaut safety issues. And I'm going to speak from the perspective of a long-time member of that NASA family, and indeed, I feel somewhat that I still am; somewhat like a Marine—always a Marine.

And, notwithstanding the comments that we heard today, the Administration's proposal opens more questions than it answers. What is the vision? Where are we going? And this abrupt change in NASA's exploration approach has no clear path; no destination, no milestone, no program focus; hence, none of the technology pull that is so important to real innovation. With no specific program, it becomes too easy, in the future, to cancel something called technology development as simply unfocused and unaffordable, and this could take NASA down a path that would completely end its human spaceflight endeavor.

NASA must maintain global leadership in human spaceflight. With the International Space Station in low-Earth orbit now, NASA has established a frontier in space. To maintain the global leadership and core competencies in human spaceflight, NASA must now focus on establishing the new frontier, beyond low-Earth orbit.

The Augustine panel had several things to say about that. This is a quote: "There is now a strong consensus in the United States that the next step in human spaceflight is to travel beyond low-Earth orbit." Another quote: "The Committee concluded that the ultimate goal of human exploration is to chart a path for human expansion into the solar system. Establishing this new frontier is inherently governmental, due to the risks that must be accepted by our professional astronauts and the huge investments required." This means, in spite of the words that we've heard today, NASA needs a destination—a goal. Whether it is Mars, Lagrange points, near-Earth asteroids, or whatever, NASA must define the roadmap and the technological achievements required to achieve this goal. This becomes the flexible path, gives us the technology pull, and focuses our investment. NASA needs a heavy-lift vehicle to accomplish these goals.

The specific questions. I want to start with astronaut safety. That was always a subject very dear to my heart, not just as an astronaut, but as a former member of the NASA family and a former chief astronaut. And, of course, Senator Mikulski, as we know, has some very specific feelings in that area, too. She said, "Astronaut safety. The safety of our astronauts is my number one priority. This means whatever transportation system is chosen, it must protect our astronauts during launch, mission execution, re-entry, including long-duration spaceflight."

As to the Space Shuttle part of this question, the Augustine Commission had several things to say there, too:

“Space operations are among the most complex and forgiving—unforgiving pursuits ever undertaken by humans. It really is rocket science.”

And, “New human-rated launch vehicles will likely be more reliable once they reach maturity, but, in the meantime, the Shuttle is in the enviable position of being through its infant mortality phase. Its flight experience and demonstrated reliability should not be discounted.”

And I think it’s important to consider, just briefly, how successful we have been. And I want to say, no one feels the loss of the *Challenger* and the *Columbia* more than I do, because I knew both of those crews. But, it’s significant to note that we have flown 130 missions now. We just completed the 130th mission of the Space Shuttle. And compare that to our previous entire space program, which was 31 total launches. All of *Mercury*, *Gemini*, and *Apollo* amounted to 31 total launches. So, therefore we have flown more than four times as many launches with the Shuttle as our entire space program prior to this. So, it has been, I think, a great accomplishment.

As for the commercial sector, they may very well ultimately achieve the success and the reliability that we demand for human endeavors, but, to me, it makes no sense to turn everything over, at this time, to an unproven vehicle. We need to allow them to establish a track record flying cargo that will allow us to evolve into human carriage with those types of vehicles.

Now, at the same time, NASA needs to help the commercial service providers to be successful. And for that to happen, we need to leverage the core talents and the abilities, the operations, the safety of our NASA human spaceflight centers, and let’s not lose the lessons that we’ve learned over 50 years of human spaceflight, some of them at fairly high cost.

We must also maintain the core expertise in the people that we have at NASA that is so necessary to keep up any human spaceflight endeavor. With the ending of the Space Shuttle program and the proposed cancellation of the Constellation program, and with no specific program to replace them, more than a third of NASA’s workforce of experience-based professionals is at risk of being lost. This would represent a major disruption in our human spaceflight program, as well as our economic and industrial base; we must make sure that we maintain that.

And Senator Mikulski also touched on that when she said, “Workforce transition. The retirement of the Space Shuttle should proceed as planned in 2012 after ISS assembly is complete, and any future direction must include a plan to maintain critical skills and incorporate lessons learned from our previous efforts to replace the Shuttle and to soften any job dislocation impacts.” That was her quote.

Commercial spacecraft, as I’ve already touched on, may eventually be reliable enough to give us the capability that we need, but there’s still a large learning curve that’s ahead of them, and for them to succeed in space is going to take a lot of involvement with the NASA centers of expertise.

There is a quote that the Augustine committee had to say, as well, about that, and it is, "If we craft the space architecture to provide opportunities to this industry, there is the potential, not without risk, that the cost to the government would be reduced." And it's this very risk inherent in this approach that demands that NASA remain vitally involved.

We also need a backup to the Russian *Soyuz* for transporting our astronauts to the ISS. The present cost, of \$51 million per crew-member, will change when we no longer have our own access to space. The head of the Russian Space Agency, Anatoly Perminov, has already stated—and this is a quote—"We have an agreement until 2012 that Russia will be responsible for this." And "this" is referring to transporting astronauts of other nations to the International Space Station. And then he goes on to say, "But, after that? Excuse me, but the prices should be absolutely different then." And his statement, "absolutely different then," is somewhat frightening to me. The Russians are new to capitalism, but they know how it works; and when you have a monopoly, you charge monopoly prices.

We have an opportunity at this time to leverage a lot of the research and the development and the funding that went into the Constellation program to continue with development of Rocket X, a vehicle that would support heavy-lift vehicle, by continuing to develop the five-segment rocket booster, the J-2 engine and the Orion spacecraft, as the quickest and most inexpensive way to working our way to a heavy-lift vehicle.

In summary, I want to state that, with the retirement of the Space Shuttle later this year, and if the administration's proposal is followed, the United States will no longer be a space-faring nation. We will have placed the future of our space program in the hands of the Russians and the unproven commercial sector. And with no program on the drawing boards, we will have ceased exploration beyond low-Earth orbit, and we'll be many years away from any hope of regaining what we once had. And what we once had was a—an exciting and vibrant space program that was the envy of the world and literally lit up the eyes of thousands of school-children around the world that I've spoken to over the last 30 years.

Mr. Chairman, I'm hopeful that you and your colleagues can alter the course that we appear to be on.

Thank you for allowing me to testify today.

[The prepared statement of Captain Gibson follows:]

PREPARED STATEMENT OF CAPTAIN ROBERT "HOOT" GIBSON, USN (RET.)
AND FORMER NASA ASTRONAUT

Mr. Chairman, good afternoon. Thank you for inviting me to address this distinguished committee, and I have to say I believe you really have your work cut out for you! In the letter from Senator Rockefeller I was asked to address the Administration's new overall direction for NASA including the following areas:

- The proposal to cancel the Constellation program
- The reliance on commercial spacecraft for access to low earth orbit
- Testing an Ares I-like rocket en route to building a heavy lift vehicle
- Astronaut safety issues associated with both the Space Shuttle and commercial spaceflight

The Administration's proposal opens more questions than it answers. What is the vision? Where are we going? The abrupt change in NASA's exploration approach has no clear path, no destination, no milestones, and no program focus, hence none of the *Technology Pull* so important to real innovation. With no specific programs, the budget cutters in future years will likely be able to reduce and eliminate funding for "Technology Development" as simply unfocused and unaffordable. This will take NASA down a path which will quickly end its Human Spaceflight endeavor.

I would like to state that it is imperative that *NASA must maintain global leadership in Human Space Flight!* With the International Space Station (ISS) in low earth orbit (LEO), NASA has established a frontier in space. The Administration has directed NASA to turn over ISS transportation to the commercial/ private sector, which I will say more about in a moment.

To maintain global leadership and core competencies in Human Space Flight, NASA must now focus on establishing the next frontier *beyond LEO*. In fact, the Summary report of the Augustine Panel stated:

"There is now a strong consensus in the United States that the next step in human spaceflight is to travel beyond low-Earth orbit."

"The Committee concluded that the ultimate goal of human exploration is to chart a path for human expansion into the solar system. This is an ambitious goal, but one worthy of U.S. leadership in concert with a broad range of international partners."

Establishing this new frontier is inherently governmental due to the risks that must be accepted by professional Astronauts and the large investments required. The commercial and private sector will then follow. International partnerships should be fully leveraged to reduce the burden on any one nation—but *NASA must lead!*

This means:

NASA needs a destination—a goal. Whether it is Mars, Lagrange Points, Near Earth Asteroids, or whatever.

NASA must define the roadmap and technological achievements required to achieve the goal. This becomes the "Flexible Path," provides the *Technology Pull*, and focuses investment.

NASA needs a heavy lift vehicle to achieve these beyond LEO goals.

A Human Spacecraft that goes beyond LEO is very different from a Spacecraft that only transports crew to and from ISS. NASA needs to start working on that vehicle right now.

As to the specific points that Senator Rockefeller asked that I address, I want to start with "*Astronaut Safety Issues associated with both the Space Shuttle and commercial spacecraft*" because crew safety has always been extremely high on my list. In fact, Mr. Chairman, in her letter to you, Senator Mikulski listed as her first principle:

"*Astronaut Safety*—The safety of our astronauts is my number one priority. This means whatever transportation system is chosen, it must protect astronauts during launch, mission execution and re-entry, including long duration space flight."

As far as the Space Shuttle part of this question, there are several other statements from the Augustine report I want to mention:

"Space operations are among the most complex and unforgiving pursuits ever undertaken by humans. It really is rocket science."

"New human-rated launch vehicles will likely be more reliable once they reach maturity, but in the meantime, the Shuttle is in the enviable position of being through its infant mortality phase. Its flight experience and demonstrated reliability should not be discounted."

I think it is important to consider how successful the Space Shuttle has actually been. I want to add that no one feels the losses of "*Challenger*" and "*Columbia*" any more than I do—I knew both of those crews. But it is also very revealing to look at how many missions we have successfully accomplished and the great steps forward we have made with the Shuttle. We have just completed the 130th Space Shuttle mission. We have launched dozens of satellites, docked with the Russian Space Station and built the ISS. The entire United States Space Program prior to Shuttle had amounted to 31 total launches! This includes all of *Mercury*, *Gemini*, *Apollo* including all the moon landings, *Apollo-Soyuz*, as well as *Skylab*. We have therefore flown more than 4 times as many flights with the Space Shuttle than our

entire previous space program, which I feel has been a great accomplishment. Our tragic losses in the program both occurred when we let our guard down in applying the necessary rigor that space flight demands. It truly is “Rocket Science.”

As for the commercial sector, they may very well ultimately achieve the success rate and reliability that we demand for human endeavors, but it makes no sense to just turn over the entire operation to an unproven vehicle or company. We need to allow them to establish a “track record” with cargo before we turn over the human portion of launches. At the same time, NASA needs to help the commercial service providers to be successful. For this to happen, the commercial providers need to be incentivized to take advantage of the operational, safety, and technical expertise of the NASA Human Space Flight Centers. Don’t lose the lessons learned over 50 years of Human Spaceflight—some of those lessons very costly.

Testing an Ares I—like rocket en route to building a heavy lift vehicle. We should most definitely continue with the testing of an Ares I vehicle in support of a heavy lift launcher. We have an opportunity at this time to capitalize on a significant investment in time and money that has gone into the development of the 5 segment solid rocket motor, the J-2 rocket engine, and the Orion vehicle as the quickest and most economical way to a heavy lift and crew capability. The launch pad has had the modifications, the launch tower is in place, the team is in place, and it makes all the sense in the world to complete this program.

This also ties into the question of *the proposal to cancel the Constellation program* and continuing the Ares I testing, and has a significant bearing on what we derive from the nearly \$10 billion investment that went into Constellation. The need for the heavy lift vehicle has already been discussed, and the cancellation costs in these contracts would add significantly to the overall price of this program, with nothing to show for it. For no more cost, the completion of the Ares I testing would support the heavy lift launcher with the technology needed such as the 5 segment booster, and the J-2 engines. To launch and fly this spacecraft will not cost any more than actually canceling it. In addition, it would maintain the skilled team in place necessary for any future space endeavor. With the ending of the Space Shuttle program and the proposed cancellation of the Constellation program, and with no specific program to replace them, more than a third of NASA’s workforce of experienced space professionals is at risk of being lost. This will result in a major disruption to our industrial base and loss of core expertise for exploration and Human Spaceflight within both industry and government. At least one of the commercial developers has stated that they can not succeed in Human Spaceflight without this core of expertise within NASA to rely on. Maintaining this knowledge base is critical to our future in Space as well as preserving our place in global competitiveness. Senator Mikulski mentions this as well in her letter stating:

*“Workforce Transition—*The retirement of the Space Shuttle should proceed as planned in 2011 after ISS assembly is complete, and any future direction must include a plan to maintain critical skills and incorporate lessons learned from our previous efforts to replace the Shuttle, and to soften any job dislocation impacts.”

The reliance on commercial spacecraft for access to low-Earth orbit. I have already touched on this subject in several other places, but there is still more to be said. As much as we all want to see the commercial sector succeed in space, there is a large learning curve that lies ahead of any such efforts, particularly in the area of human rated vehicles. The Augustine Panel said:

“If we craft the space architecture to provide opportunities to this industry, there is the potential—*not without risk* —that the costs to the government would be reduced.” (emphasis added).

It is the very risk inherent in this approach that demands that NASA remain vitally involved in this effort, and that we do not turn this over completely to the commercial sector until they have proven their capabilities.

It is additionally important to realize what the commercial segment would accomplish for the overall space program. Estimates of the length of time required for the commercial sector to develop this capability range from 3 to 5 years, and even assuming that they proceeded with no setbacks whatsoever, it only accomplishes a capability to LEO. It does not begin to achieve any of the more desirable goals mentioned in the Augustine Report; that is beyond LEO. It is not unimaginable that with failures or problems, this time could extend well into 10 years for the commercial sector.

It is relevant to consider how long it took to develop the Space Shuttle System. The propulsion system was based on rocket engine technology that was already developed, and consisted of Liquid Hydrogen/Liquid Oxygen Engines, Solid Rocket Boosters, and Hypergolic rocket motors. The airframe of the Shuttle would be of mainly aluminum construction as would the External Tank, and it would employ

avionics that were largely representative of what had been done before. The new developments would be in the realm of the Thermal Protection System (Tiles, Blankets and Reinforced Carbon-Carbon), and the fact that the Shuttle would be a reusable vehicle. Development started in 1972 and the estimate for the first space flight was originally 1976. In actuality, it required until 1981 for the Shuttle to fly, in spite of the significant amount of developed technology that was utilized in the vehicle. For all these considerations, it is incredibly premature and naïve to simply turn over all efforts toward LEO to the commercial sector.

We also need a backup to the Russian *Soyuz* for transporting our astronauts to the ISS. The present cost of \$51 Million per crewmember will change when we no longer have a way to access space on our own. The head of the Russian Space Agency, Anatoly Perminov, has already stated: "We have an agreement until 2012 that Russia will be responsible for this," about ferrying astronauts from other countries into low earth orbit. "But after that? Excuse me, but the prices should be absolutely different then!" His statement "*Absolutely different then*" is frightening to me! The Russians are new to capitalism, but they know how it works, and when you have a monopoly, you charge monopoly prices. To knowingly commit our Space Program to this for years on end, without a truly viable solution in work, is irresponsible and fiscally dangerous, not to mention the National Security implications as well!

In summary, I want to state that with the retirement of the Space Shuttle later this year, and if the Administration's proposal is followed, the United States will no longer be a space-faring nation. We will have placed the future of our Space Program in the hands of the Russians and the unproven commercial sector, and with no program on the drawing boards we will have ceased exploration beyond low earth orbit and will be many years away from any hope of regaining what we once had:

An exciting and vibrant Space Program that was the envy of the world, and literally lit up the eyes of thousands of school children that I have spoken to around the world over the last 30 plus years.

Mr. Chairman, I am hopeful that you and your colleagues can alter the course we appear to be on. Thank you for allowing me to address this distinguished group.

Senator NELSON. Thank you, Captain Gibson.
Miles O'Brien.

STATEMENT OF MILES O'BRIEN, JOURNALIST AND HOST, "THIS WEEK IN SPACE"

Mr. O'BRIEN. Mr. Chairman, Senator Vitter, thank you for allowing me to sit beside Hoot Gibson—he, in the right seat beside me; that makes him my co-pilot.

[Laughter.]

Mr. O'BRIEN. I often wondered what it was like for those poor Southwest captains when he would sit down in the right seat beside them, and there was Hoot, flying that 737. "Here—it's yours, pal."

Captain GIBSON. I'm here to support you.

Mr. O'BRIEN. Thank you. It's good to have a wingman.

I'm a freelance journalist now—18 years covering the space program, most of that with my former employer, a large cable news network.

[Laughter.]

Mr. O'BRIEN. Lowercase. I moved on. I'm now working on the Web, as a lot of my compadres in journalism are right now, in partnership with *spaceflightnow.com*. We have a weekly program called "This Week in Space," and this will be the lead story this week.

I also need to tell you, I serve as the chairman of the Education and Public Outreach Committee for the NASA Advisory Council, and, to be clear today, my views here are my own, not anything to do with my NAC business.

Mr. Chairman, Washington in general, we have a problem. There is an uproar across the land about NASA's budget, its course change, and it says a lot about how the public is no longer in the loop with the space agency. You know, the headlines read, "NASA Cancels Its Moon Mission." I would submit to you that most people reading those stories didn't know we were going to the Moon. And guess what? We really weren't, the way it was funded.

The program was packaged as "The Vision for Space Exploration." It never got its promised funding, as we've discussed here. And the vision, frankly, was focused a little bit on the rearview mirror. Constellation was touted as "Apollo on steroids," but it really turned out to be a bit of a 90-pound weakling, didn't it? It was uninspired in its attempt to bring back the magic of the 1960s. NASA, it seems to me, was acting a little bit like one of those middle-aged guys who was the high school football hero and won the State championships and spends all his time talking about the glory days. But, the country has grown up and moved on. And I think it's time for NASA to get off the barstool a little bit here and think about what's next.

And that's what I see in this budget; I see a lot of optimism here. There is—this is a grownup approach to space exploration. It syncs the goals with national needs and the budgetary realities right now. I'd love it if we could do it all. It would be great if we could go back to the Moon. But, does that lead us, really, anywhere farther out?

The space agency is getting a bit of a slap in the face. They should be saying, "Thanks, I needed that," I suppose, but what we're hearing is not that. Now, change is never easy. But, let's think about this for a minute. NASA is supposed to be all about change. In fact, if NASA cannot embrace change—actually invent change—we should close the place down.

But, there's more to this than that, because, as much as anything else, we have here a failure to communicate. I give the Administration high marks for its reassessment of priorities, but it did a horrible job telling the story. The headlines should have been, "Space is Now Open for Business," or, "Space Travel for the Rest of Us," or, "Space Station Science Gets a Reprieve," or, "NASA is Working on Green Aviation and Fixing Air Traffic Delays," or, "Focusing on Our Favorite Planet: Mother Earth." You get the idea. Instead, we got a bunch of the blue Moon stories.

Well, one of the reasons for this is, it is my understanding this decision was closely held in the White House Office of Science and Technology, and it was rolled out, essentially, to NASA—to the key people at NASA—the weekend before the budget rolled out. I guess they were reluctant to tell the kids. So—but, most people knew that Constellation was essentially a dead man walking. But, denial is a powerful thing, and so NASA was caught a bit flatfooted, with no strategic plan on how to explain the nuance of this story. And let's face it, the mainstream media doesn't have a clue, either. Reporters who know some things about this beat have been unceremoniously dumped by the big papers and networks, right and left, and many of them are—well, they're webcasting, I guess.

So, I guess you could say it's the perfect storm. The agency is really not sold on the change internally, the communication plan

was nonexistent, and the reporters are not well informed, and the public is disengaged. But, the people, like me, who care a lot about this and have a passion for it, are out there. And in advance of this testimony, I sought some opinions, via Twitter and Facebook, my little circle of space cadets, and I'd like to have those comments submitted for the record, if you don't mind. There's a lot of passion out there, and a lot of—people care deeply about what happens next.

Like so many of the people I have heard from, many of whom have worked long and hard on Constellation—and I do hope we create sort of a Space Station freedom scenario here, where pieces of this can live on—I wish that NASA had not been painted into this corner. I wish we could have been thinking about, and investing in, the next great adventure for humans in space, decades ago, so we wouldn't be facing this huge gap right now in human spaceflight capability. It could morph into abyss, if we're not vigilant. That's the hand we've been dealt. Trying to recreate the past is not the path to go; yesterday's technology is not the path. The public won't support it.

Thank you for your time.

[The prepared statement of Mr. O'Brien follows:]

PREPARED STATEMENT OF MILES O'BRIEN, JOURNALIST AND HOST,
"THIS WEEK IN SPACE"

Mr. Chairman—thanks for inviting me—it is a pleasure. I am a freelance journalist with about 18 years experience covering the U.S. space program—most of that time with my former employer—a large cable news network. Since I moved on, I have been covering space on the web—in partnership with *spaceflightnow.com*. We offer continuous live interactive coverage of shuttle launches—and draw a large global audience—in the past few month we have been producing a weekly half hour program to the web called this week in space—which has become the definitive video chronicler of the events that bring us here today.

I also need to tell you I serve as Chairman of the Education and Public Outreach Committee of the NASA Advisory Council—but to be clear—my views expressed here today are my own.

Mr. Chairman, I am a child of the Space Race and I consider myself pretty darn lucky to be able to say that. I, like most of you in this room, bore witness to a stunning moment in history—a towering accomplishment that defied the odds that made us feel good about what humanity can accomplish collectively when we combine big goals with hard work, ingenuity and bold action.

It is a lesson that my generation took to the bank. We (well not me)—but we collectively embraced the disciplines we now call STEM—science, technology engineering and mathematics. This planted the seeds of success in Silicon Valley—and insured U.S. economic dominance for many decades.

I sure wish my teenage son and daughter had been as lucky as I. They have no first hand experience with those amazing exciting days. And so, even in my household, where my interest and passion in the subject is well understood—perhaps tolerated is a better term—there is little evidence NASA is connecting well with the children of the post space race generation.

And truth be told, NASA lost many members of my generation over the past thirty years. How many people even know when a space shuttle is in on the launch pad? Or that U.S. astronauts in orbit continuously on a space station for nearly a decade now? Or that we have a space station at all. A shocking number of otherwise smart people don't have a clue.

Many of those same people did not know the shuttle program was near its end—and that, until recently, the plan was to return to the Moon in a suite of rockets and vehicles collectively called "Constellation." When they asked me for more about this, I would frequently quote former NASA Administrator Mike Griffin—who called it "Apollo on steroids." This was my (lame) attempt at making it as interesting—as say—professional sports or something.

The truth is the public in general long ago stopped paying much attention to what NASA is doing in the manned space realm. There have been some spikes of interest here and there—for Hubble repair missions, to see John Glenn fly or, sadly, for the returns to flight after the accidents—but in general—it has been a long, steady decline that really began on July 24, 1969—when Columbia capsule carrying Armstrong, Aldrin and Collins splashed down in the Pacific. Let's not forget Apollo was never built to be a sustainable program. It was all about the sprint. Is it any surprise it did not sustain public interest?

Washington, we have a problem . . .

Now a natural reaction for those of us who lived through the triumph of Apollo is to harken back to the good old days. Bring back those "One small step. . . Failure it is not an option" moments and surely our kids will get space bug—and thus we hope—they will be stirred toward STEM as well. . . . Hey—it worked like a charm then? Why not do it again for old time's sake . . .

There are a lot of good reasons the recipe for Apollo moment cannot be replicated: there's the Cold War context, the desire meet a seemingly unattainable goal set by a martyred president and, of course, there was the NASA budget that would equate to more than \$30 billion this year. Now that's some launching around money!

None of those elements are in the cards today. And let's not forget we have been there, done that—and those footprints are forever etched in the regolith. While the mission planners and engineers will point out the proposal to build a more permanent Moon base is an entirely different—and new—challenge, I am afraid this detail is lost on a jaded public that wants to hear about something entirely new and different.

So what do people care about when it comes to space? So what are the stories that leak out from under my little tent of space lovers? Well—speaking of leaks—a new image from the Cassini spacecraft which rolled out yesterday is a great example. It shows huge water plumes spurting out from the surface of Saturn's moon Enceladus. Very cool stuff. Stories about extrasolar planets get a lot of pickup . . . so do interesting images from the spacecraft that orbit and rove Mars . . . anything from Hubble—or anything about the former planet Pluto.

And when it comes to human beings in space—there is insatiable interest in the effort to open space up to the rest of us. I will never forget the thrill I had covering SpaceShipOne as it captured the X-Prize in Mojave in October of 2004. The excitement in the air was palpable—for a flight that went about as high as Alan Shepard went in May 1961.

But this time it was one of us. The candle was lit beneath a rank civilian. No Right Stuff required. Suddenly, it all seemed within our grasp—in our lifetimes. Nearly fifty years after Gagarin and Shepard flew—only 500 humans have made it to space—you Mr. Chairman are one the of the lucky ones. I had hoped to be on the list by now myself.

People want to go there themselves—simply sending a GS-13 civil servant does not thrill them anymore.

It is high time the government helped open up the space frontier to the private sector—just as it helped the railroads span the continent . . . or as it built the interstates . . . or created our aviation infrastructure. And I applaud the White House for placing this bet on what amounts to nascent spacelines that may one day carry hundreds of people to space every month . . . or every week. Arthur C. Clarke would be proud. An while this exciting aspect of the plan got lost in badly bungled public rollout of the news—I think it will generate a lot of excitement as time goes on.

I applaud extra money spent on aeronautics and earth sciences. These efforts will go a long way in helping the agency answer those every day relevancy questions that always come up. These will be good stories to tell the public.

I applaud the money that will be spent on participatory exploration. The public that wants to go to space—also demands to be looking over the shoulders of NASA scientists as they download the latest Hubble, Cassini or Opportunity images.

And I am glad the station won't be deep-sixed before it even has a chance to prove its scientific value. It turns out the absence of gravity can make germs more virulent. Turning up the volume on this might make it easier to learn how to make vaccines. There might be some real news that comes out of this unique national laboratory in the next decade.

Which bring us to the mission. What is the next great human mission in space? Frankly it isn't clear. And that is a bit worrisome. It is nice to have goals. We children of the Space Race love a destination and a deadline. But goals that simply lead to uninspired jobs programs are not what we need.

NASA was not getting anywhere doing business the way it had been. Over the years, the money required to keep flying the shuttle safely left little room to push

the envelope—as they say. With this budget, the money will be there to pursue some new propulsion technologies that might get us to Mars in a reasonable period of time; or find some better ways to arrive in orbit and on the surface of another planet; or work on closed loop life support systems; or come up with ways for future explorers to use the resources that exist on Mars.

In one sense, we won't going anywhere I suppose. But we will be exploring—taking the necessary first steps on the journey we have dreamed of for years. I only wish we had started sooner.

It is time for our space agency to reboot and rethink its mission. I look forward to telling the story of NASA 2.0.

Senator NELSON. Thank you, Mr. O'Brien.
Mr. Mike Snyder.

STATEMENT OF MICHAEL J. SNYDER, AEROSPACE ENGINEER

Mr. SNYDER. Good afternoon. Thank you, Mr. Chairman, for the opportunity to appear before the Subcommittee today to discuss the challenges and opportunities of the proposed Fiscal Year 2011 budget for NASA.

My name is Mike Snyder, and it has been my honor and privilege to work on the Space Shuttle program for the past 13 years. I'm an engineer, and I'm one—just one of the tens of thousands of people across America who work daily on the Nation's efforts in human spaceflight programs.

The views you hear today are my own, but I can assure you that they are representative and shared by many in the aerospace force at large.

The space program is often referred to as a national asset, an asset that has, does, and hopefully will continue to set the United States of America apart from all other nations. By extension, that same reference could, and should, be applied to the men and women that make it all happen.

Today, unfortunately, I must inform you that morale across the entire human spaceflight workforce, both civil servant and contractor, is low. Perhaps the single biggest contributor to the low morale is the perceived lack of any detailed plans with clearly defined objectives and timetables for the future of spaceflight.

Hanging on a wall in my office building is a poster that states, "If you aim at nothing, you are certain to hit it." And I cannot escape the potential relevance of that statement in this case. All too often, it seems, we are not allowed a policy that, while planning for the future and developing the technologies that will ultimately be necessary, that we take those first steps with our abilities and capabilities of today. We must break free of the cycle that any new program first requires the elimination of all that has come before it for the sake of that implementation.

If NASA is to make such a dramatic change in course all at once, the question the workforce is left asking is, How can all the necessary details associated with this new direction be in place a short 7 months from now, when two out of the three major human spaceflight programs are scheduled for termination? The answer, we believe, is that they will not. If that is indeed the case, then who will perform this work? Where will this work be located, and when will it be available?

Many of us, obviously, have families who we, obviously, need to support. We cannot, and will not, be able to wait around and as-

sume that better days are ahead. For the Nation and this industry, the result will be a workforce with valuable and unique skills and experience that will be greatly diminished or lost completely, and one that cannot be rebuilt without significant time and effort.

Contributing to the workforce dilemma is the apparent arbitrary 2010 retirement date of the Shuttle. It would be far easier to stand down this unique capability if there were other vehicles ready to fill the void that Shuttle retirement will surely create. We had hoped that we could pass the torch onto the follow-on program. Now, however, it simply looks like we're extinguishing it, regardless of the circumstances that that decision will create.

As of today, no American replacement vehicles exist that are operational. And the Nation is hinging the sustainment and full utilization of the International Space Station—our \$100-billion investment, 26 years in the making—on the hope and assumption that they arrive. In my opinion, that is a strategic mistake of vast proportions, and one that requires the utmost reconsideration from all levels of the Federal Government.

Instead, we have chosen to rely on a foreign nation as the sole method of transport for an unspecified amount of time to a Space Station which owes its very existence to U.S. leadership, it has been so heavily funded by the American people. In general, this has been interpreted as a lack of faith from our government in our ability to fly the most capable vehicle to ever orbit and return to the Earth in support of the ISS.

The reality of the situation is that we need a better and smoother transition that recognizes the new robustness of the Space Shuttle performance, and one that does not instantly and all at once swing the pendulum to the opposite extreme. We need a transition that not only plans for the future with a detailed program, including timetables for beyond-Earth-orbit exploration, but also supports our immediate and critical mission: full utilization of the ISS. We need a transition that takes advantage of the capabilities of multiple commercial providers, in combination with any potential NASA follow-on vehicle, to ensure that use of ISS.

At present, this use can only be accomplished with the extension of the Space Shuttle program. Once these commercial providers or other capabilities have met the appropriate performance milestones that prove their capability, then that is, and should be, the trigger for Shuttle retirement. If this Nation allows ISS to degrade and not realize its full potential, then, potentially, so does the business case for these commercial providers.

Extension of the Shuttle program also opens up the possibility of a Shuttle-derived heavy-lift vehicle. A recombination of Shuttle elements into a new inline configuration could yield that capability in just a few years and take advantage of the natural synergies between Shuttle, the potential HLV, their shared infrastructures, and the current experience base of the workforce.

Finally, we have heard a lot about education and inspiring the next generation; it's an obviously worthy goal. My fear is that kids who would otherwise do well in this field will ultimately be discouraged from entering it by multigenerational programs where we promise to go somewhere and then always retreat. If we, as a Nation, are serious about spaceflight, then that is something that we

must absolutely change. I never saw a man walk on the Moon, and that was something already relegated to history books by the time that I was born. My real concern with the current proposal is that my girls will grow up in a country where they, too, have to look to the history books to see what this Nation used to be capable of achieving.

Thank you again, Mr. Chairman, and I'm happy to respond to any questions you or other members may have.

[The prepared statement of Mr. Snyder follows:]

PREPARED STATEMENT OF MICHAEL J. SNYDER, AEROSPACE ENGINEER

Thank you, Mr. Chairman, for the opportunity to appear before your Subcommittee today to discuss the "Challenges and Opportunities of the Proposed FY 2011 Budget for NASA."

My name is Mike Snyder and it has been my honor and privilege to work on the Space Shuttle Program for the past 13 years. I am not a civil servant, a CEO of a major aerospace corporation or even a member of senior management. I am an engineer and one of the tens-of-thousands of people across America who work daily on this Nation's efforts in human spaceflight programs. The views you hear today are my own but I can assure you they are representative and shared by many in the aerospace workforce at large.

It has always been my dream to be a part of the Space Program, and even as a kid, I never wanted to do anything else. This is more than just a job to me. It is a passion. It is about diligence and dedication. It is about service and about being part of something greater than myself. However, my story is not unique as these feelings and beliefs are shared by countless others who make up the backbone of any undertaking this Nation makes with regard to spaceflight and exploration.

The Space Program is often referred to as a national asset, an asset that has, does and hopefully will continue to set the United States of America apart from all other nations. By extension, that same reference could and should be applied to the men and women that make it all happen. However, I cannot escape the impression now of being taken for granted, of being considered expendable. It seems to be assumed we are to quickly adapt and possibly relocate our families and reorient our lives easily. Perhaps most importantly, in the workplace, we are expected to compartmentalize all the unknowns and concerns about everything we have worked for seemingly slipping away and still do the job, the mission, we know we have to do. Today, I must inform you that morale across the entire human space flight workforce, civil servant and contractor, is extremely low. The lowest I have seen it in all my years of service.

Perhaps the single biggest contributor to the low morale is the perceived lack of any vision, purpose or detailed plans with clearly defined goals, objectives and timetables for the future of human spaceflight. We can all agree that Research and Development (R&D) is vitally important. However, R&D without direction and purpose, without a planned and well-defined operational concept is no more useful or sustainable than assuming we can explore the solar system and beyond without development of new technologies. I cannot stress enough the importance of having an over-arching program with clearly defined goals that focus these R&D efforts to near term as well as long term capabilities with the intent and strong National will to use them. Congress must not let our Nation fall into the trap yet again that vaguely ties these technologies and capabilities to some future date, future Administration and future Congress—because that way will ensure, in my opinion, that these expensive initiatives never bear fruit and will serve only as a disservice to this industry's current and future workforce and to the United States of America as a whole.

Along these lines, we are all told by our Center Directors, company CEOs, and our senior management that more information will be communicated about the direction of the Agency. However, the problem is that they do not yet know either. What the everyday worker does know is the inescapable fact that two of three of this Nation's major human space flight programs are proposed to be terminated. We are told by senior Agency officials that this will ultimately be good for every center, even if that does not make logical sense to us. We also know that it can be a lengthy process to chart a new course, request contract proposals, to negotiate contracts, and to turn that work on so people can do that work.

The question we are left asking is how can all of this possibly happen in any reasonable amount of time? The answer, many of us believe, is that it will not, given

the fact we are only 7 months away from the proposed end of these programs. With that knowledge, we non-civil servants are forced to choose: do we risk completing a program that was at one time in the Nation's best interest, and in which we have personally invested so much, then to find there are no jobs and that our dedication has been at the expense of our families? Or do we leave now, potentially abandoning our careers in a field and in a cause we find important, worthy and noble in order to assure our families are properly cared for? These are the questions we face and each of us will have to answer individually—but for the Nation the result will be the same: a workforce with valuable and unique skills and experience that will be greatly diminished or lost completely and one that cannot be rebuilt without significant time and effort.

Contributing to the workforce dilemma is the arbitrary 2010 retirement date of the Space Shuttle that is now upon us and all the consequences that brings. Those of us who have worked on this program for the last several years obviously knew the end of the Shuttle era was coming. We had hoped that we could “pass the torch” onto a follow-on program, but now, it looks more like we are simply extinguishing it. The Space Shuttle's main reason for existence and its primary mission was the construction and periodic resupply of a space station. By the end of this year, that mission will still only be partially complete. It would be far easier to stand down this unique capability if there were other vehicles ready to fill the void Shuttle retirement will surely create.

However, as of today, no American replacement vehicles exist that are operational and this Nation is hinging the sustainment and full utilization of the International Space Station, our one-hundred-billion-dollar investment twenty-six years in the making, on the hope and assumption that Russian, Japanese, European and unproven commercial vehicles will provide adequate personnel and logistic support to the ISS. In my opinion, this is a strategic mistake of vast proportions and one that requires the utmost reconsideration and serious attention from all levels of government. We are on the verge of giving up the inherently robust and flexible capabilities of the Space Shuttle, capabilities that are unique to this world and not likely to be duplicated by any nation or any company in the near future, simply because we choose to do so. Instead we have chosen to rely on a foreign nation as the sole method of transport, for an unspecified amount of time, to a space station which owes its very existence to U.S. leadership and has been so heavily funded by the American people. In general, this has been interpreted as a lack of faith from our government in our ability to fly the most capable vehicle to ever orbit and return to the Earth in support of the ISS, all so we can reallocate the approximately eight one-hundredths of 1 percent that represents the cost of the Shuttle Program to the Federal budget to something else.

Those of us that work on the Shuttle Program daily hear a lot about how the Orbiter is an aging vehicle on the verge of falling apart, that it has outlived its usefulness, that it is inherently unsafe and other more colorful analogies. This is the incorrect perception that constantly challenges us. As someone with intimate knowledge of our processes and procedures, I assure you each Space Shuttle flight is as safe as it can possibly be. Anyone who thinks otherwise, I invite you to Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, our other field centers, our various support and depot facilities or the countless vendors still supporting across this country. Spend a day with the everyday workers and see our attention to detail, how we rigorously test and inspect the vehicle before every flight, how we work problems to “pound them flat,” how we run countless simulations and how we manage, minimize and accept, or do not accept if the situation warrants, the risk that is and will be associated with sending humans into space for the foreseeable future. It is time to challenge the misconceptions about the Space Shuttle that have been so carefully promoted over the last several years, simply to help justify using the Space Shuttle budget for other activities.

To help dispel those misconceptions, allow me to cite just a few of the newer capabilities that make the vehicle safer than at any previous time in the Program's history. The External Tank has been significantly improved to reduce the likelihood of losing foam that can harm the Orbiter. There are cameras on and around the vehicle we did not have a few years ago giving spectacular views never before seen but, more importantly, provide invaluable data on the performance of the integrated stack during launch and ascent. We have capabilities on-orbit that allow us to know in near real-time the structural integrity of the vehicle and the state of the Thermal Protection System. This allows the opportunity to rigorously evaluate, and if necessary repair in some conditions, all abnormalities long before ever committing to entry. We have worked an effort for the past 7 years addressing all critical and critically redundant component and system level certifications verifying we “fly how we

test and test how we fly” and in some cases making the appropriate changes or performing additional testing when discrepancies were found.

All of this, along with other improvements and our normal duties, has led to the fleet performing better than it ever has, and as evidence of this, I point to the just-completed STS-130 mission. *Endeavour* returned home from a challenging and complex mission, having performed magnificently and with zero major problems and virtually nothing to be evaluated prior to committing to the next mission. That said, we stand ready to address any problems that may surface and we remain ever vigilant looking for and trying to anticipate that next problem before it even occurs. This is the product of a highly skilled team and a vehicle with history—a history whose final chapter should not be written until we are certain there will be a story on the next page so that full utilization of ISS to 2020, and possibly beyond, can truly be realized.

When I and others point out the vast improvements in Space Shuttle safety and reliability, we are often labeled as “shuttle-huggers” trying desperately to maintain the status quo for our “government-funded jobs program.” We have heard it all before and I assure you that anyone who truly knows me would not use the words “status quo” to characterize me. The reality of the situation, in my opinion, is that we need a better and smoother transition that recognizes the new robustness of Space Shuttle performance and one that does not instantly and all at once swing the pendulum to the opposite extreme. We need a transition that not only plans for the future with a detailed program including feasible and realistic timetables for beyond-Earth-orbit exploration but also supports our immediate and critical mission: full utilization of the International Space Station. We need a transition that takes advantage of the capabilities of multiple commercial providers, in combination with any potential follow-on NASA vehicle, to ensure full utilization of the ISS. At present, this full utilization can only be accomplished with an extension of the Space Shuttle Program. Once these commercial providers or other vehicles have met the appropriate performance milestones that prove their capability, then that is and should be the trigger for Shuttle retirement. However, if ISS is allowed to degrade or not realize its full potential, the business case for these commercial providers could possibly degrade with it.

Extension of the Shuttle Program also opens up the possibility of a Shuttle-Derived Heavy Launch Vehicle (HLV). Some form of an HLV has generally been agreed to be needed, along with several other potential technologies, to enable exploration beyond low-Earth orbit. It has been suggested that we spend some of the proposed R&D money on technologies to be used for another HLV that may come online twenty or so years from now. However, we have an HLV today and a recombination of the Space Shuttle elements into a new in-line configuration could yield that capability in just a few years and take advantage of the natural synergies between Shuttle, HLV and their shared infrastructures, potentially driving down the costs of both.

Finally, we have heard a lot about education and inspiring the next generation—an extremely worthy goal no doubt and one I have been fortunate enough to play a part in from time to time and will do so again as my two little girls grow. It is said that the proposed new direction will do just that. However, I believe there are some concerns that need to be considered. In my opinion and experience all young people will not get excited about only research and development that only offers the possibility of going somewhere, somehow, with something like what may be in a test stand, someday in the future. I believe the best way to inspire the next generation is for them to see real plans in action, with real hardware doing real missions and knowing there is more to come and that they too can be part of it.

I use myself as an example. I was born after the Apollo moon missions and have never seen anyone leave the confines of Earth orbit. My generation inherited the Space Shuttle Program and I am lucky enough to be a part of it and to be involved in the construction of the International Space Station. However, the Space Station Program was first announced when I was 10 years old. Today, at 36 years old, we are just finishing up construction. My fear is that kids who would otherwise do well in this field are ultimately discouraged from entering it by multi-generational programs and the constant threat of policy changes.

We are already seeing the signs of that pattern repeating, where students in college studying engineering and technology today, could be older than I am now when the theoretical HLV under the current proposal finally lifts off the ground for the first time. If we as a Nation are serious about spaceflight, then that is something we together must absolutely change. As I said earlier, I never saw man walk on the moon and that was something already relegated to history books by the time I was born. My real concern with the current proposal is that my girls will grow up in

a country where they too have to look to the history books to see what this Nation used to be capable of achieving.

Thank you again, Mr. Chairman, and I am happy to respond to any questions from you or members of the Subcommittee.

Senator NELSON. Thank you, Mr. Mike Snyder.
Mr. Tom Young.

**STATEMENT OF A. THOMAS YOUNG, FORMER DIRECTOR,
NASA GODDARD SPACE FLIGHT CENTER
AND PRESIDENT AND CHIEF OPERATING OFFICER,
MARTIN MARIETTA CORPORATION**

Mr. YOUNG. Chairman Nelson and Mr. Vitter, I'm please to have the opportunity to comment on the proposed Fiscal Year 2011 NASA budget.

As requested, I will concentrate on NASA's budget proposal beyond human spaceflight; however, I can't resist offering a few comments on human spaceflight at the conclusion of my remarks.

It's important to define the basis and criteria for my assessment. I believe what NASA does says much about our country. What NASA does is very much a part of what we believe to be important, our role in the world, and our values. I have no doubt NASA's accomplishments in the past five decades, to use an Olympic analogy, have placed the United States at the center position on the podium. We must assure that our current decisions result in a continuation of this success.

The operational elements of the NASA budget are science, aeronautics and space research and technology, and human spaceflight, including both exploration and space operations. There is significant growth in the new science budget, as compared to Fiscal Year 2010 budget. This growth is in Earth Science. Planetary science and astrophysics are largely unchanged, and some decline exists in heliophysics.

The National Academies produce Decadal Surveys that provide scientific basis and proposed priorities for each discipline of science. I have the privilege of serving as Vice Chairman of the Space Studies Board, which, along with other boards, provides oversight of the Decadal Surveys. I'm also a member of the committees currently conducting astrophysics and planetary surveys. The Decadal Survey process is enormously comprehensive, representing the best in scientific debate and decisionmaking. The result is a 10-year plan with extraordinary support and credibility.

The Earth Science Decadal has been available for a few years, and provides a sound basis for the growth proposed in the physical year 2011 budget. Astrophysics and planetary surveys are currently in development. While the proposed budget will support impressive astrophysics and planetary missions, there are extraordinary mission opportunities responsible to the most profound questions concerning our solar system and the universe that will not be affordable. I believe the same observations are true for heliophysics, which is just beginning the next Decadal Survey process.

In summary, much can be accomplished within the proposed science budget that will contribute to our understanding of Earth, our solar system, and the universe. Although it is frustrating

knowing that there are worthy opportunities that cannot be accomplished within the proposed budget, there is some consolation in knowing that we're implementing the best of the best.

The growth in aeronautics and the new space technology line are most positive. It is difficult doing the things NASA does without a strong technology base. The proposed space technology line will strengthen this critical area. The growth in aeronautics and the new space technology program should be strongly supported.

There is also considerable technology funding included in the exploration budget. While significant benefits can be realized from the total proposed technology investments, we must recognize the lack of focus and identified mission uses can result in wasteful and nonproductive hobby-shop activity.

Much is yet to be done to structure a technology program that is properly focused. It is easy to spend technology money; it's hard to spend it productively. And the critical aspect of spending it productively is to have it as a part of an integrated strategy.

That brings me to my overarching comments on human spaceflight. The Augustine Commission report had a subtitle that I believe deserves our attention: "A Human Spaceflight Program Worthy of a Great Nation." I believe the human spaceflight program contained in the proposed Fiscal Year 2011 budget fails this test. My reasons for reaching this conclusion are:

One, I believe the reliance upon commercial human spaceflight for access to low-Earth orbit is a risk too high and is therefore not a responsible course. I do hope the commercial endeavors are successful.

Two, the absence of a clearly defined human exploration program with no expectation of any human exploration for decades is not consistent with my views of a great Nation.

We can only hope that, by this time next year, we will recognize that our current course is not tenable, address those areas that need the most attention, and reestablish a human spaceflight program once again deserving of a great Nation.

Thank you.

[The prepared statement of Mr. Young follows:]

PREPARED STATEMENT OF A. THOMAS YOUNG, FORMER DIRECTOR, NASA GODDARD SPACE FLIGHT CENTER AND PRESIDENT AND CHIEF OPERATING OFFICER, MARTIN MARIETTA CORPORATION

Chairman Nelson and committee members, I am pleased to have the opportunity to comment on the proposed FY 2011 NASA Budget. As requested, I will concentrate on NASA's budget proposal beyond human spaceflight. I will also offer a few observations on human spaceflight at the conclusion of my remarks.

It is important to define the basis and criteria for my assessment. I believe what NASA does reveals much about us as a country. What NASA does is very much a part of what we believe to be important, our role in the world and our values. I have no doubt NASA's accomplishments in the past five decades, to use an Olympic analogy, have placed the United States at the center position on the podium. We must assure that our current decisions result in a continuation of this success. Greatness is determined by what one does during challenging times that is discretionary.

The operational elements of the NASA budget are science, aeronautics and space research and technology, and human spaceflight (exploration and space operations).

There is significant growth in the new science budget as compared to the FY 2010 budget. This growth is in Earth Science. Planetary Science and Astrophysics are largely unchanged with some decline in Heliophysics.

The National Academies produce Decadal Surveys that provide scientific basis and proposed priorities for each discipline of science. I have the privilege of serving

as Vice Chairman of the Space Studies Board, which, along with the other boards, provides oversight of the Decadal Surveys. I am also a member of the committees currently conducting Astrophysics and Planetary Surveys. The Decadal Survey process is enormously comprehensive, representing the best in scientific debate and decisionmaking. The result is a 10-year plan with extraordinary support and credibility.

The Earth Science Decadal has been available for a few years and provides a sound basis for the growth proposed in the FY 2011 budget. Astrophysics and Planetary Surveys are currently in development. While the proposed budget will support impressive Astrophysics and Planetary missions, there are extraordinary opportunities responsive to the most profound questions concerning our solar system and the universe that will not be affordable. I believe the same observations are true for Heliophysics, which is just beginning the next Decadal Survey process.

In summary, much can be accomplished within the proposed science budget that will contribute to our understanding of Earth, our solar system, and the universe. Although it is frustrating knowing that there are worthy opportunities that cannot be accomplished within the proposed budget, there is some consolation in knowing we will be implementing the best of the best.

The growth in Aeronautics and the new space technology line are most positive. It is difficult doing the things NASA does without a strong technology base. The proposed space technology line will strengthen this critical area. The growth in Aeronautics and the new space technology program should be strongly supported.

There is also considerable technology funding included in the Exploration budget. While significant benefits can be realized from the total proposed technology investments, we must recognize that lack of focus and identified mission uses can result in wasteful, nonproductive, "hobby-shop" activities. Much is yet to be done to structure a technology program that is properly focused.

That brings me to my overarching comments on human spaceflight. The Augustine Commission report had a subtitle that I believe deserves our attention: "A Human Space Program Worthy Of A Great Nation." I believe the human spaceflight program contained in the proposed FY11 budget fails this test. My reasons for reaching this conclusion are:

1. I believe the reliance upon commercial human spaceflight for access to low earth orbit is a risk too high and is therefore not a responsible course. Nevertheless, I do hope the commercial endeavors are successful.
2. The absence of a clearly defined human exploration program with no expectation of any human exploration for decades is not consistent with my views of a great Nation.

We can only hope that, by this time next year, we will recognize that our current course is not tenable, address those areas that need the most attention, and reestablish a human spaceflight program, once again, deserving of a great nation.

A. THOMAS YOUNG

A. Thomas Young is the former Director of the NASA Goddard Space Flight Center and President and Chief Operating Officer of Martin Marietta Corporation. Mr. Young retired from Lockheed Martin in 1995.

Mr. Young is a member of the Science Applications International Corporation (SAIC) Board of Directors. He is currently involved in various space advisory and review activities.

Mr. Young is a member of the National Academy of Engineering.

Senator NELSON. You are an excellent panel. Thank you. You have contributed mightily.

I might point out that this committee will hold a hearing on commercial spaceflight, and we will dig into the details with appropriate witnesses over the course of the next few weeks.

Let me ask just a few questions and we'll round out this hearing today.

For Hoot Gibson, how do you think NASA will certify crew safety on commercial vehicles?

Captain GIBSON. I'm not sure what their approach stands, right at this moment, but the way that they need to do it needs to be the way that we have always done it with our inherent NASA-de-

veloped crew vehicles, and namely, by following the human ratings standard that NASA has in place for these vehicles.

I don't think that we could arrive at the right place if we just say, "We're going to build it for cargo, with some relaxed requirements, launch it a couple of times and see what our success rate is, and then declare it safe for human spaceflight." I think there's going to have to be a rigorous process that we go through in the same manner that we do on the vehicles that we develop ourselves.

Senator NELSON. So, the agency is going to have to define a process to validate the commercial providers for human requirements.

Captain GIBSON. Yes. And many of these, Mr. Chairman, are very specific items—the design of the electrical systems, the design of the structure, the structural margins. All of these things are very much spelled out in the human rating standards, and we're going to have to make sure that every step of that process is followed by the commercial providers, as well.

Senator NELSON. I'm going ask a question that I know your answer is yes, but I want to get it on the record. Should the Astronaut Office be involved with this certification and validation process?

Captain GIBSON. Absolutely yes, Mr. Chairman.

Senator NELSON. You are a propulsion expert. Is heavy lift a priority?

Captain GIBSON. Yes, it is. Yes, it is. With all of the comments that we've heard from the Augustine Commission, and all of the direction that we have seen in the country, in many years now—for many years now, we need to branch out beyond low-Earth orbit, and that's going to require heavy lift, for us to do that. And the obvious path, in my opinion, for us to follow at this point, is to leverage the \$9 billion of investment that we have already made in the previous program and take the things that we have developed, which are in direct support, as I mentioned earlier, of the heavy-lift vehicle. If we take the cancellation costs that are involved in that program, and add it to the amount we've already spent, we wind up with a fairly significant price, with nothing to show for it. If we continue the testing up through the envisioned testing at this time, we can accomplish that at no additional cost over what the price would have been, and we wind up with something, instead of winding up with nothing.

Senator NELSON. So, the \$2 and a half billion in the President's budget to cancel the program—instead, use that to continue testing on Rocket X and to continue to develop a capsule that ultimately would go on the heavy lift?

Captain GIBSON. Yes, sir, exactly. Exactly the direction that, my opinion is, that we should be proceeding in. And that way, as I say, we wind up with something at the end of this whole entire process, instead of cancellation costs and winding up with nothing.

Senator NELSON. Mr. O'Brien, you have pretty well commented on the mood of the country, and we've heard it from other witnesses, as well. And yet, you noticed things that have to change, and that NASA has to change. How can you—I'm asking you an impossible question, but it's one that we have to ultimately answer—how do we get from the doom and gloom of the perceived program, through this paradigm shift, to make and remake NASA?

Mr. O'BRIEN. It's really important we bring people along for the ride, one way or another. And I thought it was really—I was struck and impressed that there is talk in this budget about participatory exploration.

You know, if you think about it, NASA has really pioneered this whole notion of bringing people along for the ride. You know, it really started way back in the Mars Pathfinder days, when scientists would be seeing images on Mars at the same time people at home were watching them on the Internet. The more we bring people along for the ride, the more they're going to be a part of this whole process. And that's why I think, you know, if we can figure out how to thread the engineering needles that Hoot has laid out here—and that's very important, that this is a safe way to fly; I don't think anybody in the commercial sector would tell you they want to do it in an unsafe manner—if we can figure out how to do that, it portends tremendous opportunities for a lot of people to go to space. We've had 500 people go to space since it all began; two of you are in the room here. And I wish I had had my opportunity, as well. We should be sending 500 people a month. And for NASA to figure a way to get out of the way in low-Earth orbit and allow this industry to thrive, I think we'll enthuse the public in ways we can't imagine.

I remember being out there to cover that X PRIZE, back in 2004—October of 2004. It was positively electric in the atmosphere out there, because even though it was a suborbital hop, something we did in 1961 with Alan Shepard, it was just a rank civilian doing it. You don't need the right stuff. And I think if NASA can make that happen, make it possible for more people to go, and bring people along for the ride in other ways, I think they'll recapture that connection to the public.

Senator NELSON. Deep down, I believe that the public has a yearning for space travel by humans, because it is our nature, as a people. We are explorers. We are adventurers. We've always had a frontier. Along the way, space travel has become ho-hum to the public. Why the disconnect?

Mr. O'BRIEN. Well, I think, because people couldn't go, or they had the feeling they couldn't be a part of it in any meaningful way, without being number one at Top Gun school. You know, I guess, when you look at the previous frontiers, anybody could get in a covered wagon and head West, right? This is a different kind of frontier. And for a long time, rightly so, it was the bastion of a very elite, exclusive club of people who got to go. Well, that's got to change. We're at the point now where we can change that, and NASA can help enable that change, if it decides to do so; and this budget is all about that.

So, you know, I think there are a lot of pitfalls here, and we're talking about a lot of unproven things. And we've been talking about a robust commercial sector for as long as I've been covering space, but this is the first time I've seen NASA, in a meaningful way, put some bets down in this area, and place some investments in a way that may open up this frontier to more people.

Senator NELSON. So, you don't think that these bets are necessarily bad, that the commercial boys will be able to produce?

Mr. O'BRIEN. Well, I'm not an engineer; I'm a history major. I just play a scientist on TV, or actually on the Web now. But, no, I can't assess the engineering aspects of it. My sense of being a student of all of this is that we're very close to making this a possibility. And it's not something that this industry can do entirely on its own; there's not a business model that stands on its own yet.

But, if you go back to the origins of NASA—the NACA—what did it do? It fostered technology and it shoved it out into the commercial sector. I think it's time to—for NASA to get back to that NACA mentality here a little bit, at least as far as it goes in low-Earth orbit. I'm not talking about commercial trips to Mars; I think that's where NASA should be, and that's where the technology push should be, and that's where—this budget recognizes that fact. Enabling the technology to go way beyond low-Earth orbit is what NASA should be doing. Getting out of the way of low-Earth orbit and helping these commercial players make it possible for lots of other people to go there is exactly what should be happening right now to keep NASA engaged and vital.

Senator NELSON. You've got as good a sense of the American public's feelings as anyone. If the President said, "We're going to go to Mars," and he laid out a vision, how do you think the American public would respond?

Mr. O'BRIEN. Well, I can imagine it would be an interesting discussion, in this time we live in, with the budgetary constraints that we're all dealing with, and with the economy the way it is. But, John F. Kennedy made his similar announcement; the economy wasn't so great, by my read of history. So, I think a broad vision, if it's supported in the context of enabling technologies, inspiring kids, and maintaining our competitiveness, keeping us, technologically, the leaders of the world. In all that context, I do think it would be supported, but it has to be laid out in those terms.

Senator NELSON. Mr. Snyder, of course we talked about how Constellation has been canceled in this program, and we've talked a bit about how the NASA budget is increased by a fairly substantial amount. In the first year, however, it's *de minimis*; it's \$6 billion over 5 years with about a percent and a half in the first year, but there is the renewed commitment to technology development. Can you give us your views about how these changes affect the overall number of jobs supported by NASA and the workforce distribution across different NASA centers?

Mr. SNYDER. I think that's the real question, Senator. What we are thinking is, we all know how long it takes to change contracts, to change directions, to get all these—the people that you need to do that work in place. And, given the fact that we are 7 months away from the end of those programs, many of us are going to have no choice but to disperse, to go off into other industries, to go potentially to other states, to other locations, to do what we need to do to support our families. Now, ultimately, eventually those contracts will be in place. Will people necessarily be able to, or want to, jump ship back to NASA? I don't think so, because they're going to be—a feeling of being burned, of it being unstable, and all those factors that will go into it. And so, you are looking at a net loss—significant net loss of experience that I do not think is going to be easily reestablished.

Senator NELSON. As I have shared privately with various people in the government, including NASA, about trying to take care of the workforce with additional work, such as an emphasis in this budget on research and development, it is my hope that you could see, in part of this workforce transition, that there is a specific plan put in place by NASA for that transition so that those areas that are hard hit by the retirement of the Shuttle and the cancellation of Constellation would have a softer landing. If I sense correctly that the Congress is at least going to make a stab at—don't call it Constellation—call it the continuation, as Captain Gibson has, of testing of test rockets that would lead us in the R&D process of developing a heavy-lift vehicle and the capsule to go do what NASA can do best, which is explore the heavens, then that, of course, will be some amelioration of the jobs and would give some part of your workforce that you're referring to some hope. You want to comment on that?

Mr. SNYDER. I think it would. But, even if we continued what has been referred to as the "program of record," I think we are still looking at a significant strategic mistake in shutting down the Space Shuttle before we need to. The Space Station is up there now. We are relying on the Russians for, you know, some unspecified amount of time. You heard General Bolden here today say that he wants redundant access. As soon as we stand down that fleet, that redundant access is gone and it's a foreign monopoly now at this point. The Shuttle is the most capable vehicle that we have ever had. I challenge anybody who will stand up and say that it is unsafe or use other more colorful analogies to describe it. Clearly, they don't know exactly what we do day-in, day-out to make sure that that fleet—every mission is as safe as it possibly can be.

I think commercial space is ultimately going to be capable of it, but, for the sake of the Space Station, all that money that we have spent on getting it up there, that we can't just walk away from it until we know that we're going to be able to support it.

If you look at what happened to the Space Station during the *Columbia* return-to-flight phase, we went from three crew to two crew. We did mainly maintenance. We did just what we had to do to get—to keep the Station operational. Today, that Station has five or six people on board. It has got many more labs, and much more complex. And yes, we have our ATVs and the HTVs from our international partners, but those were always meant to be in support of the orbiter. So, I cannot logically see how, if we get the orbiter out of the loop—the main cog out of the loop—that we just think that everything is going to be fine.

Ultimately, like I said, those commercial people could—the providers could probably get there, but until that time, I don't see that it makes sense to retire Shuttle. With the HLVs—the potential HLV—clearly, keep the Shuttle going, there is some synergies there that could certainly help ultimately drive down your cost of your HLV, as well as, potentially, the cost of your Shuttle program, because you could draw off of those and off of that workforce.

Senator NELSON. Mr. Young, you've been Vice Chairman of the Space Studies Board. Can you explain how NASA has used the results of the Decadal Surveys to determine their priorities?

Mr. YOUNG. It's actually quite a—I think, quite an impressive process, watching it work. If I can give just a tad of background, it's probably a year and a half of effort by a large number of people in the scientific community that go into producing a Decadal Survey. So, it's well thought out, well debated, and highly credible when it's finished. I think NASA—and I'll also say the Congress and the OMB, I believe, have significant—based on experience, have significant confidence in the Decadal Surveys. And NASA today—Administrator Bolden, I've heard say it clearly; Ed Weiler, who runs the Space Program; has a lot of experience; commented—they look at it as the basis for the science program that NASA and the country does today.

So, we really have a very comprehensive process that I think we should be very proud of, and the net result is that we really do do things that are the absolute best of the options that are out there, which is the reason that we make considerable progress on understanding both the Earth, our solar system, and the universe.

Senator NELSON. You have been Chairman of the independent review team that looked at the NPOESS program. This is a program between several agencies. Now, the Administration's new plan would greatly increase NASA's role. What's your reading of the Administration's recent restructuring of the NPOESS program?

Mr. YOUNG. It's extraordinarily better than status quo. And though we probably went farther in our recommendations, I think it's time to get on with the program, and I would strongly recommend support for the restructured program.

Senator NELSON. Well, we have had a good hearing. This is the first step on a journey of many, many steps.

And we will keep the record open for 2 weeks for Senators to submit questions for the record.

Thank you all for your participation. It has been excellent.

And the meeting is adjourned.

[Whereupon, at 4:45 p.m., the hearing was adjourned.]

A P P E N D I X

PREPARED STATEMENT OF HON. JOHN D. ROCKEFELLER IV,
U.S. SENATOR FROM WEST VIRGINIA

Thank you again to all of today's witnesses for their participation. I know this is Administrator Bolden's first time testifying before the Committee since his confirmation and I look forward to his testimony.

This afternoon's topic is the President's FY 2011 budget proposal for NASA. At a time when many agencies are seeing their budgets decrease, the President is proposing an additional \$300 million for NASA next year, building into an increase of \$6 billion over the next 5 years.

Significant investments in science, technology, aeronautics, and education are enormously important. They are a foundation for our future. However, I am going to be looking at this proposal very carefully and will expect strong leadership and financial accountability from the Administrator, the Chief Financial Officer, and NASA's Inspector General.

I have been critical of NASA's financial and program management in the past. And, in these extremely tough budget times, this proposed budget increase requires even more diligence and certainly, more oversight.

In addition to outlining the Administration's plans for the entire budget request for the upcoming Fiscal Year, this proposal also provides a long-awaited response to the options presented by the Augustine Commission for human space exploration.

To say that there has been some "interest" in this decision is an understatement. As the sole authorizing committee for NASA in the Senate, we will be paying very close attention to that discussion as we move forward with NASA's authorization this year.

I am pleased to see an increase in the requested funding for aeronautics research, especially at a time when jobs are this Nation's top priority. The aerospace industry is one of the few remaining manufacturing industries that continue to be a major U.S. exporter.

However, I am troubled by the significant decrease in funding for the Experimental Program to Stimulate Competitive Research (EPSCOR). EPSCOR helps states establish academic research efforts to contribute to economic development. That is why Congress went above and beyond the President's request last Fiscal Year, to make absolutely clear just how important this program is. At a time when jobs have never been more important, it seems like a bad idea to cut funding for a program that supports quality, high-tech jobs.

I realize that this budget proposal represents a significant change in direction for the agency. And I am encouraged by certain elements, including the agency's rededication to science missions.

But I also know that there is a lot of unease, particularly when it comes to the proposed plans for human spaceflight. I firmly believe this is a turning point, an incredible opportunity for Congress and the general public to reexamine what we want out of this agency. And that is exactly what I intend to do as the Commerce Committee moves forward with a reauthorization.

PREPARED STATEMENT OF HON. KAY BAILEY HUTCHISON, U.S. SENATOR FROM TEXAS

Mr. Chairman and Ranking Member Vitter, I appreciate your subcommittee holding this very important hearing on NASA's Fiscal Year (FY) 2011 Budget Request. I join you in welcoming General Charles Bolden, NASA's new Administrator, and the excellent panel of witnesses who will follow him:

- Captain Robert "Hoot" Gibson, whose distinguished career at NASA as a space shuttle pilot and commander included commanding STS-61C, the mission that included as crew members both General Bolden, as the Pilot, and the Subcommittee Chairman as a Payload Specialist in January 1986;

- Mr. Miles O'Brien, who for many years was CNN's eyes and ears on the space program, and I understand was eager to be the first Journalist in Space—once Walter Cronkite became ineligible to fly;
- Mr. Tom Young, whose distinguished first career included management of a major aerospace corporation, and his second “career” in so-called retirement has included serving on the Space Studies Board as well as leading or participating in a great many independent space-related study panels and advisory groups; and
- Mr. Michael Snyder, a constituent of mine in Houston, and a fine example of the highly skilled and dedicated workforce that functions as the real backbone of our Nation's space endeavors. I am especially grateful that Mr. Snyder has chosen to come today at his own personal expense to give us insights into the workforce and the potential impacts of the Budget Request from the perspective of the “troops in the trenches,” whom we rarely have the opportunity to hear from.

This hearing begins the Commerce Committee's consideration of the President's FY 2011 Budget Request, as we undertake our responsibility to establish the policies and authorize the funds necessary to ensure the United States maintains its leadership in space exploration. Our work is particularly vital this year, as it is critical that the Congress examine closely the very underpinnings of the proposed NASA budget request, which I believe, if accepted and supported by the Congress in its present form, would spell the end of our Nation's leadership in space exploration. That would certainly be the case in the area of human spaceflight capability.

Since the release of the FY 2010 Budget Request last year, the future of human space flight programs has been in question. As part of that request, the Administration announced it would establish an independent review panel, chaired by my good friend Mr. Norman Augustine, to review U.S. Human Space Flight Plans and provide options for how those programs should proceed in the future.

The Augustine Panel completed its review in late August of last year, and released its Summary Report in September. Shortly thereafter, this subcommittee held a hearing on the report with Mr. Augustine appearing as the sole witness. Since the release of the full report in September, we have all been waiting for the Administration's response.

The Augustine Panel provided a total of seven approaches that could be taken to ensure America's continued leadership in space—to establish a space program “worthy of a great nation,” as suggested by the title of their final report. None of those options leapt out as the obvious, consensus answer to the mix of vehicle development options and strategies necessary to meet the challenges of the next generation of human spaceflight. There was, however, a clear consensus on two important points.

First, the Panel found that, without a significant increase in the total amount of funding made available to NASA, none of the options presented could be expected to succeed—including the current plans and programs for developing the Ares I and Ares V launch vehicles and the Orion Crew Exploration Vehicle. Second, the Panel recommended that a decision be made to formally extend U.S. plans to operate and utilize the International Space Station (ISS) through at least the year 2020.

The Panel's key conclusions underscored what we in the authorizing committees have been saying for the past 5 years, and which formed the basis for the funding levels and directives that we authorized in both our 2005 and 2008 NASA Authorization Acts. Our directives would have led to a more timely and successful level of development for the vehicles to replace the space shuttle systems, and would have ensured that NASA allow operations of ISS through at least 2020.

I remind my colleagues that we imposed these requirements because up to that point, NASA's internal planning—and budget guidance from the Office of Management and Budget—was to cease operations aboard the space station in 2015, just 5 years after its assembly and outfitting would finally be completed by the remaining Space Shuttle flights.

Unfortunately, the FY 2011 Budget Request does not provide the means to ensure that the extension and full utilization of the Space Station can be realized. We are already planning to fly 10 fewer missions in completing the Space Station than had been planned in 2005. As a result, 10 flights' worth of flight-ready payloads—averaging between 40,000 to 50,000 pounds per flight—were essentially relegated to storage warehouses where most of them remain today, ready to fly, ready to use, but with no guaranteed “ticket to ride” to be of any use to the station. What is most important to remember, is that the decisions about which instruments and equipment to swap into the remaining flights were based on the internal assumption of the need to support the ISS through 2015—not through 2020.

The result of this is that we do not know how many, or which, of those “grounded payload” items might actually be needed in order to ensure the station can be supported and maintained safely and reliably until 2020. Not only that, we do not know which, or how many, of these payloads are simply too large or too heavy to be carried to orbit by any existing vehicle other than the Space Shuttle. And finally, we do not know what additional items might need to be ordered, manufactured and delivered in the future, or what launch vehicle capacity will be needed to deliver them to the station. This is simply not the way a great nation should conduct its civil space program. This is not the way to ensure that a decision and pronouncement to continue operations through 2020 will not become an empty gesture due to the deterioration, damage, or failure of equipment and systems vital to providing the oxygen, water, power to make the ISS habitable and to support scientific research.

I am also deeply troubled about the Administration’s proposal to simply cancel the Constellation programs of Ares I, the low-Earth orbit crew launch vehicle, the Ares V Heavy Lift vehicle for enabling flights beyond low-Earth orbit, and the Orion Crew Exploration capsule to carry the crews for both of those missions. The proposed budget request offers a completely different approach, which is essentially to place all of this country’s human spaceflight capability in the hands of commercially-developed crew launch systems, which are not yet defined and for which no real design requirements, development milestones, or even approximate cost estimates are provided.

There also appears to have been little thought given to how we might leverage the \$9 billion already spent on the Constellation vehicles in developing an alternative government-operated space transportation system to ensure we have the ability to take personnel into space, should those commercial efforts not succeed, or in case they are delayed. I believe that is irresponsible and unworthy of this Nation’s historical leadership in space.

I have been, and continue to be a supporter of the current COTS (Commercial Orbital Transportation Systems) activities being pursued with SpaceX and Orbital Sciences Corporation for cargo delivery services for the Space Station. But, until those efforts are proven to be successful, we have no business investing large amounts of taxpayers’ dollars to begin active development of crew-carrying commercial vehicles, especially when we have no assurance that the government will not end up being the only customer for those launch services.

Instead of sending up a white flag for our Nation’s premiere science agency, we should embrace efforts to close the gap in U.S. human space flight. If not, we must face the reality that we will be totally dependent on Russia, far from our strongest ally, for access to space until the next generation of vehicle is developed. Not only would we be turning our backs on 40 years of American space superiority, we would be giving up vital national security and economic interests to other nations that are eager to exploit this situation. I am simply not prepared to allow the United States to lose its edge in this critical area. That is why I have drafted, and will introduce, a comprehensive bill to address America’s human space flight programs. My bill would allow us to reach full utilization of the space station, provide for the Shuttle to continue operations if necessary to bring essential equipment to the station to reach a 2020 service date, and mitigate the need for our Nation to rely on others to provide access to space for our astronauts corps and researchers.

I do want to acknowledge some good news in the FY 2011 Budget Request, which is that the Obama Administration agrees with the need to continue supporting the Space Station to at least 2020, and to expand and increase its utilization for research. That is very welcome news. But my earlier concerns are very significant examples of how Obama Administration appears to have ignored the recommendations of the Augustine Panel. Therefore, I am pleased that we will begin examining these issues today, and I commend the Chairman and Ranking Member of the Subcommittee for their leadership. I look forward to the testimony of the witnesses and the discussions with the Subcommittee.

Thank you.

