

**COMMERCE, JUSTICE, SCIENCE, AND RE-
LATED AGENCIES APPROPRIATIONS FOR
FISCAL YEAR 2011**

THURSDAY, APRIL 22, 2010

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 10 a.m., in room SD-192, Dirksen Senate Office Building, Hon. Barbara A. Mikulski (chairwoman) presiding.

Present: Senators Mikulski, Shelby, Hutchison, Voinovich, and Cochran.

Also present: Senators Bennett and Hatch.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

STATEMENT OF HON. CHARLES F. BOLDEN, JR., ADMINISTRATOR

OPENING STATEMENT OF SENATOR BARBARA A. MIKULSKI

Senator MIKULSKI. Good morning, everybody. The Commerce, Justice, Science Subcommittee on Appropriations will come to order.

Today, we will be meeting with the Administrator and very interested parties, including our good Senator from Utah, Senator Hatch, on the NASA, the national space agency's fiscal year 2011 budget.

I would like to make my opening remarks, and then turn to my colleague, and then, Senator Hatch, to you. Is that agreeable, Senator?

Senator HATCH. Of course, it is.

Senator MIKULSKI. I know the Judiciary Committee is meeting.

Well, we are going to be welcoming Administrator Bolden, of course, our colleague Senator Hatch, and then Mr. John Frost, a member of the NASA Aerospace Safety Advisory Panel, who will be speaking to the subcommittee to ensure that no matter what we decide, we ensure the safety of the astronauts.

The 2011 NASA budget is \$19 billion, \$276 million more than 2010. The top highlight of this new budget includes major investments in science—\$5 billion in 2011. This is an especially heartened plus-up in Earth science. We will be talking about that in a minute.

The other that we think is quite heartening is extending the life of the International Space Station to continue its operation through 2020 and possibly beyond, meaning better value for our dollar and

better value for our astronauts' efforts. We have spent a lot of time building the space station. Now we have got to spend our time using the space station.

It is time to retire the space shuttle, and the President provides for that at the end of calendar 2010—only three more flights to go after 30 years of exceptional and honorable service. The President's budget also increases funding for aeronautic research, \$72 million above 2010, and a must-do to keep America competitive.

There are extremely dramatic changes to the Constellation program to be—and that will be a subject, I know, of a great deal of focus. And in the area of the Constellation program, we want to be sure and clarify, is the President talking about canceling the Constellation program or restructuring the Constellation program? It will be a major source of, I know, a deep Earth probe from this subcommittee.

SCIENCE BUDGET

I just want to come back to the science budget which I think, while we are going to focus a lot on Constellation, we must focus on the other aspects of NASA. There is this strong emphasis on Earth science, and the budget also includes \$1.5 billion for planetary science, for research on asteroids, Mars, Saturn, beyond—all that we need to do in order to get ready to go there.

There is also within the astrophysics budget request \$688 million for cosmic origins. We would note for our subcommittee to remember the astrophysics appropriation also supports the Hubble Space Telescope, celebrating its 20th anniversary in space, and also the building of the James Webb telescope.

We look at the field of heliophysics and how the Sun's solar flares affect our lives, including the solar probe for a launch. We note how important that is because solar flares could take down our power grid, and all that we need to know about early warnings and information is there.

HUMAN SPACE FLIGHT

As I said, the President retires the shuttle, and we want to work with the subcommittee and with all in Florida and connected to the shuttle for an honorable retirement.

Let us go directly to the area of human space flight. The area of controversy is huge. NASA requests \$2.4 billion for exploration. It is below the 2010 level by \$1.4 billion. That is big. The budget originally said cancel the Constellation program. The President, in going to Florida, elaborated and some say clarified that we are not canceling. He is not recommending the cancellation of Constellation, but rather restructuring it. This is of very, very, very keen interest in this subcommittee.

CONSTELLATION

Constellation was to be our way to go to the Moon and to Mars. A crew vehicle made up of Ares the rocket, Orion the crew capsule. The cargo vehicle made up of Ares V and also the Crew Moon Lander.

Now, just let me say what my position is. I need to know more, and that is the purpose of this hearing. And if we need to have more, we are going to do it. Congress needs to know more. We owe it to the American people. We owe it to the taxpayers. And we owe it to the astronauts to be very clear about what we are going to do and how are we going to do it. I need to know more details.

I want to know if this is the program that the Congress and the American people are going to support from one administration to the next. We cannot reinvent NASA every 4 years. Every new President can't have a new NASA agenda. That is the purpose of today's hearings. We are here to get the facts. It is not about finger-pointing. It is about pinpointing.

I have been in contact with the leaders in the space field, including our colleague, Senator Shelby, as well as Bill Nelson, our Commerce Committee authorizer. I outlined a basic set of principles that will guide me in this hearing, and it will guide me as I do the appropriation.

SAFETY

First of all, no matter what we do, my No. 1 priority is astronaut safety. We must have a reliable transportation system to protect our astronauts during launch, mission execution, and reentry.

And I want to be sure that we are applying the same safety standards for deep space exploration as we will for low-orbit work. We want to be sure that the astronauts, when they suit up, know that we have cared for them and want to protect them.

THE NEED FOR A DESTINATION

Second, we need a destination. NASA has been a mission-driven agency since its creation. Having a clear direction and a clear destination tends to keep us focused on what we need to do, the budget to which we need to adhere, and the involvement of our international partners.

I would hope that whatever we do, to focus on the fact that we do need a balanced space program that includes human exploration, a reliable and safe transportation system for both low-orbit and deep space, robust science to save our science and explore our universe, and aeronautics research to keep our country competitive. The key purpose of the space exploration must always include science and not only be derring-do missions. We also need a plan for whatever we decide for workforce transition.

The retirement of the space shuttle is anticipated to proceed as planned. This causes job dislocation anyway. We don't want to be dismissive of that. We have got to be mindful of that. This is really a big transition. Then, if we are going to cancel or restructure Constellation, it causes major dislocation in a variety of States, all of whom I know will articulate their concerns.

CONTRACT TERMINATION

In protecting the astronauts, we also need to protect the taxpayer. This new plan has significant issues with contract termination. We need to be sure that we are not paying for closing down one, or, are we going to be paying down one set of contracts to close

them out, and then paying to start new contracts? It is very complex, and I am puzzled, quite frankly, about how we are going to do it.

We also want to be sure that we do not lose our technology, no matter what the cancellation or transition is, and we do not lose our industrial base.

So we look forward to hearing where we are going to go, how we are going to get there, how we are going to protect the astronauts, and how we are going to protect the taxpayer. We have a lot of questions as we launch this hearing.

I would like to now turn to my colleague, Senator Shelby.

OPENING STATEMENT OF SENATOR RICHARD C. SHELBY

Senator SHELBY. Thank you, Madam Chairwoman, for having this critical hearing to examine the administration's continually changing plans for the future of human space flight.

The President's new plan, like his old one, shows that NASA's leadership team still does not understand the issues at stake. While the administration may have realized that its initial budget request was a failure, the new plan from the same team still ends this country's human space flight program.

Mr. Administrator, your plan does nothing more than continue the abdication of America's leadership in space. The President's own Augustine Commission highlighted what we all believe, that our human space flight program must be worthy of a great nation. I have read NASA's budget, and I find it to be anything but great.

The President's plan only ensures that for decades to come, the United States will be both subservient to and reliant on other countries for our access to space. Future generations will learn how the Chinese, the Russians, and even the Indians took the reins of human space exploration away from the United States.

This request, I believe, abandons our Nation's only chance to remain the leader in space and instead chooses to set up a welfare program for the commercial space industry. It is a plan, I believe, where the taxpayer subsidizes billionaires to build rockets that NASA hopes one day will allow millionaires, and our own astronauts, to travel to space.

The administration claims that if we build up this so-called commercial rocket industry, the private sector market will magically materialize to produce more expendable launches at a lower cost, earlier than the schedule of Constellation. What NASA and this administration have failed to disclose to the U.S. taxpayer is that NASA has no verifiable data to support their claim.

The head of the Office of Science and Technology Policy, Dr. Holdren, as well as you, Mr. Administrator, have testified that NASA did not conduct independent market research to show that this private launch market even exists.

Let me repeat that. The White House adviser on science and technology policy testified that there was no real research or verification done on the viability of the administration's approach for the commercial market to sustain America's space future. Instead, this administration is relying on information provided by the very people who stand to receive billions in taxpayer subsidies to promote their unproven products.

The primary source the administration can cite is a 2002 Futron study that has proven to be overly optimistic. This study was based on a survey of affluent individuals that predicted 33 commercial passengers would have flown between 2002 and 2010. To date, eight space tourists have gone beyond sub-orbital space.

Former Martin Marietta chief executive Thomas Young testified before Congress that the Air Force, in the 1990s, tried to commercialize their space program. The Air Force then, as NASA is proposing now, ceded top-level management of the national security space program to industry under a contracting approach called Total System Performance Responsibility.

TSPR required Air Force project managers to stand back and let industry have total responsibility of the space systems they created for the U.S. Government. Mr. Young stated, and I will quote, that “the results were devastating, and the adverse impact is still with us today.” Those are his words. This misguided program ended up costing the taxpayers billions to correct.

Also in the 1990s, commercial companies made significant investments in evolved expenditure and launch vehicles based on a commercial market that never materialized to support their vehicles. In the end, the Government had to keep this domestic commercial launch provider alive with billions of taxpayers’ dollars.

We have made these mistakes before, Mr. Administrator. Albert Einstein said the definition of insanity is doing the same thing over and over again and expecting different results. I believe that is the case here.

With this past experience in mind, where are the recent, truly independent market analysis of the booming commercial sector for delivering people to low-Earth orbit and back? We should make those public and let there be a real debate about whether taxpayers should shoulder the cost of building space rides for millionaires.

The truth is when troubles mount and a commercial rocket market again fails to materialize, the taxpayers, I believe, will be called upon to bail out these companies and their investors, a recurring theme with this administration.

SAFETY

Other than the Augustine Commission’s cursory examination of safety, there is no evidence that NASA has done any in-depth analysis related to the safety concerns of putting humans on a commercial rocket. I remain steadfast in insisting on safety as the first priority for the space program. Nothing less is acceptable.

And contrary to NASA’s position on commercial safety, the Aerospace Safety Advisory Panel, whose sole focus is to ensure that lives are not needlessly lost in our space program, stated in their 2009 report that no commercial manufacturer is currently human rating requirements qualified, despite some claims and beliefs to the contrary.

This is after the 2008 report, written in part by you, Mr. Administrator, declaring that commercial vehicles, I will quote you, “are not proven to be appropriate to transport NASA personnel.” I will ask some questions about how you could, in 2008, state that this industry was incapable of safely transporting astronauts, and yet today say just the opposite.

Madam Chairwoman, I find this abrupt change in opinion to be without evidence and highly suspect. NASA's safety experts agree that current commercial vehicles are untested and unworthy of carrying our most valuable assets—our Nation's astronauts.

As a resounding rebuke of the Augustine options and their biased and overly optimistic view of newcomers to commercial space, the Aerospace Safety Advisory Panel reaffirmed what has been known for some time, and I will quote, "To abandon Ares I as a baseline vehicle for an alternative without demonstrated capability nor proven superiority, or even equivalence, is unwise and probably not cost-effective. The ability of any current COTS design to close the gap or even provide an equivalent degree of safety is speculative. Switching from a demonstrated, well-designed, safety-optimized system to one based on nothing more than unsubstantiated claims would seem a poor choice. Before any change is made to another architecture the inherent safety of that approach must be assessed to ensure that it offers a level of safety equal to or greater than the program of record."

COMMERCIAL ORBITAL TRANSPORTATION SYSTEM (COTS)

A year ago, I had some very strong criticisms of the COTS program, and those criticisms are just as valid today as they were then.

This request represents nothing more than a commercially led, faith-based space program. Today, the commercial providers that NASA has contracted with cannot even carry the trash back from the space station much less carry humans to or from space safely.

These providers have yet to live up to the promises they have already made to the taxpayer. Not a single rocket or ounce of cargo has been launched since we met last year. Instead of requiring accountability from these companies, the President's budget proposes to reward those failed commercial providers with an additional bailout.

The President's retreat from his initial proposal last week was rolled out in the shadow of the rocket that is the basis of the new commercial vision for the future of human space flight. Yet this visionary company's first foray into rocketry—the Falcon 1—was 4 years delayed in launching a successful rocket. After three failures and a cost escalation of 50 percent, it finally got its rocket off the ground.

The Falcon 9, the very vehicle the President touted a week ago as the future for NASA, is 2 years behind schedule and counting. Yet the President's budget rewards the commercial space industry with an additional \$312 million bailout to deliver on already-signed contracts in the hope that they will actually be able to deliver something someday. This equals a 60 percent cost overrun for an unproven commodity.

Given the current record of repeated failure to deliver on their agreements, the continued schedule delays, and now the cost overruns, I believe that the President canceled the wrong rocket program.

Mr. Administrator, this plan lacks vision, is unrealistic, and jeopardizes our entire human space exploration program. I am as-

tounded by the enthusiasm with which NASA leadership has maligned the years of hard work by your own engineers.

Congress has a responsibility, I believe, to those whom your plan will put in the unemployment line, something your leadership team dismisses as mere collateral damage. However, we do not see it that way. To us, they are people who already have been devoting and maintaining the leadership and heritage of 50 years of space flight.

The jobs that are promised to be created will hardly materialize before the pink slips begin to arrive. Once those highly skilled workers leave, they will likely never come back. Given the way they have been treated so far this year, I would hardly blame them.

Now, you are even attempting to undermine the letter and the spirit of the law as it relates to the current funding of Constellation. Your destructive actions toward the Constellation program will only ensure that members cannot trust you. Mr. Administrator, you are creating an atmosphere where you and your leadership team have become a major impediment, I believe, to moving forward.

Under the administration's plan, NASA, as we know it, will never be the same. Today, NASA is immediately associated with success in spite of insurmountable odds. There is a deeply ingrained respect for what NASA can do because of what NASA has done and is doing today.

If this proposal is the best that we can do as a Nation, then we do not deserve, I believe, the rich heritage of human space flight, which previous generations sacrificed for to make the country's space program what it is—great.

The proposed NASA budget abandons most of Constellation in favor of an unproven commercial option that will devastate any goal the United States has in exploring beyond low-Earth orbit. The President's announcement of his new plan last week merely replaced one visionless plan with another.

It is clear that the administration, and more specifically you, Mr. Administrator, do not believe that American leadership in human space flight is a priority worth fighting for. No matter how many summits, press releases, or parades you conduct, hope is not a strategy. This plan would destroy decades of U.S. space supremacy by pinning our hopes for success on unproven commercial companies. This budget is not a proposal for space exploration worthy of this great Nation.

Thank you.

Senator MIKULSKI. Senator Hatch?

STATEMENT OF SENATOR ORRIN G. HATCH

Senator HATCH. Well, thank you, Madam Chairwoman, Senator Shelby, Senators Cochran, Bennett, Voinovich, and Hutchison. It is a privilege for me to be with you. I would ask, Madam Chairwoman, that my full statement be placed in the record.

Senator MIKULSKI. Without objection.

[The statement follows:]

PREPARED STATEMENT OF SENATOR ORRIN G. HATCH

Chairwoman Mikulski, Senator Shelby, Senator Bennett, and Members of the Appropriations Subcommittee on Commerce, Justice, Science, and Related Agencies, thank you for affording me the opportunity to make these brief comments during the subcommittee's hearing on the National Aeronautics and Space Administration's ("NASA") fiscal year 2011 budget request.

For more than 50 years, our Nation has made a commitment to lead the world in space exploration. This was never more eloquently expressed than by President John F. Kennedy when he said: ". . . our leadership in science and industry, our hopes for peace and security, our obligations to ourselves as well as others, all require us to . . . become the world's leading space-faring nation." I believe NASA Administrator, Charlie Bolden, recently echoed this sentiment when he expressed his strong support for a space program that inspires the creation of the technological innovations which are essential to our Nation's future prosperity.

Therefore, I am puzzled by the administration's fiscal year 2011 NASA budget request.

This proposal calls for the termination of Project Constellation, and its associated rocket systems, the Ares I and "heavy-lift" Ares V. As a result, if ratified by Congress, our Nation could capitulate its position as the world leader in space exploration as well as forgo the technological harvest which has historically accompanied such endeavors.

Let me be clear, if Project Constellation is cancelled, our Nation will not, in the near-future, be able to travel beyond low-Earth orbit. This is ironic considering the President's and NASA Administrator Bolden's recent statements that the ultimate objective of our space program is Mars.

To be fair, the President has spoken of choosing a new heavy-lift system by 2015. Yet, in a time of greatly diminished financial resources, we cannot afford to throw away the \$10 billion our Nation has invested in Project Constellation and the Ares systems and then spend billions more to research and develop new heavy-lift technologies. This point is especially germane since the other heavy-lift technologies contemplated may or may not match the capabilities of solid rocket motors.

I believe Neil Armstrong, the first man on the moon, James Lovell, the commander of Apollo 13, and Eugene Cernan, the commander of Apollo 17, said it best. If we follow the administration's plan "we will have lost the many years required to recreate the equivalent of what will be discarded."

This conclusion was echoed by the independent Aerospace Safety Advisory Panel, which in 2009 stated "to abandon Ares I as a baseline vehicle for an alternative without demonstrated capability nor proven superiority, or even equivalence, is unwise and probably not cost-effective."

In other words, an alternative to Project Constellation will take years of additional time and cost billions more.

Some opponents argue Project Constellation is a troubled endeavor. The truth is quite to the contrary. Just last fall, the world witnessed the launch of the Ares I-X rocket from the Kennedy Space Center in a stunning and successful test. In addition, the heavy-lift Ares V is designed to leverage the engineering and technologies used on Ares I. Therefore, one can surmise, in the end, there will be overall savings using this comprehensive approach versus the piecemeal approach proposed by the administration. Together, the Ares system of rockets provides our Nation and our astronauts with the most reliable, most affordable, and safest means of reaching low-Earth orbit and beyond—a fact which NASA itself has affirmed.

Let me emphasize that point. Ares is the safest system. Nothing comes close. The 2005 NASA Exploration Systems Architecture Study, of which Administrator Bolden was a member of the study's independent review team, concluded the Ares system is 10 times safer than the current Space Shuttle. This was reaffirmed by the Aerospace Safety Advisory Panel which stated that "the ability of any current COTS design to close the gap or even provide an equivalent degree of safety is speculative." The Panel also concluded that "switching from a demonstrated, well-designed, safety-optimized system to one based on nothing more than unsubstantiated claims would seem a poor choice."

This only underscores the administration's proposal relies on utilizing unproven private businesses as the means to transport our astronauts to the International Space Station. It also should be noted, many of the companies which are expected to bid for these contracts are start-ups. These new start-ups do not have any experience in carrying humans, or even cargo, into space. In addition, even under these corporations' most optimistic near-term proposals, their systems will not be able to travel beyond low-Earth orbit.

Some have argued, in this difficult fiscal environment, Project Constellation is simply too expensive and should fall victim to the budget ax. Again, this is not the case. The administration's proposed plan actually increases NASA's budget by more than \$6 billion over the next 5 fiscal years. In addition, cancelling the Ares system, and the plans associated with it, will cost the taxpayer an additional \$2.5 billion because of contractual obligations. On top of these costs, since private businesses have never previously developed a low-Earth orbit system to transport humans to the International Space Station or a heavy-lift system to explore deeper into the cosmos, one can naturally hypothesize lengthy delays and expensive cost overruns for this novel venture. It is also not hard to imagine when the inevitable delays and cost overruns occur that these private enterprises will turn to the Government with requests for additional funds.

Project Constellation should also be seen as an investment in our Nation's future economic competitiveness. In fact, studies have shown for every dollar invested in space exploration, seven dollars has been returned to our economy through the development of new technologies and industries. For example: the revolutionary developments in computers, smoke detectors, water filters, portable X-ray machines, Computer-Aided Topography, Magnetic Resonance Imaging technologies, and advanced plastics are a few of the thousands of products which were developed because of the space program. In addition, I learned, just this week, the Boeing Corporation's work on the International Space Station's electrical systems led to the development of the electrical systems for the 787 Dreamliner, which will be a major U.S. export for the foreseeable future.

Congress should also consider the nexus between the Ares system and the ability of our Nation to maintain future strategic deterrent programs. Both the Ares rockets and our land-based Intercontinental Ballistic Missile (ICBM) force use solid-rocket motors. Our Nation will shortly complete the modernization of our ICBM fleet. Since the early 1990s, NASA has served as the backbone of the solid-rocket motor industry, providing stability to offset the often inconsistent production requirements of the military and commercial sector. Therefore, the termination of Ares would cripple the solid-rocket motor industrial base and could push it beyond recovery for this and future generations.

This was one of the primary reasons I authored an amendment which was included in the fiscal year 2008 Defense Authorization Act which required the Department of Defense to conduct a study on the status, capability, viability, and capacity of the solid-rocket industrial base. The report concluded maintaining the solid-rocket industrial base is "essential to meeting national security objectives." The report also stated "delays in the NASA Ares program could have significant negative impact on the large solid-rocket motor prime contractor industrial base and more significantly on the sub-tier supplier base, specifically material suppliers."

Accordingly, I arranged for the inclusion of a second amendment in the fiscal year 2010 Defense Authorization Act. This additional amendment requires the Secretary of Defense to devise a plan to maintain the solid-rocket industrial base in order to sustain currently deployed strategic and missile defense systems and preserve an intellectual and engineering capacity to support the development and production of next-generation rocket motors. I look forward to studying its conclusions when it is published in July of this year.

However, I must admit my surprise upon learning, during a meeting between myself and Administrator Bolden last Friday, that NASA and Department of Defense officials have only recently begun to discuss the future of maintaining the solid-rocket industrial base. Frankly, I do not understand how NASA could have devised its budget request without closely coordinating its proposal with the Department of Defense, especially since the solid rocket industrial base is "essential to meeting national security objectives."

Finally, cancelling Project Constellation will have a profound effect on the employment of thousands of jobs during a period of financial uncertainty. Studies indicate approximately 12,000 jobs will be lost when the Space Shuttle program ends next year and at least another 12,000 will lose their jobs if Project Constellation is terminated. Many of these individuals have unique skills which are not easily transferred to other positions.

Therefore, based upon these facts, I can only reach one conclusion. If Project Constellation is cancelled, our Nation's objective of sending an astronaut to Mars will be replaced with the fleeting hope that one day, some day, we will be able to explore the cosmos again. In addition, our national security could be irretrievably harmed.

Again, Chairwoman Mikulski, Senator Shelby, Senator Bennett and members of the subcommittee, thank you for affording me this opportunity to share my thoughts with the subcommittee.

Senator HATCH. Well, thank you.

I am puzzled. I have to admit I am puzzled by the administration's request. This proposal calls for the termination of Project Constellation and its associated rocket systems, the Ares I.

Senator MIKULSKI. Senator Hatch, we really want to hear every word.

Senator HATCH. Should I move a little closer?

Senator MIKULSKI. Is the microphone on, sir?

Senator HATCH. Yes, it is on. Senator Feinstein always says, "Orrin, quit mumbling." I have got to speak a little louder, I am afraid.

Well, like I say, this proposal calls for the termination of Project Constellation and the associated rocket systems, the Ares I and the heavy-lift Ares V. As a result, if ratified by Congress, our Nation could capitulate our position as the world leader in space exploration, as well as forego the technological harvest which has historically accompanied such endeavors.

Let me be clear, if Project Constellation is canceled, our Nation will not in the near future be able to travel beyond low-Earth orbit. This is ironic considering the President's and NASA Administrator Bolden's recent statements that the ultimate objective of our space program is Mars.

To be fair, the President has spoken of choosing a heavy-lift system by 2015. Yet in a time of greatly diminished financial resources, we cannot afford to throw away the \$10 billion our Nation has invested in Project Constellation and the Ares systems and then spend billions more to research and develop new heavy-lift technologies. This point is especially germane since the other heavy-lift technologies contemplated may or may not match the capabilities of solid rocket motors.

I believe Neil Armstrong, the first man on the Moon, James Lovell, the commander of Apollo 13, and Eugene Cernan, the commander of Apollo 17, said it best. If we follow the administration's plan, "we will have lost the many years required to re-create the equivalent of what will be discarded."

This conclusion was echoed by the independent Aerospace Safety Advisory Panel, which in 2009 stated "to abandon Ares I as a baseline vehicle for an alternative, without demonstrated capability nor proven superiority, or even equivalence, is unwise and probably not cost-effective."

In other words, an alternative to Project Constellation will take years of additional time and cost billions of dollars more.

Some opponents argue Project Constellation is a troubled endeavor. The truth is quite to the contrary. Just last fall, the world witnessed the launch of the Ares I-X rocket from the Kennedy Space Center in a stunning and successful test. In addition, the heavy-lift Ares V is designed to leverage the engineering and technologies used in Ares I.

Therefore, one can surmise in the end there will be overall savings using this comprehensive approach versus the piecemeal approach proposed by the administration. Together, the Ares system of rockets provides our Nation and our astronauts with the most reliable, most affordable, and safest means of reaching low-Earth orbit and beyond.

Let me emphasize that point. Ares is the safest system. Nothing else comes close. The 2005 NASA Exploration Systems Architecture Study, of which Administrator Bolden was a member of the study's independent review team, concluded the Ares system is 10 times safer than the current space shuttle.

Now, this was reaffirmed by the Aerospace Safety Advisory Panel, which stated, "The ability of any current COTS design to close the gap or even provide an equivalent degree of safety is speculative." The panel also concluded "switching from a demonstrated, well-designed, safety-optimized system to one based on nothing more than unsubstantiated claims would seem a poor choice."

Now this only underscores the administration's proposal that relies on utilizing unproven private businesses as the means to transport our astronauts to the International Space Station. It also should be noted, many of the companies which are expected to bid for these contracts are startups.

These new startups do not have any experience in carrying humans or even cargo into space. In addition, even under these corporations' most optimistic near-term proposals, their systems will not be able to travel beyond low-Earth orbit.

Some have argued in this difficult fiscal environment Project Constellation is simply too expensive and should fall victim to the budget ax. Again, this is not the case. The administration's proposed plan actually increases NASA's budget by more than \$6 billion over the next 5 fiscal years. In addition, canceling the Ares system and the plans associated with it will cost the taxpayer an additional \$2.5 billion because of contractual obligations.

On top of these costs, since private businesses have never previously developed a low-Earth orbit system to transport humans to the International Space Station or a heavy-lift system to explore deeper into the cosmos, one can naturally hypothesize lengthy delays and expensive cost overruns for this novel venture. It is also not hard to imagine when the inevitable delays and cost overruns occur, that these private enterprises will turn to the Government with requests for additional funds.

Project Constellation should also be seen as an investment in our Nation's future economic competitiveness. In fact, studies have shown for every dollar invested in space exploration, \$7 has been returned to our economy through the development of new technologies and industries.

Congress should also consider the nexus between the Ares system and the ability of our Nation to maintain future strategic deterrent programs. Both the Ares rockets and our land-based intercontinental ballistic missile force use solid rocket motors. Our Nation will shortly complete the modernization of our ICBM fleet.

Now, since the early 1990s, NASA has served as the backbone of the solid rocket motor industry, providing stability to offset the often inconsistent production requirements of the military and commercial sector. Therefore, the termination of Ares would cripple the solid rocket motor industrial base and could push it beyond recovery for this and future generations.

Let me just say again, Madam Chairwoman and all of the other Senators on this illustrious subcommittee, I just want to thank you for affording me the privilege. I had much more in my original

statement, but I just wanted to get some of these ideas across. And I want to thank you very much for affording me this privilege to appear before your very important subcommittee.

Senator MIKULSKI. Well, thank you very much, Senator Hatch.

You know, your support of science is well known within the institution. We have worked well together on the FDA. We were happy to have you.

Also, I am devoted to the fact that Senator Jake Garn, another man of Utah, once chaired this subcommittee. He was a good friend and a mentor to me when I got started. I have conveyed to Senator Garn, and I want to say to the two Senators from Utah, if Senator Garn would also like to submit testimony or so on, I would be enthusiastic about welcoming it and look forward to welcoming him.

[The statement follows:]

PREPARED STATEMENT OF HON. JAKE GARN, FORMER SENATOR FROM UTAH

Madam Chair, and distinguished members of the subcommittee, former colleagues and, in the case of Senator Bennett, my successor in the seat previously held with such great distinction by his father, Senator Wallace Bennett. I consider it a privilege to be asked to submit testimony to the subcommittee regarding the very serious issues facing the Congress with regard to the fiscal year 2011 budget request for NASA.

I am well aware of the challenges you face, especially when a requested budget and changing priorities present very real challenges and would bring about changes that not all members can agree to and represent a major departure from current direction and programs—without a compelling case having been made for those changes.

Your challenge is even greater, when dealing with human space flight issues, in the face of the current economic situation, from which you and the country are still struggling to emerge, because human space flight—or any other programs NASA undertakes, whether space science, earth and climate observation, or advanced aeronautics research and technology—are not cheap.

Possibly more than ever before, we are being forced to decide whether these activities are of real and material value to the country, or just extravagant and exciting things that, in an era of scarce resources, the country is better setting aside. That, really, is the underlying issue that I believe the subcommittee and the Congress—and the American people—must come to grips with and which will decide, in the end, whether we stay in the business of space or not. Especially in the business of human space exploration.

Even before I left the Senate in 1992, after my flight aboard the Space Shuttle Discovery in April of 1985, I was asked to make far more speeches and appearances than ever before in my Senate career. I'm sure it will not surprise any of the members that, in the vast majority of those appearances, I didn't get a lot of questions about the nuances and details of the appropriations process or specific issues before the subcommittee or the Banking Committee, but I did—and still do—get *many* questions about what it was like to go into space, and view the Earth from that vantage point. Especially with the younger audiences and students. I know first-hand the extraordinary catalyst that space exploration—and especially human space exploration—has for exciting and inspiring young people to pursue studies and careers in sciences, technology, engineering and mathematics. I think that is something that must not be forgotten as you wrestle with the challenges of establishing the proper levels of funding for NASA and the programs you will support.

I am one who absolutely believes that our Nation would not have become a leader in technology and innovation without the extra catalyst provided by the space program. In recent years, we have, as a Nation, lost sight of that. As the future of the space program has seemed uncertain, after the Columbia accident, and we have begun to plan the end of space shuttle operations and even the premature, in my view, termination of the space station in 2015 that had been the plan up to this point, we have begun to lose the drawing power of space. I believe that has been reflected in the findings of the “Gathering Storm” report, prepared several years ago under the leadership of Norm Augustine.

It is somewhat ironic that Norm was asked to chair the Human Space Flight Review Committee last year to examine options for moving our human space flight programs into a more positive direction which, if we are able to do so as a Nation,

will enhance our competitive posture once again. And if we fail to do so, we will make the problems identified in the “Gathering Storm” report even deeper and even more damaging to our long-term economic stability.

That is why I am so concerned about the Obama administration’s response to the Augustine panel report. The administration seemed to ignore the most salient point of the report—that a space program “worthy of a great Nation” was one that needed adequate and sustained funding levels beyond those that had been provided over the past 5 years since the announcement of the Vision for Exploration by President Bush. The committee made it clear that the Constellation program was experiencing many of the problems that it was experiencing because the funding levels promised in the projections made in the 2005 budget request were not only not met, they were reduced by several billions of dollars, cumulatively.

I know that you know those details. And I know, too, that the allocations made available to the subcommittees on appropriations every year have their genesis in the budget resolution, which is largely based on the budget request. And the Bush administration failed to request the amounts it had originally projected to support the Vision for Exploration. The Bush administration also failed to request a single dime of funding to reimburse NASA for the cost of re-certifying the shuttle program for its return to flight after Columbia. As you know, Madame Chair, that was more than \$2.5 billion that NASA had to absorb within an essentially flat budget. You and Senator Hutchison were successful in adding a down-payment of a little over \$1 billion to reimburse NASA for those costs, and it was unanimously adopted by the Senate—a remarkable achievement. Only to have it taken out in subsequent negotiations between the House and the White House over an Omnibus appropriations bill—because the White House didn’t support it.

I remind you this is the Bush administration I am talking about. MY party was in control. But were they, in reality?

After the President’s Vision for Exploration announcement, the implementation of that plan was left to be managed and controlled not by NASA, but by the nameless, faceless, green eye-shaded bureaucrats in the Office of Management and Budget. The budget drove the policy after that, and the budget drove the program to the edge of a cliff. Not just Constellation, but the entire U.S. human space flight program. Because the budget plan included insisting on stopping the shuttle at the end of fiscal year 2010—whether its mission was accomplished or not. It didn’t start out that way in the President’s announcement. The announcement said the shuttle would retire “after the completion of the space station—which was expected to be in 2010.” But within a year, in the next budget cycle, that qualifier went away and fiscal year 2010 became a hard, unequivocal date. Why? Because the budgeteers’ plan was to take the money from the shuttle and move it to Constellation which was expected, by then, to be ready to “bend metal” and move to its next phase of development. That’s the reason for the shuttle retirement: to meet the demands of a budget plan. It’s not about safety, which I’ll refer to in more detail in a moment; it’s about money.

And the budgeteers weren’t satisfied with just raiding the Shuttle pot. They chose to take the space station funding, as well. They told the Congress, when asked, that funding of the space station beyond 2015 was “beyond the budget planning horizon.” But in reality they planned to use the space station operating funds to take Constellation to the next level of development; the manufacturing of the heavy-lift vehicle. That way they could still, they reasoned, “support” Constellation and the Vision, but not have to increase the top-line for NASA funding. They didn’t care about the scientists and researchers that had planned to conduct research on the space station, once it was completed. They had already thrown most of them overboard in 2005, when they decreed that the station would be used only for “exploration-related” research. A group of over 900 principal investigators—and their associated students and universities and organizations—was reduced to no more than 30. It took the 2005 NASA Authorization Act to even provide them a life-line, by requiring that at least 15 percent of all ISS research would be in non-exploration-related disciplines.

The budgeteers also didn’t care about what our international partners thought about having only a 5 year period of full operations for scientific research, instead of the 10 to 15 they had anticipated when they signed on to the partnership. Those partners have been wondering for the past 2 years, at the least, what the future held for the ISS, because they knew that NASA was not able to make concrete plans about the U.S. participation without the permission of the budgeteers.

National Space Policy and International Relations with our ISS partners have been driven by the Office of Management and Budget. Not by the policy process at the White House, which allowed that to happen by, at the very least, benign neglect. Not by the Congress, which, despite overwhelmingly passing authorization bills

since 2005 which endorsed the Exploration program at funding levels needed to actually have a chance at succeeding, never received a budget request that matched those levels. The Congress could only have increased those funds to necessary levels by taking the money from somewhere else within NASA or finding an off-set elsewhere within the allocations, and we all know how difficult that is to accomplish.

These are the failures of the prior administration to follow up on the Policy of the Vision for Exploration with the budget to make it happen. The question now is whether the current administration is going to do the same.

The good news is that, at least for the space station, they have agreed with the Augustine Report observation that continuing its support and operations to at least 2020 is the right and smart thing to do. It simply makes no sense to invest something like \$100 billion to build and operate it and then not provide the opportunity for scientists to finally use it as long as possible, now that is nearly complete.

What does NOT make sense to me, or to many people I've spoken to, is to cut the ribbon on the completed space station and then unilaterally and arbitrarily remove—for no more than budgetary reasons, again—the only independent means the United States has to get there: the space shuttle.

Not only that, the Obama administration proposal is to rely exclusively, for domestic capability to reach the space station, on a commercial capability that has, as yet, not been adequately defined. And even if commercial is broadly defined to include the larger, established companies, like Boeing, ATK, Lockheed Martin, United Launch Alliance, etc., as I think it should be, as well as the newer, more "entrepreneurial" style companies like SpaceX or the longer-established Orbital Sciences, none of them could conceivably provide a proven, human-rated crew launch capability within 3 or 4 years and likely even longer.

In the meantime, we are left with only one means of access to the newly-completed space station: Russian Soyuz vehicles, for which we must pay an average—today—of \$56 million per seat. And remember, we also are obligated to pay for at least two of those seats per year for our European, Japanese and Canadian partners, under the terms of the intergovernmental agreement that established the partnership.

And there is one more major failing of the administration's plan. That is that there is no consideration given, anywhere that I can see, to taking steps to ensure the space station can actually remain a viable, healthy and functional spacecraft through the year 2020. In 2005, there were 28 remaining space shuttle missions planned to the ISS. It was anticipated they would not only complete the assembly, but continue to be available to bring down equipment to be refurbished and returned to the space station, as well as exchange crews without relying on Soyuz, except for emergency crew rescue capability, and bring scientific samples and equipment back to earth for analysis and upgrades. But, once again, the masters of the budget in OMB decreed that NASA could only plan to fly 17 of those missions—plus one additional for making a Hubble servicing mission.

The result was a scramble to make sure that the 17 authorized flights were loaded with essential spare and replacement parts to ensure the station could be maintained at full capacity. But the choices made in juggling the payloads to provide that assurance were based on an internal planning date for an end-of-life for the station in 2015. Now the plan is to continue it's life to at least 2020, but without the benefit of the servicing capabilities of the space shuttle which, for large and heavy items, can only be provided by the space shuttle.

Senator Hutchison has seen this problem clearly, and has raised it in speeches and statements in hearings of the Commerce Committee, and here as a member of this subcommittee. I completely agree with her that a new assessment must be made, immediately, of what the potential equipment servicing and replacement and down-mass requirements are expected to be from 2015 to at least 2020, and determine whether the space shuttle must be available, in the short term, to deliver essential spares before it is retired. That is the only reasonable and responsible course, if one is truly serious about extending the ISS life-time. Without that analysis, there is simply no way to know if the promise of 2020 operations is only an empty gesture, with more risk than many potential researchers—or investors in commercial crew and even cargo launch development—will be willing to expose their time and resources to.

Let me repeat the last part of that, since the administration has placed such extreme reliance on the commercial sector to develop new cargo and crew launch capabilities. Without the space station as a viable, fully functional destination, there is no business case for those companies to develop their launch and delivery systems. None. At least in the crucial high-risk period of actually developing those systems. No space station equals no NASA anchor contracts for services, and no basis for ensuring investors that they should ante up the necessary matching capital to make

those efforts succeed. How the administration could adopt and propose a course that leaves the only active U.S. human spaceflight program remaining after the Shuttle, for the next 4 to 7 years, exposed to that sort of risk is simply inconceivable to me. It probably flies in the face of the painful lessons we are supposed to have learned in the past 2 years about secure and responsible management and oversight of investment practices.

That, I believe, is perhaps the major Achilles Heel of the President's plan. They can talk all they want about plans to increase utilization of the space station, and project extra hundreds of millions over time to support that, but their failure to have a plan to protect those opportunities makes that talk nothing more than empty promises. And there appears to be no interest on the part of the administration to address it in the short term through the only means available to do so: a plan for the potential continued availability of the space shuttle.

As I said before, this decision is purely budgetary, and not one—as many have tried to portray it—a matter of safety. Because the OMB has been successful in creating and promoting the Big Lie that there simply is not, cannot, and never will be an increase in NASA funding levels, even those in the aerospace industrial and support communities who know what it necessary to provide assured sustainability for the space station have not protested the shuttle termination, because they fear their opportunities for participation in the movement beyond low-earth orbit will be jeopardized by the lack of the “cash cow” represented by the end of the shuttle program. Even companies like Boeing, ATK, Lockheed-Martin, who benefit from both ongoing shuttle and station operations, are afraid or unwilling to support shuttle extension of ANY kind, for fear of having their Constellation and exploration contracts reduced and that program stretched out to the point where it makes no more sense from a cost and schedule stand-point. You can't blame them, since no one in the White House or so far a majority in the Congress, is willing to step up to the plate and demand that this Nation provide the level of funding that is absolutely necessary to secure our leadership role in space—or even our role as a second-rate participant in the community of space faring nations.

I don't need votes from ATK employees in Utah any more, so I am not advocating alternatives to the Obama plan in order to ensure their corporate interests. I am doing so because it is the right thing, I believe, for this Nation to not abandon all of the investments made in the Constellation program, and to fail to continue the capability to operate shuttles in support of the space station—even at a greatly reduced flight rate, and therefore at a greatly reduced annual cost.

I have referred frequently to the space station. As you recall, Madam Chair, in our early days working together on the subcommittee, we spoke a great deal about human space flight, and the space station, back in the days when our colleague, Senator Dale Bumpers, was actively trying to stop that program. You came to have a greater appreciation for the scientific potential of the station. Science and research has always been an important value to you. We joined together in efforts to defeat those early attempts to kill the station, and you continued that in the years after I left the Senate. In 2005, under Senator Hutchison's leadership of the Science and Space Subcommittee of Commerce, the ISS was designated as a national laboratory. I know that you were there when the Memorandum of Understanding was signed between NASA and the National Institutes of Health, setting the stage for their active use of the unique qualities of the microgravity environment to do a host of research—important to the health and well-being of people all over the world. I know the USDA research programs have signed a similar MOU, and announcements of opportunity for research have been issued—with more to follow. If you haven't had a briefing from NIH lately, I encourage you to invite Dr. Stephen Katz to come in and fill you in on the exciting potential they see.

I know, too, that you are deeply concerned about ensuring the safety of our astronauts, and that you are seeking to work closely with the authorizing committees, and Senators Nelson, Vitter and Hutchison, in making sure that safety is of the highest priority in our human spaceflight activities. I applaud all of that, and encourage you to continue those efforts.

I believe Senator Hutchison has established a strong working relationship with Democrat House counterparts in developing and introducing a Human Spaceflight Assurance and Enhancement Act, on a bipartisan and bicameral basis. That kind of approach is the best way for this problem to be addressed. Space exploration has always been a bipartisan effort, and it should continue to be so. The concerns I have and the current debate about the Obama plan is not about political expediency. It is about a way to preserve American leadership, for all Americans to receive the benefits of space exploration in their daily lives, right here on Earth.

Let me conclude by focusing for a moment on the matter of safety, as it relates to the shuttle, the Soyuz, and to any of the planned or hoped for developments in

finding replacements to the shuttle for sending humans into space to realize the science potential of the space station and to prepare to move beyond low-earth orbit to new and exciting destinations.

If someone tells you that the space shuttle is “too unsafe to fly” they are either very poorly informed or deliberately deceitful.

If someone else tells you that the space shuttle is “safe” to fly, they are either very poorly informed or deliberately deceitful.

I believe both statements to be true. And not only of the space shuttle, but of any human spaceflight vehicle. That creates an inescapable conclusion that I believe applies now—and likely will always apply to human space flight vehicles: they will never be completely safe and their “relative” safety will always depend on the question of “compared to what?”

In discussions about the shuttle replacement vehicle options, it is often argued that those vehicles will be “safer” than the shuttle, and that is based primarily on two arguments. One, that they will be simpler and less complex vehicles and two, that they will have a crew escape system for getting away from an errant or exploding launcher during ascent. It seems “logical” that that can be described as a “safer” system. On the other hand, regardless of how a spacecraft gets into orbit, it is necessary for it to return to Earth for a successful mission.

The current plan is to use the Russian Soyuz spacecraft for both ascent and descent for the 5 to 7 years between the last planned shuttle flight and the first manned TEST flight of a new vehicle, whether Government-developed or commercially-developed. Not only will we be setting the clock back to the initiation of a new and un-proven system we “hope” will work because we have paper designs and probabilistic risk assessments that say they “should.” But remember Norm Augustine’s comment about never flying on an aircraft with a tail number of less than 10. New systems inevitably have a potential high rate of “infant mortality” for the vehicles in their testing stages.

In the meantime, while waiting for those systems to be “proven,” we will be voluntarily relying on the Soyuz system, about which we have little insight into its production and maintenance standards or detailed component designs, and which has no “escape system” during re-entry. Furthermore, it has a record of having lost two crews during re-entry—that we know of. Not only that, two of its last six flights have experienced still-unexplained “anomalies” that caused the re-entry profile to be “ballistic” and which resulted in dangerous gravity forces being applied to the crews and, if steeper and more uncontrolled, could have led to the serious injury or, more likely, death of the three occupants. Imagine the situation if that were to happen under the current plan. It would mean that we would then be in a position where six crew members would still be aboard the space station and their ONLY way back to earth, in an emergency, would be on two vehicles identical to the one that would have just “crashed” and injured or killed their three recently-departed crew mates.

And again, why will this be the case? Because the budget-masters in the bowels of the White House decreed that the Nation simply could not afford to continue flying a proven system, that has been actually made safer than ever before as a result of the \$3 billion invested in redesign, modifications, recertification of systems, and improved processing techniques after the Columbia accident. How does any of this make sense for the Nation that has been the leader in human spaceflight for the past 50-plus years?

Let’s remember, too, how we established that leadership. We began by launching men with names like Shepard, Grissom, Carpenter, Glenn, and Cooper, on vehicles that were converted ballistic missiles, and which in fact had seen demonstrated failure rates exceeding those of either Soyuz or the Shuttle. Yet we launched them and held our collective breath, and were lucky enough not to lose any of them on launch. We came close to losing some of them during flight and upon re-entry, like John Glenn whose heat shield may or may not have been damaged and whose retro-rock- et pack was kept aboard during re-entry to hopefully hold it in place, but itself created a dangerous and uncertain re-entry profile. We had a Gemini spacecraft careen wildly out of control on orbit, until Neil Armstrong managed to get it back under control. And of course, later we had the crew of Apollo 13 battle against all odds to survive a circuit of the moon and return to Earth long enough to make a barely successful re-entry based on the sheer skill—and a lot of luck—of their crew and the innovative and determined supporting cast on the ground.

Human spaceflight, in reality, is no “safer” today than it was in those early days. We are just better equipped and experienced to handle the risks presented by the speeds and stresses needed to escape Earth’s gravity. Today, that skill and experience is reflected wholly in the space shuttle program and the people who prepare the shuttles to fly, operate them in space, and fly them back to Earth. We have now learned not only how to avoid or at least reduce the kind of ascent damage that

doomed Columbia, but we've shown we can closely inspect the thermal protection system and vehicle structures in flight and, if necessary repair them on orbit, none of which was possible before Columbia. And if the vehicle is structurally sound upon re-entry, nothing else in existence has the resiliency, maneuverability and capability to adapt to the sub-space flight environment that the orbiters have, to ensure a safe re-entry and landing.

Despite all of that, we seem intent on pressing hard—and possibly dangerously hard—to meet a schedule to rapidly fly out the remaining five shuttle missions in as short a time as possible—precisely the kind of pressure that was cited as a significant contributor to both the Challenger and Columbia accidents. And then we can rush to shut them down and lose the skilled workforce that maintains, assembles and operates them, creating a surge in unemployment within a key sector of the country's technical industry, where we are already facing major competitive challenges from abroad, and eliminating thousands of the very kinds of jobs that would otherwise draw more and more students into the study of the critical areas of science, technology, engineering and mathematics! And again, why are we going down this path? Because we can't "afford" to sustain the most magnificent space flying system ever developed while at the same time developing its successor systems?

How can anyone believe it makes sense to follow this plan for purely budgetary reasons—when we have just spent close to a trillion dollars on short-term relief on efforts that we will never really know whether they kept the Nation from going over an economic cliff or not? The Nation's space programs—led by the excitement and challenges of the human space flight program—are known to have been the most consistent and effective "engine of excellence" in technology, innovations and science for the past 50 years . . . the question should be: How can we afford not to fully support them and ensure that they remain indisputable factors in driving our Nation's technical, industrial and scientific excellence, securing our competitive position, and sustaining our global leadership?

Despite what I believe is the compelling logic suggesting we reconsider the decision to terminate the space shuttle at the end of the current manifest, the administration has chosen to hide behind the Bush administration mistaken plan—driven by OMB—to terminate the Shuttle program on, or close to, a date certain. But let me remind you just why they cannot credibly pretend that an irreversible decision was made that they are simply implementing. In the 2008 NASA Authorization bill, enacted in October of that year—before the election—there was language written specifically to preserve the option of some degree of continued shuttle flights for the President—whoever it was—until at least the end of April 2009. NASA was directed to take no action before that date which might preclude continuing shuttle operations. NASA insisted right up until the expiration of that provision that they were in compliance, 4 months into the current administration.

When the fiscal year 2010 budget was released the following week, it established the Augustine Panel, as mentioned above, to review options for the future direction of U.S. human spaceflight. Members of Congress encouraged NASA—and were assured by NASA that it was the case—that the option of continued shuttle operations would not be lost during the period of the Augustine review. In fact, NASA briefed the Augustine panel on a range of options for extended shuttle flights for 2, 3, and 5 year periods, and raised no concerns about it being impossible to do. And, on the basis of that information, one of the options provided to the President was to continue shuttle flights until 2015. So the option to continue shuttle operations was available to President Obama, and he cannot now credibly claim that it was a decision set in stone 5 or 6 years previously. He has chosen not to continue those operations, and so that decision—and the consequences that may follow from it, are, and will always be, his responsibility. That is simply a fact. And the Congress, even today, has that option open to them, and they, too, will own the consequences of allowing that decision to go unreviewed, and unmodified.

I believe I have stated why the need to reconsider the wisdom of that choice is something this subcommittee and the Congress as a whole, must seriously address. I strongly support Senator Hutchison's efforts to ensure that a review of space station requirements is conducted and an informed decision made before the only capable and proven system of human spaceflight this country has is lost by default and a failure to accept responsibility for the results.

That decision must not be driven by fear of another possible failure. That same fear could easily be the reason for backing away from any future crew launch system, because whatever the mathematical risk calculations one can apply, based as much on theory as experience, will be at the mercy of the incredible forces necessary to propel humans into space. The human errors that can creep into the most careful and sound engineering designs, manufacturing processes and launch preparations will always be there, to one degree or another.

Those who fly aboard the shuttle, the Soyuz, or, I'm sure, the Shenzhou, know that reality. But every single one of them is a volunteer, as I was, and as Senator Bill Nelson was.

I will never forget the experience, just under a year after I flew aboard the space Shuttle Discovery, when I flew down to the Kennedy Space Center with John Glenn and then-Vice President Bush, to meet with the families of the Challenger crew, just hours after that tragic loss. We walked into the room where the family members were gathered and the first thing June Scobee, the wife of Challenger's Commander Dick Scobee, said to us in a strong, determined voice and speaking for all those grieving family members, was that we must make sure the shuttle was not cancelled; that it would be returned to flight and that the dream of those brave crew members must be kept alive.

After the Columbia accident in 2003, there was a ceremony at the Space Mirror Memorial located at the Visitor's Center at the Kennedy Space Center to enter the names of Columbia's crew members to that large mirror. Dr. John Clark, husband of Laurel Clark, who was lost as a member of Columbia's crew, spoke for the families on that occasion. He said that despite the risks, America must remain a space faring nation and not become a space fearing nation.

Madam Chair, I know you feel strongly that safety is the number one priority. And no stone should be left unturned in understanding risks, identifying ways to mitigate them, and continuously improving our launch systems and spacecraft designs. But at some point, if we are to remain a space faring nation, and keep the dream of human spaceflight alive, and honor the sacrifice of those who gave their lives in its advancement, and for our future generations, we need to find the will and the commitment as a Congress, and as a nation, to "Go for launch."

Senator HATCH. Well, thank you. He will want to do that.

Senator MIKULSKI. Yes, and I would welcome that, and I would welcome any conversations with him.

Senator HATCH. Well, you have been great. I really appreciate it, and I appreciate every one of you on this panel. Thank you so much.

INTRODUCTION OF ADMINISTRATOR BOLDEN

Senator MIKULSKI. You are welcome.

I am going to call up Administrator Bolden to present the administration's testimony. Administrator Bolden is really also General Bolden, who served in the Marine Corps with a great deal of distinction, a graduate of the Naval Academy like John McCain, a Marine helicopter pilot who went on to be an astronaut in the Astronaut Hall of Fame. So we look forward to his testimony.

I want to remind members that we have a two-tier hearing, that after Administrator Bolden and questions from our colleagues, we will also then hear from John Frost of the Aerospace Advisory Committee, and I know this committee's deep commitment.

Senator Bennett, I understand you have a time challenge. I would like for Administrator Bolden to present his testimony. Then let us work out how we can accommodate everyone with the greatest courtesy, but robust questioning.

Administrator Bolden?

STATEMENT OF HON. CHARLES F. BOLDEN, JR.

Administrator BOLDEN. Madam Chair and members of the subcommittee, thank you for the opportunity to discuss the President's fiscal year 2011 budget request for NASA. I am incredibly grateful for the support and guidance of this subcommittee, and I look forward to working with you on consideration of the President's bold new direction for the agency.

All of us at NASA were honored to host the President one week ago at the Kennedy Space Center, where he said, and I quote, "I am 100 percent committed to the mission of NASA and its future because broadening our capabilities in space will continue to serve our society in ways we can scarcely imagine, because exploration will once more inspire wonder in a new generation, sparking passions, launching careers. And because, ultimately, if we fail to press forward in the pursuit of discovery, we are ceding our future."

Since the introduction of the budget, many have asked what is the destination for human space flight beyond low-Earth orbit under the President's plan? As the President made very clear last Thursday, NASA's deep space exploration efforts will include crude test flights early next decade of vehicles for human exploration beyond low-Earth orbit, a human mission to an asteroid by 2025, and a human mission to orbit Mars and return safely to Earth by the 2030s.

We can and must identify the missing capabilities needed for such a mission or such a suite of missions and use them to help define many of the goals of our emerging technology development. The right investments in technology will allow us to map out a realistic path to this destination that will continue to inspire generations of school children, just as it inspired me many years ago growing up in Columbia, South Carolina, and watching Buck Rogers go to Mars with ease each week from my seat in the balcony of the Carolina Theater.

FISCAL YEAR 2011 BUDGET REQUEST

The President's fiscal year 2011 budget request for NASA is \$19 billion, as you have mentioned, including an increase of \$276 million over the enacted 2010 level. Longer term, I am pleased that the budget commits to 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.

As we celebrate the 40th anniversary of Earth Day today, I want to note that the proposed budget supports an enhanced, robust program of Earth science research and observation. Earth observation from space produces the critical data sets we need to understand our changing planet. At the same time, we will continue our robust efforts to observe the rest of the universe through missions like the Hubble telescope and the Solar Dynamics Observatory, for which we released its first stunning images of the Sun yesterday.

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 space flight, Earth sensing, and aeronautics capabilities. These investments will produce additional opportunities for U.S. industry and spur new businesses such as a recently announced partnership between NASA and General Motors to build an advanced dexterous humanoid robot, R2.

CONSTELLATION PROGRAM

As the Constellation program is transitioned in an orderly manner, I want to thank all of the NASA employees and contractors who have worked so hard on the program. 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. Many of the things NASA has learned from the Constellation program will be critical as the agency moves forward, especially as we restructure the Orion project as a crew escape vehicle and incremental test crew vehicle for missions beyond low-Earth orbit.

However, as the Augustine Committee concluded, the overall human space flight program is on an unsustainable trajectory. If we continue on our current course, we will have to make even deeper cuts to the other parts of NASA's budget, terminating support of the International Space Station early and reducing our science and aeronautics efforts.

The President's proposal to transition Constellation enables us to present a 2011 budget that includes the flagship technology demonstration and development program that allows us with our international and commercial partners and other Government entities to demonstrate critical technologies; automated autonomous rendezvous and docking and closed-loop life support systems; heavy-lift research and development that will investigate a broad scope of R&D activities to support development, test, and ultimately flight of a heavy-lift launch vehicle sooner than projected for the Constellation program as assessed by the Augustine Committee.

As the President committed, we will decide on the right heavy-lift vehicle no later than 2015; 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; in concert with our international partners, extension of the utilization of the International Space Station to 2020 and beyond; pursuit of cross-cutting 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 sustainable; 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; aeronautics R&D, including critical areas of next-generation air transportation system or NextGen, green aviation, and safe integration of unmanned aircraft systems into national air space; education initiatives, including the Summer of Innovation pilot program to inspire middle school students and better equip their teachers for improved classroom performance in STEM-related courses.

We understand that many concerns are being expressed about this budget, but I believe it is the right vision for NASA. I look forward to continued discussion with you and our authorizers about your concerns and how we might solve them. I want to acknowledge to the subcommittee the subcommittee's concerns that details such as our justification documents were slow in reaching you. I

apologize and ask for your continued patience as we finalize the details of this historic change in NASA's direction.

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 their dreams into real achievements for all humankind through the missions we execute. This budget gives NASA a road map to even more historic achievements as it spurs innovation, employs Americans in exciting jobs, and encourages people around the world.

PREPARED STATEMENT

Madam Chair, thank you again for your support and that of this subcommittee. I would be pleased to respond to any questions from you or other members.

[The statement follows:]

PREPARED STATEMENT OF HON. CHARLES F. BOLDEN, JR.

Madam Chair and members of the subcommittee, thank you for the opportunity to appear today to discuss the President's fiscal year 2011 budget request for NASA. NASA is grateful for the support and guidance received from this subcommittee through the years and looks forward to working with you on enactment of the President's bold new direction.

The President's fiscal year 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 fiscal year 2010 Consolidated Appropriations Act (Pub. L. 111-117), and an increased investment of \$6.0 billion in NASA science, aeronautics, human spaceflight and enabling space technologies over the next 5 years compared with last year's budget plan. Enclosure 1 displays the details of the President's fiscal year 2011 budget request for NASA.

Before I discuss the details of the NASA budget request, I would like to talk in general about the President's new course for human exploration of space. With this budget, the United States has positioned itself to continue our space leadership for years to come.

The President's fiscal year 2011 budget request is good for NASA because it sets the agency on a sustainable path that is tightly linked to our Nation's interests. One measure of this is that it increases the agency's top-line, in a time when many agencies have been flat or taken a cut. Even more, it reconnects NASA to the Nation's priorities—creating new high-tech jobs, driving technological innovation, and advancing space and climate science research. It puts the agency back on track to being the big-picture innovator that carries the Nation forward on a tide of technological development that creates our future growth. We should make no mistake that these are the drivers for NASA's proposed budget increase of \$6 billion dollars over the next 5 years.

At the highest level, the President and his staff, as well as my NASA senior leadership team, closely reviewed the Augustine Committee report, and we came to the same conclusion as the Committee: The Constellation program was on an unsustainable trajectory. And if we continue on that course, at best we would end up flying a handful of astronauts to the moon sometime after 2030. But to accomplish that task, we would have to make even deeper cuts to the other parts of NASA's budget, terminating support of the International Space Station (ISS) early and reducing our science and aeronautics efforts. Further, we would have no funding to advance the state of the art in any of the technology areas that we need to enable us to do new things in space, such as lowering the cost of access to space and developing closed-loop life support, advanced propulsion technology, and radiation protection. The President recognized that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration. In doing so, the President put forward what I believe to be the most authentically visionary policy for real human space exploration that we have ever had. At the same time, under the new plan, we will ensure continuous American presence in space on the ISS throughout this entire decade, re-establish a robust and competitive American launch industry, start a major heavy lift R&D

program years earlier, and build a real technological foundation for sustainable, beyond-LEO exploration of our moon, near-Earth asteroids, Lagrange points, and, ultimately, Mars.

Now let me turn to describe the fiscal year 2011 NASA budget request in detail.

HIGHLIGHTS OF THE FISCAL YEAR 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 fiscal year 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 fiscal year 2011 budget plan followed by more details. In fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011 to fiscal year 2014 compared to the fiscal year 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 fiscal year 2011, the Glory and Aquarius missions will launch; and fiscal year 2011 should close with the launch of the NPOESS Preparatory Project. The Landsat Data Continuity Mission will complete spacecraft integration and test, the Oper-

ational 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 fiscal year 2011, the SMAP mission will transition from formulation to development, and ICESAT-2 will begin design. Also in fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011. NASA will also begin Advanced Stirling Radioisotope Generator development in fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011. The fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011. The next Explorer Announcement of Opportunity will be released in 2010, with selection for Phase A studies in fiscal year 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 1 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 1 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 fiscal year 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 fiscal year 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 fiscal year 2011, NASA will invest \$20.0 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 fiscal year 2011 budget request for Aeronautics includes \$82.2 million for Airspace Systems. The focus of this program is to develop improved air traffic management procedures, which will expand the capacity and reduce the environmental footprint of the air transportation system. 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 fiscal year 2011 budget request for Aeronautics includes \$113.1 million for the Integrated Systems Research Program. Begun in fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011 budget request for Exploration is \$4,263.4 million, an increase of \$483.6 million above the fiscal year 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 fiscal year 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 fiscal year 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. Lastly, the Exploration fiscal year 2011 budget request includes funding for the Constellation Program close out activities spread across fiscal year 2011 and fiscal year 2012.

In the near term, NASA is continuing Constellation work to ensure an orderly closeout of the program in fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011, and a total of \$3,100.0 million is included in the 5-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 fiscal year 2011, and \$3,000.0 million is included in the 5-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 fiscal year 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 5-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 fiscal year 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 fiscal year 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 fiscal year 2011 budget request includes \$215.0 million for the Human Research Program, an increase of more than 40 percent over the fiscal year 2010 enacted level, and an investment of \$1,075 million over the 5-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 fiscal year 2011 budget request includes \$1,900.0 million for Constellation Closeout requirements, and a total of \$2,500.0 million over the fiscal year 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 ad-

vanced 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 fiscal year 2011 budget request for Space Technology is \$572.2 million, and \$4,925.9 million is included in the 5-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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 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 80-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.

Fiscal year 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 fiscal year 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 6-person permanent crew, and during the STS-127 mission last July, the Station hosted 13 astronauts representing the 5 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 research 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 fiscal year 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 fiscal year 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 the 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, longterm, 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 fiscal year 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 fiscal year 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 fiscal year 2011 and should be ready for operations throughout the solar system. The SCaN operational networks will continue to provide an unprecedented level of communications and tracking services to over 75 spacecraft and launch vehicles during fiscal year 2011.

The LSP has five planned NASA launches in fiscal year 2011 including Glory, Aquarius, Juno, 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 21st 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 fiscal year 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 fiscal year 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 fiscal year 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 fiscal year 2011 request includes funding for Summer of Innovation over a 3-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 fiscal year 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 fiscal year 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 fiscal year 2011 budget request includes \$3,310.2 million for Cross Agency Support.

NASA's fiscal year 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 fiscal year 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 fiscal year 2011, activities associated with the Innovative Partnerships Pro-

gram are transferred to the Space Technology program. The fiscal year 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 Web site 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 fiscal year 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 fiscal year 2011 budget request.

Madam Chair, 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.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—PRESIDENT'S FISCAL YEAR 2011 BUDGET REQUEST SUMMARY
 [Budget Authority, in millions of dollars]

	Fiscal Year 2009 Actual	Recovery Act	Fiscal Year 2010 Enacted	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013	Fiscal Year 2014	Fiscal Year 2015
Science:								
Earth Science	1,377.3	325.0	1,420.7	1,801.8	1,944.5	2,089.5	2,216.6	2,282.2
Planetary Science	1,288.1	.....	1,341.3	1,485.7	1,547.2	1,591.2	1,630.1	1,649.4
Astrophysics	1,229.9	75.0	1,103.9	1,076.3	1,109.3	1,149.1	1,158.7	1,131.6
Helioastronomy	607.8	.....	627.4	641.9	647.6	679.8	704.4	750.8
Total, Science	4,503.0	400.0	4,493.3	5,005.6	5,248.6	5,509.6	5,709.8	5,814.0
Aeronautics and Space Research and Technology:								
Aeronautics Research	500.0	150.0	507.0	579.6	584.7	590.4	595.1	600.3
Space Technology .....	.....	.....	.....	572.2	1,012.2	1,059.7	1,063.9	1,217.9
Total, Aeronautics and Space Research and Technology	500.0	150.0	507.0	1,151.8	1,596.9	1,650.1	1,659.0	1,818.2
Exploration:								
Exploration Research and Development .....	.....	.....	.....	1,551.4	2,577.4	3,318.9	3,623.3	3,979.3
Commercial Spaceflight .....	.....	.....	.....	812.0	1,400.0	1,400.0	1,300.0	1,300.0
Constellation Transition .....	.....	.....	.....	1,900.0	600.0	.....	.....	.....
Constellation Systems	3,033.2	400.0	3,325.8	.....	.....	.....	.....	.....
Advanced Capabilities	472.3	.....	454.0	.....	.....	.....	.....	.....
Total, Exploration	3,505.5	400.0	3,779.8	4,263.4	4,577.4	4,718.9	4,923.3	5,179.3
Space Operations:								
Space Shuttle	2,979.5	.....	3,139.4	989.1	86.1	.....	.....	.....
International Space Station	2,060.2	.....	2,317.0	2,779.8	2,883.6	3,129.4	3,221.9	3,182.8
Space and Flight Support	725.0	.....	724.2	1,119.0	1,220.6	1,123.9	1,140.7	947.7
Total, Space Operations	5,764.7	.....	6,180.6	4,887.8	4,290.2	4,253.3	4,362.6	4,130.5
Education	169.2	.....	183.8	145.8	145.8	145.7	145.7	146.8
Cross-Agency Support:								
Center Mgmt & Ops	2,024.3	.....	2,067.0	2,270.2	2,347.4	2,427.7	2,509.7	2,594.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—PRESIDENT'S FISCAL YEAR 2011 BUDGET REQUEST SUMMARY—Continued

[Budget Authority, in millions of dollars]

	Fiscal Year 2009 Actual	Recovery Act	Fiscal Year 2010 Enacted	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013	Fiscal Year 2014	Fiscal Year 2015
Agency Mgmt & Ops	921.2	.....	941.7	841.2	842.2	849.1	856.8	867.9
Institutional Investments	293.7	50.0	23.4	.....	.....	.....	.....	.....
Congressionally Directed Items	67.2	.....	63.0	.....	.....	.....	.....	.....
Total, Cross-Agency Support	3,356.4	50.0	3,095.1	3,111.4	3,189.6	3,276.8	3,366.5	3,462.2
Construction and Environmental Compliance and Restoration:								
Construction of Facilities .....	.....	.....	381.1	335.2	316.3	319.5	344.6	349.0
Environmental Compliance and Restoration .....	.....	.....	67.2	62.1	47.5	47.4	48.9	49.5
Total, Construction and Environmental Compliance and Restoration .....	.....	.....	448.3	397.3	363.8	366.9	393.5	398.5
Inspector General	33.6	2.0	36.4	37.0	37.8	38.7	39.6	40.5
Total, NASA Fiscal Year 2011	17,782.4	1,002.0	18,724.3	19,000.0	19,450.0	19,960.0	20,600.0	20,990.0
Year to Year Change (percent) .....	.....	.....	5.3	1.5	2.4	2.6	3.2	1.9

SAFETY

Senator MIKULSKI. Thank you very much, Administrator Bolden.

I am going to ask a few questions, and then the courtesy of Senator Shelby says we will turn to Senator Bennett. Then we will return to our regular order and go straight on down. Does that sound like a good way to go?

Administrator Bolden, I have many questions. Actually, I have 13 pages of questions. And my original questions were going to focus, of course, on space science as well as human exploration, but I think we have got to get right to the human exploration aspects.

My No. 1 concern, while we have to always look at the budget, is the safety of the astronauts. Many members on this subcommittee have been to launches, but we have also been there when the Challenger went down, and witnessed the terrible tragedy of the Columbia. We say a grateful Nation will never forget. Well, whatever course of action, we don't want to forget.

So my question will be the safety standards. First of all, how will you ensure the safety of the astronauts in this new proposed program? And will NASA have one safety standard for humans in space, not one safety standard for Government development programs that are very tough and another for commercial companies?

One commercial company said they could produce a crew vehicle in 3 years. Well, that sounds promising. It also sounds ambitious. My look at the history books showed that the shuttle took 12 years from when President Nixon approved it to the first human test, from 1969 to 1981. Again, tell me about the safety standards, and are we going to have one set of safety standards for low-orbit and commercial vehicles and so on, because it would be my hope that there is one safety standard.

Administrator BOLDEN. Madam Chair, as has been pointed out already by several speakers, I was a member of the Aerospace Safety Advisory Panel, the NASA safety advisory panel that now advises me. When I was a member of that panel, as John Frost, who will testify after me will comment, we were concerned that NASA was not sharing its human rating requirements with the commercial vendors.

I think and I hope Mr. Frost will attest to the fact that since my becoming the NASA Administrator, we share the human rating standards with all of the prospective vendors, whether they are large or small business, whether they are entrepreneurial or not. We are actually developing a set of human rating requirements for commercial vehicles that will take the massive numbers of engineering requirements and various other requirements and put them in one source document that will be available for all who wish to enter the commercial launch market.

In terms of safety and reliability are very interesting factors. When I talk about safety of a vehicle and satisfying myself that a vehicle is safe, there are a number of criteria that have to be met. The No. 1 criteria are demonstrated reliability. I would point out that we have three candidate vehicles at the present time: Ares I, Falcon 9, and Taurus II. The demonstrated reliability of all three vehicles is zero. We have never flown an Ares I. We have never flown a Falcon 9. We have never flown a Taurus II. So while there

are predictions of the safety of all these vehicles and their reliability, they are equal. They are all zero.

I will also point out that when we flew the space shuttle, when I came to NASA in 1980, the predicted reliability and safety factors for the space shuttle, I think, was going to be 1 in 1,000. We were going to fly 50 flights a year. I think most people know that we now struggle, the maximum we flew when I was in the astronaut office, I think we had a banner year in which we flew nine space shuttle missions. That was an incredible year for us.

The demonstrated reliability of the space shuttle today is 1 in 125, or somewhere in that neighborhood. So I would caution anyone to get carried away with predicted safety and predicted reliability numbers because we all know, as we say in the military, that no plan survives crossing the line of departure. So I am very comfortable that I can guarantee before I put a human being in any vehicle, whether it is Government-produced or commercially produced, it will meet the safety standards that have been required.

Senator MIKULSKI. Do I take it to say that there will be one safety standard?

Administrator BOLDEN. There will be one safety standard for any vehicle that carries human beings from this planet to anywhere.

CONTRACT TERMINATION

Senator MIKULSKI. Well, thank you for that. I would like to ask a contract termination question. Because if this is what you want, if this is what the President is proposing, how do you intend to handle contract termination and the workforce dislocation? But for us, and I know others will be asking questions about safety—

Administrator BOLDEN. Yes, ma'am.

Senator MIKULSKI. But what is your plan for the contractors who will be forced to terminate your work if this proposal is accepted? And are you planning to terminate all Constellation contracts? The issue of saving technology is one thing, but this has tremendous implications for our budget.

Administrator BOLDEN. Yes, ma'am. Madam Chair, we are in the process of transitioning the Constellation program from where it was when I inherited it to where it is going to be in the future. The term contract—termination liability, potential termination liability is one that has caused a lot of angst recently, and it is because it is a term that is used in procurement and it is a factor in all of NASA contracts. Every NASA contract has a stipulation that the contractor should provide for termination expenses, and every contractor knows that. So we are not changing requirements. We are not modifying requirements. Those have existed in prior NASA contracts, and they exist in our contracts today.

Senator MIKULSKI. I am puzzled by this. How have you been reminding contractors of their obligation to have reserve funds. How does that square with the fiscal 2010 appropriations law that prevents you from terminating or restructuring contracts for this fiscal year?

Administrator BOLDEN. I cannot terminate anything that has to do with the Constellation program, and we are doing that. If I can just make just one minor correction—we are not informing contrac-

tors that they have to maintain reserve funds. We are reminding them that it is their responsibility to determine—I guess technically for them, it is to determine what level of risk the company is willing to accept in terms of being able to handle a termination if it should come. So we are not telling them that they need to reserve funds. We are telling them that they do have to be aware of the fact that termination liabilities, some of them lie on them by their contract. It is the company's determination of what level of risk they want to incur, whether they put aside funds or whether they assume that they are not going to need them.

Senator MIKULSKI. Well, I want to ask more about this.

Administrator BOLDEN. Yes, ma'am.

Senator MIKULSKI. I do want to make sure that other members have a chance.

Senator Bennett.

I have a great deal of questions about this.

STATEMENT OF SENATOR ROBERT F. BENNETT

Senator BENNETT. Thank you very much, Madam Chairwoman, and I very much appreciate your courtesy in allowing me to participate in this.

General Bolden, I am a businessman. If I was sitting on the board of directors and you were making this pitch to the board of directors as to the direction in which you are going to take the company, I would tell you, you haven't made the sale. And let me give you four areas where I think you have failed to make the sale.

PREPARED STATEMENT

By the way, Madam Chairwoman, I have a formal statement and would appreciate it put in the record.

Senator MIKULSKI. Without objection.

[The statement follows:]

PREPARED STATEMENT OF SENATOR ROBERT F. BENNETT

Madam Chairwoman, I would like to express my appreciation to you for allowing me to join this subcommittee hearing this morning. This issue is extremely important to Utah and to me personally, so I am sincere in my gratitude.

Utah has a rich history in supporting NASA's human space exploration missions. For decades, talented workers in Utah have helped engineer, design, and manufacture solid rocket motors that have safely and efficiently launched our astronauts into outer space. We have launched over 100 shuttle flights, all of which have begun their journey on solid rocket motors made in Utah, a fact of which I am extremely proud. Even though there have been some setbacks along the way, they have made us stronger and have taught us valuable lessons that have made subsequent flights safer and more reliable.

And now, at the end of this year, the Space Shuttle that has helped the United States maintain its role as the leader in space exploration, leading to life-changing technological discoveries along the way, will be retired. But the end of the Space Shuttle was not supposed to be the end of human space exploration. Rather, the Constellation program, which grew out of the Challenger disaster several years ago, was supposed to seamlessly take over for the Space Shuttle to continue to ferry our astronauts to the International Space Station and, eventually, beyond low-earth orbit by venturing back to the moon and eventually to mars, a plan that was approved by both Republican and Democratic leadership.

And now after several years and billions of dollars of investment in this program, the President has decided to cancel the program. Why? To me, it's not clear, and neither the President nor anyone in his administration has made a compelling case for why we should abandon the Constellation program. The President made a decision to cancel the Constellation program and laid out his vision for space exploration

earlier this year, and then last week he “revised” that vision. This type of “on-the-fly” decisionmaking has made me very concerned about who may actually be making these decisions.

Regardless, I have several very serious concerns about canceling the Constellation program. If we are going to cancel this program and pursue a different path, we should only do so under the following conditions: (1) the President has demonstrated a clear vision for human space exploration and adequately explained why it is superior to the Constellation program; (2) the alternative provides significant advantages in cost, schedule, performance, and safety; (3) the potential consequences of changing course mid-stream do not outweigh the anticipated advantages of such a significant shift in policy; and (4) we are able to maintain our leadership in space exploration. Unfortunately, the President’s alternative plans to replace the Constellation program fail these conditions miserably.

First, since the President announced he was cancelling the Constellation program, he has already announced changes to his new plan. His new plan is short on details and expected costs, relying on the commercial industry to take over the role of transporting crew and cargo to the International Space Station, increasing the role of robotics for exploration, and speeding up development of a “heavy lift” vehicle by 2015. The problem is that the commercial industry has not proven to be able to meet any safety or budget deadlines and the Constellation program already has a heavy lift vehicle, the Ares V, in the works. So, here we have a program that is meeting all of its milestones and has a demonstrated capability to achieve our space objectives with Constellation, and we are scrapping it for a commercial industry that has not proven its worth in space travel and for a heavy lift vehicle that we will begin working on in 5 years. And do we intend to go to the moon? To Mars? To an asteroid? What exactly do we hope to achieve with the new plan envisioned by the President? The problem is I can’t tell.

Second, the President’s alternative plan will actually cost us more money and delay our ability to get ourselves into space. The Ares program, which is a major component of Constellation, is a prime example of how this program is on track. Just last year we launched a successful test flight of the Ares I rocket. It went perfectly. It has been under design and testing phases for over 4 years, with \$6 billion already invested in perfecting the rocket. The Ares I is built off of the same manufacturing format as the current rockets that have been putting our space shuttle into space for over two decades, so we know we have a proven technology that takes advantage of an existing manufacturing base and capability. Scrapping this investment and starting fresh does not make sense to my business sense. The Augustine Panel said we’d need about \$3 billion a year to keep the program on track. This year alone the President wants to spend \$2.5 billion to cancel the Constellation program, with billions more in funding set aside to subsidize the commercial industry. This makes no sense. And finally, the Ares I design is proven to be the safest mode of transporting our astronauts. The Safety Advisory Panel that found that the model embraced by Ares would be the safest for our astronauts, and now we are going to pretend that safety doesn’t matter. This has me very concerned. The President’s alternative plan does not provide significant advantages in cost, schedule, performance, or safety.

My third point of concern is regarding the consequences of canceling Constellation. I don’t believe the administration fully understands the drastic impact this decision will have on our national security. Ending Constellation will devastate an industrial base critical to our national security. The Constellation Program is powered by the Ares I, a large scale solid rocket motor. If there are no large solid rocket motors in production with the cancellation of Constellation (other than NAVY D-5 at 12 motors a year under their “warm line” program), the current industrial base will be too large to support small solid motor production, requiring massive layoffs. In Utah alone, this means losing about 2,000 jobs. Producing only small solid motors would not be sufficient to keep the supplier base engaged as many of them would go out of business or stop producing highly specialized components because the economies of scale won’t justify the decision to remain in business. This will certainly lead to price spikes at the Department of Defense for smaller tactical missiles (which are solids-based), and lead to hundreds of millions of dollars in price increases on tactical weapons systems every year. It could also mean that DOD may have difficulty getting solid-based tactical missiles produced in the future at all, which is not good for either readiness or costs.

And finally, I don’t believe the current plan of the President will allow the United States, a country which has been the leader in space technology development for over 40 years, to continue to lead the world in space exploration. It’s almost embarrassing that we will rely on the Russians to take our astronauts into space starting next year. And what happens if the commercial industry isn’t able to deliver on

time? Do we rely on the Russians for the next decade to meet our space needs? And what about other emerging nations like China and India? Will they surpass the United States? Of course I applaud other nations in further developing their technologies, but I believe if we continue down the path this President wants to take us, we will lose our global competitive advantage that space exploration has helped us develop. We cannot allow this to happen.

SCIENCE

Senator BENNETT. The four areas that I think you haven't made the sale are No. 1, the science; No. 2, protecting the industrial base; No. 3, the money; and No. 4, the law. And let me run through those very quickly, and then you can respond to them as you will.

You made a statement just now that I find incredible when you say the demonstrated reliability of Ares is zero. Now, you probably have seen this, but let me show it to you. Time magazine just 6 months ago, in November 2009, published the 50 best inventions of the year, and No. 1 of the 50 is Ares—the best invention of the year. Doesn't sound like shabby science to me. It doesn't sound like something that is obsolete.

And they say—you can contradict this—they talk about this, and I am quoting from Time, "In 2004, the U.S. committed itself to sending astronauts back to the Moon and later to Mars, and for that, you need something new and nifty for them to fly. The answer is the Ares I, which had its first unmanned flight on October 28 and dazzled even the skeptics."

That doesn't sound like there is no demonstration of reliability. I think there is a definition problem here. None of the other things you talked about can match the tested perfection of Ares with the test that has already been done. So I challenge that one.

INDUSTRIAL BASE

No. 2, the industrial base, you said the President will make a decision as to what will be done by 2015. If you kill the industrial base of solid rocket motors now with this action, in 2015 you cannot get it back.

This is not like—this is not saying, "Well, we are going to stop buying this kind of car, and we will look at buying another kind of car or pickup truck or SUV 4 or 5 years from now, and there is an industrial base that will have those kinds of cars or trucks available to us." This is the only game in town.

And you shut down the industrial base of rockets, solid rocket motors, and there will be no contractors available in 2015 if you make the decision that is the way you want to go. And I think that is a very significant issue you have to address now.

PROTECTING THE MONEY

No. 3 Money, you have not made the case that this is going to save money. And let me point out two particular things with respect to money. On the—Senator Shelby has referred to this already—the fiscal 2011 budget includes \$2.5 billion in Constellation contract termination costs; \$6 billion for new commercial providers, whom we don't really know who they are, who likely will suffer the normal cost and schedule growth that has been referred to in the opening statements already with their level of inexperience; an additional \$312 million for COTS money that was never planned.

So you have got the \$2.5 billion. You have got the uncertainty of where you are going. And it seems to me, a much more responsible use of taxpayer dollars would be to use the combined \$8.8 billion that is represented in your budget to finish the program that has had 5 years' worth of progress and accomplishments and is designed to deliver a safer and more reliable way to send our astronauts to orbit than something that we are just guessing about.

I think the prudent financial circumstance is to stay with what we have got instead of plunging into the unknown. And looking at construction costs, I would like you to address what I find a significant gap in your money calculations. You stated in congressional testimony that the Ares program to fly would cost approximately \$4 billion a year.

Doug Cook, the Associate Administrator for Exploration Systems Mission Directorate, recently stated in testimony that the recurring cost for Ares is \$140 million per flight, you have got to have a lot of flights at \$140 million to get to the \$4 billion per year. I find that to be a disturbing kind of thing that I think you need to explain.

PROTECTING THE LAW

Finally, the law, this subcommittee—Congress in the fiscal 2010 omnibus appropriations bill expressly prohibited using any 2010 funds to terminate or in any way change or modify the Constellation program. Just yesterday, ATK received a notice that funds for their contract under the launch abort system will be limited, and no additional funds will be forthcoming after April 30, 2010. That is a week away.

It seems to me this is a clear violation of the law that says no money will be used—no funds will be used in any way to change or modify the program for fiscal 2010. Fiscal 2010 has not run out yet.

So, to summarize what I said in the beginning, I think your conclusion on science runs afoul of the experience of what we have found with the testing of Ares. I think the threat to the industrial base casts doubt upon your ability to do something in 2015 if the President decides, or whatever President it is decides they want to go back to solid rocket motors. They won't be able to. I think your numbers on the money don't add up, and I think what is being done right now is a contravention of the law.

So I would very much appreciate your reaction to those four points.

SCIENCE

Administrator BOLDEN. Thank you, Senator. I will try to go down the line.

The first thing is the science. And with all due respect, we are very proud of having been recognized for the No. 1 invention of the year by a number of different authoritative publications and the like.

Perhaps we were not very good in explaining to people that Ares I-X is not Ares. Ares I-X was a four-segmented rocket that had a dummy fifth stage, fifth segment, and a dummy interstage, and a

dummy nose cap. The Ares I vehicle is a five-segmented solid rocket motor that has never flown.

So we are very proud of Ares I-X and its recognition for what it did because it gave us 700 pieces of data from sensors that were put on the vehicle, and I always told people it was the greatest wind tunnel test conducted by humans ever. But that was not an Ares I. That was an Ares I-X, an experimental rocket that we wanted to do a number of things just to demonstrate that the shape and form would work.

So the science does—

Senator MIKULSKI. In the interest of time, we are not going to have a debate. We appreciate the extensive data that you could provide, but if you could answer the question, because there are several other members, I would like to keep a well-paced hearing.

PROTECTING THE MONEY

Administrator BOLDEN. Yes, ma'am. The money—there is a big difference between the per-flight cost and recurring costs. Most of the recurring costs from shuttle and from Constellation would come from just maintaining the infrastructure. So that is the reason that the money difference is.

PROTECTING THE LAW

The law—we have not terminated any contracts. We have not directed anyone to stop work on anything. If you were talking about the launch abort system test that is still scheduled for May—I may be misunderstanding your comment. But the launch abort system test is still scheduled for May 5, and we are very much looking forward to seeing that because, again, we will get a lot of data from that test.

INDUSTRIAL BASE

And then the industrial base, unfortunately, the solid rocket industry has been overcapitalized for many, many years. It was far overcapitalized for the shuttle because we said we were going to fly 100 missions a year, or 50 missions a year. And that is what it was set up to service. We ended up flying eight missions a year.

It would have been overcapitalized—it was overcapitalized for the shuttle. It would have been grossly overcapitalized for Constellation. And so, the business decision, and since you are a businessman, sir, the business decision that needs to be made by the only company that is legitimately in that industry right now is “how do I downsize?” if they want to be competitive.

There is a big difference between what NASA uses in solid rocket motors. We use large, segmented, solid rocket motors. Since the cancellation of the Titan program, there is no other use for that type of solid rocket motor. So we are carrying 70 percent of the industry for a capability that nobody uses but NASA.

I am concerned about the industrial base, and we are doing everything we can to work with our counterparts in DOD, to work with ATK to help them in any way we can because we still need solid rocket motors.

Senator MIKULSKI. Administrator Bolden, we need really shorter—

Administrator BOLDEN. Those are the four questions.

Senator MIKULSKI. I need good answers, and so does Senator Bennett, but—

Administrator BOLDEN. I am done.

Senator MIKULSKI. No, he asked about the law.

Administrator BOLDEN. I said, ma'am, we have not violated the 2010 Appropriations Act and the stipulations in that. I have not terminated any contracts nor directed people not to go forward with, to my knowledge.

Senator MIKULSKI. Senator Bennett, I know you had many more questions. I must turn to other members. I want to ask the Administrator and also invite my colleagues to submit other questions in writing, to leave them open for the record so that there is an extensive record of these deliberations and proceed that way.

Is that satisfactory?

Senator BENNETT. Absolutely, Madam Chairwoman. I very much appreciate your courtesy and apologize for letting my enthusiasm and desire to engage get hold of me.

Senator MIKULSKI. We have got a lot of people who want to talk and ask questions.

Let us turn to Senator Shelby, the ranking member.

Senator SHELBY. Thank you, Madam Chairwoman.

SPACE PROGRAM

Madam Chairwoman, I have two articles. One appeared in Tuesday's Globe and Mail in Toronto regarding the space program, and one appeared in Florida Today, and I would like to ask that they be made part of the record.

Senator MIKULSKI. Without objection.

[The information follows:]

[From Globe and Mail, Tuesday, April 20, 2010]

There is no doubt, given the serious deficits facing the United States Government, that some retrenchment at NASA was unavoidable. The space administration will spend \$18.6 billion in 2010, an increase of \$900 million over 2009. These are not insignificant figures, even in the context of vast U.S. Government expenditures. However, the plan to fundamentally reposition NASA to concern itself more with "earth science" goes beyond an exercise in fiscal rectitude. U.S. President Barack Obama has lowered the ambition of America.

In February, Mr. Obama cancelled the Constellation program, which committed the United States to returning people to the moon by 2020. "We've been there before," he said, adding "there's a lot more of space to explore." Except that most experts think a Moon mission is a practical and necessary first step to sending people to Mars, and the cancellation means that the \$10 billion already spent on the mission has been wasted.

Mr. Obama's own plan, announced last week, really only feigns interest in space exploration, and indeed, were it not for some funding for a new crew capsule, would have effectively ceded manned spaceflight entirely to Russia. Mr. Obama did announce a fuzzy commitment to land on an asteroid by 2025, and to land people on Mars by 2035, but these are more or less sops to science fiction enthusiasts. Without an interim step of a return to the Moon, such missions may prove impracticable. Contrast this with Mr. Obama's 60 percent hike over the next 5 years in funding for NASA's Earth sciences program, with its overarching emphasis on climate change research.

That is no doubt also a priority. But somehow, investments in Earth science research satellites, airborne sensors and computer models, do not have the same capacity to inspire the popular imagination, and generate the potential for game-changing innovation, as NASA's traditional mission to "pioneer the future in space

exploration." As Neil Armstrong has written, "Without the skill and experience that actual spacecraft operation provides, the United States is far too likely to be on a long downhill slide to mediocrity." Under the Obama plan, space is not the final frontier, Earth is.

[From Florida Today, April 16, 2010]

A "DEVASTATING" PLAN—OBAMA DOESN'T GET IT; SPACE IS LAST FRONTIER

KENNEDY SPACE CENTER.—President Obama in effect pulled the plug on our space program in a speech here Thursday, although he masked it with some vague long-term suggestions.

The late President John F. Kennedy must have turned over in his grave. JFK launched the moon-landing program in the 1960s because he understood that any nation that wants to remain No. 1 on Earth must also be No. 1 in space.

We are now No. 2 behind Russia and soon may be No. 3 behind China. Even India and Brazil are developing ambitious space programs.

Obama's proposal not only abandons our space shuttle, he also has no timetable or real plan for what he says ultimately will send humans to Mars. Obama doesn't seem to care that soon we will have to hitchhike rides with the Russians just to get our astronauts to the International Space Station.

Unfortunately, some political and business leaders in Florida are buying the Obama plan because it may provide a few jobs for some of those thousands who will be unemployed here when the shuttle program ends. That should not be the most important of our Nation's concerns.

Fortunately, some of those who pioneered our space program get it. Neil Armstrong, the first human to step on the moon, called the Obama plan "devastating."

Obama's proposal is all about money priorities and our inexcusable war costs, not about peaceful world leadership. His proposed budget for 2011 makes that clear:

—*Wars.*—\$159.3 billion.

—*Space.*—\$19 billion. That suggests Obama thinks that wars in places like Afghanistan and Iraq are nearly 10 times more important than exploring the last frontier in space. I voted for Obama for president. But, Neuharth lives in Cocoa Beach. He is the founder of "USA Today" and FLORIDA TODAY.

CONSTELLATION PROGRAM

Senator SHELBY. And I would like to quote just a little from, first, Tuesday's Globe and Mail about the Obama plan. This plan basically, they say, and I paraphrase, "U.S. President Barack Obama has lowered the ambition of America. Under the Obama plan, space is not the final frontier, Earth is." That is part of the article.

Under the Florida Today article, appeared April 16, says, "Obama doesn't get it. Space is last frontier. President Obama, in effect, pulled the plug on our space program in a speech here Thursday," talking about in Florida, "although he masked it with some vague, long-term suggestions. The late President John F. Kennedy must have turned over in his grave. JFK launched the Moon landing program in the 1960s because he understood that any nation that wants to remain No. 1 on Earth must also be No. 1 in space."

A couple of questions, it is my understanding, Mr. Administrator, that there has been a lot of internal discussion at NASA regarding how to circumvent the fiscal year 2010 language that limits NASA's ability to terminate or to alter the current Constellation program. Given the importance of this issue, we need to understand here in the subcommittee the legality of the decisions NASA is making related to the program of record, especially in view of legislation.

Could you provide to this subcommittee, the Appropriations Committee overview, within the next week a letter and the decision documents from NASA's general counsel regarding NASA's interpretation of the 2010 appropriations language and the applicability of the Antideficiency Act. Could you do that?

Administrator BOLDEN. I will do that, sir.

[The information follows:]

There are no "decision documents from NASA's General Counsel." NASA has neither intended nor attempted to circumvent the restriction on terminating Constellation programs, projects, or activities. Instead, NASA's focus has been on ensuring compliance with the strict terms of the provision. The fiscal year 2010 appropriations act contained a general appropriation for Exploration activities without specifically addressing the Constellation program. The appropriations act then included a provision that there be no termination or elimination of the architecture of Constellation, and no creation or initiation of a new program, project, or activity without further authority. The fiscal year 2010 appropriations act provided as follows:

". . . Provided, That . . . none of the funds provided herein and from prior years that remain available for obligation during fiscal year 2010 shall be available for the termination or elimination of any program, project or activity of the architecture for the Constellation program nor shall such funds be available to create or initiate a new program, project or activity, unless such program termination, elimination, creation, or initiation is provided in subsequent appropriations acts."

Title III, Consolidated. Appropriations Act, 2010, Public Law No. 111-117, 123 Stat. 3034 (2009).

GAO defines "program, project, or activity" (PPA) as "an element within a budget account." Terms and Definitions, "A Glossary of Terms Used in the Federal Budget Process," GAO-05-734SP Budget Glossary, September 2005. "Program activity" is defined as "[a] specific activity or project as listed in the program and financing schedules of the President's budget." *Id.*

Thus, based on established usage, the restriction on Constellation termination contained in the 2010 appropriations act is limited to termination of a PPA, or an element within the Exploration account. NASA has not terminated any specific contract, although NASA could do so under the restrictive language of the appropriations act, which only prohibits termination of any program, project, or activity of the Constellation architecture.

The Antideficiency Act ("ADA") provides in relevant part that no officer of the United States may make or authorize an expenditure or obligation exceeding an amount available in an appropriation, fund, or formal subdivision of funds. 31 U.S.C. §§ 1341(a)(1), 1517. The ADA also requires that an agency ensure it does not contract for work in excess of the appropriations available to fund the work. 31 U.S.C. §§ 1341(a)(1), 1517. Most of the Constellation contracts, including all of the major primes, are incrementally-funded, cost-reimbursement contracts, which are required to have, and do contain, a Limitation of Funds ("LOF") clause to ensure work is performed within the limits of the funding allotted to the contract. The LOF clause (Federal Acquisition Regulation 52.232-22), in paragraph (h), states "the Government is not obligated to reimburse the Contractor for any costs incurred in excess of the total amount allotted by the Government to this contract, whether incurred in the course of the contract or as a result of termination" (emphasis added). Allotted funding therefore includes all costs under the contract, for performance and for any costs resulting from termination.

NASA is acting to comply with both the ADA and the fiscal year 2010 appropriations act. The fiscal year 2010 appropriations act, prohibiting use of funds for termination of Constellation PPA, does not require that NASA risk an ADA violation, and certainly does not create an exception to the ADA. Reading the fiscal year 2010 appropriations act with the ADA, NASA is bound to take steps to ensure that the Constellation contracts are managed according to their existing terms, including the express terms of the Limitation of Funds clause. GAO, Principles of Appropriations Law Vol. 11, at 7-48 (2009). As stated previously, NASA has not terminated any Constellation contracts; but NASA has issued letters to two Constellation contractors, reminding the companies of obligations under the LOF clause. This is prudent contract management, intended to avoid coercive deficiencies in violation of the ADA, and should not be interpreted in any other way. Most importantly, it does not terminate any PPA within the Exploration account.

Senator SHELBY. Okay. Has NASA sought any guidance from the Department of Justice on this? And if so, what was their legal opinion? Could you—

Administrator BOLDEN. Sir, I will submit that for the record. [The information follows:]

NASA received input from the Department on the drafting of the letters referenced above. However, NASA did not receive a legal opinion from the Department.

Senator SHELBY. And the subcommittee.

Administrator BOLDEN. Just in summary, the discussion with the Department of Justice had to do with potential termination liability, as the chairwoman was, Madam Chair was talking.

ARES I VERSUS FALCON 9

Senator SHELBY. Thank you.

I want to get into Ares I versus the Falcon 9. General Bolden, it is my understanding that you have stated to congressional members that you think Ares and Orion are no safer than the Falcon 9 and Dragon capsule. However, according to a July 2009 independent safety review of rocket options initiated by NASA, the Valador report states that the Ares I launch vehicle “is clearly the safest launch vehicle option and that it is superior to all other options.”

What information do you have that validates the safety of the Falcon 9? And if you have it, would you furnish it to the committee?

Administrator BOLDEN. Sir, we will get what information we have. But my comment to people over the last week has been, specifically when asked by Senator Hatch earlier, my gut tells me that Ares would be safer than anything else, but that is not what the data says.

Senator SHELBY. But you will furnish this to the subcommittee?

Administrator BOLDEN. I will furnish the data, yes, sir. Yes, sir. [The information follows:]

DEMONSTRATED SAFETY RECORD

Any current risk estimates for future launch vehicles are based on modeling probabilistic risk analysis (PRA). When referring to safety records, demonstrated safety records are far more important.

Both NASA's Ares-I program and SpaceX have launched test flights—NASA's Ares I-X suborbital flight and SpaceX's inaugural Falcon 9 orbital flight. However, even SpaceX has not yet flown its Dragon capsule, so these flights do not equate to a demonstrated safety record, and thus no design has yet proven itself to be safer.

ACCESS TO SPACE

Senator SHELBY. The new capsule plan. The latest plan restructures the Orion capsule so that it will be the—as we understand will be nothing more than a space station escape pod. I fail to see how this escape pod will lessen our reliance on other nations for our access to space. We are still going to pay the Russians for a roundtrip. We are going to pay for a commercial rocket and capsule, and we will now pay to build our own return vehicle. What is the—tell me, explain this to me.

Administrator BOLDEN. Sir, the restructuring of the Orion program is actually an—it is my desire that it be an incremental approach to develop a vehicle that will one day take us to the Moon

and Mars and beyond low-Earth orbit. We need to have a domestically produced capability to get crews back and forth to the International Space Station, and the original version that the President talked about last week would be a vehicle that we could get there much quicker than anyone else because we don't have to human rate it for ascent. We would send it to space just on any launch vehicle, but it would be rated to comply with the visiting vehicle requirements and rated for human rating for entry, descent, and landing.

COMMERCIAL SPACE FLIGHT

Senator SHELBY. General Bolden, if the commercial route is truly the route that you are headed; wouldn't it be cheaper and wiser to just use a Dragon capsule for this purpose? If not, why not?

Administrator BOLDEN. Senator, we hope it would be cheaper and wiser, and that is our long-range intent. The first use of a re-structured Orion, is because we think we can get it there in 3 years. So that gives us a domestically produced return vehicle on the International Space Station in 3 years. It also relieves some of the pressure from the commercial vendors to try to deliver a vehicle that has the human-rated capability in a shorter period of time.

SAFETY PROGRAM

Senator SHELBY. General, you are a four-time veteran of space flights as an astronaut, and each time you arrived safely home, thank God. You have also been a member of the Aerospace Safety Advisory Panel, a group that was founded to help ensure the safety of our astronauts. Of all the possible people to lead NASA on its missions of human exploration, you are more than qualified to understand the role of safety.

Now you appear to be deliberately choosing to ignore safety concerns from the very people at NASA that you entrusted your life with and you came home four times. Could you explain to the subcommittee and the people at NASA who made the United States such a leader in space for 50 years, why you, as the Administrator, are ignoring their record, basically, they claim, of safety and engineering excellence?

Administrator BOLDEN. Are you referring to the ASAP, sir?

Senator SHELBY. I am talking about the overall safety program.

Administrator BOLDEN. Oh, I am not ignoring the inputs of anyone from the safety program.

Senator SHELBY. They believe you are.

Administrator BOLDEN. If you ask Bryan O'Connor, who is my conscience, he is my Director of Safety and Mission Assurance, Bryan, I think, will tell you that I listen to him every day. John Frost is going to come up, and I think John Frost will tell you that I listen to him every day. We are decidedly looking at everyone's concerns on safety, and that is why I can assure everybody that before we put a human in a vehicle and launch him off this planet, we are going to have the safest possible vehicle.

I am a safety professional. It is my life. It is in NASA's core values, and there are not a lot of other companies in the country that can say that safety is one of their core values.

Senator SHELBY. But you benefited from it four times, did you not?

Administrator BOLDEN. I flew four times, and I had every confidence in the world that I was going to return safely to Earth, and that is going to be the case with every astronaut that I launch, whether they are on a privately produced vehicle, a foreign-produced vehicle, or any other vehicle.

Senator SHELBY. That is not the message that is being received at NASA right now.

Thank you, Madam Chair.

Senator MIKULSKI. Senator Cochran.

ROBUST TESTING PROGRAM

Senator COCHRAN. Madam Chairwoman, thank you for your leadership in this subcommittee.

And Mr. Administrator, we appreciate your cooperation with the subcommittee. I remember our visit in my office when you were making the rounds of the Hill after assuming the position you now have, and I was very impressed with your commitment to moving us forward in the space exploration program, and got the impression that that also includes a robust testing program.

We are very proud of the fact that in my State, the Stennis Space Center provides testing facilities and experience to help make sure that we do have demonstrated reliability, which were your words to describe your test for NASA safety standards.

Do you continue to have the view that a robust testing program is essential to a reliable and safe and successful space exploration program?

Administrator BOLDEN. Senator, I continue to hold that. There is nothing better than a robust testing program. The \$312 million that the President has proposed in the fiscal year 2011 budget for commercial will allow us to buy down some risk by trying to help the commercial industries do maybe some more tests than they may have planned in their present portfolio. So I am a believer in tests.

Senator COCHRAN. Well, I was worried that the budget request doesn't have any funds that are specifically designated for the testing program at Stennis Space Center.

Administrator BOLDEN. Senator, the heavy-lift propulsion development program will contain tests that will be run at Stennis. I think you know we are continuing the retrofits to the A-3 test stand. We already have commercial entities that have contracted to test their engines at Stennis. Stennis is critical. It is vital to the future of any kind of space flight because we want it to be the center for testing of propulsion systems, whether they are for the military, commercial, or NASA.

Senator COCHRAN. Well, that is reassuring, and I appreciate the clarification of that. I also want to let you know that we appreciate the comments that you are 100 percent committed to the mission of NASA and its future. Broadening our capabilities in space will continue to serve our society in ways we can scarcely imagine. I share that enthusiasm and commit to you our best efforts here in this subcommittee to identify how we can invest the public funds so that we achieve those goals.

Administrator BOLDEN. Thank you, sir.
 Senator COCHRAN. Thank you.
 Senator MIKULSKI. Senator Voinovich.

GLENN RESEARCH CENTER—PLUMBROOK FACILITY

Senator VOINOVICH. Thank you, Madam Chairwoman.

First of all, I would like to say that NASA Glenn in my State and the Plum Brook station are unique and a powerful resource for our State. More than 3,500 highly skilled civil service and contractor employees work at these facilities, and your agency's economic impact to the State exceeds \$1.2 billion.

Further, it is a catalyst for 1,200 aerospace-related companies in our State, companies that employ more than 100,000 Ohioans. And the undertow in a lot of the comments that you are getting today is that NASA has been very, very helpful to our respective States, and the Constellation program has been very important to NASA Glenn.

On the other hand, last year, for every dollar this country spent, we borrowed 41 cents. Our debt is out of control. It is not sustainable. As far as we look down the road, we have budgets that are not balanced. And we have to come to some point where we start to analyze what we are doing. And I think that it is important that you do a better job of clarifying just exactly what it is that you are trying to get done.

Administrator BOLDEN. Yes, sir.

PRIVATE SECTOR COMPETITION

Senator VOINOVICH. Are you trying to get a rocket made real quickly so you can go up to the space station, and you think you can do it better by having competition from the private sector? Are you intending to go to Mars and the rest of it, as President Bush talked about? And if you are, I think you mentioned how far out is it and what are the things we have to do in order to reach it?

But I think that you have to do a better job of clarifying things.
 Administrator BOLDEN. Yes, sir.

NASA AND COMMERCIAL COMPANIES

Senator VOINOVICH. And the question I want to ask you is that the thing that you laid out in your budget represents a fundamental shift in the direction and fundamental shift in the relationship that NASA has with commercial companies. What was it about the way the agency has been doing business that led the agency and this administration to believe it is needed to undertake such a dramatic overhaul in the way you are doing business?

Is it because of the budget? Is it because you think you can get there quicker by going the route you are going? Or is it a combination thereof?

Administrator BOLDEN. Senator, if I can summarize it, the No. 1 thing is we are trying to meet the expectations of the Congress and the Nation that go back to the 2008 Space Act that put as a primary challenge to NASA to help develop a commercial space industry. We see that commercial space industry as allowing NASA to focus on exploration beyond low-Earth orbit, while the commer-

cial industry provides access to low-Earth orbit. So it is a combination of things.

But we are not trying to do anything fast. I have always heard it said if you want it quick and fast, you will get it quick and fast, and it probably won't be very good. So urgency is important. Speed is not something that I am asking my people to do with any of this, but I do want them to try to get us where we want to go with a sense of urgency.

INTERNATIONAL SPACE STATION

Senator VOINOVICH. Well, there is a lot of feeling in the country that we are going to have to rely upon the Russians to get up to the International Space Station. And by the way, more countries should be paying for the operation of that, and I would like you to look into that and how we can get others to pick up the tab because we are not Uncle Sugar anymore. We are in a little different position. In fact, we are probably worse off than some of the people that are our partners up there.

But the fact is people are concerned about that. How much are they going to charge us? How long is that going to last? That has got something to do with how people feel about where we are going. We want to get out from under them.

Administrator BOLDEN. Yes, sir. Senator, that will require a fundamental change in the way that NASA and its partners have operated the International Space Station. From day one, the fundamental agreement was that the Russians would provide access for humans to and from the International Space Station. NASA, because we had the most remarkable vehicle ever known to man and the space station that could carry large cargo, would provide the vehicle to carry cargo to orbit. So it is not new that we rely on the Russians to get humans to the International Space Station and back. That has always been a basic, fundamental agreement in the partnership. So that is not new.

SUSTAINABLE EXPLORATION PROGRAM

The other fundamental change is that this President, through his budget, has decided that he must and we must build a sustainable exploration program, and the way we were operating until now was not sustainable. That was my gut feel as an outside observer, in the 14 years that I was outside NASA after my leaving before and coming back now, and this—we are now going to have a sustainable program.

Senator VOINOVICH. You are going to have to do a big job—

Administrator BOLDEN. Oh, yes, sir. I understand.

Senator VOINOVICH [continuing]. Convincing this subcommittee about it not being sustainable—

Administrator BOLDEN. Yes, sir.

Senator VOINOVICH [continuing]. And what you are doing with the money that we are going to make available to you. And many of us are interested in whether or not the money that we have already put into Orion is just going to be poured down the drain, or whether or not it is going to be able to stay in the game in terms of competition in order to go forward with this because of all the work that we have done.

Administrator BOLDEN. Yes, sir. We intend to do that.

Senator MIKULSKI. Senator Voinovich does that—

Senator VOINOVICH. That is it.

Senator MIKULSKI [continuing]. Complete your testimony?

Senator VOINOVICH. Thank you.

Senator MIKULSKI. Senator Hutchison.

SPACE PROGRAM

Senator HUTCHISON. Well, thank you, Madam Chairwoman, and I do appreciate your holding this hearing, and I would say that as the ranking member of the Commerce Committee, I have invited the Administrator to come to a hearing next week where others have been invited, but have been told the Administrator is not available. And I hope, Madam Chairwoman, that changes, General Bolden, because I think after the incredible consequences of the President's decision that I would ask you to be available.

Senator MIKULSKI. Senator, may I inquire the day, time and date of the hearing?

Senator HUTCHISON. April 28 at what time? 2:30.

Senator MIKULSKI. Perhaps, Senator, Administrator Bolden's able staff could check it while we are engaging in this questioning.

Administrator BOLDEN. Madam Senator, I think there may be some confusion or lack of communications between your office and mine. It was my understanding that we had moved the hearing to May 12, and I was going to be there because I am scheduled to be at the Johnson Space Center on the day of the hearing that you originally scheduled, but we will resolve the issue.

SCIENCE

Senator HUTCHISON. Thank you.

General Bolden, I read your testimony. I have heard your testimony. I have heard the President's speech. And it just doesn't all come together. And I will say that I was one who was very supportive of your nomination for the reasons that others have stated because I knew that you would be committed to the missions of NASA and would understand it and would be a great leader.

But I am concerned about a very mixed message. The President says that he is committed to science. I don't see how you can have a commitment to science, but not a commitment to having humans in space at the same time. Because the space station is right now one of the key areas of science. There are others—the Hubble, which I support completely, and all of the other scientific missions—but the space station is the future.

INTERNATIONAL SPACE STATION

Congress and the President have embraced extending the space station until 2020, but we have not been assured that we can get people there. And I know you said that it isn't a change that the Russians were tasked with putting people in the space station, but it was always envisioned, in my estimation, that American shuttles would be going to the space station.

For one thing, you have to make sure that you have the equipment. The second thing is you need to make sure that if there are

repairs or something that you might need in the future, that you have the maximum capability. We were never going to have a gap in the beginning. Now, the gap started coming, of course, because, frankly, I think NASA has been starved throughout several administrations.

So I think that you are going to have to work with us, I hope in a constructive way, toward keeping people in space and keeping American control over our own destiny.

COMMERCIAL CAPABILITY

The emphasis, to the tune of \$6 billion, into a very fledgling commercial capability I just think is not sound, and it is certainly not going to be reliable. They are very short—I mean, it was even said that you have all of the expenses of closing down a contract, but then we are going to have to have new contracts.

So let me just say that I am skeptical and very disappointed that we would have a goal of keeping science in the forefront, but no plan to keep people involved in that effort under American control and under the control of NASA.

I think we are too heavily relying in the President's plan on commercial capabilities, which we had a hearing in Commerce Committee. We had the leaders of the commercial—the two commercial space operations. They are, in my opinion—I attended the hearing—not ready for this kind of reliance, and I don't think we can take that kind of chance.

CREW RETURN VEHICLE

So let me just ask you the questions that I can. If the Russian Soyuz has an accident or something happens that the crew return vehicle isn't operable, what if you had the accident, and it grounded the Soyuz for an extended period of time and we don't have our own reliable efforts?

Or I would ask you, how long would it take before the six-person crew that would still be aboard the International Space Station at certain points would have to evacuate using two of the Soyuz vehicles that just experienced a critical failure, assuming the failure occurred on descent? I mean, what are your plans here?

Administrator BOLDEN. Senator, I am going to try to understand the scenario you are placing. If that scenario takes place between now and 2015 with the existing program of record, Constellation, after shuttle is retired in September, or whenever we fly our last mission, we have no way to get Americans or anyone else to the station. We have two vehicles on station. We would be able to get the six-person crew home, but that would terminate all use of the International Space Station. The Constellation program was not going to provide that capability. The gap that you refer to actually began in 2004, probably began even before then. But when the vision for space exploration was given and then not funded sufficiently, the gap began to materialize and grow and grow and grow.

As Senator Voinovich mentioned, one of my primary drivers in recommending to the President what I did was I could not responsibly ask him to put the Nation into even more debt by putting the amount of money into Constellation that would have been required for us to try to catch it up. In fact, we still would not have been

able to gain that gap. Money can do a lot of things. It would not have been able to close the gap appreciably. So we were looking at about 2015 before we would have a domestic, NASA-built, with industry, capability to get humans to space.

Senator HUTCHISON. Well, General Bolden, the starving of NASA started before 2004.

Administrator BOLDEN. Oh yes, ma'am. I agree. I agree.

Senator HUTCHISON. I mean it has been starved for over 20 years. And so, we don't need to place blame so much as we need to address the issue.

Administrator BOLDEN. Yes, ma'am. I agree.

CONSTELLATION MISSION

Senator HUTCHISON. And I am concerned. First of all, I think we need to go forward with the Constellation or the next generation. If skipping from Ares I to Ares I-X or Ares V is necessary, I am not committed to the Constellation, but I am committed to the Constellation mission.

Administrator BOLDEN. Yes, ma'am.

Senator HUTCHISON. Which is to transport people to and from the space station, and with all due respect, I think we ought to be looking at not adding to the number of shuttles, but delaying the timeframe. That would bridge a gap, and it can be done if all of us work together without an additional budget over and above what the President is asking. It is reworking the budget that the President has said is the budget.

But if we had over 2 or 3 years, the same number of space shuttles so that you have the ability to assess and use the Soyuz in between to take people to and from, I think that would be a much more innovative approach. And it would give us more of the filling in of the gap for emergencies or for the scientific capabilities at the same time that we are developing our own Constellation-type operation.

So I hope that we can work on something that would not say we are going to be closed down in September, and 2015 would be the first time. In fact, in your own testimony, you said that we would be able, under the President's plan which you are supporting, to put humans into space early in the next decade. Well, I am assuming that since this is 2010, you are talking about 2020. That is early in the next decade.

Administrator BOLDEN. Perhaps I didn't make myself clear. Under the President's budget and his vision, we will have humans going beyond low-Earth orbit in 2020 or very shortly after that.

I have just selected a class of astronauts in this past year who were brought on strictly to occupy and operate the International Space Station. In reference to your concern about science, we now have the capability with a fully occupied International Space Station to do incredible science. And thanks to the President recommending that we—and funding—providing the funds to extend the International Space Station to 2020 and beyond, we now know that we are going to have 10 more years of human occupation and science being done on-station.

INTERNATIONAL SPACE STATION SURVIVAL

Senator HUTCHISON. I know that my time is up. Let me finish with just the last direct question. And that is, the Soyuz has an accident, and we can't get there for 2 years or 3. How can the station survive? How is that possible? Even the Augustine report said——

Administrator BOLDEN. Ma'am, the International Space Station use will, as I said, in the scenario that you mention in today's environment, with the program of record, unfortunately, because we allowed this gap to grow, there is no way to do what you and I both want to do. We will be single-string once the shuttle stops flying.

Senator HUTCHISON. I think we can——

Administrator BOLDEN. We will be just like we were after the Columbia accident, for a couple years.

Senator HUTCHISON. I think we can fix it, General Bolden.

Administrator BOLDEN. Yes, ma'am.

Senator HUTCHISON. And a couple years would be okay. Five, 7, 10, is not okay, and I hope that all of the Senators that are interested in this will work with you, with the administration. I think we can do better than this.

Thank you.

Administrator BOLDEN. Thank you very much.

CLOSING REMARKS TO NASA

Senator MIKULSKI. Thank you, Senator Hutchison.

There are many more questions, but Mr. Frost has been quite patient. It is now 11:30. We anticipate a vote over the next 30 minutes, so we want to hear from Mr. Frost and have time to really explore the safety issue.

So, Ambassador you are in treaty negotiations. And what we will have will be a whole series of other questions we will submit to you and to your team for our record. I will have a particular set of questions related to space science and particularly also to green science.

We are heartened by the fact that the President did provide reliable, undeniable, survivable \$5 billion in the science appropriations request. But we just don't want to be spending money. We also want to be able to get results for our science.

I am so proud of the work that is done at Goddard. You can't be the Senator that has the Hubble telescope kind of based in your State, if you will, through Goddard and the Space Telescope Institute at Hopkins, without being very proud of what we do in science. It is what the world relies on us to be able to do. We want to make sure we have money in the appropriations, but that we also have outcomes we seek. So we will move with that.

So we will excuse you today. Obviously, there must be more conversations on this around our mission, around our workers and the industrial base, and look forward to further conversation with you.

Administrator BOLDEN. Thank you very much.

Senator MIKULSKI. Thank you very much.

Administrator BOLDEN. I appreciate it. Thank you.

Senator MIKULSKI. Thank you, Administrator Bolden.

The chair now calls Mr. John C. Frost, who is a member of the NASA Aerospace Safety Advisory Panel. He comes with a distinguished background in safety, serving both DOD, as well as his work in NASA. And rather than going through a long bio, I am going to put your bio in the record so that, really, you come with extensive experience, outstanding credentials, and a real commitment to both safety and knowing what Government needs to do, that when Government asks people to do things that we keep them safe.

[The information follows:]

BIOGRAPHICAL SKETCH OF JOHN FROST

Mr. John C. Frost is an independent safety consultant who retired from Federal Service with 33 years of Safety Engineering experience. Mr. Frost was the Chief of Safety for the Army Aviation and Missile Command (AMCOM) with worldwide responsibility for missile and aircraft safety. Mr. Frost directed and implemented a comprehensive System Safety Program for all aspects of a major high technology organization that develops, fields and supports all of the state-of-the-art aircraft and missile/rocket systems for the Army worldwide and provides facilities and services for approximately 20,000 residents, workers, visitors and contractors on Redstone Arsenal. Prior to this, he served as the Chief of the MICOM Safety Office and held other supervisory positions leading various Missile Command (MICOM) System Safety, Radiation Protection, Explosive Safety, Test Safety and Installation Safety program elements. Mr. Frost began his Federal career in the Safety Office of the Army's Electronics Command at Fort Monmouth, New Jersey, where he became Chief of System Safety Engineering.

Mr. Frost was born and raised in Birmingham, Alabama and earned a Bachelor of Science in Electrical Engineering from the University of Virginia where he was a DuPont Scholar. He completed a Master of Science specializing in safety engineering from Texas A&M and an additional year of advanced safety engineering training. Mr. Frost is a senior member of the International System Safety Society, a professional member of the American Society of Safety Engineers, and remains active in various system safety organizations and initiatives. He was previously registered in Massachusetts as a professional engineer in the specialty of safety engineering and as a certified safety professional. He and his wife Linda, of 33 years, have two sons, Christopher and Hampton.

Senator MIKULSKI. So why don't we get right to your testimony, and thank you for your patience.

STATEMENT OF JOHN C. FROST, COUNCIL MEMBER, AEROSPACE SAFETY ADVISORY PANEL

Mr. FROST. Thank you, Madam Chair. I appreciate that, and I think that is a good path ahead.

Good morning to you, to Ranking Member Shelby, and the rest of the subcommittee, if they had been here.

I do appreciate the opportunity to approach the panel and explain our views on these issues. I am very comforted to see that you obviously have read what we have written and you are already very tuned in to our concerns.

Our chairman, Admiral Dyer, could not be with us today, but he sends his regards to you all.

The Aerospace Safety Advisory Panel, or the ASAP, was created by Congress in 1968 to provide independent safety assessments and recommendations to NASA after the tragic Apollo 1 fire that took the lives of three of our astronauts. We also advise Congress on NASA's overall safety challenges and performance. We issue quarterly recommendations to the NASA Administrator, and we publish an annual report to Congress.

Our role here may be somewhat unique because, as we say in Alabama, we don't have a dog in this fight. So maybe we can bring that view to the table.

Before I begin, I want to express a heartfelt commendation that I believe is shared by every member of the ASAP. That commendation is for the quality of leadership and the commitment to safety that has long been demonstrated by Administrator, General Charlie Bolden. When it comes to the safety of our astronauts, I can think of no better hands for the agency to be in.

Now, on to our key 2009 findings, first, the life of the space shuttle is nearing its end. In view of the inherent hazards of the shuttle design, the age of the critical subsystems that it contains, and the need to recertify the fleet, the panel believes that the life of the space shuttle should not be extended significantly beyond completion of its current manifest. To do so would require substantial efforts even after which the vehicle could not be considered safe by modern standards.

Second, I will address the follow-on to the shuttle, which is really the subject today, I think. After detailed evaluations, we have found that because of the fundamental vehicle architecture choices made at its concept stage, the use of the heritage-based subsystems with proven track records, and the intense involvement of the experienced NASA safety design professionals, the Ares I and the Orion offer the basis for a high degree of inherent safety.

In fact, they are being designed to provide a tenfold improvement over the safety of any existing vehicles. In our opinion, such inherent safety simply cannot be taken as a given in possible alternative launchers, as some would like to be the case. As we have already been quoted a couple of times today from our 2009 report, we believe that to abandon Ares I as a baseline vehicle for any alternative without demonstrated capability nor proven superiority, or even equivalence, is unwise and probably not cost-effective.

We are aware that commercial entities hope to provide safe and low-cost access to orbit in the future, and we look forward to their innovations. We do support their work, but we must point out that NASA has not yet even established what the safety requirements for these commercial providers will be. The potential safety of these alternatives cannot be evaluated until the safety requirements, such as the acceptable risk level for loss of crew, are established and the proposed designs are evaluated against them.

Our bottom-line safety recommendation is to not abandon the progress already made on the program of record before determining if the alternatives can provide equal or better safety for our astronauts.

My third topic concerns the workforce. NASA has developed detailed transition plans that carefully map the skills and the funding streams to move from the shuttle operation to the Ares-Orion development. If a major change in the mission of these workers is the path that is chosen, it is imperative that a new plan be developed quickly to clearly show these workers their place in the new vision. Otherwise, we face a risk of loss of the key personnel that are essential to safe space flight.

Finally, I must report to you that we are seeing examples of facility degradation, which concern us, across NASA. Adequate fund-

ing for NASA facilities and infrastructure must be considered on an even ground with that of the more visible missions that come out of these facilities.

In conclusion, Madam Chair, the ASAP believes that America's human space flight program stands at a critical juncture today. Choices made today will impact the safety of astronauts for at least a generation to come. Safety must be an inherent part of the vehicles that we use to launch those astronauts. It cannot simply be added on after the fact.

Just as importantly, the resources provided to NASA must be consistent with whatever mission they are assigned, and both the resources and the mission must be kept stable. Asking NASA to attempt too much too fast with too little can only lead to danger and to disappointment.

I will be happy to answer any questions that you or the other members may have.

[The statement follows:]

PREPARED STATEMENT OF JOHN C. FROST

Good morning Madam Chair, Ranking Member Shelby and other members of the subcommittee. Thank you for the opportunity to discuss the Aerospace Safety Advisory Panel's observations as they relate to the scope of your subcommittee. Because of a schedule conflict, our chairman, Admiral Joseph Dyer could not be with us today but sends his best regards.

Let me start with a brief background of the Aerospace Safety Advisory Panel, or ASAP. The ASAP was established by Congress in 1968 to provide independent safety assessment and recommendations to NASA after the tragic Apollo 1 fire that took the lives of three astronauts. By law, we now serve two functions: (1) Provide independent safety advice to the NASA Administrator; and, (2) Advise Congress on NASA's overall safety challenges and performance. We visit different NASA Centers and activities once a quarter where we probe and question all the elements of the Agency's safety program, both for spaceflight and for terrestrial operations. We issue quarterly recommendations to the NASA Administrator and publish an annual report to Congress, summarizing our findings and recommendations. I will attempt to very briefly summarize for you our key findings and observations from the last year as they relate to your pending budget considerations.

First, let me express a heartfelt commendation that I believe is shared by every member of the ASAP. That commendation is for the quality of leadership and commitment to safety that has been long demonstrated by the new administrator General Charlie Bolden. When it comes to the safety of our astronauts, I can think of no better hands for the agency to be in.

Now on to the key findings of our 2009 report that relate most directly to the issues that your subcommittee is dealing with at this time.

Space Shuttle.—As you know, the life of the Space Shuttle is nearing its end. Because of the Herculean efforts of the managers and workers at NASA and its contractors, this complex flying machine has performed admirably during its 29 year life. Sadly, the very power and complexity that enable it to accomplish the wide variety of missions for which it was designed, have also contributed to two tragic accidents and the loss of 14 lives. The ASAP has closely monitored Shuttle operations since its inception. In view of the inherent hazards of the basic Shuttle multi-function design, the age of some critical subsystems, and the need to recertify the fleet as identified by the Columbia Accident Investigation Board, the Panel believes that the life of the Space Shuttle should not be extended significantly beyond completion of its current manifest. To do otherwise would require funding the substantial efforts required to ensure that life extension vulnerabilities are identified and corrected in a timely manner. Additionally, the inherent risk of continuing to operate this system would have to be accepted by the Nation's leaders.

Follow-on to Shuttle.—The Panel has intensely monitored the progress of the Space Shuttle replacement program since its beginnings. We found that the Ares 1 vehicle has been optimized for crew safety since its inception. Because of fundamental vehicle architecture choices made at its concept stage, the widespread use of heritage-based subsystems with proven track records and the intense involvement of experienced NASA space design professionals serving as the systems integrators,

the ASAP believes the Ares 1/Orion offer a high degree of inherent safety. In fact, they are being designed to provide a tenfold improvement over the safety of existing vehicles. In our opinion, space vehicle safety simply cannot be taken as “a given” as some would like to be the case. As we stated in our 2009 report to Congress, “To abandon Ares 1 as a baseline vehicle for an alternative without demonstrated capability nor proven superiority, or even equivalence, is unwise and probably not cost-effective.” We are aware of course that several commercial entities hope to provide safe, low-cost access to Low Earth Orbit in the not too distant future. We have not evaluated their proposals and cannot comment on their eventual safety; however we must point out that NASA has not yet established any safety requirements for these commercial providers. Even more importantly, the agency has not yet established a process that can provide the right mix of insight and oversight to ensure the safety of NASA astronauts traveling in these vehicles. The safety of potential commercial providers cannot be evaluated until key safety requirements, such as the acceptable risk level for Loss of Crew, are established and proposed designs are evaluated against them. While progress is now being made on establishing these requirements and processes, it is too early to tell if the commercial options that are contemplated can eventually be deemed safe enough for our astronauts. Our bottom line recommendation is to not abandon the well-established progress already made on the Program of Record in favor of an alternative, until such time that it is determined that the alternative provides equal or better safety for our astronauts.

Workforce Transition.—The “magic bullet” that has allowed NASA to achieve the incredible feats for which they are known around the world is its highly dedicated and motivated workforce. At every Center that we visit, we see this dedication and excitement in every face. Maintaining this talent, momentum, and enthusiasm during a time of transition from a Shuttle based Manned Spaceflight Program to an alternative is the key to the future of the agency. In the past 4 years, NASA has expended significant effort developing detailed transition plans that map skills, talent, and necessary funding streams from a “Shuttle Centric” organization to one that is Ares/Orion based. The Panel has found this Transition Plan paying off already in the form of workers’ excitement and satisfaction over their role in the coming exploration of our solar system. If a major change in the future roles and missions of these NASA workers is the path chosen, it is imperative that a new transition plan be developed quickly, clearly showing these workers their place in the new vision. The turmoil created by uncertainty can result in loss of key personnel which presents obvious safety concerns.

Infrastructure.—As the panel visits the various Centers, we carefully watch for facility conditions that could contribute to mishaps or hurt mission performance. I must report to you that we are seeing examples of such conditions which concern us. While, to a person, the employees “can-do” attitudes help them cope with the impediments of these conditions, it is inevitable that worker performance and safety could be impacted. Adequate funding for NASA facilities and infrastructure must be considered on even ground with that of the more visible missions that actually come out of these facilities.

In conclusion, Madam Chair, in the view of the ASAP, NASA stands at a critical juncture. Choices made today about the future of Human Spaceflight will impact the safety of astronauts for a generation to come. Most importantly, resources and schedules provided to NASA must be consistent with whatever mission they are assigned. Asking NASA to attempt too much, too fast, with too little can only lead to danger and disappointment. I will be happy to answer any questions that you or the other members of the subcommittee may have about our observations.

Senator MIKULSKI. I am going to turn to Senator Shelby to ask his questions. He has many duties also related to the Financial Services.

Senator Shelby.

Senator SHELBY. Thank you. Thank you, Madam Chairwoman.

Mr. Frost, welcome to the subcommittee. We are glad to have you here, but more than that, we appreciate your background and your statement.

The future of human space flight is being proposed to be given, as I understand it, to companies that have never launched humans before. That is disturbing to me because your own panel for years has advised that they are not ready. If there is substantial risk in

relying on unproven commercial providers to put our astronauts in orbit, do you have a suggestion on how to reduce that risk?

Mr. FROST. The risk that the panel sees is principally the unknown nature of their abilities. If we bet our entire future on those as yet unproven abilities, there is risk that they may not pan out. A common method of handling that kind of risk is hedging your bet or as one member of the Augustine panel I believe was quoted as saying, "If it is a horse race, bet on the field, and then you can pick the winner a little later."

So keeping redundant capabilities and not being single-string dependent can greatly reduce that risk. There is a cost to that.

Senator SHELBY. A big cost, though, isn't it?

Mr. FROST. That is right.

Senator SHELBY. Do you believe that NASA should relinquish its role in ensuring safety through rigorous testing during development and production if NASA were to allow their astronauts to fly on any spacecraft, commercial or otherwise?

Mr. FROST. At the current time, for NASA to put its employees, its astronauts onboard something as potentially hazardous as a rocket ship, they are going to have to have a robust program to check its safety. There may come a day when it becomes as routine as a commercial airline. That day is far away, in my personal opinion.

Senator SHELBY. Thank you, Madam Chairwoman.

Thank you, sir.

Senator MIKULSKI. First of all, Mr. Frost, I would like to thank you for the service that you have done through the ASAP Committee, and also please thank the other people who participate, who put a lot of time into this, and we have read your reports. We also note that there is regularity to the actual visitation, that this isn't some think-tank egghead intellectual exercise reading memos or mathematical simulations. And we take to heart all of your comments, including the degradation of the NASA facilities and your caution about maintaining morale and competency among our workforce.

Well, let us get right to this whole issue of going commercial. There is an inherent tension here between boldness and innovation and looking because technology moves fast in its development, much faster than Government contracts and procurement. But at the same time, we are not sending cases of Tang into space. We are sending our astronauts and the astronauts from other countries. They rely on us.

So here goes the question. On page 3 of your testimony, you say, "We have not evaluated their proposals and cannot comment on their eventual safety." Here is the key point. "However, we must point out that NASA has not yet established any safety requirements for their commercial providers."

Now, as you recall, in my questions to General Bolden, I said is there going to be a single standard? He told me yes. Then he told me they have this manual that they have either developed or are in the process of completing. I am confused. Is there a standard? Is there not a standard? Is there a manual? Could you share with us your comments on this?

Mr. FROST. Yes, I will be happy to. My understanding is, and we have been briefed and evaluated this very carefully, that NASA does have a human rating—NPR, it is called. It was recently updated in 2008. It specifically did not address and exempted commercial providers. It was aimed at the type of program where NASA manages the hardware. And that is critical because the way you state and explain and track the safety requirements depends on the kind of program it is.

If you are buying a taxi ride, you have a different set of requirements than if you are developing a taxi. So that was exempted. The ASAP made that a primary recommendation for, I think, about 2 years that that section of the standard be built out so that the people trying to develop commercial vehicles knew what to aim for.

General Bolden has taken the initiative to make that a priority. The current estimate is that some type of standard for those commercial providers will be available by the end of 2010 setting the requirements.

Senator MIKULSKI. So if, in fact, you say to these bold, innovative companies on which we are now betting the future of our astronauts going to the space station or in a low orbit there is going to be a safety standard, but we won't have it complete until 2010?

Mr. FROST. That is the current estimate. That is correct. And I might point out that that is the hardware requirements. Then we need a process, set of processes that will take longer.

Those processes depend on how much knowledge we have of the provider. If we don't have much insight into how they develop their rocket ship, if you will, then we will need very extensive testing and verifications. And that process will take longer, in my opinion, than 2010.

Senator MIKULSKI. So then there are the processes. Now, there is the hope that they will be ready to go in 3 years. You know, that is all part of the glitz and the glory that we are hearing about, that they are going to be ready to go in 3 years, when—I am looking at the development of the shuttle—we have followed the development of the shuttle together. Senator Shelby and I came to the Congress and have worked together since we came, and the shuttle had problems. But remember, the shuttle was going to go 100 flights, and it was going to be like the Greyhound bus to wherever we wanted to go.

Now what I am saying, is if, in fact, the safety manual is not done until 2010, and those processes that are really mandatory, usual, and customary, then how could a commercial vehicle just getting what they need to know in the standards, be able to meet a 3-year timeframe? Do you think that is realistic?

Mr. FROST. I am not privy to the development schedule of the COTS folks. That sounds highly optimistic to me.

Senator MIKULSKI. I am not trying to pin you down. I am trying to get your experience.

Mr. FROST. My experience would be that that is going to be a tough schedule to meet. And one safety concern that drives our panel is that they are designing parts of those vehicles today. There are engineers at tables picking safety factors and design features that may or may not comply with the requirements that will

be developed later in the year. In which case, we will either have to accept the risk or step back and redesign. Both involve risk.

Senator MIKULSKI. So they are designing today without having the firmness and definite—the definite nature of NASA standards.

Mr. FROST. That is correct. They are attempting to design to what they think the standards will be. And if they are right, then we will be in good shape. And if they are wrong, then we will have difficulty.

Senator MIKULSKI. Next question. Senator Hutchison presented a really doomsday scenario. When she said it, actually, I thought, “Oh, my gosh, she is so right.” I think you get a flare here. When it comes to the space program, we have really been a bipartisan group. And for those of us who have the centers and meet with the astronauts and so on, you know, we feel like we are all in this together.

But when Senator Hutchison said she is concerned about bringing them back home if something happens to Soyuz, Bolden says it would be the end of the space station. Well, yes, it is also the end of those astronauts that are up there.

What do you think? Because you talked about it in your testimony, you say “end the shuttle.” Senator Hutchison presents this very troubling scenario. Is there a way we can have it both ways, which is to have a shuttle on reserve for rescue, keep flying it maybe for a specific mission, but have it? In other words, is she on to something that we should explore?

Because in both your oral and written remarks, you say it is time to say good-bye to the shuttle, and every scientist, engineer, et cetera, and NASA Administrator has said the same. Could you tell us what you think about extending the life of the shuttle? And would it be possible, or is it really would be—what would be your observations?

Mr. FROST. I will be happy to. First, to the premise, I think she is absolutely on to something of the nightmare scenario, that being single-string dependent, having humans in orbit, and only one elevator to get there subject to catastrophic failure, in which case it can be shut down, as we have seen, is definitely a high risk, and I think needs to be thought of.

There are several solutions. Minimizing the gap, in my view, is the best approach. You could keep flying the shuttle. There is no question. We see no—we call it “knee of a curve.” It won’t wear out in July, but it is getting old, and principally, it has a very high level of risk.

Each launch is something like 1 chance in 78 to maybe 1 chance in 100, somewhere in that range, of losing the crew, the more times you fly it, the more likely that you are going to find that result.

Senator MIKULSKI. In other words, just to be sure of the risk analysis, after a certain date, the longer you keep the shuttle flying, the more increased the risk to the astronauts.

Mr. FROST. We don’t see an increase per flight, but as you do more flights, it is like playing Russian roulette. The more times you pull the trigger, the more likely you—

Senator MIKULSKI. I know you math whizzes will get into probabilities, but I think we got the picture. Thank you.

Mr. FROST. But we don't see the shuttle wearing out immediately. It is simply that there is great risk involved, and the Nation could accept that risk. And the astronauts, I am sure, are willing to live with it. That is a very high level of risk, in our opinion.

Senator MIKULSKI. But what do you think—you know, we all have these kind of now movie fantasies, the way we think the world works like the movies or now like video games. Could you literally take the shuttle and put it aside and keep it prepped and ready to go if there would have to be a very daring rescue mission?

Mr. FROST. I think the movie was "Space Cowboys"—great movie.

In safety, there is a concept called OPTEMPO, and that is that if you fly too many missions too frequently, it becomes unsafe. You are pressing your crews too hard. But on the other side of that, if you fly too rarely, they lose their skills, their edge, and their abilities. They don't remember exactly how to tighten the bolts that they used to know how to tighten, and safety degrades greatly. And that curve is generally a bell-shaped curve. If you just put the shuttle in storage and didn't use it, I would have great concern about the reliability of that launch as it came out of cold storage.

Senator MIKULSKI. Well, I appreciate that. This is my final question. Will the ASAP Committee be involved in assessing the safety issues of these commercial enterprises?

Mr. FROST. Yes, we have made that a central focus of our committee. We are not staffed to do a technical evaluation and an independent review of the hardware, but we will look at the processes that will be used to do that.

Senator MIKULSKI. Well, I think these were excellent.

Senator Shelby, do you have—

Mr. Frost, first of all, I would like to thank you for your answers here, I think they were very instructive to us. We would look forward possibly as this—our process of evaluation goes on to come back to you and other members of the committee. Again, thank you for excellent testimony.

We would also welcome from the committee this issue of center infrastructure degradation, because no matter what we do, we have got to keep—we have got to make sure that they are fit for duty.

So thank you very much. This subcommittee will excuse you, but we would ask you and your committee to be available for ongoing—and the staff—for ongoing conversation.

Mr. FROST. We will be happy to do that. Thank you.

Senator MIKULSKI. Senator Shelby.

Senator SHELBY. Madam Chairwoman, I just want to thank Mr. Frost, too, for his incisive answers and his background and his experience of safety.

Thank you.

Mr. FROST. Thank you.

Senator MIKULSKI. I also want to note that for NASA's 2011 budget, it affects many States, and I know that there is an interest in other Senators with this topic and that there are going to be follow-up questions that are budgetary, programmatic, mission-focused, and how we can do this within this budget.

Senator SHELBY. Madam Chairwoman, I hope we could reserve the right to hold another hearing on this matter, if warranted.

Senator MIKULSKI. I absolutely agree that we will hold another hearing to be able to pursue any topics. I would suggest now that our able staff connect with NASA, really sift through this rather content-rich nature of what we have listened to.

I would also like to thank all of the members who participated for their civility and for their very insightful questions. I believe if we all focus on where we want America to be in space, and how we protect Americans who we ask to do things we will be able to find solutions to how we work through these complex challenges.

Again, Mr. Frost, thank you.

ADDITIONAL COMMITTEE QUESTIONS

If there are no further questions this morning, Senators may submit additional questions for the subcommittee's official record. We are going to ask NASA's response within 30 days.

[The following questions were not asked at the hearing, but were submitted to the Department for response subsequent to the hearing:]

QUESTIONS SUBMITTED TO HON. CHARLES F. BOLDEN, JR.

QUESTIONS SUBMITTED BY SENATOR BARBARA A. MIKULSKI

COMMERCIAL SPACE FLIGHT

Question. As part of canceling Constellation, NASA has advocated for the commercial space sector to support low-orbit mission, spending \$6 billion in the next 5 years for commercial crew and cargo vehicles.

What led the administration to put its faith in commercial space flight for transporting crew to low Earth orbit?

Answer. A more robust role for the private sector in spaceflight has been recommended by many groups over the years, including the U.S. Congress in the 2005 and 2008 NASA Authorization Acts. Most recently, the Augustine Committee found that: "Commercial services to deliver crew to low-Earth orbit are within reach."

NASA has a long history of partnership with the commercial space sector. Nearly all NASA Science payloads are launched aboard commercially owned and operated vehicles. And the commercial sector is instrumental in each space shuttle launch, as nearly 90 percent of the shuttle workforce are industry contractors. Additionally, the commercial space industrial sector has a demonstrated record of safe and reliable launches. For example, United Launch Alliance, a provider of commercial launch services, has successfully launched 25 Department of Defense (DOD) satellites consecutively. This impressive launch record underscores a continuing capability to deliver high-value payloads to orbit via an established U.S. commercial space industry.

Question. What if this commercial venture fails?

Answer. NASA is confident in the ability of our commercial cargo partners to develop the capability to deliver cargo to/from the International Space Station, and to ultimately deliver cargo under the Commercial Resupply Services (CRS) contracts. We also are looking forward to working with commercial partners on a commercial crew development effort in the near future.

The development of a commercial crew transportation capability shares the same risks that are typical in any aggressive, challenging space hardware development program. NASA is in the process of structuring its plan to support development of a commercial crew transportation capability, should the fiscal year 2011 budget provide funding for this activity. The President's budget request provides NASA with resources to support the development efforts of multiple providers and to provide significant technical support during the development phase. This will maximize the likelihood that selected commercial providers will successfully complete development activities and will minimize the impact to the agency if any one commercial provider is not fully successful in its development activities.

Question. Does this mean the United States won't be able to send astronauts into space for 10 years?

Answer. NASA is in the process of developing a procurement solicitation for commercial crew, should the fiscal year 2011 appropriation include this activity. There-

fore, the timing for the availability of commercial crew services will not be known until NASA receives proposals for the development of this capability. However, the Augustine Committee had noted that commercial crew launch service could be in place by 2016. Estimates provided to the Augustine Committee by potential providers said commercial crew services could be in place 3 to 5 years from the point of funding.

Question. What is NASA's back-up plan?

Answer. With regard to cargo, NASA plans to pre-position spares onboard the ISS with the final logistics flights to provide some margin for delay in commercial cargo services. Additionally, NASA plans to rely on the transportation capabilities of Russia, the European Space Agency and Japan to transport cargo to ISS. Russia's Progress vehicle has been providing cargo services to ISS through a contract with NASA. The ESA Automated Transfer Vehicle had a successful initial flight to the space station in 2008. The Japanese HII Transfer Vehicle had a successful first flight in 2009. ESA's and Japan's services are provided through barter agreements. Beyond that, there is no planned back-up capability for ISS commercial cargo. Time-ly commercial cargo capability is critical for effective ISS operations. Without U.S. commercial cargo capability, the crew size and research operations planned for ISS would need to be reduced.

With regard to commercial crew transportation services, NASA hopes to award development funding for up to four proposals, thus increasing the chances that multiple partners would succeed at developing a commercial crew vehicle. After the commercial crew services procurement is released, NASA is hopeful that more than one partner will be selected to supply those services, thus providing redundancy of capabilities. Additionally, should those capabilities fail to materialize on time, NASA has purchased Soyuz seats through 2014 and has legislative authority to purchase additional seats through July 1, 2016. If we need to purchase seats beyond July 1, 2016, NASA would need to extend the current exception under the Iranian North Korean Syria Nonproliferation Act that permits purchase of Soyuz launch services. Lastly, NASA intends to provide significant technical support to commercial providers during the development and demonstration phase, thereby helping to increase their chances of success both programmatically and with respect to safety.

Question. Did NASA look at options other than the commercial sector?

Answer. This information is pre-decisional.

Question. What about building upon the successes of the Delta and Atlas rocket programs and using Evolved Expendable Launch Vehicles (EELV) as an interim means to reach the space station?

Answer. Evolved Expendable Launch Vehicles (EELVs), including the Delta and Atlas rockets, are commercial vehicles and they are certainly candidates for the Commercial Crew Program. In fact, the program will be open to any domestic company interested in providing these services in accordance with existing U.S. laws and policies. Any domestic company that had been part of the Constellation Program can, if it chooses, compete with others as part of this new commercial crew transportation program. In addition, Boeing and United Launch Alliance were chosen earlier this year for NASA awards under our Commercial Crew Development (CCDev) initiative designed to develop and demonstrate technologies that enable commercial human spaceflight capabilities.

Question. How do you balance leaving companies alone while managing oversight of issues like safety, cost and performance, and technical soundness?

Answer. Safety is and always will be NASA's first core value, so we will provide significant—but not intrusive—oversight over any commercial venture, whether it be cargo or crew. For example, NASA has a Commercial Orbital Transportation Services (COTS) Advisory Team comprised of approximately 100 NASA technical experts from across the agency. These experts work with our partners and review partner technical and programmatic progress for each milestone and provide progress assessments to NASA's Commercial Crew Cargo Program Office. Additionally, they participate in all major design reviews providing technical review comments back to our partners. The advisory team provides another method by which NASA gains confidence that our partners will be able to perform their flight demonstrations.

One of the strengths of the COTS venture is that companies are free to do what they do best, that is developing truly unique spaceflight vehicles using innovative processes that are not available within the Federal bureaucratic framework. NASA provides requirements that they must meet and we ensure that they have met those requirements, but we try not to dictate how they meet those requirements. For example, each COTS partner must successfully verify compliance with a detailed set of ISS interface and safety requirements prior to their planned ISS berthing missions. These requirements are imposed on all visiting vehicles wishing to visit to the

International Space Station (ISS). Both COTS partners are currently working with the ISS program on a daily basis to ensure they meet the ISS visiting vehicle requirements. This also helps to give NASA independent insight into their progress and it builds confidence in their abilities.

With regard to commercial crew, at no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. NASA has unique expertise and history in this area, and a clearly demonstrated record of success in transporting crew. NASA will bring that experience to bear in an appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. For example, NASA will have in-depth insight of the vehicle design via NASA personnel who are embedded in the contractor's facility. Additionally, NASA will impose strict requirements and standards on all providers that will be carefully evaluated and reviewed at multiple stages before a vehicle system is certified by NASA for crewed flight.

Question. If the program experiences cost overruns, who pays? The companies or the Government?

Answer. With regard to potential cost overruns in the Commercial Crew Development program:

If NASA uses SAAs, it is likely that such agreements will be structured similarly to NASA's COTS development SAAs. For the COTS SAAs, the Government provided a pre-negotiated set amount of funding to our two current partners. Each partner is awarded funding as they successfully meet pre-negotiated milestones and commercial partners are responsible for additional costs in excess of NASA's investment.

If NASA uses fixed-price contracts, those contracts will similarly use pre-negotiated performance-based milestones. So, under this approach as well, the company will be responsible for any cost overruns. NASA's investment will be fixed.

Question. What are commercial companies contributing to this plan?

Answer. Although NASA is still preparing a strategy to support development of commercial crew, in general, we intend for NASA's investment to supplement private investment in developing a commercial crew capability, thus providing strong incentive for industry partners to perform and "stay in the game."

It is important to remember that NASA did not specify a minimum level of cost sharing for COTS partners because the agency felt that it would be inappropriate to prejudge a potential partner's business case. NASA reviewed each proposal as a whole, and assessed each proposal based on its own merits. That included review and evaluation of the type of vehicle system proposed, the development process proposed, as well as market factors such as the potential for other non-government customers, the amount of investment each company plans to contribute, the company's experience in similar endeavors, etc. No single factor is necessarily more important than another.

Question. Who are the other customers? Is there a market for sending humans into space?

Answer. NASA has not conducted any market surveys. However, there are general indicators that such a market exists. For example:

- From an historical perspective, Russia and the United States have been providing human space transportation services to astronauts from other countries since 1978. Since that time, Russia and the United States have transported nearly 100 astronauts representing 30 nations. In addition, eight people have flown to space in the past decade as spaceflight participants.
- Another strong indicator came from NASA's CCDEV solicitation. In answer to NASA's CCDEV solicitation for commercial crew spaceflight concepts, the agency received 36 proposals—an indicator that there is robust interest from U.S. industry in developing human spaceflight capabilities.
- Helping to support an enhanced U.S. commercial space industry will create new high-tech jobs, leverage private sector capabilities, spawn other businesses and commercial opportunities, and spur growth in our Nation's economy.
- Most importantly, the administration's proposal to extend and fully utilize the ISS provides a reliable, sustainable market for commercial human space transportation services likely to 2020 or beyond.

Studies in the public domain suggesting that commercial providers can be successful include:

- Collins, P. and Isozaki, K. "Recent Progress in Japanese Space Tourism Research," IAC Italy, October 1997.
- O'Neil, Bekey, Mankins, Rogers, Stallmer "General Public Space Travel and Tourism," NASA-MSFC, March 1998.

- Aerospace Commission “Final Report of the Commission on the Future of the United States Aerospace Industry,” November 2002.
- Space Tourism Market Study, Futron Corporation, 2002.
- Webber, D. and Reifert, J. “Filling in Some Gaps”, Executive Summary of the Adventurers’ Survey of Public Space Travel,” September 2006.
- Commercial Spaceflight Federation “Commercial Spaceflight in Low Earth Orbit is the Key to Affordable and Sustainable Exploration Beyond,” input to the Review of U.S. Human Space Flight Plans Committee, June 29, 2009.
- Final Report of the Review of U.S. Human Spaceflight Plans Committee, 2009.

Question. Are we subsidizing space tourism?

Answer. NASA is not subsidizing space tourism. Rather, NASA is helping to develop a critical capability that is needed by the agency. By investing \$6 billion in commercial crew efforts over the next 5 years, NASA can focus on the forward-leaning work we need to accomplish for beyond-LEO missions. Additionally, this investment will:

- Reduce the risk of relying solely on Russia to transport astronauts to the ISS following the retirement of the space shuttle;
- Free up NASA resources to focus on the difficult challenges in technology development, scientific discovery, and exploration;
- Make space travel more accessible and more affordable.
- Build an enhanced U.S. commercial space industry that creates new high-tech jobs, leverages private sector capabilities, spawns other businesses and commercial opportunities, and spurs growth in our Nation’s economy.
- Inspire a new generation of Americans by these commercial ventures and the opportunities they will provide for additional visits to space.

SPACE SHUTTLE RETIREMENT

Question. The President’s budget makes it clear that the space shuttle will retire at the end of 2010, marking the end of an era. Only four more launches are planned. Do you need any additional funding to close out the shuttle program?

Answer. No. The President’s fiscal year 2011 budget request includes \$600 million to fly the space shuttle through the first quarter of fiscal year 2011. The last shuttle mission, STS–134/AMS, is now scheduled for February 2011. Because of additional savings that have been identified in 2010, NASA will not require funding beyond that requested in the President’s budget to close out the space shuttle program.

Question. Will we have the right people in place to safely see the shuttle program all the way to the end?

Answer. While many space shuttle workers have expressed the desire to stay with the program until the shuttle retires, NASA and its space shuttle contractors have worked to ensure that the program retains the critical skill mix needed to fly out the remaining missions safely. As one example, NASA has offered retention bonuses for workers who continue with the program through shuttle retirement. The contractors are conducting incremental layoffs designed to ensure that they can meet shuttle manifest requirements safely, and the agency is confident that the program will have the personnel necessary to accomplish this.

Question. What steps are you taking to make sure a major safety misstep does not occur as workers face the end of the program and the potential loss of their job?

Answer. NASA and its contractors are emphasizing the criticality of focusing on each of the remaining missions in turn in order to ensure a safe flight. Each mission is processed and flown according to time-tested procedures and safety protocols, and reporting lines of communication encourage employees to raise any safety concerns they may have. The agency and shuttle contractors are also supporting a variety of efforts to help transition workers after the end of the program.

Question. What are the budgetary implications of the delay in the Advanced Magnetic Spectrometer (AMS) which will delay STS–134?

Answer. The President’s fiscal year 2011 budget request includes \$600 million to fly the space shuttle through the first quarter of fiscal year 2011. If STS–134, which will carry the AMS experiment to ISS, launches in February 2011, as currently planned, NASA will not require further funding beyond that requested in the President’s fiscal year 2011 budget request.

WORKFORCE TRANSITION

Question. The retirement of the space shuttle program will affect as many as 12,000 workers. The Constellation program was supposed to help transition some—though not all—of this high-tech workforce over to good jobs. Now, with the proposed cancellation of Constellation, the “Jobs Gap” grows larger and deeper. The ad-

ministration has suggested that 1,700 new jobs over 5 years in Florida will help support commercial rockets.

On April 15, President Obama pledged \$40 million to help displaced Florida space workers transition to new, high-technology jobs.

Where does the proposed \$40 million come from?

Answer. To ease the transition for workers dislocated while the new space strategy is being implemented, the President, on June 11, 2010, as part of a fiscal year 2011 budget amendment, proposed to dedicate up to \$100 million of the funds requested for the Constellation transition in fiscal year 2011 to transform the regional economy around KSC and prepare the workforce for these new opportunities, as well as other geographic areas affected to the shuttle and Constellation transitions.

Question. What about workers in other severely impacted States? What is the plan for transitioning these workers to other jobs?

Answer. As noted in an earlier response, the administration has recently announced a comprehensive initiative, funded at a level up to \$100 million, to support economic growth and job training in Florida and other regions affected by the shuttle retirement and other programmatic changes in NASA's exploration program. While the initiative began on April 15 when the President announced a \$40 million initiative to aid the areas around Kennedy Space Center, the group was also directed to prepare a plan that "explores future workforce and economic development activities that could be undertaken for affected aerospace communities in other States, as appropriate."

Several States and county officials have been applying for workforce-related grants through existing Federal programs. On June 2, 2010, Secretary of Labor Solis announced the award of an additional \$15 million in workforce re-training funds for aerospace workers in Brevard County, Florida. In addition, on April 30, 2010, the Department of Labor announced a \$1.2 million grant to assist approximately 200 workers affected by layoffs at ATK Launch systems in Corinne, Utah, in connection with the transition of the space shuttle and Constellation programs. It is our understanding that the communities impacted within the State of Texas have also applied for assistance from the Department of Labor.

In 2009, NASA established the Space Shuttle Transition Liaison Office (SSTLO) in response to direction in the NASA Authorization Act of 2008 (Public Law 110-422). The agency was directed to assist local communities affected by the termination of the space shuttle program by offering non-financial, technical assistance to the identified communities and to identify services available from other Federal, State, and local agencies to assist in such mitigation. NASA is working diligently to determine how best to leverage these efforts to support the transition resulting from the proposed cancellation of Constellation. Specifically, the Office:

- Serves as a clearinghouse by gathering and disseminating information to the affected communities about opportunities available through other Federal, State, and local agencies; and,
- Serves as a key point of contact for the community beyond NASA for information about how the agency is working with local communities to provide non-financial, technical assistance during transition.

The SSTLO consists of several organizations including NASA Headquarters, the NASA Human Space Flight Centers, shuttle prime contractors, and State and local organizations in communities affected by shuttle retirement. To identify applicable resources and build partnerships with other Federal departments and agencies, members of the SSTLO established relationships with the Employment and Training Administration, Department of Labor, and the Economic Development Administration in the Department of Commerce. Ongoing SSTLO meetings are leading to communication at the State and local level among the workforce and economic development agencies and the affected companies and communities.

COST OF CONSTELLATION

Question. To date, NASA has already spent roughly \$9.5 billion on Constellation. The fiscal year 2011 budget requests an additional \$1.9 billion just to terminate the program.

The Augustine Commission has suggested that Constellation would require billions more annually than what the Bush administration had budgeted for it. The Commission suggested that even with this investment, the U.S. gap in access to low earth orbit could last until 2019.

How much money—over and above the levels provided—would be needed to finish the Constellation Program?

Answer. The Constellation Program is envisioned in two phases—the ISS phase and the beyond-low Earth orbit or lunar phase.

The first key milestone for the ISS phase is the Initial Operational Capability (IOC) for Ares I and Orion, which is defined as the first crewed flight of Orion to the ISS. Based on the fiscal year 2010 President's budget request, NASA anticipated that Constellation would need approximately \$35.2 billion total to achieve IOC for Ares I and Orion in March 2015. As of May 2010, NASA had spent \$10.6 billion on Constellation—leaving \$24.6 billion—or around \$23 billion if the \$1.9 billion for Constellation termination in the fiscal year 2011 budget request were applied to continue Constellation. (Note, at this time, a March 2015 IOC is not achievable due to fiscal year 2010 funding constraints such as the Continuing Resolution, the enacted fiscal year 2010 appropriation, termination liability, and new Construction of Facility appropriations controls on the total Program.)

For the Augustine review in the summer of 2009, NASA estimated that the Constellation Program of Record, using Orion, Ares I, Altair, Ares V, and supporting elements, could deliver a crewed lunar mission by 2020, for \$109 billion since the inception of the Constellation Program. Of this \$109 billion since inception, \$100.2 billion would be required in fiscal year 2010 and out (the same time period as the Augustine estimates), and \$96.7 billion would be required in fiscal year 2011 and out. If the \$1.9 billion of Constellation transition funding in the President's fiscal year 2011 budget were applied to continue the Program of Record, approximately \$95 billion of additional funding would be required in fiscal year 2011 and beyond. However, achieving a crewed lunar mission by 2020 for this funding assumes that authority to proceed with lunar development occurs early in fiscal year 2011, and sufficient funding is available in the early years of lunar development.

Question. If NASA's budget were to receive no additional funds, where would you cut in the existing budget to come up with the annual amount needed to cover the cost of finishing Constellation?

Answer. If NASA were to continue development of Ares I and Orion, the year-to-year rate would be approximate to the total of \$5.4 billion per year, which would include funding for Ares and Orion development as well other Constellation elements (mission control, launch complex, ground processing facilities, program integration functions, etc.) However, it is unwise to fund Constellation on this year-by-year situation because a development program such as Constellation needs a steady and dedicated funding stream to succeed, and unfortunately, given tight budget years, that funding stream has come at the expense of other NASA programs and projects.

If NASA were to take the entire amount for Exploration in the President's fiscal year 2011 budget request and assumed runout and apply it to continuing Constellation and the fiscal year 2010 Advanced Concepts theme that supports Constellation—assuming that NASA has a flat-line budget with zero growth through 2020, there would be a shortfall of more than \$50 billion through 2020 when Constellation was expected to return to the Moon. Under this same zero-growth funding scenario through 2020, funding for the remaining agency programs—earth and space science, aeronautics, technology, space station, and center and agency operations—would need to be reduced by about one-third. Even if ISS were not extended through 2020, funding for the remaining agency programs would need to be reduced by about one-sixth through 2020.

Question. How expensive would Constellation be to operate annually compared with the space shuttle and how would those costs compare to what you expect to pay annually to utilize the purely commercial system envisioned in the 2011 budget request?

Answer. NASA estimates the complete costs of operating two Constellation flights per year to the ISS as \$3.6–\$4 billion per year in the 2016–2020 timeframe. This estimate would include funding for sustaining engineering; production/refurbishment of flight hardware; all ground operations; all mission operations; EVA suits; program integration etc.

This is comparable to appropriately-inflated shuttle costs, given that Constellation is based on shuttle hardware, infrastructure, and practices.

NASA does not know what costs commercial crew vendors will be able to achieve, but the intent is that a commercial, less-prescriptive, requirements-based approach, coupled with innovative and clean-sheet infrastructure, will result in costs substantially lower than shuttle or Constellation.

Question. Are there elements of the existing Constellation program that you would consider retaining as part of an overall path forward on human space flight?

Answer. Following the release of the fiscal year 2011 budget request, NASA established six study teams within NASA's Exploration Systems Mission Directorate to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation program and to plan for the implementation of the new Exploration program. The work undertaken by

these teams is a necessary part of that planning. One team, the Constellation Transition team, has initiated a broad survey of current workforce, contracts, facilities, property, security, knowledge capture, information technology, and other Government agency interface issues to determine what infrastructure and hardware could be used by the new programs and projects.

Despite the early nature of these planning efforts, NASA is optimistic that there will be many capabilities developed by the Constellation program that will feed forward into the new programs. For example, options using the Orion capsule are currently being pursued for autonomous rendezvous and docking; and many of the capabilities we are pursuing at a low level through the Exploration Technology Development program are directly applicable to the new programs. Other important areas that will enable further advancement in the new initiative areas are: advanced robotics, propulsion development and test, friction stir welding, autonomous landing and hazard avoidance, and entry, descent, and landing technologies.

Given that the fiscal year 2011 budget request is still pending with Congress, NASA has not yet made any final decisions with regard to what capabilities will and will not transfer to the new programs. Therefore, it would be premature for NASA to provide estimates about how much the agency has already invested in these technologies.

Question. If NASA employed testing and oversight functions like those used by the Air Force in its launch program, how much money could be saved in completing all or at least some of the critical parts of the Constellation program?

Answer. An apples-to-apples comparison between NASA and the U.S. Air Force is extremely difficult for several reasons:

- The Air Force EELV fleet is in operational mode, whereas the Constellation program is currently in the design, development, test and evaluation phase of the program.
- The Air Force launch program only manages the launch vehicle and ground systems required to support launch, whereas the Constellation program currently includes two launch vehicles, a capsule to carry astronauts to the ISS and to the Moon, as well as all the ground and mission operations infrastructure to operate the capability and future lunar surface capabilities.
- Many of the costs incurred by the Ares I and early Constellation elements actually support development of future Constellation architectural elements, such as the Ares V and the Altair lunar lander.

Question. The \$1.9 billion to terminate this program seems like a large amount. What exactly will these funds cover?

Answer. The fiscal year 2011 budget request transitions away from the Constellation program, and in doing so, provides a total of \$2.5 billion in fiscal year 2011 and fiscal year 2012 for Constellation closeout and transition costs—funding that is expected to cover closeout activity associated with facilities, environmental remediation, workforce, and prime and support contracts. A portion of this funding will also be used to support the retraining of shuttle program contractors as that program is brought to a successful close. It should be noted, however, that at present, the breakdown of costs is not complete. The agency is using the current budget planning activities to develop the details; and an implementation plan and coordinated communications with NASA responsible offices and current Constellation contractors are required to further refine this estimate, which is consistent with past planning experience and cost estimation for the Space Shuttle Transition and Retirement. NASA's experience with close-out of the shuttle program will serve as a useful reference for the complexity of the tasks and the potential associated costs.

CONTRACT TERMINATION—FOLLOW-UP

Question. Under the fiscal year 2011 budget plan, NASA will eventually need to terminate the Constellation program and the Government contracts that go with it. The fiscal year 2010 bill prevents NASA from canceling Constellation. It seems clear that current law prevents NASA from terminating or significantly restructuring contracts in the current fiscal year.

At our April 22 hearing, you stated: “We are reminding them (the contractors) that it is their responsibility to determine, I guess technically for them, it's to determine what level of risk the company is willing to accept in terms of being able to handle a termination if it should come. So, we are not telling them that they need to reserve funds. We're telling them that they do have to be aware of the fact that termination liabilities, some of them lie on them by their contract. And it's the company's determination of what level of risk they want to incur, whether they put aside funds or whether they assume that they are not going to need them.”

What does this mean in practical terms? Is the ultimate impact to reduce the amount of work planned in 2010? Are you essentially forcing the contractors to self-terminate so you won't have to?

Answer. The cited testimony is clear on this point. NASA is not forcing the contractors to do anything, but has simply reminded certain of them that the terms of their contracts limit the obligations of the Government for reimbursement of costs, including termination costs, to the amount allotted to the contract.

Question. Is this NASA's usual practice? What has NASA done regarding termination liability when it has terminated contracts in the past?

Answer. NASA has terminated very few contracts in the past, and we are not aware of a situation in which NASA waived contract terms during the termination of a contract.

Question. Are you planning to terminate all Constellation contracts?

Answer. NASA has no current intention of terminating any Constellation contracts in fiscal year 2010.

Question. What will it cost to terminate work related to Constellation in fiscal year 2011, both for Government employees and for contractors?

Answer. NASA recognizes that the transition away from the Constellation program will personally affect thousands of NASA civil servants and contractors. 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 offer new opportunities for them to partner with the agency on our new Exploration portfolio.

With regard to contract termination costs, NASA is working with our prime contractors to gather current estimates of their potential termination liability (PTL) costs should Constellation contracts be terminated. The chart below provides PTL estimates as of June 21, 2010. Please note that PTL costs can vary over time, depending on current contract activity, such as status of long-lead items, active sub-contractors and suppliers, facility/lease costs etc.

[In millions of dollars]

Current PTL required for Prime Contracts	As of June 21, 2010
ATK	\$500
Lockheed Martin	350
PWR	48
Boeing	81
Oceaneering	15
Current PTL required for non-Prime Contracts	66

With regard to program transition and termination costs, NASA is confident that the \$2.5 billion provided in the fiscal year 2011 budget for Constellation closeout and transition would be sufficient to cover closeout activity associated with facilities, environmental remediation, workforce, and prime and support contracts. However, at present, the breakdown of costs for transitioning away from Constellation is not complete, for several reasons:

—Following the release of the fiscal year 2011 budget request, NASA established six study teams within ESMD to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new Exploration program. One team, the Constellation Transition team, has initiated a broad survey of current workforce, contracts, facilities, property, security, knowledge capture, information technology, and other Government agency interface issues to determine what infrastructure and hardware could be used by the new programs and projects—information that will be key to understanding the exact costs for Constellation transition. However, the work of each team is still ongoing. It is expected that these teams will complete a majority of their work by the end of the third quarter of fiscal year 2010, and we will share those findings with Congress as they are finalized.

—Additionally, NASA is still developing mission requirements and subsequent cost estimates for the development of an emergency crew return vehicle, announced by the President on April 15, 2010. NASA hopes to be able to finalize these cost estimates in the near future and provide them to Congress.

Question. How do you propose to pay for contract termination costs?

Answer. Except for two contracts that contain a special termination costs clause, the Constellation prime contract terms limit the Government's obligation to make payments, including payments for termination costs, to the amounts allotted to the contracts. Accordingly, termination costs would be paid with funds allotted to the

contracts. For the two contracts containing special termination clauses, termination costs would be paid from funds that NASA is required to, and has, set aside for that purpose.

SATELLITE SERVICING

Question. Building upon the important role that humans have played in the success of Hubble by servicing it a record five times, this subcommittee provided funds in fiscal year 2009 and 2010 for the development of a sustained aggressive satellite servicing capability.

What is NASA doing with the \$20 million provided in 2009 and the \$50 million in 2010 to develop a full scale, world class satellite servicing program? What activities are involved? What are near term technical and schedule milestones to demonstrate critical tasks like “in flight” refueling of satellites?

Answer. The Satellite Servicing Study has two major thrusts. The first is an analytical study in which NASA is engaging with industry, academia, and other agencies to determine the extent of the potential satellite servicing market and the customers’ capability needs. A Request for Information (RFI) on the Feasibility of Using Human Spaceflight or Robotic Missions for Servicing Existing and Future Spacecraft was released on December 8, 2009, and openly solicited ideas on satellite servicing concepts and capabilities. NASA received over 70 responses to the RFI.

Subsequently, NASA conducted an International Workshop on On-Orbit Satellite Servicing at the University of Maryland University College Inn and Conference Center, March 24–26, 2010. The workshop brought together 234 registered participants from industry, academia, other U.S. Government agencies and foreign entities. Others participated via Webex, Twitter, and Ustream (audio). The live audio stream received 280 hits on the first day. The opening plenary addressed NASA’s vision for satellite servicing as well as national security space and commercial space perspectives. The remainder of the workshop was divided into 5 themed sessions with over 50 presentations. About one-half of the RFI respondents spoke at the workshop. The themes addressed Missions and Customers of Satellite Servicing, Business and Commercial Case for Satellite Servicing, Servicing with Humans, Robotic Servicing Technology, and more general Servicing Technology. Presentations clearly marked for unrestricted distribution are available on the servicing study Web site at http://servicingstudy.gsfc.nasa.gov/workshop_1_presentations.htm.

Fact finding discussions are continuing between NASA and potential servicing customers, technologists, systems developers and operators, including other Government agencies, commercial satellite operators and possible commercial servicing providers. NASA is also developing several notional satellite servicing mission concepts which will help identify implementation approaches, costs, and technology gaps. A report documenting findings from these analytic activities will be issued this fall. This report will provide a foundation upon which to determine future spacecraft servicing architectures, desired capabilities and future implementation plans, including cost and schedule.

The second thrust involves implementing two technology demonstrations on the International Space Station (ISS) using the station’s Special Purpose Dexterous Manipulator (SPDM) “Dextre” robot. The Robotic Refueling Dexterous Demonstration (R2D2) will show that a robotic mission can potentially refuel and repair satellites which were not designed for on-orbit servicing. It will include an end-to-end refueling demonstration as well as a busy-board for demonstrating the ability of the robot to access and interface with satellite test ports. An R2D2 Systems Requirements Review (SRR)/Preliminary Design Review (PDR) was held in March 2010. A Critical Design Review was conducted in June 2010. Hardware completion is planned for October 2010. The other demonstration is a Dextre Pointing Package (DPP) to enhance orientation and control of Dextre. DPP, positioned to view vehicles as they approach or depart ISS, will be used to evaluate various sensors and algorithms for future autonomous acquisition, rendezvous, and capture of customer spacecraft. The DPP SRR/PDR was conducted in June 2010. Hardware integration is scheduled for completion in December 2010. Additionally, robotic technology development capability at West Virginia University is being established to refine and mimic orbital robotic contact dynamics in the ground environment. This will assist in developing algorithms for on-orbit use. A 1G demonstration is planned for August 2010. These demonstrations will reduce risk and enable future satellite servicing missions.

Question. Is NASA having any success in enlisting the interest of other Federal agencies in developing this capability?

Answer. NASA is discussing satellite servicing needs and potential collaboration opportunities with other Federal agencies, mostly in the National Security community. Additionally, relevant systems, technologies and needs of the Department of

Defense and other Government agencies were addressed in presentations at the International Workshop on On-orbit Satellite Servicing held at the University of Maryland University College Inn and Conference Center, March 24–26, 2010.

Question. What are the five top tasks that you envision this satellite servicing capability having, how much funding would each task require, and what is the relative schedule for executing and completing each task or capability development?

Answer. Please see earlier response. Fact finding discussions are ongoing between NASA and potential servicing customers, technologists, systems developers and operators, including other Government agencies, commercial satellite operators and possible commercial servicing providers. NASA is also developing several notional satellite servicing mission concepts which will help identify implementation approaches, costs, and technology gaps. A report documenting findings from these analytic activities will be issued this fall. This report will provide a foundation upon which to determine future spacecraft servicing architectures, desired capabilities and future implementation plans, including cost and schedule.

SATELLITE ACQUISITION

Question. NASA serves as the procurement agent for its own large satellites and for complex satellite systems on behalf of other Government agencies. To ensure the best value for the Government, procurement law is very specific about the circumstances when NASA and other Federal agencies may pursue contracts in a manner other than by full and open competition.

What are NASA's guidelines for issuing sole source contract awards for spacecraft above \$50 million and which NASA official(s) are responsible for approving these awards?

Answer. In addition to applicable Federal Acquisition Regulations, the guidelines for issuing sole source contract awards are set forth in the NASA Federal Acquisition Regulation Supplement (NFS), 1806.304–70 (<http://www.hq.nasa.gov/office/procurement/regs/nfstoc.htm>) Approval of NASA justifications. These guidelines apply to all sole source contract awards regardless of the commodity or service as follows:

For proposed contracts over \$11,500,000 but not exceeding \$78,500,000:

—*Concurring Officials.*—Center Procurement Officer and Center or Headquarters Competition Advocate

—*Approving Official.*—Head of the contracting activity.

For proposed contracts over \$78,500,000:

—*Concurring Officials.*—Center Procurement Officer, Center or Headquarters Competition Advocate, Head of the contracting activity and, Agency Competition Advocate

—*Approving Official.*—Assistant Administrator for Procurement

The approval authority of FAR 6.304(a)(3) may not be delegated to other than the installation's Deputy Director. For proposed contract actions requiring approval by the Assistant Administrator for Procurement, the original justification shall be forwarded to the Assistant Administrator for Procurement, Office of Procurement, Program Operations Division. Regardless of dollar value, class justifications shall be approved by the Assistant Administrator for Procurement.

Question. Does NASA plan to acquire or procure any commercial spacecraft from industry under other than full and open competition, leading to a sole source contract, for any science missions with a spacecraft value of greater than \$50 million?

Answer. NASA's Science Mission Directorate is committed to full and open competition leading to the selection of its spacecraft and hardware. Missions and instruments are selected based on their scientific merit through peer review. However, in the wake of the loss of the competitively selected Orbiting Carbon Observatory (OCO) in February 2009 and in response to national needs for a carbon monitoring capability, NASA has awarded JPL authority for a near-identical OCO replacement, OCO-2. This unique procurement strategy minimizes the cost, schedule, and performance risk of the replacement mission.

With the restructuring of the NPOESS program, NASA is now assuming responsibility for the procurement of the Nation's next generation weather and environmental monitoring satellites. Options to procure spacecraft to minimize any gaps in NOAA's weather and climate monitoring requirements will consider sole source procurements where appropriate.

Question. If so, what is the justification for these sole source spacecraft?

Answer. For the OCO-2 procurement, JPL concluded that any deviation from the original OCO mission would require substantial re-engineering/re-testing, re-writing of existing documentation, and would infuse significant risk to the project. To minimize additional testing and mitigate risk, JPL's intent is to procure identical items wherever possible. For example, the Orbital spacecraft bus procurement will provide

for an exact duplicate of the OCO spacecraft while the Northrop cryocooler procurement will provide for the closest-to-identical replacement cryocooler currently available.

Continuity of measurements supporting accurate weather and climate predictions is a clear national priority. No sole-source decisions have been made to date for any future NPOESS/JPSS spacecraft. Any sole-source procurements of spacecraft for the future Joint Polar Satellite System will be considered only if required to ensure continuity at reasonable risk.

EARTH SCIENCE

Question. NOAA and NASA are leaders in the U.S. Climate Change Research Program. With an increase in severe storms and severe drought, accurate seasonal and yearly forecasts are becoming more of a necessity. The amount of Earth observation data coming from NASA's satellites, reinforce the concerns that our data must be handled properly and efficiently, and not ending up in a "data mortuary".

Are there clear lines for collaboration between the NOAA and NASA, especially when it comes to moving research to operations?

Answer. Yes. NASA and NOAA established a Joint Working Group (JWG) in response to section 306(a) of the NASA Authorization Act of 2005. The JWG meets at the level of the NASA Earth Science Division Director and the NOAA Assistant Administrator for Satellite and Information Services. The JWG meets approximately quarterly, with the next meeting planned for July 9, 2010. In this forum, NASA and NOAA coordinate plans for Earth observation and research, and especially the subject of transitions of NASA research satellite capabilities to NOAA for NOAA operation in support of NOAA's mission. NOAA's fiscal year 2011 budget request to begin development of the Jason-3 ocean altimetry mission is the first major outcome of this joint planning. Jason-1 (following TOPEX Poseidon) was a joint NASA/CNES (France) mission; Jason-2 was developed and launched by NASA/CNES, but is being operated by NOAA and EUMETSAT (NOAA's European counterpart). Jason-3 will be developed as NOAA/EUMETSAT partnership (with NASA/JPL's assistance under a reimbursable agreement).

In the area of research, NASA and NOAA are collaborators with the DOD and NSF in the Joint Center for Satellite Data Assimilation, which works to accelerate the use of research satellite data to improve routine weather and climate prediction using global numerical models. NASA and NOAA established the Short-term Prediction Research and Transition (SPoRT) Center in 2002 to demonstrate the application of NASA satellite measurements to improve short-term weather forecasts on regional and local scales. NASA continues to operate 13 satellites that provide many of the space-based observations needed by the U.S. Global Change Research Program to accomplish its research goals. Data from several of these satellites are also used by NOAA for climate monitoring.

The GOES program, begun in 1974, is another example of NOAA-NASA cooperation. NOAA funds and manages the program and determines the need for satellite replacement. NASA acts as NOAA's acquisition agent to design, develop, and launch GOES satellites. After a satellite is launched and checked out by NASA, the spacecraft is turned over to NOAA for its operation. The latest GOES satellite, GOES-15, was launched on March 4, 2010, and is presently in the final stages of on-orbit checkout.

In addition to cooperation on satellite systems, NASA and NOAA also have a history of collaborating on research campaigns. For these campaigns, NASA and NOAA contribute aircraft, ships, and/or sensors to make complementary measurements of environmental conditions of interest to both agencies. For example, in 2008, NASA collaborated with NOAA on the Southern Ocean Gas Exchange Experiment (GasEx) to study how gases move between the atmosphere and oceans under high winds and seas. NASA funded science investigations that took place on-board NOAA's Research Vessel Ronald H. Brown. In April 2010, NASA concluded the Global Hawk Pacific mission (GloPac), the initial science mission with the Global Hawk Unmanned Airborne System (UAS). GloPac's purpose is to obtain unique observations of the lower stratosphere and upper troposphere in association with NASA's Aura satellite and both NASA- and NOAA-instrument teams participated in the campaign. In the future, NASA is planning the Genesis and Rapid Intensification Processes (GRIP) airborne campaign for summer 2010 to better understand how tropical storms form and develop into major hurricanes. NASA plans to use the DC-8 aircraft and the Global Hawk UAS. NOAA will participate and deploy one or two low-altitude P-3 aircraft and possibly a Gulfstream IV aircraft for the upper troposphere measurements.

Question. What percentage of NASA's earth science data is utilized by scientists? How does that utilization compare with NOAA's satellite data?

Answer. In fiscal year 2009, the NASA Distributed Active Archive Centers (DAACs) distributed over 250 million data products to users around the world. In fiscal year 2009, NASA recorded over 910,000 distinct users of EOSDIS data and services. Ninety percent of the distributed products and 88 percent of the distributed volume (Gigabytes delivered) went to science users. Data is also typically accessed for educational or applications purposes.

Last year, the DAACs identified 466 papers that used data from NASA DAACs in various peer-reviewed science journals, such as *Advances in Space Research* and *Journal of Geophysical Research*. As it is not mandatory that researchers who use NASA data cite the source of that data, this number represents a low estimate of the numbers of papers that used NASA data.

NASA does not monitor the use of NOAA data. However, NASA scientists do make broad use of the NOAA data.

Question. Now that NASA will be heavily involved in the successor program to NPOESS, how will you ensure that it undertakes this task effectively without diverting budget or manpower resources from the key missions to which NASA is committed and which are presented in the 2011 budget?

Answer. The Joint Polar Satellite System program will actually be easier to manage from a budget and manpower planning standpoint for NASA than NPOESS was. In NPOESS, NASA did not have a direct development management role; NASA needed to identify manpower resources to help with NPOESS instrument development problems on a non-predictable basis. JPSS, on the other hand, will be run much the way the POES program was for three decades. NOAA will budget for the program and reimburse NASA for its satellite development work; since all JPSS work is reimbursable, there is no impact to NASA's budget. This more stable program, with stable roles, enables effective long term planning. POES and GOES proceeded in parallel with NASA's development of the Earth Observing System in the 1990s and early 2000s, and the workforce synergies were beneficial to both programs. We foresee the same for JPSS and NASA's development of its research missions.

While JPSS will require an unusually rapid ramp-up, Goddard currently manages 18 flight projects and has a large and experienced workforce. The immediate challenge will be the need to quickly assign a cadre of very experienced senior level managers, and GSFC has already identified a strong leadership team to initiate the transition from NPOESS to JPSS. Many of these individuals are coming off programs that have launched in the past months or are about to launch, including Hubble Space Telescope Servicing Mission 4 and the Solar Dynamics Observatory. The plan is to ramp up to 150 Civil Servant and Contractor employees during the first year, with an ultimate program/project size of 300–350 people. In the short term, Goddard will manage the reassignment of people with the intent of minimizing impact to its other flight projects.

Question. What efforts will NASA take to make its earth science more relevant to pressing regulatory challenges like carbon monitoring and other greenhouse gas issues?

Answer. The President's fiscal year 2011 budget request includes funds for an Orbiting Carbon Observatory-2 mission to be developed for launch in February 2013. The policy and science communities look forward to the availability of these data, from which CO₂ sources and sinks can be inferred. Further, the OCO-2 funds are planned to enable generous instrument spare parts development. This will both reduce risk in OCO-2 schedule and, upon achievement of a successful OCO-2 launch, enable assembly of a second instrument copy to be flown as a mission of opportunity or as part of the Decadal Survey ASCENDS mission. The result will be extended data continuity, which is essential for carbon monitoring.

The fiscal year 2011 budget request also funds the continuation of NASA's pilot Carbon Monitoring System activities begun in fiscal year 2010. The goal of these activities is to generate and test an improving set of products on carbon storage and exchange between the surface and the atmosphere. These information products will be provided on a regular basis to policy and decisionmakers as well as to scientists and program managers designing the future evolution of a carbon monitoring capability.

For other greenhouse gases and aerosols, the fiscal year 2011 budget request funds the refurbishment of an existing Stratospheric Aerosols and Gas Experiment-III (SAGE III) to be hosted on the International Space Station, which operates at an ideal orbital inclination for this instrument. NASA continues development of the Ozone Mapper and Profiler Suite-Limb instrument for flight on NPP in a collaborative activity with NOAA on climate data continuity.

As part of the Earth Science Research Program, NASA is investing over \$160 million in research related to understanding the quantity of carbon on the Earth's surface, in the atmosphere, and the oceans, as well as how carbon is cycled between these reservoirs. The Carbon Cycle and Ecosystem Program uses six NASA satellites already in operation to monitor global carbon levels. The Land Cover and Land Use Change program, which is part of the Carbon Cycle and Ecosystems Program, monitors and models the interactions of land cover and land use change with the carbon cycle. New research opportunities through the Carbon Cycle and Ecosystems Program seek to better understand and model human-ecosystem-climate interactions.

Question. We have an annual report of Hubble's science accomplishments. Why have we never received anything comparable for NASA's earth science program even though we spend more than \$1.5 billion per annum on it? What are the five most important discoveries in NASA's earth science program for each of the past 5 years? (2004–2009)

Answer. While NASA's Earth Science program does not have an equivalent to Hubble's Space Telescope Institute which prepares that annual report, we do report annually on Earth science accomplishments through the Aeronautics and Space Report of the President and through contributions to the annual Our Changing Planet report of the U.S. Global Change Research Program. NASA would be pleased to provide more information on our accomplishments in Earth Science in any form the subcommittee would find useful.

2009

NASA Satellite Reveals Dramatic Arctic Sea Ice Thinning

Using the ICESat spacecraft, researchers showed that Arctic sea ice thinned dramatically, with thin seasonal ice replacing thick "multi-year" ice as the dominant type for the first time on record. These measurements represent the first time that changes in ice thickness and volume were measured over the entire Arctic Ocean. Such information is used to calculate annual ice production and has shown periods of near-zero replenishment of the multi-year ice cover and significant transport of ice out of the Arctic. http://www.nasa.gov/home/hqnews/2009/jul/HQ_09-155_Thin_Sea_Ice.html

Methane, Carbon Monoxide Heat Up the Home Planet

A team of NASA researchers at the Goddard Institute for Space Studies found that two greenhouse gases have a significantly more powerful impact on global warming than previously thought. In a paper published in October, the team conducted one of the first modeling experiments designed to rigorously quantify the impact of greenhouse gas-aerosol interactions on climate and air quality. The study found that methane's global warming impact has been underestimated, and the combined impact of emissions that cause both warming and air pollution have as much effect on warming as carbon dioxide. This improved knowledge of the warming effect of these greenhouse gases will help policymakers devise more efficient strategies to mitigate climate change. <http://eosps.gsf.nasa.gov/newsroom/viewStory.php?id=1585>

NASA Satellites Unlock Secret to Northern India's Vanishing Water

Using NASA satellite data, scientists found that groundwater levels in northern India have been declining by as much as 1 foot per year over the past decade. A team of hydrologists led by Matt Rodell of NASA's Goddard Space Flight Center found that northern India's underground water supply is being pumped and consumed by human activities, such as irrigating cropland, and is draining aquifers faster than natural processes can replenish them. The finding is based on data from NASA's Gravity Recovery and Climate Experiment (GRACE), a pair of satellites that sense changes in Earth's gravity field. These changes directly relate to changes mass distribution, including water masses stored above or below Earth's surface. The results were published in October. http://www.nasa.gov/topics/earth/features/india_water.html

Using NASA Data to Improve Public Health Tracking

High concentrations of 2.5 micron particulate matter (PM_{2.5}) are associated with heart and lung disease. Accurately monitoring concentrations of PM_{2.5} are difficult using ground observations alone. Similarly, 10 micron PM (from naturally occurring dust) are associated with asthma and other respiratory distress in the desert Southwest. NASA and the CDC have been partners in linking PM_{2.5} and PM₁₀ and health observations to enhance public health surveillance through the CDC Environmental Public Health Tracking Network (EPHTN). The EPHTN, a surveillance tool

that scientists, health professionals, and—for the first time—members of the public can use to track environmental exposures and chronic health conditions, went operational in July 2009. NASA was an integral partner in enhancing the capabilities of this system as it was developed, using surfacing algorithms, modeling capabilities, and observations from and CALIPSO. <http://www.naphsis.org/index.asp?bid=983>

NASA Researchers Evaluate Impacts of the Montreal Protocol

A team of NASA-led scientists have simulated “what might have been” if chlorofluorocarbons (CFCs) and similar chemicals were not banned through the Montreal Protocol. CFCs are known to deplete ozone in the atmosphere, which results in an increase in ultraviolet radiation reaching the surface of the Earth. The simulation used a comprehensive model that included atmospheric chemical effects, wind changes, and radiation changes. The simulation has shown that, without regulation, by 2065, 67 percent of the overhead ozone would be destroyed in comparison to 1980. Large ozone depletions in the polar region would become year-round rather than just seasonal, as is currently observed in the Antarctic ozone hole. Ozone levels in the tropical lower stratosphere remain constant until about 2053 and then collapse to near zero by 2058 as a result of “polar ozone hole” chemical processes developing in the tropics. In response to ozone changes, ultraviolet (UV) radiation increases, tripling the “sun-burning” radiation in the northern summer mid-latitudes by 2065. <http://www.atmos-chem-phys.net/9/2113/2009/acp-9-2113-2009.html>

2008

Arctic Sea Ice Decline Continues

In September, Arctic sea ice coverage reached the second-lowest level recorded since the dawn of the satellite era, according to observations from the NASA-supported National Snow and Ice Data Center at the University of Colorado. While slightly above the record-low set in September 2007, this season further reinforces the strong negative trend in summer sea ice coverage observed during the past 30 years. In March, when the Arctic reached its annual maximum sea ice coverage during the winter, scientists from NASA and the data center reported that thick, older sea ice was continuing to decline. NASA developed the capability to observe the extent and concentration of sea ice from space using passive microwave sensors. http://www.nasa.gov/home/hqnews/2008/sep/HQ_08234_Artic_Sea_Ice.html

Linking Rainfall Amounts to Pollution

Rainfall data from TRMM has shown the impact that human activities have on the environment. Researchers found that midweek storms in the southeastern United States tend to be stronger, larger, and wetter than weekend storms. They found a positive correlation between this precipitation data and airborne particle pollution data from the EPA, concluding that human activities such as driving help seed the atmosphere and encourage rain. http://www.nasa.gov/home/hqnews/2008/feb/HQ_08031_pollution_rain.html

Mapping Global Carbon Dioxide

Using data from the Aqua satellite, a NASA-led research team produced the first global satellite maps of carbon dioxide in the Earth’s mid-troposphere. From the data, the team found that carbon dioxide concentrations are highly dependent on atmospheric circulation patterns and major surface sources of carbon dioxide. Concentrations vary by hemisphere due to the relative abundance of land in the Northern Hemisphere. <http://www.nasa.gov/topics/earth/features/airs-20081009.html>

Understanding Microseisms

A team led by NASA-scientists were able to pinpoint a source of microseisms, small Earth tremors created when ocean waves traveling in opposite directions merge together, solving a 50-year-old mystery. The researchers found that some microseisms originate in the North Atlantic Ocean, where ocean waves combine to form stationary waves that beat down on the ocean floor, causing it to vibrate. These vibrations generate seismic waves that propagate for thousands of miles. <http://www.jpl.nasa.gov/news/features.cfm?feature=1626>

Identifying the Influence of El Niño Storms on Wintertime Storms

A team of NASA-led scientists have found that El Niño-Southern Oscillation (ENSO) events can lead to more intense winter storms in certain regions in the United States, specifically, the west coast, Gulf States, and the Southeast. By comparing historical rainfall and snow records and computer models, the scientists

found that ENSO events can double the probability of certain extreme winter storms. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=826>

2007

NASA Satellites Unearth Antarctic "Plumbing System"

Scientists using NASA satellites discovered an extensive network of waterways beneath a fast-moving Antarctic ice stream that provide clues as to how "leaks" in the system affect sea level and the world's largest ice sheet. Data from the Moderate Resolution Imaging Spectroradiometer instrument aboard NASA's Aqua satellite, and data from the Geoscience Laser Altimeter System on NASA's Ice Cloud and Land Elevation Satellite, provided a multi-dimensional view of changes in the elevation of the icy surface above a large subglacial lake and surrounding areas during a 3-year period. Those changes suggest the lake drained to the nearby ocean. http://www.nasa.gov/vision/earth/lookingatearth/antarctic_plumbing.html

Using NASA Satellites to Predict Tropical Cyclone Intensity

NASA and university scientists announced in November 2007 the development of a promising new technique for estimating the intensity of tropical cyclones from space. This new method of estimating intensity requires cloud profiling information from over or near a storm's eye, including simultaneous, accurate measurements of cloud-top temperatures from the Aqua satellite, and cloud-top height and cloud profiling information from the CloudSat satellite. Both satellites fly in formation as part of NASA's "A-Train" of Earth-observing satellites. Initial results show the technique's estimates agreed with available weather data and this method could one day supplement existing techniques, assist in designing future tropical cyclone satellite observing systems, and improve disaster preparedness and recovery efforts. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=809>

Using NASA Satellites to Study Algal Blooms

NASA satellite data helped scientists solve a decades-old puzzle about how vast blooms of microscopic plants can form in the middle of otherwise barren mid-ocean regions. The research team published findings in May 2007 that used the data to show that episodic, swirling current systems known as eddies act to pump nutrients up from the deep ocean to fuel such blooms. Data sets came from NASA's TOPEX/Poseidon, Jason, Aqua and QuikSCAT satellites. The fate of all of that biomass also is important, as plankton blooms can remove substantial amounts of carbon dioxide from surface waters and sink it to the deep ocean. The plants in the bloom either die and sink when the bloom runs its course or are consumed by animals, which then make fecal pellets that drop to the sea floor. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=771>

NASA Satellites Measure Antarctic Snow Melt

A 2007 study led by team of NASA and university scientists found clear evidence that extensive areas of snow melted in west Antarctica in January 2005 in response to warm temperatures. This was the first widespread Antarctic melting ever detected with NASA's QuikScat satellite and the most significant melt observed using satellites during the past three decades. The affected regions encompass a combined area as big as California. Changes in the ice mass of Antarctica, Earth's largest freshwater reservoir, are important to understanding global sea level rise. Large amounts of Antarctic freshwater flowing into the ocean also could affect ocean salinity, currents and global climate. The 2005 melt was intense enough to create an extensive ice layer when water refroze after the melt. However, the melt was not prolonged enough for the melt water to flow into the sea.

Amazon Rainforest Resilient to Drought

Using data from Terra and TRMM, researchers have found that the Amazon Rainforest is more drought-tolerant than originally predicted. Forest productivity increases and the forest canopy becomes greener during the dry season when more light is available due to cloudless conditions. Unlike plants in the pasture regions, plants in the forest are able to tap into deep soil water during the short dry season, allowing them to continue growing. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=801>

2006

NASA Satellites and Science Ozone Studies

NASA-funded researchers have provided new insights into the processes driving ozone chemistry and the impacts of ozone on pollution and climate change. By tracking chemicals present in the Earth's atmosphere using Aura, the researchers found

that the burning of biomass in the tropics increase pollution by producing carbon monoxide and nitrogen oxides, two pollutants that lead to the formation of ozone. In a second study, researchers found that the amount of ozone in the tropics is dependent on the Madden-Julian Oscillation is a cyclical pattern of slow, eastward-moving waves of clouds, rainfall and large-scale atmospheric circulation anomalies that can strongly influence long-term weather patterns around the world. Low-pressure systems increase the amount of subtropical total ozone. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=730>

NASA Satellites Show Decline of Arctic Perennial Sea Ice

In fiscal year 2006, analysis of NASA data showed that Arctic perennial sea ice, which normally survives the summer melt season and remains year-round, shrank abruptly by 14 percent between 2004 and 2005. According to researchers, the loss of perennial ice in the East Arctic Ocean neared 50 percent during that time as some of the ice moved from the East Arctic to the West. Researchers have long suggested that the icy surface of the Arctic's waters is retreating due to a warming climate. Sea ice functions as an indicator of changing water, air, and sea surface temperatures, and is important to the continued well-being of Arctic mammals such as polar bears. A research team that used NASA's QuikScat satellite to measure the extent and distribution of perennial and seasonal sea ice in the Arctic discovered that, while the total area of all the Arctic sea ice was stable in winter, the distribution of seasonal and perennial sea ice experienced significant changes. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=696>

NASA Satellites Show Changes in Greenland and Antarctic Ice Sheets

In the most comprehensive survey ever undertaken of the massive ice sheets covering both Greenland and Antarctica, NASA scientists confirmed that climate warming is changing how much water remains locked in Earth's largest storehouses of ice and snow. The survey showed a net loss of ice from the combined polar ice sheets between 1992 and 2002 and a corresponding rise in sea level. The survey provided the first documentation of the extensive thinning of the West Antarctic ice shelves, an increase in snowfall in the interior of Greenland, and thinning at the edges. All these phenomena are indicators of a warming climate previously predicted by computer models.

NASA Scientists Uncover Lost Mayan Ruins

Using remote sensing capabilities from satellites and NASA airborne instruments, researchers were able to locate Mayan architectural sites otherwise not visible in the dense jungle of Guatemala. Remote sensing instruments were able to detect changes in the local fauna indicative of the presence of Mayan buildings. Certain plant species were suppressed around building sites, while other plants were discolored due to changes in soil chemistry from the erosion of the buildings. <http://eosps0.gsfc.nasa.gov/newsroom/viewStory.php?id=651>

Using Satellites to Predict Wildfires

By observing plant conditions from space, researchers are able to predict when and where wildfires may occur. Plant moisture and the proportion of live to dead plant material, as measured by MODIS and AVIRS, provide strong indicators of the conditions favorable for wildfires. Such data can be assist operational agencies in their forecasting of fire potential across the United States. http://www.nasa.gov/centers/goddard/news/topstory/2006/wildfire_threat.html

2005

NASA Satellites Assist in Hurricane Katrina Recovery Efforts

NASA's Earth-observing "eyes in the sky," including Earth orbiting satellites, aircraft, and the International Space Station, provided detailed images of the flooding and devastation in areas affected by Hurricanes Katrina and Rita. NASA, along with academic institutions and partner agencies, worked to ensure that the Department of Homeland Security and the Federal Emergency Management Agency had the best available information to aid the rescue and recovery effort. The images and associated data helped characterize the extent of the flooding, the damage to homes, businesses, and infrastructure, and the potential hazards caused by the storms and their aftermath. http://www.nasa.gov/mission_pages/hurricanes/main/index.html

NASA Satellites Assess the Impacts of the Indonesian Earthquake and Tsunami

The December 2004 Indonesian earthquake caused a massive tsunami to wash over 10 countries in South Asia and East Africa. NASA satellites were able to capture the effects of the earthquake and tsunami in this region. Using Earth observa-

tions from before and after the Indonesian earthquake, NASA scientists calculated that it slightly changed the planet's shape; the Earth's oblateness (flattening on the top and bulging at the equator) decreased by a small amount and the North Pole shifted by about 2.5 centimeters. The earthquake also increased the Earth's rotation and decreased the length of day by 2.68 microseconds. Physically, this is like a spinning skater drawing their arms closer to the body resulting in a faster spin. <http://www.jpl.nasa.gov/news/news.cfm?release=2005-009>

Developing a Decision-support Capability in Central America

Through NASA's Applied Sciences Program, scientists developed SERVIR, a regional visualization and monitoring system that integrates many different satellite data sets, forecast models, and ground-based observations in order to provide better information to policymakers and stakeholders on a range of issues including disaster management, agricultural development, biodiversity conservation and climate change. SERVIR serves communities in Central America by providing easily accessible customized visualization tools and services utilizing NASA data. Building on the success of SERVIR in Central America, NASA expanded SERVIR in 2008 to serve communities in East Africa. SERVIR-Africa is primarily focused on applications related to disasters, health, and biodiversity. <http://www.servir.net/>

Measuring the Earth's Radiation Budget

Using a combination of global climate models, ground-based measurements, and satellite observations, NASA researchers found that the Earth absorbs about 0.85 Watts of energy per square meter more than is radiated back to space. While some of this imbalance has led to increased global temperatures and snow and ice melt, a large portion of the energy is absorbed by the Earth's oceans making the overall effect to the Earth's temperature less than what would otherwise be expected. <http://www.giss.nasa.gov/research/news/20050428/>

Monitoring Sea Level

Using a number of NASA satellites, including TOPEX/Poseidon, Jason, ICESat, and GRACE scientists were, for the first time, able to understand the rate at which the Earth's sea level is changed by establishing a reference sea level independent of land. Such information can be used not only to measure changes in sea level, but also can be used to identify the causes of those changes and their significance. For example, this information can be used to monitor the rate at which ice is growing or shrinking. http://www.nasa.gov/home/hqnews/2005/jul/HQ_05175_sea_level_monitored.html

2004

Black Soot and Snow—a Warmer Combination

A NASA study found that emissions of soot, or black carbon, alter the way sunlight reflects off snow. A computer simulation indicated that soot may be responsible for as much as 25 percent of observed global warming over the past century. Soot on snow absorbs more of the Sun's energy and heat than icy, white backgrounds, which reflect the Sun's rays. With global warming, many snow- and ice-covered areas are already melting. As can be seen when glaciers and ice sheets melt, they tend to get dirtier as the soot becomes even more concentrated. Soot thereby adds to the warming effect as ice melts, making icy surfaces darker and absorbing more solar energy. Soot is generated from traffic, industrial pollution, outdoor fires, and household burning of coal and other fuels, and is the product of incomplete combustion. <http://www.giss.nasa.gov/research/news/20031222/>

Satellites Used To Discover Chameleon Species New to Science

NASA-supported biologists developed a modeling approach that uses satellite data and specimen locality data from museum collections to successfully predict the geographic distribution of 11 known chameleon species in Madagascar. The model also helped lead to the discovery of seven additional chameleon species new to science. The discovery shows that NASA satellite data and data from museum collections can help identify places to survey for new species of life, while locating areas likely to be of conservation importance. The study appeared in the December 2003 issue of the *Nature* journal and demonstrated that existing museum collections and satellite measurements of Earth's surface and climate hold great promise for the accurate prediction of species distributions. <http://www.nasa.gov/vision/earth/livingthings/lizards.html>

Measuring the Lense-Thirring Effect

The combined use of high-accuracy space geodetic tracking of the LAGEOS 1 and 2 satellites and GRACE gravity field data has validated the Lense-Thirring effect as predicted by Einstein's theory of General Relativity. As we have come to learn from Einstein, the gravity of massive objects warp the time and space continuum. This same theory also predicts that rotating massive objects drag this continuum with them; the Lense-Thirring effect calls this frame dragging. By carefully monitoring shifts in the position of the two LAGEOS spacecraft, researchers were able to identify anomalous motions consistent with those predicted by the Lense-Thirring effect. http://www.nasa.gov/vision/earth/lookingatearth/earth_drag.html

Hurricanes Help Plants Bloom in "Ocean Deserts"

By measuring ocean color from the SeaWiFS instrument on the SeaStar satellite, scientists have found that ocean productivity increases in the wake of a hurricane over a 2-3 week period. The high winds associated with a hurricane help bring nutrients and phytoplankton to the ocean's surface, helping the plants to bloom. In addition, the scientists found that the larger the hurricane, the larger the resulting bloom. <http://www.gsfc.nasa.gov/topstory/2004/0602hurricanebloom.html>

Question. Isn't it true that we are relying on more and more satellite based assets for Earth science data? What is NASA doing to consider working with the commercial satellite sector for advancing Earth science missions?

Answer. Space-based assets are essential for providing global, frequent, consistent and optimal resolution sampling to create the data sets that form the foundation for much Earth science research. NASA works with the commercial satellite sector to acquire spacecraft and launch services, and to some extent instruments, for these satellite assets. An example is our work with Orbital Sciences Corporation, a leading commercial satellite firm in all three areas, in the Glory mission.

With respect to commercial satellite firms that develop and deploy their own satellite systems for communications or remote sensing, NASA's relationship is one of synergy. The commercial market for remote sensing, for example, is in imagery with a resolution of less than 2 meters. NASA does not compete with the commercial sector in this area; we develop and operate remote sensing satellites with coarser resolution (but more frequent revisit times and tighter calibration). NASA and the commercial sector benefit from each other's efforts; NASA satellite data provides the contextual imagery that users of high-resolution commercial satellites employ to aid in interpretation of higher resolution imagery.

In limited instances, NASA is also able to purchase Earth science data from commercial satellite sources. The longest-running instance is NASA's involvement with the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) instrument that flies aboard GeoEye's SeaStar spacecraft, which launched on August 1, 1997. NASA uses SeaWiFS to acquire data that are critical for the study of the role of the oceans in the Earth's biogeochemical process, especially the effect of the temporal and spatial variability in phytoplankton and their impact on the global carbon cycle. Under this arrangement, NASA provided approximately \$30 million up front to the development of the instrument, and maintained a close involvement with SeaWiFS since its inception, especially in the areas of algorithm development, calibration/validation, and archival and distribution of data for scientific research. Since 2005, NASA has had a contractual relationship with GeoEye for a large volume of space-based multispectral imagery of the Earth from the SeaWiFS instrument.

The future holds the prospect of more collaborative NASA/commercial satellite partnerships. The fiscal year 2011 budget request funds a new feature of the Venture class program—annual competitive solicitations for development of Earth observing instruments to fly on missions of opportunity. Coupled with the development of standard instrument-to-spacecraft interfaces funded in the fiscal year 2011 budget, this will enable NASA to take advantage of rapidly-emerging opportunities for international and commercial partnership offers.

CYBER SECURITY

Question. During fiscal years 2007 and 2008, NASA reported 1,120 security incidents that resulted in unauthorized access to sensitive information. NASA has taken action to better defend against cyber attacks, but GAO recently concluded that NASA remains vulnerable. Basic IT security practices, such as using proper password protection, encrypting sensitive information and restricting access to privileged systems are not being implemented.

Why has NASA neglected to fully implement its own information security program?

Answer. In recent years, NASA has struggled with the paradox of using its budget to satisfy dated FISMA requirements and implementing a meaningful risk-based approach to securing NASA's information systems. An inordinate investment in compliance rather than a true understanding of risk fails to improve security and has placed NASA at greater risk of data loss, disruption to enterprise services, and disruption to mission operations.

In the face of these challenges, and with limited resources, NASA has begun to implement the following capabilities to improve situational awareness and to operationalize compliance-based activities:

- The Security Operation Center (SOC) centrally collects and analyzes network monitoring and incident data to identify attack trends. As a result of the SOC's initial operating capability, NASA has discovered the great extent of network traffic that must be monitored and the resources required to remediate incidents across the agency.
- The Cyber Threat Analysis Program (CTAP) identifies common and advanced threats, vulnerabilities, and attack vectors in order to develop risk profiles and mitigation solutions for the agency. NASA is now increasingly aware of the alarmingly advanced, persistent nature of the attacks against its information systems, and of the resources required to detect and respond to these attacks.
- NASA's IT Security Enterprise Data Warehouse (ITSEC-EDW) will provide a near-real-time inventory of all network assets, including such security information as existing vulnerabilities, patch status, anti-virus status, and conformance to standard configurations (e.g., FDCC, USGCB). As more data sources are integrated into ITSEC-EDW NASA will gain a more complete view of its risk posture, and will become capable of supporting automated continuous monitoring of the agency's most critical security controls.
- NASA's migration to the use of HSPD-12 compliant smart cards further enhances the secure access to desktop and application resources across the agency.
- The IDMax portal ensures that secure account authorization to NASA applications is established, controlled, and terminated as part of the employee and contractor management processes. NASA must now work to integrate additional applications into this portal.

Additionally, NASA is working closely with the White House, the Federal CIO, Department of Homeland Security, Department of State, OMB, and public sector organizations such as the SANS Institute to further realize the benefits of a truly risk-based information security program. NASA's emphasis must clearly be to securely enable its mission by balancing risk with mission and business needs.

NASA is working diligently to improve its information security programs and has made great strides toward a more complete approach.

Question. How does NASA's fiscal year 2011 budget improve IT security when the request for "IT Management" drops from \$28.6 million to \$16.1 million?

Answer. In previous years, IT Security was captured under IT Management Project Reporting Activities (PRA) but during the budget formulation cycle for FY 2011, the OCIO reprogrammed its budget to better align functionalities and capabilities or the agency-wide IT service (AITS) projects to the PRA. Therefore, the IT Security programs originally budgeted under IT Management are being executed under Infrastructure to more accurately align NASA with Industry standards.

The fiscal year 2011 IT Infrastructure budget, which includes IT Security, increases significantly due to the above mentioned realignment and also as AITS is focusing on improving IT security and efficiency, NASA is implementing new AITS contracts that consolidate or replace agency and center specific contracts. Currently, there are multiple approaches in place for funding for IT services across the NASA Centers making it difficult to efficiently execute critical IT services. Additionally, funding was transferred to AITS for transformation and renewal of the NASA IT network infrastructure at the NASA Centers. This IT initiative will mitigate IT security threats and vulnerabilities through network security zones and provide enterprise-wide benefits of consolidated network management and monitoring, coupled with sufficient capacity and reliability to support increasing mission-related data transfer requirements.

FINANCIAL MANAGEMENT

Question. Last year, Congress appropriated \$18.7 billion for NASA, this subcommittee's largest account. GAO and the NASA inspector general have both recently reported that financial management at NASA continues to be a serious problem. Recent independent reviews by Ernst & Young have identified significant financial deficiencies at NASA that lead to delayed and inaccurate reporting.

How has NASA met the IG's and GAO's recommendation for better financial management?

Answer. As of September 30, 2009, NASA had one remaining material weakness related to legacy property, plant, and equipment, or PP&E, and two other significant, but not material, deficiencies. The first deficiency related to processes used to estimate NASA's Environmental Liability. The second deficiency related to a lack of substantial compliance with the Federal Financial Management Improvement Act of 1996, resulting primarily from a lack of integration between NASA's real property system and its core financial system.

NASA is working closely with the IG, GAO and the agency's auditors, Ernst & Young, to resolve these remaining weaknesses. NASA is working on three specific actions that directly address fiscal year 2009 financial audit recommendations:

- As encouraged by Ernst & Young, NASA is adopting a new accounting standard, SFFAS No. 35, Estimating the Historical Cost of General Property, Plant, & Equipment: Amending Statements of Federal Financial Accounting Standards 6 and 23, that will help to resolve the legacy PP&E material weakness. SFFAS No. 35 permits the agency to establish auditable estimates for those legacy assets—particularly the International Space Station and space shuttle, and real property—for which the agency does not have the full historical cost records or for which it would not be cost effective to recreate such records.

NASA, in collaboration with the IG, GAO, and its auditor, is working to establish the basis for reasonable estimates, the approaches for implementing those bases, the information required to support the resulting estimates, and the timeframe within which the estimates can be generated.

- NASA continues to utilize the agency's ongoing Continuous Monitoring Program (CMP) to monitor and improve key financial activities and controls. The CMP is a monthly process that provides for robust and rigorous reviews to validate the quality and sufficiency of information for key accounts and accounting transactions. Changes in key processes are accompanied by reviews and, if required, improvements in the related CMP control activities.

- NASA has integrated its real property asset financial records into the core financial system's asset management module in fiscal year 2010. This improves overall PP&E accounting, and addresses the FFMIA weakness identified in the auditor's fiscal year 2009 Report on Internal Control.

Today, using current systems and processes, NASA is able to track and control its funds, account for the costs related to individual programs and projects, and manage the agency's day-to-day operations. The agency is committed to resolving its remaining weakness and deficiencies as it continues to improve its financial management.

Question. Please break out by program area, the 2010 and 2011 budgets for civil servant salaries and expenses, travel and support service contractors, including a crosswalk by each NASA field installation and headquarters.

Answer. For fiscal year 2010, we have provided budget for civil service salaries and expenses, travel and procurement by center at the mission level. The estimates are based on actual labor and travel costs through April 2010 with projections through the remainder of the fiscal year. At the agency level, NASA does not budget and account specifically for support contractors, but accounts for all contract and grant activities including support contractors, prime contractors, facilities and other items within the procurement line. Please note that the Headquarters Procurement funding estimate for 2010 includes approximately \$500 million that has not yet been distributed to centers.

FISCAL YEAR 2010 APPROPRIATION FUNDING ESTIMATES

[In millions of dollars]
 [Projections based on costs through April 30 and budget distributions through June 23]

	TOTAL	HO ¹	ARC	GRC	LaRC	DFRC	GSFC	MSFC	SSC	JSC	MSC	JPL
Science	4,448	388	180	39	80	65	2,173	139	3	21	266	1,094
Labor	277	1	28	10	19	13	186	16	1	4	.....	.....
Travel	17	1	2	1	1	1	9	1	.....	.....	.....	.....
Procurements	4,154	386	151	28	60	51	1,978	122	2	16	266	1,094
Aeronautics Research	500	43	107	128	164	56	2	.....	.....	.....	.....	.....
Labor	184	38	38	55	75	16	.....	.....	.....	.....	.....	.....
Travel	6	1	1	1	2	.....	.....	.....	.....	.....	.....	.....
Procurements	310	43	67	72	86	40	2	.....	.....	.....	.....	.....
Exploration Systems	3,757	107	98	133	92	39	31	1,279	106	1,660	169	43
Labor	445	2	32	51	42	8	8	125	5	117	59	.....
Travel	20	2	2	2	2	1	.....	3	.....	6	1	.....
Procurements	3,293	106	65	80	48	31	23	1,151	101	1,537	109	43
Space Operations	6,142	403	14	43	6	8	246	893	38	3,927	387	178
Labor	429	3	3	15	2	1	21	61	8	217	101	.....
Travel	19	1	.....	1	.....	.....	1	3	.....	8	4	.....
Procurements	5,694	401	11	27	4	7	224	829	30	3,701	281	178
Education	180	60	7	14	16	15	49	3	1	8	5	2
Labor	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Travel	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Procurements	177	60	6	14	16	15	48	3	1	8	4	2
Cross-Agency Supt	3,193	415	255	277	323	72	495	433	64	453	381	25
Labor	1,204	190	100	87	116	37	242	143	21	148	120	.....
Travel	34	9	2	3	4	1	3	4	1	4	3	.....
Procurements	1,954	216	153	187	202	35	250	286	42	301	259	25
CoF & ECR	488	65	36	70	18	22	45	27	33	74	66	14
Labor .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Travel .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Procurements	488	65	36	70	18	22	45	27	33	74	66	14
OIG	36	36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Labor	28	28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Travel	1	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Procurements	8	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
TOTAL	18,724	1,517	697	704	697	277	3,041	2,774	245	6,143	1,273	1,356

Labor	2,570	218	201	218	254	74	458	346	35	486	280	0
Travel	97	15	7	8	10	4	13	12	1	19	8	0
Procurements	16,057	1,284	489	478	433	200	2,570	2,417	209	5,638	984	1,356

¹HQ Procurement funding includes approximately \$500 million that has not yet been distributed to centers.

For fiscal year 2011, we have provided a spreadsheet, attached, that shows how NASA civil service labor and expenses are proposed to be reallocated from the programs and projects for establishment of a new Civil Service Labor and Expenses theme. This information was submitted to the Committees on Appropriations by letter dated June 1, 2010. These estimates are based on centers' pricing analysis of total center FTE ceilings and their associated expenses, and inputs provided by the missions on the required civil service, travel and procurement requirements by project. Because of the competitive nature of many of the agency's projects across all missions and the uncertainty of which center may win the selection, NASA budgets these funds at NASA Headquarters until the completion of the selection process. These competitive selection processes limit the ability to provide complete budget data at the center by mission level for the civil service salaries and expenses, travel and procurement estimates that are requested.

	Fiscal Year 2011 Request	Labor Transfer	Updated Fiscal Year 2011
Science			
Earth Science:			
Earth Science Research:			
Earth Science Research and Analysis	324.6	-36.2	288.4
Computing and Management	113.5	-7.1	106.4
Total, Earth Science Research	438.1	-43.3	394.8
Earth Systematic Missions:			
Global Precipitation Measurement (GPM)	128.8	-17.1	111.7
Glory Mission	21.9	-1.3	20.6
Landsat Data Continuity Mission (LDCM)	156.8	-11.9	144.9
NPOESS Preparatory Project (NPP)	64.4	-5.6	58.8
Ice, Cloud, and land Elevation Satellite (ICESat-2)	68.5	-12.2	56.3
Soil Moisture Active and Passive (SMAP)	82.5	-2.4	80.1
Other Missions and Data Analysis	286.5	-27.8	258.7
Total, Earth Systematic Missions	809.3	-78.3	731.0
Earth System Science Pathfinder:			
Aquarius	17.0	-0.4	16.6
OCO-2	171.0		171.0
Venture Class Missions	79.5		79.5
Other Missions and Data Analysis	36.2	-2.1	34.1
Total, Earth System Science Pathfinder	303.8	-2.5	301.3
Earth Science Multi-Mission Operations	161.2	-7.3	153.9
Earth Science Technology	52.8	-6.3	46.5
Applied Sciences: Pathways	36.6	-3.5	33.1
Total, Earth Science	1,801.8	-141.2	1,660.6
Planetary Science:			
Planetary Science Research:			
Planetary Science Research and Analysis	131.0	-6.6	124.4
Other Missions and Data Analysis	23.9	-2.3	21.6
Education and Directorate Management	5.1	-0.3	4.8
Near Earth Object Observations	20.3		20.3
Total, Planetary Science Research	180.4	-9.1	171.3
Lunar Quest Program:			
Lunar Science	74.7	-3.6	71.1
Lunar Atmosphere and Dust Environment Explorer	57.9	-7.6	50.3
International Lunar Network	4.0	-1.5	2.5

	Fiscal Year 2011 Request	Labor Transfer	Updated Fiscal Year 2011
Total, Lunar Quest Program	136.6	- 12.7	123.9
Discovery:			
Gravity Recovery and Interior Laboratory (GRAIL)	104.8	- 0.1	104.7
Other Missions and Data Analysis	97.2	- 2.3	94.9
Total, Discovery	202.0	- 2.4	199.6
New Frontiers:			
Juno	184.2	- 0.6	183.6
Other Missions and Data Analysis	39.6	- 1.5	38.1
Total, New Frontiers	223.8	- 2.1	221.7
Mars Exploration:			
2009 Mars Science Lab	231.6	- 0.5	231.1
MAVEN	161.2	- 6.5	154.7
Other Missions and Data Analysis	140.0	- 1.4	138.6
Total, Mars Exploration	532.8	- 8.3	524.5
Outer Planets	103.5	- 2.1	101.4
Technology	106.5	- 8.0	98.5
Total, Planetary Science	1,485.7	- 44.8	1,440.9
Astrophysics:			
Astrophysics Research:			
Astrophysics Research and Analysis	60.2	- 5.0	55.2
Balloon Project	27.1	- 4.0	23.1
Other Missions and Data Analysis	68.7	- 1.2	67.5
Total, Astrophysics Research	156.1	- 10.1	146.0
Cosmic Origins:			
Hubble Space Telescope (HST)	102.7	- 3.6	99.1
James Webb Space Telescope (JWST)	444.8	- 23.3	421.5
Stratospheric Observatory for Infrared Astronomy (SOFIA)	79.6	- 12.6	67.0
Other Missions and Data Analysis	60.6	- 2.0	58.6
Total, Cosmic Origins	687.7	- 41.5	646.3
Physics of the Cosmos: Other Missions and Data Analysis	103.3	- 6.0	97.3
Exoplanet Exploration: Other Missions and Data Analysis	42.5	- 1.7	40.8
Astrophysics Explorer:			
Nuclear Spectroscopic Telescope Array (NuStar)	32.1	- 0.4	31.7
Gravity and Extreme Magnetism	21.0	- 5.3	15.7
Other Missions and Data Analysis	33.6	- 4.1	29.5
Total, Astrophysics Explorer	86.7	- 9.8	76.9
Total, Astrophysics	1,076.3	- 69.0	1,007.3
Heliophysics:			
Heliophysics Research:			
Heliophysics Research and Analysis	31.7	- 1.4	30.3
Sounding Rockets	48.9	- 4.7	44.2
Research Range	19.6	- 1.5	18.1
Other Missions and Data Analysis	66.7	- 11.1	55.6

	Fiscal Year 2011 Request	Labor Transfer	Updated Fiscal Year 2011
Total, Heliophysics Research	166.9	- 18.7	148.2
Living with a Star:			
Radiation Belt Storm Probes (RBSP)	140.0	- 1.1	138.9
Solar Probe Plus	14.1	- 0.6	13.5
Other Missions and Data Analysis	60.2	- 2.1	58.1
Total, Living with a Star	214.3	- 3.8	210.5
Solar Terrestrial Probes:			
Magnetospheric Multiscale (MMS)	143.8	- 18.2	125.6
Other Missions and Data Analysis	19.1	- 1.3	17.8
Total, Solar Terrestrial Probes	162.9	- 19.5	143.4
Heliophysics Explorer Program:			
IRIS	69.0	- 2.0	67.0
Other Missions and Data Analysis	28.7	- 1.8	26.9
Total, Heliophysics Explorer Program	97.7	- 3.9	93.8
New Millennium	0.1	.....	0.1
Total, Heliophysics	641.9	- 45.8	596.1
Total, Science	5,005.6	- 300.8	4,704.8
Aeronautics and Space Research and Technology			
Aeronautics Research:			
Aviation Safety	79.3	- 33.4	45.9
Airspace Systems	82.2	- 22.4	59.8
Fundamental Aeronautics	228.5	- 102.6	125.9
Aeronautics Test	76.4	- 25.6	50.8
Integrated Systems Research	113.1	- 20.6	92.5
Total, Aeronautics Research	579.6	- 204.6	375.0
Space Technology:			
Early Stage Innovation:			
Space Technology Research Grants	70.0	- 3.9	66.1
NIAC Phase I and Phase II	3.0	- 0.5	2.5
Center Innovations Fund	50.0	- 8.5	41.5
SBIR/STTR	165.6	- 7.3	158.3
Centennial Challenges	10.0	.....	10.0
Total, Early Stage Innovation	298.6	- 20.2	278.4
Game Changing Technology:			
Game-Changing Developments	123.6	- 19.0	104.6
Small Satellite Subsystem Technologies	6.0	- 1.2	4.8
Total, Game Changing Technology	129.6	- 20.1	109.5
Crosscutting Capability Demonstrations:			
Technology Demonstration Missions	75.0	- 7.5	67.5
Edison Small Satellite Demonstration Missions	10.0	- 1.3	8.7
Flight Opportunities	17.0	- 1.2	15.8
Total, Crosscutting Capability Demonstrations	102.0	- 10.1	91.9
Partnership Development and Strategic Integration	42.0	- 9.7	32.3

	Fiscal Year 2011 Request	Labor Transfer	Updated Fiscal Year 2011
Total, Space Technology	572.2	- 60.2	512.0
Total, Aeronautics and Space Research and Technology	1,151.8	- 264.8	887.0
Exploration			
Exploration Research and Development:			
Technology Demonstration	652.4	- 111.1	541.3
Heavy Lift and Propulsion Technology	559.0	- 67.6	491.4
Robotic Precursor Missions	125.0	- 31.0	94.0
Human Research	215.0	- 19.0	196.0
Total, Exploration Research and Development	1,551.4	- 228.7	1,322.7
Commercial Spaceflight:			
Commercial Cargo	312.0	- 5.3	306.7
Commercial Crew	500.0	- 18.5	481.5
Total, Commercial Spaceflight	812.0	- 23.8	788.2
Constellation Transition	1,900.0	- 337.6	1,562.4
Constellation Systems:			
Constellation Systems			
Commercial Crew and Cargo			
Advanced Capabilities:			
Human Research Program			
Exploration Technology Development			
Lunar Precursor Robotic Program			
Total, Exploration	4,263.4	- 590.1	3,673.3
Space Operations			
Space Shuttle:			
Space Shuttle Program:			
Program Integration	284.8	- 46.4	238.4
Flight and Ground Operations	373.2	- 21.8	351.4
Flight Hardware	331.1	- 15.3	315.8
Total, Space Shuttle	989.1	- 83.5	905.6
International Space Station:			
International Space Station Program:			
ISS Operations	1,923.0	- 173.2	1,749.8
ISS Cargo Crew Services	856.8		856.8
Total, International Space Station	2,779.8	- 173.2	2,606.6
Space and Flight Support (SFS):			
21st Century Space Launch Complex	428.6	- 13.7	414.9
Space Communications and Navigation:			
Space Communications Networks	371.2	- 19.4	351.8
Space Communications Support	62.6	- 4.9	57.7
TDRS Replenishment	19.0	- 4.5	14.5
Total, Space Communications and Navigation	452.9	- 28.8	424.1
Human Space Flight Operations	114.4	- 28.7	85.7
Launch Services	78.9	- 33.8	45.1

	Fiscal Year 2011 Request	Labor Transfer	Updated Fiscal Year 2011
Rocket Propulsion Test	44.3	- 7.1	37.2
Crew Health and Safety			
Total, Space and Flight Support (SFS)	1,119.0	- 112.1	1,006.9
Total, Space Operations	4,887.8	- 368.8	4,519.0
Education			
Higher Ed. STEM Education:			
STEM Opportunities (Higher Education)	16.9	- 0.9	16.0
NASA Space Grant	27.7	- 1.4	26.3
Experimental Program to Stimulate Competitive Research	9.3	- 0.5	8.8
Minority University Research & Education Program	27.2	- 1.4	25.8
Global Climate Change Education			
Total, Higher Ed. STEM Education	81.0	- 4.2	76.8
K-12 STEM Education:			
STEM Student Opportunities (K-12)	46.1	- 2.0	44.1
STEM Teacher Development (K-12)	16.7	- 0.7	16.0
K-12 Competitive Educational Grant Program			
Total, K-12 STEM Education	62.8	- 2.7	60.1
Informal STEM Education:			
Science Museums and Planetarium Grants			
NASA Visitor Centers			
NASA Informal Education Opportunities	2.0	- 0.7	1.3
Total, Informal STEM Education	2.0	- 0.7	1.3
Total, Education	145.8	- 7.6	138.2
Cross-Agency Support			
Center Management and Operations:			
Center Institutional Capabilities	1,776.1	- 590.1	1,186.0
Center Programmatic Capabilities	494.0	- 346.8	147.2
Total, Center Management and Operations	2,270.2	- 936.9	1,333.3
Agency Management and Operations:			
Agency Management	432.0	- 244.4	187.6
Safety and Mission Success:			
Safety and Mission Assurance	49.0	- 11.9	37.1
Chief Engineer	103.6	- 40.6	63.0
Chief Health and Medical Officer	4.1		4.1
Independent Verification and Validation	45.0	- 5.0	40.0
Total, Safety and Mission Success	201.6	- 57.5	144.1
Agency IT Services (AITS):			
IT Management	16.1	- 0.5	15.6
Applications	79.1	- 8.6	70.5
Infrastructure	82.6	- 3.6	79.0
Total, Agency IT Services (AITS)	177.8	- 12.7	165.1
Strategic Capabilities Assets Program:			
Simulators	11.7	- 4.8	6.9
Thermal Vacuum Chambers	8.4	- 1.8	6.7

	Fiscal Year 2011 Request	Labor Transfer	Updated Fiscal Year 2011
Arc Jets	9.7	-2.6	7.2
Total, Strategic Capabilities Assets Program	29.8	-9.1	20.7
Total, Agency Management and Operations	841.2	-323.7	517.5
Civil Service Labor and Expenses		2,792.6	2,792.6
Congressionally Directed Items			
Total, Cross-Agency Support	3,111.4	1,532.0	4,643.4
Construction and Environmental Compliance and Restoration			
Construction of Facilities:			
Institutional CoF	280.8		280.8
Science CoF	40.5		40.5
Exploration CoF			
Space Operations CoF	14.0		14.0
Total, Construction of Facilities	335.2		335.2
Environmental Compliance and Restoration	62.1		62.1
Total, Construction and Environmental Compliance and Restoration	397.3		397.3
Inspector General			
IG Program			
Inspector General	37.0		37.0
Total, NASA Fiscal Year 2011	19,000.0		19,000.0

Question. Why has NASA failed to comply with the subcommittee's repeated directives to provide more budget detail in the Congressional justifications like is submitted by the DOD and individual military services in their R-2 documentation as part of their budget justifications?

Answer. NASA is not aware of repeated directives to provide more budget detail in the Congressional justifications like is submitted by the DOD and individual military services. NASA provides information that is comparable to the DOD R-2 documentation for all of NASA's projects in formulation and development within the Congressional Justification Budget book. Both the formulation and development sections in the Congressional Justification book provide descriptions of the project's purpose, parameters, deliverables, schedule commitments, budget trace from previous years President's budget submission, a description of project management, acquisition strategy and independent reviews which far exceed documentation requirements for R-2. In addition, the projects in development sections contain additional information for explanation of project changes, project commitments, development cost and schedule summary, development cost details and project risk management.

NASA-SPONSORED CONFERENCES

Question. Starting in 2008, this subcommittee asked NASA's Inspector General (IG) to examine the costs NASA was spending on its conferences. In a report released on March 23, the IG found that NASA had failed to follow NASA and Government guidelines regarding conference planning, resulting in excessive travel and food and beverage costs.

At one conference, the IG found that NASA spent \$66 per person per day on coffee, fruit, cookies, and bagels. Ironically, this was the same conference put on for NASA procurement officials whose job is to spend the Government's money wisely. Do you think this was a reasonable and appropriate expense?

Answer. We agree that \$66 per civil servant would have been excessive for light refreshments alone. However, that was not the case with the Procurement Training Conference, since the price for food and beverages (F&B) was part of a package deal

that included hotel meeting rooms at no additional charge. This bundling of facility rentals and services like F&B is a common practice, and hotels will regularly discount or omit charges for meeting rooms when a minimum level of services and occupancy are procured. All of the other hotels reviewed as potential sites for the Procurement Training Conference offered similar, but more expensive, bundled rates for F&B and meeting room charges.

If you compare this to another meeting NASA recently held in Annapolis, Maryland, the per person charge for meeting rooms was almost as high as the per person charge for meeting rooms plus refreshments (bundled) at the Procurement Training Conference. A competitive comparison used to plan the Annapolis conference showed that rates in Annapolis and Baltimore hotels for facilities rental alone ranged from \$20,570 to \$45,000, for a meeting one-third the size, as compared to the bundled F&B/facilities charge of \$62,611 for the Procurement Training Conference. Thus, per person charges for facilities rental plus F&B for the Procurement Training Conference (\$65.84) were only slightly higher than per person charges in the Baltimore/Annapolis area quoted for hotel meeting room rentals alone (\$61.22). The Baltimore/Washington area is expensive, but there are advantages to holding some events in this area. In conclusion, the comparison shows that charges for the Procurement Training Conference appear to have been reasonable all circumstances considered.

Question. How will NASA meet the IG's recommendation for better financial management in its conference planning?

Answer. NASA's IG noted in its report that the Procurement Training Conference was held prior to the issuance of NASA's revised conference policy, NASA Interim Directive (NID) 9312.1, on January 12, 2009. In the past year NASA has implemented a number of process improvements and issued two updates to NID 9312, the most recent being issued on April 23, 2010. With each iteration, NASA has improved its ability to track and report on conferences, and increased the level of detail required for approval of a NASA Sponsored Conference. A key focus for the changes in the first two versions of NID 9312 was on insuring that NASA did not exceed the Congressionally mandated \$5 million cap on fiscal year 2009 conference spending and 50 person limit on foreign conference attendance. A new NASA Conference Tracking System was implemented to automate key parts of this process in conjunction with use of NASA's e-Travel systems. With the most recent update to NID 9312 and its revised reports, NASA has incorporated all the further recommendations made by the IG in its March 23, 2010 report. Among other enhancements relating to NASA Sponsored Conferences, approval is now required in advance for any Government furnished meals or snack/refreshment service, and NASA now specifically requires written justification and senior level approval (Center Director or equivalent) for charges in excess of 33 percent M&IE for light refreshments.

QUESTIONS SUBMITTED BY SENATOR DIANNE FEINSTEIN

OVERVIEW

Question. Like many of my colleagues on this subcommittee, I was encouraged by the administration's new vision for NASA. The bold decision to eliminate the Constellation program will enable NASA's to dedicate the necessary resources to develop the required technologies for manned spaceflight beyond low-earth orbit and the moon. I believe that this is an appropriate role for NASA, and I share the Presidents belief that these changes will also create jobs and benefit the domestic U.S. space industry as a whole.

However, the President's budget and his justification lacked specificity. Specifically, the budget was lacking details in three critical areas: astronaut and rocket safety, preservation of strategic industrial capacities, and exploration timelines.

SAFETY

Proponents of the Constellation program believe that the Ares rocket is a proven rocket that meets higher safety standards than the private rockets which the President proposes to use to ferry astronauts and cargo to the International Space Station in the coming years.

Is the Ares I a safer rocket than the Falcon 9 or Taurus II?

Answer. Ares I was designed to be the safest crew vehicle ever flown, but that was based on modeling probabilistic risk analysis (PRA). When referring to safety records, it is best to speak in terms of demonstrated safety records. Although NASA and SpaceX have both launched test flights—NASA's Ares I-X suborbital flight and SpaceX's inaugural Falcon 9 orbital flight (a non-NASA flight), these test flights do

not equate to a demonstrated safety record. Neither vehicle has entered its operational phase and hence neither vehicle has a demonstrated safety record. As such, NASA does not have any documentation about the Falcon 9's safety record or PRA that it can provide to the subcommittee at this time.

Question. Will NASA safety standards be relaxed to accommodate the private companies who are developing rockets for NASA?

Answer. Safety is and always will be NASA's first core value, so we will provide significant—but not intrusive—oversight over any commercial venture, whether it be cargo or commercial. NASA will have equivalent safety standards for commercial crew. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. NASA has unique expertise and history in this area, and a clearly demonstrated record of success. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so.

Question. What oversight will NASA conduct to ensure that high standards are set for crew and cargo safety in privately owned NASA space launch vehicles?

Answer. As noted in the above response, safety is and always will be NASA's first core value, so we will provide significant—but not intrusive—oversight over any commercial venture, whether it be cargo or commercial.

For example, NASA has a Commercial Orbital Transportation Services (COTS) Advisory Team comprised of approximately 100 NASA technical experts from across the agency. These experts work with our partners and review partner technical and programmatic progress for each milestone and provide progress assessments to NASA's Commercial Crew and Cargo Program Office. Additionally, they participate in all major design reviews providing technical review comments back to our partners. The advisory team provides another method by which NASA gains confidence that our partners will be able to perform their flight demonstrations.

One of the strengths of the COTS venture is that companies are free to do what they do best, that is developing truly unique spaceflight vehicles using innovative processes that are not available within the Federal bureaucratic framework. NASA provides requirements that they must meet and we ensure that they have met those requirements, but we try not to dictate how they meet those requirements. For example, each COTS partner must successfully verify compliance with a detailed set of ISS interface and safety requirements prior to their planned ISS berthing missions. These requirements are imposed on all visiting vehicles wishing to visit to the ISS. Both COTS partners are currently working with the ISS program on a daily basis to ensure they meet the ISS visiting vehicle requirements. This also helps to give NASA independent insight into their progress and it builds confidence in their abilities.

With regard to commercial crew, at no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. NASA has unique expertise and history in this area, and a clearly demonstrated record of success in transporting crew. NASA will bring that experience to bear in an appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. For example, NASA will have in-depth insight of the vehicle design via NASA personnel who are embedded in the contractor's facility. Additionally, NASA will impose strict requirements and standards on all providers that will be carefully evaluated and reviewed at multiple stages before a vehicle system is certified by NASA for crewed flight.

Question. Will the Aerospace Safety Advisory Committee have the access and authority it needs to review/suggest modifications to new launch vehicles prior to NASA missions?

Answer. The Aerospace Safety Advisory Panel will be provided access to review new launch vehicles development to the same level that NASA has access and the Aerospace Safety Advisory Panel will continue to have the authority to make recommendations or suggestions to NASA concerning the launch vehicles.

PRESERVATION OF STRATEGIC SOLID ROCKET CAPACITY

Question. In an interview with Deputy Undersecretary of the Air Force for Space Programs Gary Payton, published in Space News on April 19, 2010, Deputy Undersecretary Payton concluded that the President's new direction for NASA would have a small, but manageable, impact on Navy and Air Force ballistic missiles, and only

a “trivial impact” on DOD space launch capacity. Do you share Deputy Undersecretary Payton’s conclusions? Will the President’s new direction for NASA undermine the ability for the Department of Defense to conduct meaningful space and missile programs?

Answer. I share the view that the President’s direction will not undermine DOD’s ability to conduct meaningful space programs. I believe that we have to rely upon the assessment of DOD’s leadership on this matter, and I do. I also recall General Kehler, Commander of Air Force Space Command, stating in a recent hearing that, while he saw the potential for some challenges regarding solid rocket motors, those challenges would be manageable. At the same time, my colleagues in DOD have stated that the investment that NASA plans in terms of research and development for a new liquid engine is a good opportunity in which DOD would very much like to collaborate. They see that as a good opportunity for the country going forward. DOD also sees our plans to improve launch infrastructure as a mutually beneficial one. We similarly see potential benefits to national security from some of our COTS and technology investments. NASA and DOD work closely on the management of the National government space enterprise, and discussions are under way at all levels about ensuring we carefully consider and maintain the space industrial base that supports both our civil and national security needs.

Question. With the wind-down of the space shuttle program already disrupting the job market in the aerospace industry, what additional disruption do you expect to occur in the aerospace job market as a result of the termination of the Constellation program?

Answer. The President’s fiscal year 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 fiscal year 2010 Consolidated Appropriations Act (Public Law 111–117), and an increased investment of \$6.0 billion in NASA science, aeronautics, human spaceflight and enabling space technologies over the next 5-years compared with last year’s budget plan. The President’s strategy and accompanying funding increase means more jobs for the country, more astronaut time in space, and more investments in innovation. NASA has initiated planning activities to be able to effectively and efficiently implement these new activities in a timely manner upon enactment of the fiscal year 2011 budget.

The proposed changes to the human spaceflight program in the fiscal year 2011 budget request will have an impact on civil service and contractor workforce planning. While NASA is not planning reductions to the civil service workforce, the nature of the work done by the civil service workforce would change under the President’s fiscal year 2011 budget plan. NASA has also made preliminary program assignments across the Centers for new or extended activities proposed in the fiscal year 2011 budget, helping to clarify the work opportunities for contractors under the proposed portfolio and preparing NASA to execute the work content.

Also in fiscal year 2011, NASA will provide up to \$100 million from within the funds requested for the National Aeronautics and Space Administration’s Exploration account to develop a plan to spur regional economic growth and job creation along the Florida Space Coast and other affected areas. This workforce plan furthers the administration’s bold new course for human space flight, which revitalizes NASA and transitions to new opportunities in the space industry and beyond.

In 2009, NASA established the Space Shuttle Transition Liaison Office (SSTLO) in response to direction in the NASA Authorization Act of 2008 (Public Law 110–422). The agency was directed to assist local communities affected by the termination of the space shuttle program by offering non-financial, technical assistance to the identified communities and to identify services available from other Federal, State, and local agencies to assist in such mitigation. NASA is working diligently to determine how best to leverage these efforts to support the transition resulting from the proposed cancellation of Constellation. Specifically, the Office:

- Serves as a clearinghouse by gathering and disseminating information to the affected communities about opportunities available through other Federal, State, and local agencies; and
- Serves as a key point of contact for the community beyond NASA for information about how the agency is working with local communities to provide non-financial, technical assistance during transition.

Question. What steps will NASA take to ensure that the job market disruptions caused by the termination of both the space shuttle and Constellation programs in fiscal year 2011 do not cause a long term brain-drain in the United States or hurt the long term viability of the domestic space industry?

Answer. The President’s fiscal year 2011 budget request and plans articulate a strong commitment to NASA’s mission and future U.S. human space exploration. NASA will ensure continuous American presence in space on the International

Space Station (ISS) throughout this entire decade and likely beyond, re-establish a robust and competitive American launch industry, launch more robotic probes into our solar system as precursors for human activity, invest in a new heavy lift research and development (R&D) program, and build a technological foundation for sustainable, beyond-LEO exploration, with more capable expeditions in lunar space, and human missions to near-Earth asteroids, the Moon, Lagrange points, and, ultimately, Mars. 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.

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.

NASA has initiated planning activities to be able to effectively and efficiently implement these new activities in a timely manner upon Congressional enactment of the fiscal year 2011 budget. On April 7, NASA outlined the agency's planned major program assignments across the agency's centers for new or extended activities proposed as part of the President's fiscal year 2011 budget request. These planned assignments build on the deep knowledge and expertise that NASA has built up over five decades, recognize the wealth of experience, commitment, and expertise resident at the NASA Centers, and expand upon the strengths at each center. The establishment of program offices and initiation of effort in support of new or extended activities for this proposed new work is contingent upon congressional approval of the President's fiscal year 2011 request for these activities. These planned program assignments will enable NASA to engage workforce at the agency's centers in formulation activities and planning activities to minimize disruption in the job markets.

EXPLORATION TIMELINES

Question. The President's budget and justification do not include a timeline with set benchmarks and destinations. I believe that these goals are necessary, and that they will help drive the important work being done at NASA. Will you please elaborate on when NASA will be able to accomplish the following tasks under the President's proposal, and under the program of record?

After the shuttle retires, when will NASA be able to re-supply the Space Station with cargo? If the Constellation program is continued, when would the United States be able to resupply cargo to the ISS?

Answer. Whether or not the Constellation program is continued, NASA plans to rely on U.S. industry to re-supply the International Space Station (ISS) with cargo after the space shuttle retires. NASA anticipates that the first two such flights under the Commercial Resupply Services (CRS) contracts will be in July and October 2011. The agency can also continue its use of Russian Progress cargo spacecraft through the end of calendar year 2011, in the event the CRS vehicles are delayed.

Under Constellation—the Program of Record—the Orion Crew Exploration vehicle was not designed to carry cargo to the ISS. Rather, NASA was planning to depend on commercial cargo providers to resupply the ISS, along with international partners.

Question. After the shuttle retires, when will NASA be able to carry astronauts to the space station? If the Constellation program is continued, when would the United States be able to transport astronauts to the ISS?

Answer. After the retirement of the space shuttle, NASA will continue its use of the Russian Soyuz spacecraft for crew transportation and rescue services for U.S., European, Japanese, and Canadian ISS astronauts until a U.S. commercial crew transportation system becomes available, possibly as early as 2015.

The Augustine Committee noted that commercial crew launch service could be in place by 2016. Estimates provided to the Augustine Committee by potential providers said commercial crew services could be in place 3 to 5 years from the point of funding.

Under the Program of Record and based on fiscal year 2010 funding constraints, NASA can no longer achieve an Initial Operational Capability (IOC) for Ares I and Orion—the first crewed flight to the ISS—in March 2015. The Augustine Committee concluded that, were the ISS to be deorbited in 2015, IOC could take place in the mid-late 2010s.

Under the proposed fiscal year 2011 budget request, NASA is targeting 2015 as the start of commercial-crew transportation services, with development efforts beginning in 2011.

Question. When will NASA be able to carry astronauts beyond low earth orbit under the President's plan? If the Constellation program is continued, when will U.S. astronauts be able to leave low earth orbit?

Answer. Under the proposed fiscal year 2011 budget, NASA plans to develop the technologies that would allow NASA to support manned beyond-LEO missions in the mid-2020 timeframe, if funding was later provided for such missions as part of later budget cycles.

The Augustine Committee concluded that the Program of Record, constrained to the fiscal year 2010 budget profile, would be capable of crewed missions beyond low Earth orbit in the late 2020s and a lunar landing well into the 2030s. In support of that committee, NASA estimated that the Constellation Program of Record, could deliver a crewed lunar mission by 2020 using Orion, Ares I, Altair, Ares V, and supporting elements, for \$109 billion since the inception of the Constellation Program. Of this \$109 billion since inception, \$96.7 billion would be required in fiscal year 2011 and out.

Question. When will NASA astronauts reach the Moon under the President's proposal? When would astronauts be able to reach the Moon under the program of record?

Answer. Please see the above response for an answer to the human lunar return date under the current program of record.

Under the President's fiscal year 2011 budget request, NASA would build technologies with the goal of supporting a sequence of deep-space destinations matched to growing capabilities, progressing step-by-step, beginning with crewed flight tests—perhaps a circumlunar mission—early next decade of vehicles for human exploration beyond LEO, a human mission to an asteroid by 2025, and a human mission to orbit Mars and return safely to Earth by the 2030s. A date for a manned lunar mission, however, has not been established.

NASA also plans to send precursor robotic missions to candidate destinations such as the Moon, thus paving the way for later human exploration of the Moon, Mars and its moons, and nearby asteroids. Like the highly successful Lunar Reconnaissance Orbiter and Lunar Crater Observation and Sensing Satellite missions that captured the Nation's attention last fall, future exploration precursor missions will scout locations, gather key knowledge and demonstrate technologies to identify the most compelling and accessible places to explore with humans and validate potential approaches to get them there and back safely. These missions will provide vital information—from soil chemistry to radiation dose levels to landing site scouting to resource identification—necessary to plan, design and operate future human missions. These missions will help us determine the next step for crews beyond LEO, answering such questions as: Is a particular asteroid a viable target for crewed mission? Do the resources at the lunar poles have the potential for crew utilization? Is Mars dust toxic? NASA plans to begin funding at least two dedicated precursor missions in fiscal year 2011, and to identify potential future missions to begin in fiscal year 2012 and/or 2013.

Additionally, a new portfolio of explorer scouts will execute small, rapid turnaround, highly competitive missions to exploration destinations. Generally budgeted at between \$100–\$200 million lifecycle cost, these missions will allow NASA to test new and innovative ways of doing robotic exploration of destinations of interest to future human exploration. Selected projects may provide multiple small scouting spacecraft to investigate multiple possible landing sites, or provide means of rapid-prototyping new spacecraft approaches.

Question. When will NASA astronauts reach Mars under the President's proposal? When would astronauts be able to reach Mars under the program of record?

Answer. Based on the information provided to the Augustine Committee, as outlined in the above response, NASA estimated that the Program of Record could achieve a manned Mars mission in the 2030s. While the Augustine Committee noted that Mars should be the ultimate destination for human exploration, it did not provide a specific date for when such a mission could be achieved by the Program of Record or under any of the options the committee developed. Under the proposed fiscal year 2011 budget, NASA plans to develop the technologies that would allow NASA to support a manned Mars mission in the 2030s, as part of a sustainable beyond-LEO human exploration program.

Question. The President stated in his April 13, 2010 speech at Kennedy Space Center that the plan to utilize the commercial space industry for low earth orbit missions has the potential to save the American taxpayer money. How much do you

expect the shift toward private industry handling low earth orbit services to save American taxpayers?

Answer. NASA anticipates that industry, through increased efficiencies will be able to provide human space transportation to low-Earth orbit (LEO) at a lower cost than would be possible through the use of Government-operated transportation systems, though the magnitude of the savings is not known at this time. In addition to making space travel more accessible and more affordable, the agency believes that 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.

QUESTIONS SUBMITTED BY SENATOR KAY BAILEY HUTCHISON

COMMERCIAL SPACE FLIGHT INITIATIVE AND ISS ACCESS AND SAFETY

Question. In your response to my question at the hearing, you said that you agree that if there were an accident with the Soyuz, either with the launch vehicle on ascent or the crew module on descent, which were serious enough to ground the Soyuz for an extended period of time while an accident investigation were completed and any necessary changes made, that same Soyuz vehicle would be the only vehicle astronauts could use to evacuate the ISS.

How long would it be before the six-person crew still aboard the ISS would have to evacuate?

Answer. In addition to providing crew rotation capabilities, the Soyuz vehicle also plays a critical role as the crew rescue vehicle. The Soyuz is currently the only vehicle that can provide this function for ISS expeditions, as it is the only vehicle that remains on-orbit for extended periods of time and provides emergency crew return capability. As explained in detail below, should there be a stand-down on Soyuz launches, NASA and its International Partners would have 2–4 months to understand the Soyuz issue and to resolve it before the ISS would need to be de-crewed.

Should there be an incident which results in Soyuz vehicles being grounded, there are several factors involved in determining the timeframe in which to downsize the ISS crew or de-crew the ISS. For this scenario, these factors include Soyuz spacecraft life and the length of time the on-orbit crew has been on board ISS.

The Soyuz spacecraft maximum mission duration is 200 days (vehicle launch to vehicle landing), due to systems certification. Mission duration beyond 200 days exceeds the certified lifetime of the vehicle and is not recommended.

Based on a myriad of health factors, including radiation exposure and other biomedical factors, a continuous on-orbit limit of 220 days for crewmembers has been established. Crew rotations are planned so that no crewmember is on-orbit longer than 220 days at a time. Should a reduction in crew size or de-crewing of the ISS be necessary, NASA and the ISS International Partners have developed guidelines and a timeline for an orderly de-crewing of the ISS. In general, the procedures for the reduction in crew size or de-crewing of ISS begin 15 days prior to the departure of the Soyuz and involve configuring the ISS for an extended period of unmanned operations.

Indirect handovers are planned to most effectively utilize the ISS resources and ground support operations. ISS docking port availability and utilization requires that a Soyuz vehicle depart prior to its replacement arriving at ISS. Russian assets are utilized to support both a Soyuz landing and a Soyuz launch, including the contingency support should an abort occur during launch. The availability of these resources and time required to support both events dictate a 2-week interval between a Soyuz landing and the subsequent launch of its replacement vehicle.

Moreover, typical spacing between Soyuz launches is a minimum of 2 and a maximum of 4 months. If a problem arose with a Soyuz launch, the on-orbit Soyuz would have 2–4 months of life remaining. Therefore, NASA and its International Partners would have 60–120 days to understand the Soyuz issue and to resolve it before the ISS would need to be de-crewed.

Question. Under this scenario, how will NASA determine if it is safe for astronauts escaping or otherwise departing the station to use versions of the same vehicle that just suffered an accident or failure significant enough to ground the entire Soyuz fleet?

Answer. NASA and Roscosmos (and its major contractors) have developed over the years a close working relationship in regard to safety and flight worthiness. As demonstrated by the Soyuz separation anomaly resolution, Roscosmos shared with NASA in-depth information about the design and safety of the Soyuz in a timely

manner in order to assess the re-entry risk to the crew. In the event of a grounding of the Soyuz launch vehicle and spacecraft, NASA fully expects that Roscosmos will again share vital data that are necessary to ensure the safety of our crew.

Question. If, in this scenario, the ISS crew had to abandon the station, how long could the untended ISS remain viable in a minimal state of ground-controlled automated activity, before its orbit might deteriorate or systems might begin to fail without crew maintenance, to the point it would be irretrievable or impossible to reactivate once the Soyuz were able to fly again?

Answer. NASA has plans and procedures in place for the crew to take necessary measures to configure the ISS platform in order to maintain safe untended operations for an extended period. Among the tasks the crew would perform would be to configure the ISS for a minimum power usage and close all hatches. The ISS systems that are needed to maintain a stable and viable vehicle are robust in their ability to perform even after failures and anomalies. Key systems such as the electrical power system; guidance, navigation and control; communications; and active propulsion have multiple layers of redundancy. The ISS could also be boosted to a higher orbit to maintain sufficient altitude without a risk of re-entry for several years.

Question. Given the seriousness of this very plausible and possible scenario, it is of great concern to me that answers to these questions are not clearly available and have not been fully addressed before the decision was made to launch the country on this path for human space flight, with only a single life-line to and from to the International Space Station for any period of time.

Please explain why these contingencies have not been fully—and satisfactorily—addressed before the fiscal year 2011 budget and the new plan for human space flight was adopted by the administration?

Answer. The reliance of the ISS partners on a single crew transportation system (Soyuz) for a period of time between the retirement of the space shuttle and the development of a follow-on system was established years ago when it was determined to retire the shuttle at the completion of ISS assembly. NASA cannot simultaneously fund continuing shuttle operations while developing the next generation U.S. human space flight program, so a period of “single-string” reliance on Soyuz was unavoidable. The new direction for the agency aims to minimize this period by encouraging a robust commercial space industry that can provide crew transportation services to the United States and its European, Japanese, and Canadian ISS partners.

Question. From the standpoint of relatively near-term human spaceflight, the President’s proposed budget and associated plan seem focused on: (a) The development of a commercial, as opposed to Government-owned human space flight launch capability and (b) The continuation—and expansion—of support to the International Space Station to at least 2020.

Would you agree with me that, in actual fact, the two initiatives are directly interwoven, in that the real driver behind the business case for commercial space launch capability—for both cargo, as under the COTS program now underway, and for human space flight, at least in its early stages—is the existence of a viable, healthy, safe and functioning International Space Station?

Answer. NASA considers the ISS a key component in the agency’s attempt to encourage and promote a robust commercial space industry, both in terms of the scientific and engineering research that can be conducted aboard this National Laboratory in orbit and as a destination that requires the transportation of personnel and cargo to and from low-Earth orbit (LEO). The continuing viability of ISS as both a spacecraft and research facility bolsters the business case for commercial space launch capability.

Question. As you begin to develop the requirements for a competition for a commercial crew development contract, what would be the target date for full operational capability, and how would you define that? If a target date has not been set, what is your best estimate for when a commercial crew launch system might be fully operational?

Answer. NASA is targeting 2015 as the start of operations for commercial crew services. However, NASA may adjust this date as we receive proposals from industry.

SUSTAINABILITY OF INTERNATIONAL SPACE STATION

Question. In 2005, the OMB mandated that of the 28 remaining flights then planned in support of ISS; NASA could only plan on performing 17 of them (plus an option for 1 for Hubble Telescope servicing). NASA was forced to reconfigure the payloads from the 10 cancelled missions to ensure that necessary spares and re-

placement parts could be delivered to the ISS on the 17 remaining flights. However, the decisions made regarding critical spares and equipment was based on what was at that time an internal planning date for end-of-life for ISS as 2015.

Given the near-certain extension of ISS—pressed by the Congress in the 2008 NASA Authorization Act, and now agreed to by the administration, what steps are you taking to understand the requirements for sustaining the ISS vehicle and systems through 2020?

Answer. As part of NASA's yearly budgetary planning cycle, the ISS Program has defined the necessary spares, logistics, operations, training and transportation services necessary to extend the operations of the ISS to at least 2020. NASA along with its International Partners is also in the process of certifying the ISS platform to 2028.

Question. The 2008 NASA Authorization Act (Public Law 110-422) required a report, within 9 months of enactment (Due July 15, 2009) of what would be necessary to sustain the ISS vehicle and systems through at least 2020. That report was received on August 9, 2009. It provided information that was not particularly helpful and contained contradictory information—such as descriptions of critical systems for which analysis would be done in 2011—after the planned end of shuttle operations. For many of these systems it appears transport to the ISS appears unlikely on any vehicle other than the shuttle. In most cases, reliance for delivery was placed on “planned” availability of COTS cargo capability, because the additional cargo-delivery systems, the Russian Progress vehicle, the Japanese HTV and the European ATV, would still leave a short-fall of 40 metric tons of required supplies. There was no analysis of the potential impact of a failure of either the COTS cargo capability or the ATV and HTV systems, neither of which had flown to the ISS at that stage. Most importantly, there was no analysis of potential spare part requirements that might need the space shuttle payload bay in order to deliver them to the station.

What, if anything, has been done since August of last year, when the report was filed, to ensure us that NASA has a complete understanding of what is needed to sustain the space station through at least 2020? If that has in fact been studied, please detail extensively the results and knowledge gained.

Answer. The planning and analysis required to keep ISS flying is a continuous process. There is a real-time component that monitors on-board failures and spares. The goal is to keep adequate spares on ISS to cover all failures. With the retirement of the shuttle, NASA is repositioning almost all available spares on orbit, so the agency is protecting against multiple component failures. There is also a strategic component for manifest planning. NASA runs models with reliability and maintenance estimates. These models are used to set the basic yearly launch upmass estimates. The models are continually updated with real failure rate data. In summary, the ISS storage space is almost fully utilized. The agency has a process in place that has been demonstrated to keep ISS flying. This process has been updated, and NASA has adequate margin to maintain ISS with the remaining shuttle flights, the European Automated Transfer Vehicle (ATV), the Japanese H-II Transfer Vehicle (HTV), and commercial cargo coming on line in late 2011.

Question. Since the decision to extend the space station was announced as part of the fiscal year 2011 budget request, what additional work has been done—or started—that would provide the Congress the confidence that the needs of ISS sustainability are fully understood and considered? If that has in fact been studied, please detail extensively the results and knowledge gained.

Answer. As part of NASA's yearly budgetary planning cycle, the ISS Program has defined the necessary spares, logistics, operations, training and transportation services necessary to extend the operations of the ISS to at least 2020. NASA along with its International Partners is also in the process of certifying the ISS platform to 2028.

Question. It seems clear that there is no way of knowing, with any degree of assurance, whether or not there are requirements for spares, replacements, or refurbishment of parts that would require shuttle flights beyond the end of this year in order to protect our investment in the space station and maximize its research potential. That suggests an inability to guarantee the “destination” of the space station with a low risk profile sufficient to allow commercial transportation systems, for either cargo or crew, to be able to convince investors that they should put venture capital into those projects.

Given that situation, would NASA and the administration consider the option of stretching out the remaining manifest (remaining shuttle flights) into the end of next year, combined with the activation of the contingency mission as a full mission capable of taking payloads to the space station, while immediately conducting the assessment necessary to determine whether there are requirements that could be met by using that added mission?

Answer. In formulating the payloads to be carried to ISS under the current space shuttle manifest, NASA carefully reviewed the station's likely requirements for spares, replacements, and refurbishment of parts in order to ensure the continued viability of ISS after the retirement of the shuttle. By the time the manifest has been completed, ISS will have been fully assembled (this is essentially the case now) and outfitted for long-term operations and utilization. After this point, the cargo capacity of the shuttle will no longer be required, and future components will be compatible with existing and anticipated cargo vehicles. Even such critical large items as Control Moment Gyros (CMGs) can be redesigned and/or repackaged to fly aboard smaller vehicles (in the case of CMGs, several smaller gyros can take the place of a single large unit).

Stretching out the shuttle manifest would be disruptive to our workforce, and potentially increase risk, since the operating tempo would be reduced to a point where personnel proficiency might suffer. In addition, the Aerospace Safety Advisory Panel recommended against an extension of the shuttle past the current manifest for these reasons. At this time, STS-335 is slated as the Launch On Need (LON) mission for STS-133, should that flight encounter an emergency.

Question. Regarding the new plan announced by the President to revive the Orion Crew Exploration Vehicle, but in a design modification that would allow it to be launched unmanned on an expendable launch vehicle, to serve as a life-boat for the ISS: How is that development going to be paid for, and what is your estimate for the cost and the schedule for delivery to the ISS?

Answer. NASA is currently assessing cost and schedule to develop an emergency crew return derivative of the Orion spacecraft, per this new direction from the President's April 15, 2010 address. The goal is to be as cost effective as possible, taking maximum advantage of the work performed to date on Orion design, development, and testing while deferring further work on systems that would provide capabilities not needed for emergency crew return.

It is not yet determined precisely where the funding will come from. The sources will be dependent on the magnitude of the estimated cost, which is still in work. The total proposed budget for NASA did not change with this new direction to develop an Orion emergency crew return module. Therefore, its costs will need to be offset by reductions to other line-items.

Question. How many such vehicles would be required? Would they be cycled every 6 months, like the Soyuz vehicles, or would they have a longer on-orbit stay-time?

Answer. NASA is just beginning to assess what the specific requirements for an emergency crew return derivative of the Orion spacecraft should be. Very likely, the four-person capability currently in work under the Constellation program of record will be preserved for this emergency return variant. The specifics of an Orion-derived crew return spacecraft are in development.

Question. How many seats would they provide? Would they enable the four seats per year that the United States is still obligated to provide under the Memoranda of Understanding and Intergovernmental Agreements for ISS signed in 1998?

Answer. NASA is just beginning to assess what the specific requirements for an emergency crew return derivative of the Orion spacecraft should be. Very likely, the four-person capability currently in work under the Constellation program of record will be preserved for this emergency return variant.

Question. Would that mean that the total station crew size could be expanded to seven, as originally planned, thus enabling greater potential for crew time being applied to research, as opposed to ISS maintenance?

Answer. The ISS today is capable of supporting a crew of seven as originally designed.

Question. If so, how would that impact the cargo and supply requirements?

Answer. This has not been factored into the extension assessment.

Question. Given the three-seat limitations on Soyuz, would that make it impossible to expand the station crew size because of no way to deliver the sufficient number of crews to ISS?

Answer. If Soyuz were the only vehicle to service ISS, the crew size could not be increased to seven permanent crew.

Question. If so, what is the advantage of developing and using the Orion as a crew-rescue vehicle only?

Answer. It will enable a cost-effective American crew escape capability that will increase the safety of our crews on the space station, reduce our dependence on foreign providers, and simplify requirements for commercial crew providers.

This effort will also help establish a technological foundation for future exploration spacecraft needed for human missions beyond low Earth orbit and will preserve some high-tech contractor jobs in Colorado, Texas, and Florida.

Continuing Orion as a rescue vehicle only will reduce costs by simplifying the design and eliminating development, testing, and production costs for systems associated with launching humans such as the Orion launch abort system and human rating the expendable launch vehicle. Continuing work associated with launching humans to the ISS aboard Orion would be duplicative of the commercial crew development efforts.

Question. How would the cost of development and launch of the Orion CRV compare to the cost of simply continuing to pay for Russian Soyuz to serve the crew escape function?

Answer. NASA procures services from Roscosmos that cover all aspects of transportation and rescue using Soyuz. This includes crew training, launch, landing, and having the spacecraft available at ISS for a 6-month “increment” as a rescue vehicle, should an emergency arise. The cost of using the Soyuz uniquely as a rescue vehicle has not been broken out, and would need to be negotiated, in any case.

CONTINUOUS U.S. HUMAN SPACEFLIGHT CAPABILITY—COMPLIANCE WITH THE LAW

Question. In the 2005 NASA Authorization Act, signed into law as Public law 109–155, the Congress stated that it was “the policy of the United States to possess the capability for human access to space on a continuous basis.” The law went on to make it clear that such capability for human access to space on a continuous basis was to be provided by U.S. transportation systems, not by other nations’ capabilities that we would “rent” or purchase access from. It is also a matter of international agreement, within the ISS implementing agreements, that the U.S. would be responsible for providing access to the ISS for European, Japanese, and Canadian crew members. The decision to terminate space shuttle operations in 2010, at least 4 years before any replacement U.S. capability was then planned to be available, was a direct violation of both the spirit and the letter of that law. When you and your Deputy Administrator each took the oath of office as Administrator, after confirmation by the Senate, you both swore to uphold the laws of the United States.

What have you done, since assuming your positions, to ensure that the law of the United States, establishing a policy of continuous U.S. capability for human space flight, is upheld?

Answer. As noted in the above response the “gap” in U.S. human spaceflight capability was the result of NASA not having sufficient resources to simultaneously fund continuing shuttle operations while developing the next generation U.S. human space flight program. The fact of the gap has been long established; the questions have been how long the gap would last, and what domestic system(s) the United States would use in the future. The new direction for the agency aims to minimize this period by encouraging a robust commercial space industry in LEO that can provide crew transportation services to the U.S. and its European, Japanese, and Canadian ISS partners.

Question. If a proposal by the administration—whether the Obama administration or the Bush administration, created and imposed on NASA by the Office of Management and Budget, or by the Office of Science and Technology Policy—represents a direct circumvention of the law, what is your responsibility, as the Administrator of the agency empowered to implement that law, to take steps to inform the authors of that proposal that their actions are in violation of the law, and to insist that they adhere to the law and policy established by the Congress?

Answer. It is the responsibility of everyone in public service to uphold the laws of the United States, and to ensure that proposals they advocate adhere to the law. In April 2009, NASA submitted to the Congress its Human Space Flight Capabilities report, which responded to language in section 611(a) of the NASA Authorization Act of 2008 (Public Law 110–422) directing NASA to report on the lack of a U.S. human space flight system to replace the space shuttle upon its planned retirement. This requirement was an amendment to a reporting requirement in section 501 of the NASA Authorization Act of 2005 (Public Law 109–115), referenced above. This report was required by law in case it was determined that the United States would not be able to maintain the capability for human access to space on a continuous basis.

QUESTIONS SUBMITTED BY SENATOR ROBERT F. BENNETT

BUDGET PROCESS

Question. The decision to shut down the Ares I and V programs have significant impact to the Aerospace Industrial base, especially to the Solid Rocket Motor industry. In lieu of this, did you coordinate or consult with the Department of Defense

when making this decision to shut down Constellation which will have immediate and far-reaching impacts to our national defense?

If so, when was this done and with whom?

Answer. NASA, the Department of Defense (DOD), and the National Reconnaissance Office (NRO) have worked closely on the management of the Nation's space enterprise for many years. In the context of the President's budget proposal and subsequent Congressional action, discussions have been underway at all levels about ensuring that we carefully consider and maintain the Nation's space industrial base. I have been working with Secretary of the Air Force Michael Donley, General Robert Kehler, the Commander of Air Force Space Command, and General Bruce Carlson, the NRO Director, throughout my tenure as NASA Administrator on these crucial subjects. While the President has proposed a restructuring of the Constellation program, he is also seeking to invest significant funding to develop technologies and infrastructure to enable human exploration both to low-Earth orbit and beyond. These provide to benefits to both DOD and NASA, as evidenced by statements by senior DOD representatives on the subject over the past months.

I have held several discussions with Secretary Donley, General Kehler, and General Carlson on this topic and met most recently with them on June 24, 2010. A key objective of these discussions has been to help ensure that we remain aware of launch options from a strategic perspective. I am committed to continuing to work closely with the DOD and the NRO as we move forward. As one example among many, the Office of the Undersecretary of Defense for Industrial Policy is leading a Solid Rocket Motor Industrial Base assessment in order to plan for the impact of changes in NASA's program, and NASA is a key participant in this assessment. We are additionally working with the national security space community on several other reviews and assessments to ensure that our civil and national security space objectives are met, while ensuring a robust national space industrial base.

Question. When did you learn of the cancellation of the entire Constellation program?

—Were you directly part of this decision?

—Considering this was the largest program eliminated in the Federal budget for fiscal year 2011, did you discuss cancellation of the entire program with the President directly?

—If not, who told you of the cancellation of Constellation?

Answer. I can tell you that I participated in the construction of the fiscal year 2011 budget request. That's part of my responsibility as the NASA Administrator, and I represent the inputs that NASA made to the budget formulation process.

Question. Were NASA's top technical and program folks engaged in crafting the budget? If so, who was involved with crafting the technical details of this new plan?

Answer. Key NASA personnel were involved in the preparation of the fiscal year 2011 budget request.

CONSTELLATION COSTS

Question. The administration seems to be throwing out different cost figures about how expensive it would be to simply continue the Ares program. General Bolden testified in front of the House Science Committee on March 23 by asserting that Ares would cost \$4–\$4.5 billion a year, and \$1.6 billion per flight, which seems awfully inflated. However, in a subsequent House Science Subcommittee hearing on March 25, NASA Associate Administrator for Exploration Systems Doug Cooke, testified that an earlier NASA written cost estimate provided to Representative Suzanne Kosmas (D-FLA) in 2009, citing a “marginal” cost of \$176 million per launch was still a “reasonable estimate.” (his words). This NASA estimate further clarifies that if there were only one Ares I/Orion flight in a given year, the cost would be \$919 million. (It explains that the \$919 million figure represents both fixed costs of \$781 million, and marginal costs of \$138 million). This \$919 million figure for one flight is roughly the same as the \$1 billion cited by the Augustine report. However, and this is key . . . the document goes on to explain that most of the fixed costs are in the first flight. And that subsequent flights of the Ares/Orion are much cheaper. In fact, this NASA document states that a second flight would cost \$138 million, and a third flight would cost another \$138 million, and a fourth flight another \$138 million, and so-on. So, given both NASA written and oral testimony in this regard, it is entirely possible to fly the Ares 1 with Orion capsule for continuing U.S. space flight to low earth orbit, and the International Space Station (ISS) and stay within NASA's constrained budgets. For example, for approximately \$1.5 billion, it seems that NASA could fund 4 launches of the Ares and Orion in a given year, continuing a robust manned space program and not having to rely on the Russians for transportation. This is well within NASA's budget. Do you disagree with previous NASA

testimony on Ares costs? What are the correct cost figures, and what specifically do you include in those cost figures?

Answer. To understand the cost of the Ares I project, it is important to understand the full cost of the Constellation Program. Based on the fiscal year 2010 budget request, NASA estimates it would cost approximately \$5.4 billion in fiscal year 2011 to continue the full Constellation Program, including Ares I and Orion development and testing, and all supporting elements (ground processing facilities, mission control, program integration etc.), which together would lead to an Initial Operational Capability for two crewed flights to the International Space Station per year. Of the \$5.4 billion figure, the Ares I project was estimated to cost \$2.1 billion, with Orion costing \$1.8 billion, and other Constellation supporting elements equating to about \$1.5 billion.

The fiscal year 2011 budget request transitions away from the Constellation Program. Therefore, under this assumption, if NASA were required to continue only the Ares I project, the cost to do so would be about approximately \$4–\$4.5 billion in fiscal year 2011—which would pay for the project elements and also include the full cost of all supporting elements outlined in the fiscal year 2010 budget request, such as ground processing facilities, mission control, program integration etc. Without these supporting elements, the Ares I could not fly. This scenario also assumes that Orion would be cancelled, so close-out costs for Orion were factored into this estimate. (Note: Without an Orion, this scenario would not provide an IOC capability.) Additionally, it is important to remember that under the fiscal year 2010 budget request and its 5-year runout, the Constellation Program as a whole was expected to begin ramping up work in fiscal year 2011, and in doing so, was expected to also begin assuming additional Shuttle infrastructure and workforce costs in addition to increased development costs, currently estimated to be \$600–700 million. Therefore, those costs are factored into the continuation cost estimate.

With regard to marginal costs for Ares I, NASA recognizes that there is often confusion with regard to publicized flight cost estimates associated with the Ares projects, largely because those estimates often include different assumptions. One key point of confusion, for example, comes from the fact that the Ares I and Ares V share significant fixed costs for vendor production base and sustaining engineering, since both vehicles would use similar solid rocket boosters, upper stage engines and avionics. Therefore, there are two ways to consider the cost of an Ares I flight—one, where the Ares I fixed costs are lower because it is assumed that certain fixed operational costs would be shared with the Ares V, and another, where the Ares I fixed costs are higher because the current shared-cost scenario is not assumed.

In general, NASA does not budget by flight, but rather by fixed and marginal costs expected on an annual basis. The fixed cost (i.e. prime and non-prime support labor, costs of facilities) would be the cost that must be incurred whether one rocket or multiple rockets are built. In other words, the fixed cost is absorbed by the first annual flight and is not counted again that year. The marginal costs, on the other hand, are those costs that can be cleanly attributed to the production of one unit, and that cost is generally the same, unit by unit. So for each subsequent annual flight, NASA adds on only the marginal cost, given that the fixed cost has already been absorbed into the first. It is important to note, however, that NASA's formula of calculating the cost of an Ares I flight (or subsequent annual flights) does not include the project costs for the associated support elements, such as ground operations, mission operations, EVA and program integration. Those costs would be book kept under their respective project lines.

With regard to the cost per flight, NASA currently estimates that both Ares I and Orion account for \$69 million each in marginal costs for a flight unit, thus totaling \$138 million in marginal costs for each flight since each flight would be assumed to have a capsule and a rocket. However, the fixed cost per flight would vary based on whether Ares I and Ares V shared operational costs were assumed.

For example, the fiscal year 2010 budget request assumed that Ares I and Ares V would share some operational costs—approximately \$700 million per year, which would, in turn, equate to lower fixed costs for the Ares I. Therefore, under that scenario—which was provided to Congressman Aderholt's staff in November 2009—the total cost for the first flight would be \$919 million (\$781 million in fixed cost plus \$138 million in marginal costs) with each subsequent flight costing \$138 million extra in marginal costs, as outlined in the chart below:

ESTIMATED ANNUAL OPERATIONS FIXED AND MARGINAL COSTS FOR ARES I AND ORION WITH
ARES I AND ARES V SHARING OPERATIONAL COSTS

[In millions of dollars]

	Fiscal Year 2008
Fixed Costs (Ares I and Orion)	781
Marginal Cost for 1st flight	138
Total Cost for 1st flight	919
Marginal Cost for 2nd flight	138
Total Cost for 2 flights per year	1,057
Marginal Cost for 3rd flight	138
Total Cost for 3 flights per year	1,195

Note.—This assumes Ares I fixed costs are shared with Ares V. It also excludes fixed costs for supporting elements.

However, if the assumption is that Ares I and Ares V would not share operational costs, it is equally true to say that the cost of an Ares I flight is nearly \$1.6 billion. Under this scenario, all operational costs would be carried by Ares I—which would account for an approximate \$700 million increase in the fixed cost for Ares I. Thus, under this scenario, the total cost for the first flight would be \$1.461 billion in fixed cost plus \$138 million in marginal costs, with each subsequent flight costing \$138 million extra in marginal costs, as outlined in the chart below:

ESTIMATED ANNUAL OPERATIONS FIXED AND MARGINAL COSTS FOR ARES I AND ORION WITH
ARES I CARRYING ALL OF THE OPERATIONAL COSTS

[In millions of dollars]

	Fiscal Year 2008
Fixed Costs (Ares I and Orion)	1,461
Marginal Cost for 1st flight	138
Total Cost for 1st flight	1,599
Marginal Cost for 2nd flight	138
Total cost for 2 flights per year	1,737
Marginal Cost for 3rd flight	138
Total Cost for 3 flights per year	1,875

Note.—This assumes Ares I fixed costs are not shared with Ares V. It also excludes fixed costs for supporting elements.

Question. What, in your opinion, is a higher priority—the safety of our astronauts or potential cost savings? With that in mind, I'd like to quote from the Aerospace Safety Advisory Panel's 2009 annual report which states, "the Ares I vehicle has been designed from the beginning with a clear emphasis on safety. Its architecture was selected by NASA's Exploration System Architecture Study (ESAS) team because of its potential to deliver at least 10 times the level of crew safety as the current shuttle. The launch vehicle configuration has been developed to provide the best possible allowances for crew escape in the event of a launch failure." In your opinion, what are safer, solid rocket motors or a propulsion system based on liquid fuel? I'd like to know what are NASA's plans to ensure that any manned system designed and developed by private industry will be as safe as the system which is being developed under Project Constellation, the current program of record.

Answer. One measure of launch vehicle safety is identifying the approximate probability of failure for the launch vehicle which can then be determined by summing up the chances of failure of all of its subsystems. For launches of U.S.-built vehicles in the last 20 years, problems with the propulsion system represented a significant portion of all failures therefore addressing reliability during the design of a launch vehicle is paramount to ensuring a safe vehicle. The type of propulsion system (solids versus liquids) is not a discriminator; rather simplicity and redundancy are the keys to high design reliability for any system and launch vehicles are no exception.

With regard to commercial crew, at no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. Sim-

ply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. NASA has unique expertise and history in this area, and a clearly demonstrated record of success in transporting crew. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. For example, NASA will have in-depth insight of the vehicle design via NASA personnel who are embedded in the contractor's facility. Additionally, NASA will impose strict requirements and standards on all providers that will be carefully evaluated and reviewed at multiple stages before a vehicle system is certified by NASA for crewed flight.

COTS AND RESUPPLYING THE INTERNATIONAL SPACE STATION WITH CARGO AND CREW

Question. Please explain the line in the fiscal year 2011 budget proposal for commercial cargo of \$312 million. The COTS program was established under a Space Act Agreement which has a fixed cost attached to it. If so, why a few years later is there a need to throw additional money at the Space Act Agreement holders? Could this be seen as a funding stream for the COTS providers because they are behind schedule and costs?

Answer. The fiscal year 2011 budget request includes \$312 million for commercial cargo development efforts, which NASA intends to allocate as follows:

- \$288 million would be an augmentation to the current Commercial Orbital Transportation Services (COTS) funded agreements for additional milestones that would add additional capabilities or tests that would reduce risks and expedite the pace of cargo delivery for the ISS. The funding would be equally split between SpaceX and Orbital.

- \$14 million would be for currently negotiated milestones expected to be completed in fiscal year 2011—part of the original \$500 million COTS investment.

- \$10 million would be for program operations for the Commercial Crew and Cargo Office at Johnson Space Center in fiscal year 2011.

Question. Administrator Bolden I would like to understand what NASA and the taxpayers have received for this total COTS expenditures to date of approximately \$618 million? What hardware has been delivered? What services have been provided? What does NASA own, IP rights?

Answer. The dollar amount cited in the question includes payments made as part of the COTS cargo development effort and the Commercial Resupply Services (CRS) contract.

With regard to COTS, expenditures as of mid June 2010 for our two funded Space Act Agreement (SpaceX and Orbital Sciences) total \$393 million. To date, our partners have completed all major design reviews, including Preliminary and Critical Design Reviews. Both partners have begun testing programs designed to qualify their respective cargo transportation systems for launch and spaceflight environments. Additionally, both partners are progressing through the ISS visiting vehicle integration.

SpaceX has recently completed its Falcon 9 maiden flight, including the Dragon capsule qualification unit. Although this was a non-NASA milestone, this flight provided data for the company to verify launch-vehicle operations for the new vehicle, and NASA expects data gathered from this test flight will be instrumental to our first COTS demonstration. NASA's COTS Demo flight 1 hardware is progressing. The COTS Demo 1 flight first stage has completed integration and is being readied for the integrated stage testing in Texas. Likewise, the COTS Demo 1, second stage integration, has been completed and is being readied for its integrated stage testing in Texas. Once integrated stage testing is complete, both stages will be shipped to Cape Canaveral for flight. The COTS Demo 1 Dragon Capsule integration is finishing up. The integrated spacecraft has been powered up and is currently flowing data to mission control. Currently, the launch is scheduled for August.

Orbital continues to make progress as well. Its first stage static test article has been completed and initial static tests have been completed. The first stage engine, AJ-26, is currently planned to begin testing at the NASA Stennis Space Center in August this year.

Regarding intellectual property (IP) rights for the COTS agreements, since 1980, with the passage of the Bayh-Dole Act (with regard to small businesses, universities and non-profits) and 1983, under Executive Order 12591 (with regard to large business), it has been the policy of the Federal Government to permit contractors and others who receive Federal funds to develop technology to retain the commercial rights to that technology, including the right to make a profit from technology developed with funds received from the Federal Government. Consistent with Bayh-Dole

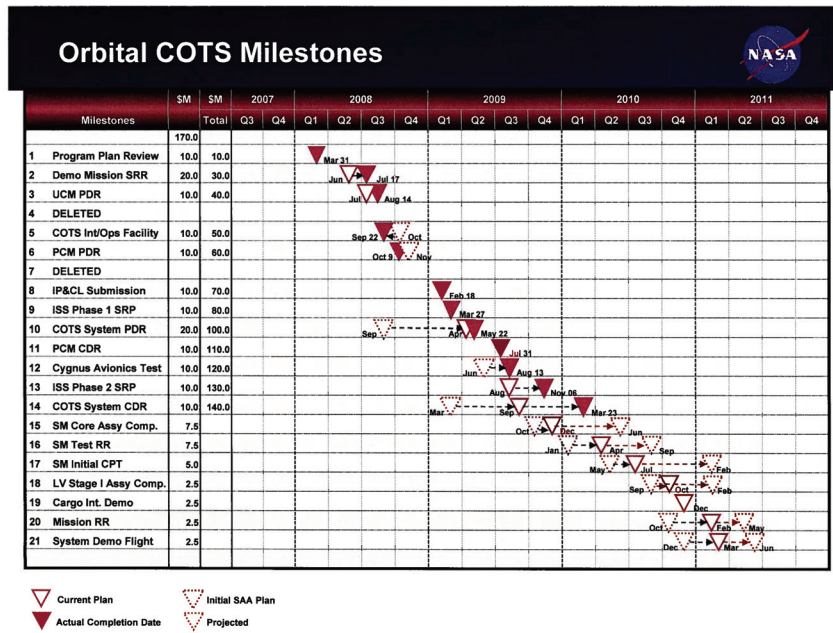
and EO 12591, NASA will not own any IP rights under the COTS SAAs. NASA will receive a Government purpose license to use inventions developed under the SAAs that commences 5 years after the completion of the SAAs. Consistent with the law and Federal policy, NASA encourages, and will continue to encourage, its contractors and partners to make commercial use of technology development funded by NASA. NASA retains “march in rights” for data and inventions if the COTS partners do not achieve practical application of IP developed under the COTS SAAs.

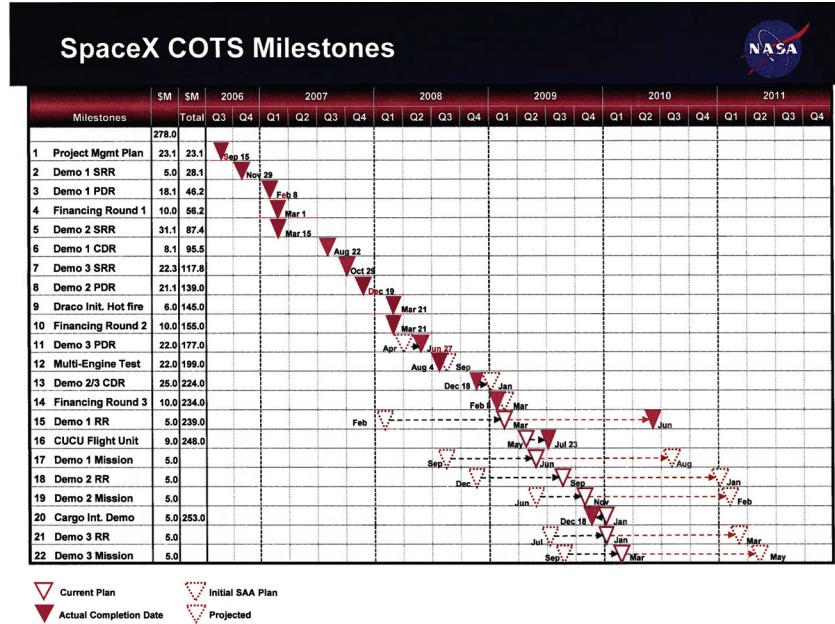
With regard to NASA’s CRS contracts, on December 23, 2008, NASA awarded contracts to SpaceX and Orbital for the delivery of cargo to the ISS after the retirement of the space shuttle. The scope of the CRS effort includes: delivery of pressurized and/or unpressurized cargo to the ISS; disposal or return of cargo from the ISS; and, non-standard services and special task assignments and studies that can be ordered to support the primary standard resupply service. The first two CRS flights to ISS are scheduled for July and October of 2011.

Under these contracts, NASA does not purchase hardware; NASA purchases services. Payment for services is made upon completion of milestones. SpaceX has completed through the third milestone, Mission Integration Review, for delivery flights 1 and 2, and through the second milestone, Vehicle Baseline Review, for delivery flight 3. OSC has completed through the third milestone, Vehicle Baseline Review, for its delivery flight 1, and through the second milestone, Long Lead Order Placement for delivery flight 2. As of late April 2010, SpaceX and Orbital had received \$101 million and \$127 million, respectively, for their CRS work.

Question. What is the schedule performance since COTS was started? Can you explain where the two current COTS providers are in terms of their original schedule milestones?

Answer. Please see milestone charts below which shows milestones accomplished to date, payments made and projected dates for future milestones. The chart also includes the original milestone dates for each COTS funded partner.





Question. The COTS program was designed to create lower cost cargo access to the ISS. With the current Resupply Service Contracts for SpaceX costing \$135 million per flight and Orbital costing \$235 million per flight, and with Doug Cooke’s recent testimony that the much more robust Ares vehicle recurring flight cost of \$178 million per flight, are we really finding dramatic cost savings through COTS, doesn’t seem like it from these numbers?

Answer. The aforementioned CRS and Ares I costs cannot be compared in the manner cited because the missions are different. While Ares I was designed to go to the ISS, it was designed to carry crew and not cargo. The CRS missions, on the other hand, are designed to carry only cargo, so comparing costs between the two missions is not appropriate.

Under CRS, NASA is purchasing cargo delivery services via a fixed-price contract. Thus, NASA is paying a pre-set cost per delivery, and therefore, the company is responsible for paying for its own infrastructure and personnel costs, for example. However, NASA will have additional costs for its own infrastructure and workforce associated with commercial crew.

In comparison, and as noted in an earlier response, NASA’s estimate for Ares I marginal costs reflects only the costs that can be cleanly attributed to the production of one unit. However, that number does not include the fixed development costs for the Ares I program, nor does it include the project costs for the associated support elements, such as ground operations, mission operations, EVA and program integration. Therefore, to understand the cost of the Ares I project, it is important to understand the full cost of the Constellation Program.

Question. The original plan for commercial transportation to space was to have the COTS providers demonstrate cargo capability before moving to crew, a logical progression in spaceflight capabilities. What has changed that pushes us to begin commercial crew investment before even a single cargo demonstration has occurred?

Answer. Nothing has changed. NASA is still pursuing an incremental strategy by establishing commercial cargo resupply services prior to establishing the provision of commercial crew services. NASA has always planned for the eventual provision of commercial crew services and Congress authorized NASA to pursue those activities in the NASA 2008 Authorization Act. Congressional authorization, coupled with the endorsement of the Augustine Committee which stated in its final report that “Commercial services to deliver crew to low-Earth orbit are within reach,” and the decision to extend the life of the ISS likely to 2020 or beyond, enabled the administration and NASA to fund the development and demonstration of commercial crew transportation as part of the President’s fiscal year 2011 budget request.

Question. Is this putting too great of pressure on these companies, helping to ensure their failure?

Answer. NASA has not yet selected the companies that will provide commercial crew services. However, NASA will evaluate the capability of all bidders during the proposal evaluation process and select those companies that have the necessary capabilities and plans for providing commercial crew services.

Question. Current projections for new entrants into national human spaceflight, like India, project 10–12 years before ready for first human launch, and China has demonstrated that it took them 11 years after they had a certified launch vehicle to be ready. Why do we believe a commercial crew capability could occur in less than 5 years? On what do we base that projection besides claims of companies that have not placed a single human into space?

Answer. During previous COTS announcements, multiple commercial companies proposed a crew transportation capability that could be developed in 36–48 months. These inputs were from established, low-risk companies who have placed humans into space, as well as smaller entrepreneurial companies.

Question. Given NASA has not yet delivered human rating requirements for commercially provided vehicles, coupled with the fact that the COTS providers are running about 2 years behind on their cargo capability, how can you expect crew capability by 2015 and have confidence in this schedule?

Answer. NASA has recently released a draft set of commercial human rating requirements for industry to review and provide comments. Comments were due back to NASA by June 18. These comments will be used to mature the requirements set in time to support a commercial crew announcement that meets the program's timeline.

During previous COTS announcements multiple commercial companies proposed a crew transportation capability that could be developed in 36–48 months. These inputs were from established, low-risk companies who have placed humans into space, as well as smaller entrepreneurial companies.

Both SpaceX and Orbital have encountered technical challenges and schedule delays normally attributed to complicated endeavors such as fielding new launch vehicles and spacecraft. SpaceX, however, proceeded from signing the NASA SAA to launching its Falcon 9 launch vehicle in less than 48 months. Orbital Sciences is on target to fly its Taurus II in approximately 40 months from SAA signature.

It is important to note that both of these COTS efforts include not only the launch vehicle but also spacecraft and all needed ground and mission support capabilities as well.

Question. General Bolden, as we all know, the acquisition process, especially one of the magnitude of designing, and developing a manned space capability, is full of milestones, testing, reviews and much, much more. I'm curious to know, what are the acquisition-related steps that would need to be followed by the Government in the development and procurement of commercial crew transport services, e.g., development of a COTS-like demonstration program; COTS RFP preparation and release; competition for COTS awards; negotiation of COTS agreements; DDT&E phase; demonstration phase; RFP preparation and release for commercial crew transport contracts; contract competition, award, negotiation, potential protest resolution, etc.; and certification for operations involving U.S. astronauts before commencing commercial crew transport services to the International Space Station? Historically, how long has it taken to complete such acquisition steps in the development of new aerospace systems to be used by the Government?

Answer. NASA released a Request for Information (RFI) in May 2010, which represented a critical element in the agency's overall proposed strategy for commercial crew. This RFI requested industry feedback to the NASA plans for certifying commercial crew vehicles for NASA services, including the Draft Commercial Human Rating Plan. In addition, the RFI sought input on the general acquisition strategy and philosophy. A second RFI is planned in the late summer timeframe for industry feedback on the ISS Service Requirements Document (SRD) and Interface Requirements Document (IRD). With this feedback, NASA will finalize the remaining requirements, reference documents, and acquisition strategy.

Information from these RFIs will be used to finalize NASA's proposed commercial crew acquisition strategy. Upon strategy approval, the draft announcement (including ISS SRD and IRD) will be completed and released for further comment, clarification, and questions from industry.

Historically, it has taken 6–9 months from instrument release (Request for Proposal (RFP), Announcement of Opportunity (AO), NASA Research Announcement (NRA), Cooperative Agreement Notice (CAN), Space Act Agreement (SAA)) to award.

CONSTELLATION

Question. Was there any consideration of taking more of a “Commercial” approach to Constellation? Allowing for the cost and schedule savings that could be accomplished by taking this type of approach, but keeping the workforce transition plans in place and leveraging the investment in the program and benefiting from the safety regime incorporated, couldn’t this be a prudent way to consider moving forward? Was this even considered and if so, what were the reasons that this approach was not selected, what concerns do you have to this approach?

Answer. Budget formulation discussions are pre-decisional information and cannot be provided for the public record. However, in general, as part of normal fiscal year 2010 operations, the Constellation Program has been in discussions with the prime contractor about ways to reduce costs and improve schedule. Additionally, the commercial crew competition will be fully open, so the Ares I and Orion contractors can compete for those development awards as well.

Question. Can you explain what the White House has done with the human spaceflight budget? While NASA’s top line increases by \$6 billion over the next 5 years, the Exploration account contains significant reductions over that same period. Over the next 4 years, the budget run-out for Exploration is almost \$6 billion below last year’s run-out. In just this year’s request alone the Exploration budget has a \$1.8 billion cut from last year’s projected number, how is that a commitment to Human Space Exploration? This also includes the \$1.9 billion of close out costs for fiscal year 2011 also, so the actual budget for Exploration is that much lower even. Doesn’t this go completely against the funding recommendation by the Augustine panel your boss commissioned?

Answer. In the fiscal year 2011 President’s budget request, the requested budget for Exploration is almost \$500 million more than the fiscal year 2010 enacted level, and the projected budget for Exploration in fiscal year 2015 is \$1.4 billion higher than the fiscal year 2010 enacted level—an increase of 37 percent in 5 years. While the fiscal year 2011 budget request, reflects less funding for Exploration than anticipated in the fiscal year 2010 request, funding for NASA as a whole increases \$6 billion over 5 years despite a tough budget environment.

Although funding for Exploration decreases when compared to the fiscal year 2010 budget runout, funding was increased for other spaceflight priorities that were either critical to enable a safe and effective near-term human spaceflight program—such as allowing the shuttle to safely complete its manifest, extending the International Space Station to 2020 and enhancing its utilization—or that were key to supporting human spaceflight activities in the long-term, such as cross-cutting technology; and developing commercial crew transport capabilities.

Extending the spatial and temporal boundaries of human spaceflight is an important goal for the Nation and for NASA. However, human spaceflight remains an endeavor with substantial risks, and these risks must be identified, managed and mitigated appropriately to achieve the Nation’s goals in space. Thus, as highlighted in the Review of U.S. Human Spaceflight Plans Committee report and as supported by the fiscal year 2011 budget request, investment in a well-designed and adequately funded space technology program is critical to enable progress in exploration. Exploration strategies can proceed more readily and economically if the requisite technology has been developed in advance. That is why the fiscal year 2011 budget request is so critical for NASA.

Question. NASA’s Safety Advisory Panel, which you were a member of prior to becoming Administrator, strongly advised you against the new approach you are defending today. Can you explain why this path was chosen from a safety perspective? And how as a former member of this panel that worked on the recently released report, can you argue with its findings? Have their findings drastically changed since you were on the ASAP?

Answer. I was a member of the NASA Aerospace Advisory Panel (ASAP) from August 2006 to July 2009 and did not work on the development of their 2009 Annual Report. The administration’s decision to undertake a new plan for human exploration was based in large measure on the findings and recommendations provided by independent Review of U.S. Human Spaceflight Plans Committee, chaired by Norm Augustine, which delivered its final report to NASA and the White House in October 2009. The new plan for NASA’s exploration activities outlined in NASA’s fiscal year 2011 budget request was not considered during my tenure on the ASAP. As we move forward to implement our new plan for human exploration, however, I can assure you that NASA remains committed to safety in all aspects of our activities. I frequently meet with the members of the ASAP in my capacity as the NASA Administrator and I have asked the ASAP to continue to independently review and

assess our proposed activities and to provide specific recommendations on how NASA should be proceed to ensure the safety of our people and our programs.

Question. Part of the Ares/Orion plan was to enable a smooth workforce transition of the space shuttle program. With thousands of Aerospace critical skills at stake, announcing the cancellation of Constellation has created quite a high level of unrest across the industry. What plan do you have now to address this?

Answer. The President's fiscal year 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 fiscal year 2010 Consolidated Appropriations Act (Public Law 111-117), and an increased investment of \$6.0 billion in NASA science, aeronautics, human spaceflight and enabling space technologies over the next 5-years compared with last year's budget plan. The President's strategy and accompanying funding increase means more jobs for the Nation, more astronaut time in space, and more investments in innovation. NASA has initiated planning activities to be able to effectively and efficiently implement these new activities in a timely manner upon enactment of the fiscal year 2011 budget.

The proposed changes to the human spaceflight program in the fiscal year 2011 budget request will have an impact on civil service and contractor workforce planning. While NASA is not planning reductions in the civil service workforce, the nature of the work done by the civil service workforce would change under the President's fiscal year 2011 budget plan. NASA has also made preliminary program assignments across the centers for new or extended activities proposed in the fiscal year 2011 budget request, helping to clarify the work opportunities for contractors under the proposed portfolio and preparing NASA to execute the work content.

In 2009, NASA established the Space Shuttle Transition Liaison Office (SSTLO) in response to direction in the NASA Authorization Act of 2008 (Public Law 110-422). The agency was directed to assist local communities affected by the termination of the space shuttle program by offering non-financial, technical assistance to the identified communities and to identify services available from other Federal, State, and local agencies to assist in such mitigation. NASA is working diligently to determine how best to leverage these efforts to support the transition resulting from the proposed cancellation of Constellation. Specifically, the Office:

- Serves as a clearinghouse by gathering and disseminating information to the affected communities about opportunities available through other Federal, State, and local agencies; and
- Serves as a key point of contact for the community beyond NASA for information about how the agency is working with local communities to provide non-financial, technical assistance during transition.

The NASA workforce amendment would provide up to \$100 million from within the funds requested for the National Aeronautics and Space Administration's Exploration account to develop a plan to spur regional economic growth and job creation along the Florida Space Coast and other affected areas. This workforce plan furthers the administration's bold new course for human space flight, which revitalizes NASA and transitions to new opportunities in the space industry and beyond.

Question. The fiscal year 2011 budget includes \$2.5 billion in Constellation contract termination costs, and \$6 billion for new "commercial providers" who likely will suffer the normal cost and schedule growth especially with their level of inexperience and \$312 million for additional COTS money that was never planned. It would seem to be a much more responsible use of taxpayer dollars to use this combined \$8.812 billion to finish the program that has had 5 years worth of progress and accomplishments that is designed to deliver a safer, more reliable, way to send our astronauts to orbit then to hope that the "commercial" providers might come through? Can you please explain how this is not a waste of taxpayer dollars.

Answer. At the highest level, the President and his staff, as well as NASA senior leadership, closely reviewed the Augustine Committee report, and came to the same conclusion as the committee: The human spaceflight program was on an unsustainable trajectory.

To continue on the previous path we had to decide to either continue the ISS, support a program to get humans beyond LEO, or to make even deeper cuts to the other parts of NASA's budget. Further, we would have insufficient funding to advance the state of the art in any of the technology areas that we need to enable us to do new things in space, such as lowering the cost of access to space and developing closed-loop life support, advanced propulsion technology, and radiation protection.

The President determined that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration.

Following the release of the fiscal year 2011 budget request, NASA established six study teams within Exploration Systems Mission Directorate (ESMD) to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new Exploration program. Despite the early nature of these planning efforts, NASA is optimistic that there will be many capabilities developed by the Constellation Program that will feed forward into the new programs. For example, options using the Orion capsule are currently being pursued for autonomous rendezvous and docking; and many of the capabilities we are pursuing at a low level through our Exploration Technology Development Program are directly applicable to the new programs. Other important areas that will enable further advancement in the new initiative areas are: advanced robotics, propulsion development and test, friction stir welding, autonomous landing and hazard avoidance, and entry, descent, and landing technologies.

SOLID ROCKET MOTORS AND THE INDUSTRIAL BASE

Question. In the Solid Rocket Motor Capabilities report to Congress that was released in June 2009, in the executive summary on page 47 it says, "Delays in the NASA Ares program could have significant negative impact on the large solid rocket motor prime contractors industrial base, and on some of the SRM sub-tier base, specifically material suppliers." So the key phrase was "significant negative impact." So if a delay in NASA's Ares program would have a significant negative impact, what would the cancellation of the Ares program have if the administration recommendation goes through as part of the NASA budget in fiscal year 2011? If a delay is a significant negative impact on solid rocket motor industrial base, what's an outright cancellation going to do to the solid rocket industrial base?

Answer. NASA is currently the only customer for large segmented PBAN solid rocket motors and a major user of Ammonium Perchlorate (AP) used to make solid rocket motors (SRMs). As such, cancellation of Constellation would have a major impact on these two industries. However, NASA and DOD are continuing to jointly assess the impacts in the joint study lead by the Office of the Undersecretary of Defense for Industrial Policy on the SRM industrial base. The DOD does not use PBAN large segmented SRMs, but rather smaller monolithic SRMs for strategic missiles, interceptors, and launch vehicle strap-on booster, so they are currently studying the impacts and options as part of the SRM industrial base study. NASA and DOD are also jointly studying heavy lift launch and propulsion related options in a different study, so NASA's future demand for SRBs is not yet clear. Constellation cancellation would require the DOD to fully carry the costs of the necessary SRM industrial base for National security needs and AP costs would likely increase given the lower demand and associated reduced economies of scale.

Question. Please explain why the new Space Exploration plan seeks to stop using solid rocket motors which are the most reliable and capable first stage booster in NASA's inventory with over 100+ successful missions and decades of continuous design and manufacturing process improvements to rely upon a new, unproven system that could put the lives of our Nation's astronauts in jeopardy?

Answer. One measure of launch vehicle safety is identifying the approximate probability of failure for the launch vehicle which can then be determined by summing up the chances of failure of all of its subsystems. For launches of U.S.-built vehicles in the last 20 years, problems with the propulsion system represented a significant portion of all failures therefore addressing reliability during the design of a launch vehicle is paramount to ensuring a safe vehicle. The type of propulsion system (solids versus liquids) is not a discriminator; rather simplicity and redundancy are the keys to high design reliability for any system and launch vehicles are no exception.

With regard to commercial crew, at no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so. NASA has unique expertise and history in this area, and a clearly demonstrated record of success in transporting crew. NASA will bring that experience to bear in the appropriate way to make sure that commercial crew transportation services are a success both programmatically, and with respect to safety. At no point in the development and acquisition of commercial crew transportation services will NASA compromise crew safety. For example, NASA will have in-depth insight of the vehicle design via NASA personnel who are embedded in the contractor's facility. Additionally, NASA will impose strict requirements and standards on all providers that will be carefully evaluated and reviewed at multiple stages before a vehicle system is certified by NASA for crewed flight.

At the highest level, the President and his staff, as well as NASA senior leadership, closely reviewed the Augustine Committee report, and came to the same conclusion as the committee: the human spaceflight program was on an unsustainable trajectory. To continue on the previous path we had to decide to either continue the ISS, support a program to get humans beyond LEO, or make even deeper cuts to other parts of NASA's budget. One key area that is a contributor to the unsustainable nature of the human spaceflight program is the size of the propulsion industrial base. Additionally, we would have had insufficient funding to advance the state of the art in any of the technology areas that we need to enable us to do new things in space, such as lowering the cost of access to space and developing close-loop life support, advanced propulsion technology, and radiation protection. The President recognized that what was truly needed for beyond LEO exploration was game-changing technologies; making the fundamental investments that will provide the foundation for the next half-century of American leadership in space exploration.

With regard to commercial crew, as has been stated earlier, safety is and always will be NASA's first core value. Simply put, U.S. astronauts will not fly on any spaceflight vehicle until NASA is convinced it is safe to do so.

Question. What will happen to the unique workforce that our Nation's defense programs rely upon for the future needs in the Solid Rocket Motor industry if this cancellation of the Ares program is preserved?

Answer. NASA, a discretionary funding-based civil space agency, is not responsible for primary support to the Nation's defense programs. If the Ares projects are cancelled, the DOD will have to fund an appropriately-sized SRM industrial capacity commensurate with its current and future requirements. NASA and DOD are jointly assessing the impacts and solution options. The Office of the Undersecretary of Defense for Industrial Policy is leading a SRM Industrial Base assessment in order to plan for this impact and adequately meet national security needs.

Question. What role do you see the Solid Rocket Motor industry playing in the President's requested plan? What timeframe would solid rocket work be available in the new plan so as to not have to layoff the entire workforce and shutter needed facilities?

Answer. Although NASA has almost 30-years of extensive experience with solid rocket motors on the space shuttle, if humans are to explore destinations beyond low-Earth orbit in the 2020–2025 timeframe, the Nation needs to aggressively bring about an affordable launch capability. The fiscal year 2011 budget request focuses on investing in technologies to improve the costs of liquid propulsion systems in an effort to reduce the overall cost of launch, as well as maintain the propulsion industrial base. NASA will begin heavy-lift vehicle system analyses on all launch vehicle concepts to determine the best affordable and reliable approach.

The fiscal year 2011 budget request does not provide specific funding for SRM development or direct production. However, NASA and DOD are jointly studying heavy lift launch and propulsion-related options in a different study, so NASA's future demand for SRBs is not yet clear. Additionally, any domestic company, including those who have been part of the Constellation program, can, if they choose, compete to be part of NASA's proposed commercial crew development program.

Question. In the technology development program account being created, there is funding for a new 1st stage liquid motor. Who is intended to be the customer using the new liquid first stage motor? How does the research on a new Liquid first stage engine impact the future of the solid rocket industry for NASA and DOD?

Answer. The fiscal year 2011 budget request funds NASA to develop affordable engines for use by multiple customers (NASA, other Government agencies, and commercial) with associated technologies to support those engine development activities. NASA plans to work closely with DOD and commercial entities to develop an affordable, highly reliable hydrocarbon engine that will have multiple users. While there are significant synergies for propulsion system development between NASA and DOD, negotiations are currently underway to formalize a mutually-beneficial development effort to meet the National needs.

As a part of normal program formulation activities, NASA will continue to examine the trade space with regard to heavy-lift vehicles for the next-generation human spaceflight system. The most recent NASA heavy lift study was conducted in November 2009, which resulted from recommendations of the Augustine Committee for NASA to move toward a "flexible path" human exploration. This study included variations of LOX/LH₂ heavy lift vehicle architectures with solid rocket boosters and as well as LOX/Hydrocarbon heavy lift launch vehicle architectures. The LOX/Hydrocarbon vehicle concepts were less mature than the LOX/LH₂ concepts at the time of the November study.

NASA plans to continue studying heavy-lift issues in partnership with the DOD to continue to mature the LOX/Hydrocarbon concepts and to assess potential commonality between NASA, DOD, and potential commercial needs with the primary figure of merit of as “affordability and operability.” As part of this ongoing review, NASA and DOD plan to perform an assessment of the industrial base, as required by Congress.

PRESIDENT’S APRIL 15 SPEECH IN FLORIDA

Question. When the President rolled out his plan for the future of NASA and the manned space program last week, he stated that one of the advantages in re-directing NASA and cancelling the program of record was that his new strategy “begins major work on building a new heavy lift rocket sooner, with a commitment to decide in 2015 on the specific heavy-lift rocket that will take us deeper into space. Can you please explain to me how waiting another 5 years to decide on what technology to use to get us beyond Low Earth Orbit will allow us to develop a heavy-lift capability sooner than what is currently planned with the Ares V? Can you provide a timeline that lays out the specific details how this new plan will be faster?”

Answer. NASA’s goal is to reduce costs and shorten development timeframes for future heavy-lift systems for human exploration. The Nation needs to aggressively bring about an affordable launch capability if humans are to explore destinations beyond low earth orbit in the 2020–2025 timeframe.

The fiscal year 2011 budget request includes funds for NASA to conduct the important research and development and analysis necessary to make an informed decision on a heavy-lift vehicle no later than 2015. A primary focus of this effort will be to conduct research and development on a U.S. first-stage hydrocarbon engine for potential use in heavy lift and other launch systems, as well as basic research in areas such as new propellants, advanced propulsion materials manufacturing techniques, combustion processes, propellant storage and control, and engine health monitoring. Additionally, NASA will initiate development and testing of in-space engines. Areas of focus could include a liquid oxygen/methane engine and lower-cost liquid oxygen/liquid hydrogen engines. This work will build on NASA’s recent R&D experience in this area, and the test articles will be viewed as a potential prototype for a subsequent operational engine that would be re-startable and capable of high acceleration and reliability. These technologies will increase our heavy-lift and other space propulsion capabilities and is intended to significantly lower costs—with the clear goal of taking us farther and faster into space consistent with safety and mission success criteria. In support of this initiative, NASA will explore cooperative efforts with the DOD and also develop a competitive process for allocating a small portion of these funds to universities and other non-governmental organizations. This research effort along with many of our new technology initiatives will be coordinated with the broader agency technology initiative led by NASA’s new Chief Technologist.

In addition to investing in transformative heavy-lift technologies, on April 15, 2010, the President called upon NASA to select a rocket design no later than 2015 and then begin to build it; a decision no later than 2015 means that major work on building a new heavy-lift rocket will likely begin 2 years sooner than in the previous plan.

NASA is in the process of assessing the best approach for implementing this new direction. The initial strategy employs a rigorous systems analysis effort starting at the overall launch vehicle system level to define the top-level requirements for the heavy lift launch system that can support multiple end users. This includes setting performance goals, identifying lift capability, propellant suite for each launch vehicle stage as examples of top-level requirements.

On May 3, 2010, NASA issued a Request for Information (RFI) seeking general information regarding potential launch or space transportation architectures (expendable, reusable, or a hybrid system) that could be utilized by multiple customers (e.g., NASA, commercial and other Government agencies). The RFI solicits information regarding propulsion system characteristics; technology challenges for propulsion systems; as well as innovative methods to manage a heavy-lift development program to include effective and affordable business practices. The RFI is open to the broad space community, including commercial, other Government agencies and academia. Information obtained from the RFI will be used for planning and acquisition-strategy development for current heavy-lift planning activities, funded in the fiscal year 2010 Consolidated Appropriations Act (Public Law 111–117).

Related to the RFI, on May 19, 2010, NASA posted a draft Broad Area Announcement (BAA). This draft BAA is soliciting proposals for a Heavy Lift and Propulsion Technology Trade study and seeks industry input on technical solutions in support

of heavy lift system concepts studies. This draft BAA requests offerors to expand upon the previous NASA technical assessments. The final BAA solicitation, issued on June 30, 2010, incorporates information obtained via the RFI as well as inputs from an Exploration industry workshop held in May 2010. These concept studies will include architecture assessments of a variety of potential heavy lift launch vehicles and in-space vehicle architectures employing various propulsion combinations and how they can be deployed to meet multiple mission objectives. All possible launch vehicle concepts will be evaluated to identify the best configuration to meet the Nation's needs. In addition, the studies performed during the execution of the BAA will identify technology gaps for heavy lift and propulsion systems to influence the suite of space launch propulsion technologies that need to be addressed as part of a development program. (Please note, the BAA is addressing fiscal year 2010 planned activities which may also contribute to future plans and activities.)

The first major decision point for a heavy lift launch vehicle is anticipated to be in March 2011, at the completion of the BAA study effort, where NASA will have defined the optimum lift capability to meet multiple end users (NASA, DOD, and commercial) propellant suite for the launch vehicle stages, engine thrust level as well as other launch vehicle performance goals. At this point, without additional study funding, NASA will have the necessary information to make an informed decision to start the development of a heavy lift launch vehicle, pending adequate funding is available for the follow on heavy-lift vehicle development effort.

Question. When the President submitted his budget in February, it was thought by many that he was proposing cancelling the entire Project Constellation Program to include the Orion crew capsule? Can you provide insight as to why the change? In other words, what happened between February and April of this year that made him change his mind? Was the decision based on a cost analysis or some new requirement? To that end, did NASA program managers and cost analysts review the program at that time to compare the pros and cons of a full Orion crew capsule versus one that will only be used as an emergency escape vehicle?

Answer. The President clarified our position on Orion during his April 15 speech at Kennedy Space Center, Florida. NASA's efforts to develop an emergency rescue vehicle would be based on the good work already completed on the Orion crew capsule and would focus the effort to provide a simpler and more efficient design that would provide crew emergency escape from the ISS and serve as part of the technical foundation for advanced spacecraft to be used in future deep space missions. This approach also would preserve a number of critical high-tech industry jobs in key disciplines needed for our future deep space exploration program. NASA has put together a formulation team including Headquarters and Center personnel to develop a baseline approach that meets these requirements, balanced with the other priorities proposed in the President's fiscal year 2011 budget request. NASA will provide this information to Congress, including estimated costs, as soon as they are finalized.

Question. Since the President is proposing an increase in the NASA budget of \$6 billion over the next 5 years, the change in NASA emphasis is clearly not about trying to reduce deficit, correct? With the overall budget increasing, how much does the exploration portion for the budget change? If the previous exploration budget did not result in a sustainable program, how does a major reduction of \$2 billion this year for exploration and \$6 billion over the next 4 years alleviate that problem? Doesn't such a major reduction in exploration budget substantiate the public concern that we are on a path to nowhere?

Answer. In the fiscal year 2011 President's budget request, the requested budget for exploration is almost \$500 million more than the fiscal year 2010 enacted level, and the projected budget for exploration in fiscal year 2015 is \$1.4 billion higher than the fiscal year 2010 enacted level—an increase of 37 percent in 5 years. While the fiscal year 2011 budget request, reflects less funding for exploration than anticipated in the fiscal year 2010 request, funding for NASA as a whole increases \$6 billion over 5 years despite a tough budget environment.

The fiscal year 2011 budget request outlines an innovative course for human space exploration, but does not change our goal—extending human presence throughout our solar system. NASA will lead the Nation on this new course of discovery and innovation, providing the technologies, capabilities and infrastructure required for sustainable, affordable human presence in space. NASA's investment in gaining critical knowledge about future destinations for human exploration, as well as transformational technology development and demonstration will serve as the foundation of NASA's ongoing space exploration effort, broadening opportunities for crewed missions to explore destinations in our solar system that we have not been to before.

The President stated in his speech at KSC on April 15, 2010, that, “Early in the next decade, a set of crewed flights will test and prove the systems required for exploration beyond low Earth orbit. And by 2025, we expect new spacecraft designed for long journeys to allow us to begin the first-ever crewed missions beyond the Moon into deep space. So we’ll start—we’ll start by sending astronauts to an asteroid for the first time in history. By the mid-2030s, I believe we can send humans to orbit Mars and return them safely to Earth. And a landing on Mars will follow. And I expect to be around to see it.”

With a NEO and Mars as the key long-term destinations for NASA, we must begin to identify missing capabilities needed for such a mission. Mass is a huge barrier for a Mars mission because higher mass drives up cost, and it slows down progress. More mass without advanced technologies, such as advanced propulsion techniques or ways to prevent fuel boil-off in space, means that it will take more trips to lift resources into LEO for Mars missions and substantially more flights required to transport required resources to Mars. The same sort of scenarios also apply to missions for other beyond-LEO missions—more mass without advanced technologies will only serve to drive up costs and extend schedule, pushing our chances of breaking free of LEO even further into the future.

In summary, while a timeline and budget plan for a manned Mars and other beyond-LEO missions is still in work, NASA believes that the benefits of the aforementioned technology development efforts along with anticipated infrastructure efficiencies will lead to sustainable manned missions to beyond-LEO destinations sooner and at less cost than missions currently envisioned under the Constellation Program.

Question. Please quantify how the new plan creates 2,500 more jobs than Constellation would have by 2012? Since the new plan is advertised to be so good at creating new jobs in general and in Florida in particular, why is a \$40 million transition program needed to retrain the displaced aerospace workers at Kennedy Space Center? Is this also going to be available in other States impacted by this decision?

Answer. The fiscal year 2010 plan, which included retirement of the space shuttle and little need for build-up of workforce for Constellation launches, shows a drop of nearly 7,000 in total workforce demand in Florida, from just over 14,000 total contractors needed in 2010 to approximately 8,500 needed in 2012. These estimates include direct labor and support labor in Florida, both contractor and civil servant, for both fiscal year 2010 and fiscal year 2011 President’s budget request (PBR) plans.

The fiscal year 2011 PBR plan extends the space shuttle 3 months, and locates a large amount of work in Florida, including but not limited to the 21st Century Space Complex construction and the program office for the Commercial Crew Program. Additionally, NASA’s proposed plan identifies Kennedy Space Center as the deputy program office for the new Flagship Technology Demo program, which will bring some additional workforce demand. The estimates are that workforce demand for the fiscal year 2011 PBR plan will begin and remain higher than the fiscal year 2010 plan, starting at nearly 15,000 needed and falling to approximately 12,000 needed in 2012. This is an increase of as much as 3,500 over the fiscal year 2010 plan, depending on assumptions of how much design and manufacturing work the commercial crew providers locate in Florida.

NASA will continue to refine these estimates as program definition matures in preparation for the August 2010 Workforce Transition Strategy report submitted to Congress.

The space shuttle program employs thousands of people in the Kennedy Space Center area. While the proposed fiscal year 2011 programs and funding planned for the Kennedy Space Center will create more jobs than the previous plans, NASA anticipates job losses in the community by the end of space shuttle program. The transition funding mentioned is intended to mitigate the impact of this loss.

The administration has recently announced a comprehensive initiative, funded at a level up to \$100 million, to support economic growth and job training in Florida and other regions affected the shuttle retirement and other programmatic changes in NASA’s exploration program. While the initiative began on April 15, 2010, when the President announced a \$40 million initiative to aid the areas around Kennedy Space Center, the Task Force established pursuant to the President’s direction was also directed to prepare a plan that “explores future workforce and economic development activities that could be undertaken for affected aerospace communities in other States, as appropriate.”

Several States and county officials have been applying for workforce-related grants through existing Federal programs. On June 2, 2010, Secretary of Labor Solis announced the award of an additional \$15 million in workforce re-training funds for aerospace workers in Brevard County, Florida. In addition, on April 30,

2010, the Department of Labor announced a \$1.2 million grant to assist approximately 200 workers affected by layoffs at ATK Launch systems in Corinne, Utah, in connection with the transition of the space shuttle and Constellation programs. It is our understanding that the communities impacted within the State of Texas have also applied for assistance from the Department of Labor.

Question. The latest proposal by the President changes the Orion crew capsule development effort to provide stand-by emergency escape capabilities for the space station—thereby reducing our reliance on foreign providers. Does this in any way impact our ability to send U.S. Astronauts into space? If not, how much are we planning on spending on this “empty-shell” capsule? Isn’t the net result an expensive crew escape vehicle that duplicates what Soyuz already does and eliminates capability of using Orion for beyond Low Earth Orbit (LEO) missions? Does this change in Orion mission change the potential termination liability to Lockheed-Martin if Orion were to have been cancelled as proposed in original budget submittal from the President?

Answer. NASA will provide details of this plan, including estimated costs, as soon as they are finalized.

In addition to developing a U.S. commercial crew capability, creating an American-made crew escape capability will improve our ability of sending astronauts into space because it will lessen our dependence on foreign providers. Currently, NASA has purchased Soyuz seats through 2014 and it has legislative authority to purchase additional seats through 2016. However, if we need to purchase seats beyond July 1, 2016, NASA would need to secure legislative relief from the Iranian North Korean and Syria Nonproliferation Act.

While it is likely that the President’s proposed change to the Orion crew capsule would change Lockheed Martin’s current estimate of potential termination liability, it is too early in the process to estimate the difference.

Question. In late 1990s and early 2000s NASA embarked on game changing technology developments and spiral development of launch vehicles to significantly reduce cost of access to space, as part of Next Generation Launch Technology (NGLT) and 2nd Generation Launch Vehicle (2ndGen) programs. These initiatives resulted in the spending of billions of dollars on X-33 and X-34 single stage to orbit (SSTO) vehicles, RS-84 LOX/RP engine, and Orbital Space Plane (OSP), to mention a few, all of which were canceled. How is the current plan going to be successful when the same approach failed a decade ago? Why do we want to spend \$3 billion on heavy lift technology development of a LOX/RP engine that is the same technology that flew on Saturn V 40 years ago? How is LOX/RP engine development considered game changing technology development?

Answer. Several recently released reports have described the agency’s current plans for development of vehicles to access to LEO as being unsustainable for various reasons. The Office of Science Technology and Policy (OSTP) also performed an assessment of the current U.S. space launch industry (published in a report dated December 22, 2009) and came to a key conclusion: that although “. . . the U.S. space launch propulsion industrial base provides a diverse range of technologies and more than adequate production capacity . . .” the current U.S. industrial base “. . . is under significant stress, due largely to low demand.” The OSTP report further identifies a key driver in the loss of U.S. space launch services to foreign providers is due to development costs and overall performance. This situation has numerous serious consequences for the Nation, including loss of the global space launch market to foreign providers to the atrophy of the propulsion systems supply chain and associated loss of workforce skills and sub-tier providers. This imbalance between supply and demand could lead to the erosion of the Nation’s technical leadership should this overcapacity and low demand scenario be allowed to continue.

An approach to solving this imbalance is to direct the U.S. Government to invest in space launch propulsion-related activities that will “identify potential breakthrough cost savings or performance opportunities in launch vehicle propulsion.” (OSTP December 22, 2009 report.)

Question. Orion is part of Project Constellation. As such, it is being designed and developed concurrently with other major components of the program. I assume it is being designed to fly on an Ares rocket. Since the proposed plan appears to cancel Ares, are there any concerns that designing the capsule independently of the booster will create mating problems or interoperability problems at some point in the future?

Answer. The Orion Crew Exploration Vehicle is being designed—and will continue to be designed until a change is authorized by Congress—to fly on an Ares I launch vehicle. In the President’s proposed plan, the emergency return vehicle (ERV) variant of Orion would be launched on an existing expendable launch vehicle system. Integration of the ERV with its launch vehicle (including factors such as physical

mating interfaces, interoperability, induced loads environments, and rocket lift capability) will be extremely important to assess in detail as the design and implementation moves forward, assuming Congress approves the President's budget recommendation. Preliminary, low-fidelity assessments to date suggest that there are feasible options for launching an ERV on an existing rocket. Design-driving loads and environments induced by Ares I, for which Orion is currently designed, are expected to envelope those for existing rockets. Thus, major problems with launch vehicle integration are not expected.

Question. Specifically related to cost, I would also like to know NASA's plans for operating the Orion crew capsule. Can you tell me how expensive it will be to launch the escape capsule? Would an Orion escape capsule be redundant seeing the Russian Soyuz capsule that our American astronauts would still need to use to get to the ISS would be docked and capable of being used as an emergency capsule?

Answer. NASA has put together a formulation team including Headquarters and Center personnel to develop a baseline approach for the ERV. NASA will provide details of this plan, including estimated costs, as soon as they are finalized. However, in general, the objective is to create an American crew escape capability that will increase the safety of our crews on the space station, reduce our dependence on foreign providers, and simplify requirements for other commercial crew providers. This effort will also help establish a technological foundation for future exploration spacecraft needed for human missions beyond low-Earth orbit and will preserve some critical high-tech contractor jobs in Colorado, Texas, and Florida.

Question. I imagine the escape vehicle would need to be periodically inspected and replaced to ensure it is operational in the critical time of need. How often would the Orion emergency escape capsule need to be replaced once docked to the ISS? To go beyond Low Earth Orbit, will another crew capsule need to be developed, i.e. will Orion have the capability of being used for anything other than an emergency vehicle for the ISS? How much money is saved by restricting the Orion crew capsule vice the current program of record? Does the analysis for any potential cost savings take into account the money NASA would provide private industry to develop a different manned crew capsule?

Answer. The ERV would have to be maintained in a safe and ready state during its entire stay at the ISS. Indeed, periodic inspections and checkouts by the ground and/or ISS crew will likely be required, but details for such will not be established until design work commences. The current Orion Crew Exploration Vehicle is being designed to stay docked to ISS for up to 210 days. In contrast, the ERV would be designed to at least equal this life, but a longer docked life is being assessed as a goal for the ERV requirements. Initially, the ERV would be designed only for the ISS emergency return mission. However, per the President's proposed plan, it will also serve as a technical foundation for a future crew exploration vehicle. The specific extensibility of ERV technologies to the future vehicle(s) is currently being assessed. A bottoms-up cost estimate for the ERV is in work, along with the program requirements, acquisition plan, and implementation strategy. Results are expected to be completed over the next couple of months, and cost comparisons with the existing Orion project will be available at that time.

FUTURE OF CONSTELLATION

Question. General Bolden, in a meeting with two of my colleagues in the Utah Congressional Delegation on Friday April 16, you reportedly clarified that, as far as you are concerned, the Constellation program was not dead under the administration's new plan. You reportedly said that you wished that the term "cancelled" could be removed from the current debate. What do you mean, exactly, by stating that you don't think Constellation is dead? It's clear that you would kill the Ares solid rockets, would you not? You would kill everything except a scaled-down Orion space capsule? Is that one piece of hardware from Constellation—the Orion capsule, sufficient for you to consider that Constellation lives? Please define what you mean by Constellation is still alive?

Answer. Following the release of the fiscal year 2011 budget request, NASA established six study teams within ESMD to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation program and to plan for the implementation of the new Exploration program. The work undertaken by these teams is a necessary part of that planning. One team, the Constellation Transition team, has initiated a broad survey of current workforce, contracts, facilities, property, security, knowledge capture, information technology, and other Government agency interface issues to determine what infrastructure and hardware could be used by the new programs and projects.

Despite the early nature of these planning efforts, NASA is optimistic that there will be many capabilities developed by the Constellation program that will feed forward into the new programs. For example, options using the Orion capsule are currently being pursued for autonomous rendezvous and docking; and many of the capabilities we are pursuing at a low level through our Exploration Technology Development program are directly applicable to the new programs. Other important areas that will enable further advancement in the new initiative areas are: advanced robotics, propulsion development and test, friction stir welding, autonomous landing and hazard avoidance, and entry, descent, and landing technologies.

Additionally, on April 15, 2010, President Obama laid out the goals and strategies for his new vision for NASA. In doing so, he directed NASA to build on the good work already completed on the Orion crew capsule and focus the effort to provide a simpler and more efficient design that would provide crew emergency escape from the ISS and serve as part of the technical foundation for advanced spacecraft to be used in future deep space missions. NASA plans to be able to launch this vehicle within the next few years, creating an American crew escape capability that will increase the safety of our crews on the space station, reduce our dependence on foreign providers, and simplify requirements for other commercial crew providers. This approach also will preserve a number of critical high-tech industry jobs in key disciplines needed for our future deep space exploration program.

NASA'S GOALS

Question. General Bolden, one of the biggest criticisms of the administration's and NASA's old and new plan is the lack of a clear goal for all of this new science and technology that you purport to develop and fund on the carcass of Constellation. The President said he hopes to live to see the day when the United States has a mission to Mars, or to an asteroid. That's all well and good, but that's so vague without a specific roadmap on how to get there. At least Constellation had a clear goal; back to the moon as a stepping stone for perfecting long-term basing in space, and then on to Mars. Does this new, revised plan have a specific goal, with specific timelines or milestones we can look to in judging its effectiveness?

Answer. Under the fiscal year 2011 budget proposal, NASA would build technologies to support a sequence of deep-space destinations matched to growing capabilities, progressing step-by-step, beginning with crewed flight tests—perhaps a circumlunar mission—early next decade of vehicles for human exploration beyond LEO, a human mission to an asteroid by 2025, and a human mission to orbit Mars and return safely to Earth by the 2030s. A date for a manned lunar mission, however, has not been established.

NASA's ESMD would lead the Nation on this new course of discovery and innovation, providing the technologies, capabilities and infrastructure required for sustainable, affordable human presence in space. Many of these capabilities have been recommended consistently for at least 24 years in national level reports of committees and commissions addressing future human space exploration. ESMD's investment in gaining critical knowledge about future destinations for human exploration, as well as transformational technology development and demonstration will serve as the foundation of NASA's ongoing space exploration effort, broadening opportunities for crewed missions to explore destinations in our solar system that we have not been to before. We have not sent people beyond low-Earth orbit in 38 years, and this budget gives us the great opportunity to focus on scouting and learning more about destinations to further explore our solar system and to develop the game-changing technologies that will take us there. It is important that we pursue these objectives to continue leading the world in human space exploration.

Pursuant to the President's proposed new course, NASA has initiated planning activities to be able to effectively and efficiently implement these new activities in a timely manner upon Congressional enactment of the fiscal year 2011 budget. In April, NASA outlined for the subcommittee the agency's planned major program assignments across the agency's centers for new or extended activities proposed as part of the President's fiscal year 2011 budget request. These planned assignments build on the deep knowledge and expertise that NASA has built up over five decades, recognize the wealth of experience, commitment, and expertise resident at the NASA centers, and expand upon the strengths at each center. Additionally, following the release of the fiscal year 2011 budget request, NASA established study teams within ESMD to ensure we understand the steps (and the implications of those steps) that would need to be taken for an orderly transition of the Constellation Program and to plan for the implementation of the new initiatives in the Exploration program. The work undertaken by these teams is a necessary part of that planning.

NASA is taking prudent steps to plan for the new initiatives included in the fiscal year 2011 budget request, including Requests for Information (RFI), workshops, and preliminary studies. NASA is eager to seek external input from industry, academia, and other partners, and plans to accomplish this via a series of RFIs and industry workshops conducted this spring and into the summer. Doing so will ensure that NASA receives important feedback from our space partners before it begins to finalize its implementation plans for the proposed technology demonstrations and human spaceflight systems development activities that will be supported by the fiscal year 2011 budget, once approved by Congress. During CY 2010, NASA plans to issue a series of program formulation documents seeking input from the broader space community.

Finally, NASA also has established the Human Exploration Framework Team (HEFT) to serve as a cross-agency planning activity. The team is being led by the ESMD and staffed with technical leaders from across NASA centers. The team is focused on developing and reviewing the integrated set of requirements and technologies required for future human spaceflight missions to many destinations, including Mars. As part of its broad integration charter, HEFT will develop implementation recommendations on the performance and pacing requirements for the technologies needed for future human exploration missions using “design reference missions,” or DRMs. These DRMs will be the basis for validating capabilities and missions for 5-, 10-, and 15-year horizons, with milestones including crewed missions beyond the Moon into deep space by 2025, sending astronauts to an asteroid, and eventually landing on Mars. NASA expects to have initial products from the HEFT team this summer.

FUTURE OF SOLID ROCKETS AND ARES TECHNOLOGY

Question. General Bolden: Do you foresee any opportunity for NASA to avail itself of the Ares solid rocket technology under the new revised announcement by the President? Will Ares be considered eligible to compete for any of the \$3.1 billion he announced for research and development into a heavy-lift vehicle?

Answer. NASA will begin heavy lift vehicle system analyses on various launch vehicle concepts to determine the best approach that meets the affordability and reliability figures of merit. The administration is not opposed to using solid rocket motors. Concept heavy-lift launch vehicles could include solid rocket motors as well as liquid strap-ons and all concepts will be evaluated during a rigorous systems analysis effort to identify the best heavy-lift configuration to meet the Nation’s needs.

QUESTIONS SUBMITTED BY SENATOR THAD COCHRAN

ROCKET TESTING COMPLEX

Question. Administrator Bolden, the budget includes more than \$2 billion over the next 5 years for development of a 21st Century Launch Complex at Kennedy Space Center. I am concerned that we are building a 21st Century Launch Complex, but will be stuck with a 20th century engine testing complex. No rocket will be launched from Kennedy without first undergoing extensive testing at Stennis. Yet there are no funds in the budget request for facility upgrades at Stennis. Given NASA’s interest in safety, shouldn’t we invest a proportional level of resources into NASA’s premier engine testing complex? What upgrades would you propose to make Stennis a 21st century rocket testing complex?

Answer. NASA is providing \$13.8 million in American Recovery and Reinvestment Act appropriations for the following activities at Stennis Space Center (SSC): (1) test stand upgrades to support commercial AJ26 engine testing; (2) modernization of the high pressure gas facilities that support the test stands; (3) completion of test complex communication systems; and (4) repair of the Test A2 liquid oxygen/hydrogen delivery system. These activities can support both NASA and commercial engine development activities. In the initial fiscal year 2010 Operating Plan, NASA added \$3.0 million for the A-3 test stand, increasing the budget from \$16.9 million to \$19.8 million in fiscal year 2010. The additional funds have enabled work to continue on this project.

Beyond these efforts, NASA is working to determine what further investments are to be made at SSC to support launch vehicle testing. The Exploration Systems Mission Directorate has identified preliminary estimates for Stennis facility requirements in support of Heavy Lift and Propulsion Technology, which involve test stand investments that are expected to be needed for all heavy-lift options being addressed. While preliminary assessments are still being refined, NASA currently expects to conduct fiscal year 2011 effort in the following areas:

- Continued Construction of A-3 Rocket Propulsion Test Facility.
- E-Complex (RP component testing); funding will support test stand design activities and long lead item ordering.
- B2 Test Facility (RP engine testing); funding will support design activities, refurbishment, long-lead ordering.
- LOX/LH2 engine testing; Exploration Systems will likely recommend LH2 testing of an existing engine but it will not require facility mods.

HEAVY LIFT VEHICLE

Question. Mr. Administrator, when we met in October, I was very pleased to hear your enthusiasm for NASA's role in development of a Heavy Lift Vehicle and for the unique capabilities the A-3 test stand at Stennis is going to provide for the engine testing of these vehicles. As NASA moves forward with research, development and testing of a Heavy Lift Vehicle, what will be the role of this unique national asset, the A-3 test stand, and is completion of its construction critical to the development of a Heavy Lift Vehicle?

Answer. NASA made a determination in June to complete the A-3 test stand. NASA is in the early planning stages of identifying the preliminary engine testing that will be required within the heavy lift program, and specific test facilities have not been identified to date.

TESTING OF COMMERCIAL LAUNCH VEHICLES

Question. Given the proposed focus of allowing the private sector to develop and operate Low Earth Orbit launch vehicles and your commitment to safety, it seems NASA's testing facilities would take on an increased significance. What are your plans to ensure testing capabilities and facilities are adequately funded for the future, and what role could you see Stennis Space Center playing in the testing of commercial launch vehicles?

Answer. NASA is providing \$13.8 million in American Recovery and Reinvestment Act appropriations for the following activities at Stennis Space Center (SSC): (1) test stand upgrades to support commercial AJ26 engine testing; (2) modernization of the high pressure gas facilities that support the test stands; (3) completion of test complex communication systems; and (4) repair of the Test A2 liquid oxygen/hydrogen delivery system. These activities can support both NASA and commercial engine development activities.

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- LOX/LH2 engine testing; Exploration Systems will likely recommend LH2 testing of an existing engine but it will not require facility mods.

NASA's upgrades at SSC can support both Government and commercial launch vehicle testing, and the agency will make the facility available as an option for commercial vendors.

HEAVY LIFT VEHICLE

Question. Administrator Bolden, President Obama said in his speech last week that he is committed to choosing a final design for the new Heavy Lift Vehicle no later than 2015. You and I agreed in our October meeting that development of a Heavy Lift Vehicle is one of the most critical initiatives NASA will take on in the coming years. Would choosing a Heavy Lift Vehicle design earlier than 2015, say in 2011 or 2012, accelerate the President's proposals and fill some of the Space Center mission gaps that have members of this body so concerned? This seems like it could be a major part of a fairly reasonable compromise between the President's goals and the wishes of those in Congress who are concerned about the cancellation of Constellation.

Answer. NASA's goal is to reduce costs and shorten development timeframes for future heavy-lift systems for human exploration. The Nation needs to aggressively bring about an affordable launch capability if humans are to explore destinations beyond low-Earth orbit in the 2020–2025 timeframe. Thus, as noted in the question, on April 15, 2010, the President called upon NASA to select a rocket design no later than 2015 and then begin to build it; a decision no later than 2015 means that major work on building a new heavy-lift rocket will likely begin 2 years sooner than in the previous plan. NASA is in the process of assessing the best approach for implementing this new direction. The initial strategy employs a rigorous systems analysis effort starting at the overall launch vehicle system level to define the top-level requirements for the heavy lift launch system that can support multiple end users. This includes setting performance goals, identifying lift capability, propellant suite for each launch vehicle stage as examples of top-level requirements.

On May 3, 2010, NASA issued a Request for Information (RFI) seeking general information regarding potential launch or space transportation architectures (expendable, reusable, or a hybrid system) that could be utilized by multiple customers (e.g., NASA, commercial and other Government agencies). The RFI solicits information regarding propulsion system characteristics; technology challenges for propulsion systems; as well as innovative methods to manage a heavy-lift development program to include effective and affordable business practices. The RFI is open to the broad space community, including commercial, other Government agencies and academia. Information obtained from the RFI will be used for planning and acquisition-strategy development for current heavy-lift planning activities, funded in the fiscal year 2010 Consolidated Appropriations Act (Public Law 111–117).

Related to the RFI, on June 30, 2010 NASA posted a Broad Area Announcement (BAA). This BAA is soliciting proposals for a Heavy Lift and Propulsion Technology Trade study and seeks industry input on technical solutions in support of heavy lift system concepts studies. It requests that offerors expand upon previous NASA technical assessments and incorporates information obtained via the RFI as well as inputs from an Exploration industry workshop held in May 2010. These concept studies will include architecture assessments of a variety of potential heavy lift launch vehicles and in-space vehicle architectures employing various propulsion combinations and how they can be deployed to meet multiple mission objectives. All possible launch vehicle concepts will be evaluated to identify the best configuration to meet the Nation's needs. In addition, the studies performed during the execution of the BAA will identify technology gaps for heavy lift and propulsion systems to influence the suite of space launch propulsion technologies that need to be addressed as part of a development program. (Please note, the BAA is addressing fiscal year 2010 planned activities which may also contribute to future plans and activities.)

The first major milestone for a heavy lift launch vehicle is anticipated to be in March 2011, at the completion of the BAA study effort, where NASA will have defined the optimum lift capability to meet multiple end users (NASA, DOD, and commercial) propellant suite for the launch vehicle stages, engine thrust level as well as other launch vehicle performance goals.

SAFETY AND MISSION ASSURANCE TECHNICAL AUTHORITY

Question. The Center Management and Operations Program, Safety and Mission Assurance (SMA) Technical Authority fiscal year 2011 budget has an increase of \$4 million over the fiscal year 2010 enacted level (\$51.6 million fiscal year 2010 enacted to \$55.5 million fiscal year 2011), however, Stennis Space Center, who received funding in fiscal year 2010 is not included in this portion of the President's fiscal year 2011 budget. Stennis is the only center to receive funding in fiscal year 2010 and not be included in the fiscal year 2011 budget. Your fiscal year 2010 budget projected continued funding for SMA Technical Authority at Stennis Space Center? What has changed to cause that funding to no longer be necessary?

Answer. The table included on Page CROSS—12 of the fiscal year 2011 budget estimates are incorrect. The total shown for SMA Technical Authority is correct, but the Stennis Space Center line was inadvertently omitted from the table. The correct table is shown below:

[In millions]

SMA Technical Authority	2010 Enacted	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013	Fiscal Year 2014	Fiscal Year 2015
Ames Research Center	\$3.4	\$3.8	\$3.9	\$4.1	\$4.2	\$4.4
Dryden Flight Research Center	\$4.6	\$4.9	\$5.0	\$5.2	\$5.4	\$5.6
Glenn Research Center	\$2.1	\$2.2	\$2.3	\$2.4	\$2.5	\$2.6
Goddard Space Flight Center	\$12.6	\$14.5	\$15.1	\$15.8	\$16.4	\$17.1

[In millions]

SMA Technical Authority	2010 Enacted	Fiscal Year 2011	Fiscal Year 2012	Fiscal Year 2013	Fiscal Year 2014	Fiscal Year 2015
Johnson Space Center	\$6.8	\$6.6	\$6.8	\$7.1	\$7.3	\$7.6
Kennedy Space Center	\$9.3	\$10.7	\$11.0	\$11.3	\$11.6	\$11.9
Langley Research Center	\$3.1	\$3.2	\$3.3	\$3.4	\$3.6	\$3.7
Marshall Space Flight Center	\$8.2	\$8.5	\$8.8	\$9.2	\$9.4	\$9.8
Stennis Space Center	\$1.3	\$1.4	\$1.4	\$1.5	\$1.5	\$1.5
Total	\$51.6	\$55.6	\$57.6	\$59.9	\$62.0	\$64.2

Note.—Totals may not sum precisely due to rounding.

QUESTIONS SUBMITTED TO JOHN FROST

QUESTIONS SUBMITTED BY SENATOR KAY BAILEY HUTCHISON

SPACE STATION SAFETY AND SUSTAINABILITY

Question. On page two of your Annual Report for 2009, it is stated: “While many threats impact the safety of the astronauts and the ISS, one of the biggest challenges is resupply and sustainability. A combination of shuttle, Soyuz and Progress flights has performed this mission admirably over the past 6 years.” It went on to describe NASA plans to develop commercial Cargo Resupply Services, as well as developments of resupply capabilities by the European and Japanese space agencies, and express “satisfaction” at the progress being made in developing those capabilities. Beyond that, there is not much said about space station safety and sustainability in your report. Elsewhere in your report, and in the previous year’s report, your panel states its view that continued shuttle flights beyond the planned termination date of 2010 is “unwise.” You don’t say it is “unsafe,” as many media reports and others have claimed.

I presume that, if the Panel felt the space shuttle was “unsafe” you would have recommended it stop flying immediately. Is that a correct assumption?

Answer. Safety is a concept that only has meaning in a comparative sense. No significant activity, especially one in space, is free of risk. The question to be asked is whether the anticipated risk exceeds that which the program has found as acceptable. If the ASAP felt that the risk involved in continuing to fly the shuttle to complete its manifest was inconsistent with the level NASA had judged as acceptable, or if the risks were unnecessary or inconsistent with policies and procedures that NASA had described as applicable, the ASAP would have certainly informed NASA and Congress of that fact. Our reports to Congress have consistently provided the assessment that while the shuttle does not, and cannot, offer the degree of safety that a modern, safety optimized vehicle can provide, given the scrupulous attention to detail and extraordinary care NASA has been applying to its support, it is capable of completing its assigned missions with a risk that NASA has long accepted.

Question. During questioning following your verbal testimony, you claimed the shuttle was unsafe simply because each flight increases the odds of an accident on the next flight, not because each shuttle deteriorates in an unsafe manner from one flight to the next. This analysis is not included in any ASAP report. Please detail extensively any reasons or rationale ASAP considers shuttle flights beyond the planned termination date of 2010 to be “unsafe” or “unwise.”

Answer. The ASAP does not believe that “each flight increases the odds of an accident on the next flight”. As I stated in my testimony, because the shuttle’s systems have not exhibited signs of an imminent “wear out”, its short term risk is thought to be relatively steady. The increasing risk that I referred to in my testimony was the accumulation of risk over time with each launch as the shuttle’s safety systems are challenged more and more times. Statistically, this can be equated to rolling dice. The probability of eventually rolling snake eyes is proportional to the number of times you roll the dice. That being said, the Shuttle certainly is an aging system which, over the years, has had desirable safety improvements tabled or only partially implemented because of its limited remaining service life. The risk decisions behind those choices would need to be reexamined were the shuttle to continue to fly for any significant extended period. Additionally, many Shuttle components are gradually reaching the end of their safe use life. These components would also require evaluation, test and potential replacement. The Columbia Accident Investigation Board recognized that this process was both natural and inevitable and there-

fore recommended that if the shuttle were to be extended that it go through a rigorous recertification program. We agree.

Question. It is clear that no thorough and complete analysis has been done by NASA to ensure that the basic space station systems, including life support systems, aboard the ISS will be able to function through 2020 without additional spares, replacements, or refurbishment. It is also unclear whether any such items that might be needed are of a size and weight that can only be delivered by the space shuttle (things like spare radiators or solar arrays, which are essential for power and thermal control of the station.)

Shouldn't this be an issue of concern to the Aerospace Safety Advisory Panel?

Answer. We agree and have begun a more detailed look at these issues. The ISS life extension is significant and could have broad safety implications.

Question. Have you begun any review of this issue or requested information from NASA, in view of the decision to extend the station through at least 2020?

Answer. While the Panel has not performed a detailed assessment of an ISS life extension, the Panel did provide one member of a congressionally mandated cross functional review in 2007 of the space station survivability given the various risks to which it is exposed. That review concluded that the largest threat to ISS survivability was Micrometeorite/Orbital Debris impact. Recommendations were made to minimize that risk. The ASAP has now begun to look at the various issues that are involved in the ISS life extension.

Question. In your report for 2009, you mention the Safety and Mission Assurance Technical Excellence Program (STEP) and state "One STEP goal is to transition the Safety and Mission Assurance professionals' focus from an operating focus for shuttle and space station to a design focus for building the next generation of manned space vehicles."

Given a decision to extend the station through 2020, shouldn't there remain a focus by the STEP program on space station safety issues?

Answer. Yes, recent programmatic changes, including the ISS life extension, will require adjustments in the focus of the STEP Program.

Question. Which safety issues in particular should be assessed?

Answer. Significant changes are being proposed in the role that NASA personnel play in the research and development, acquisition, and operation of space programs. The proposed use of commercial providers for crew transport in particular would require a very different approach to verification, validation, and certification than NASA has traditionally used. Once policies to address these requirements are solidified, significant changes in the training, allocation, and organization of NASA personnel may be required. STEP will need to be adjusted accordingly.

HUMAN RATING REQUIREMENTS—COMMERCIAL AND SOYUZ

Question. The ASAP Report addressed the issue of Human Rating Requirements for commercial crew capabilities, which had been raised as an option during the Augustine panel review—a review of which the report was rather critical. While a focus by the panel on the development of those requirements is appropriate, a statement made in that section of the report regarding potential international crew transportation services raises significant concern. The report (on page 6) states: "International transportation service that would extend beyond that currently in use (Russia) should be evaluated against the same performance standard as COTS human transportation services from U.S. Vendors." Obviously, without actually saying it, the reference is to the Russian Soyuz crew transportation system.

A reading of that language suggests that the Soyuz is exempt from "the same performance standard as COTS human transportation services." What would the basis be for that exemption?

Answer. The Soyuz has already passed through the "gate" of NASA human rating by virtue of assessments done prior to its utilization by NASA crews and its long history of providing safe transport to Russian Cosmonauts. This history, and a close working relationship between the agencies of the two countries, has provided NASA with significant insight into the design and operation of the Soyuz and given them confidence in its abilities.

Question. Has the Panel conducted any sort of review of safety and reliability measures for the Soyuz vehicle? If so, have you reported on that review? If not, can you explain why not?

Answer. The Panel has had regular discussions with senior NASA experts on their processes for gaining confidence in the Soyuz system. Particular attention was focused on resolution of re-entry anomalies that were experienced in recent years. While the Panel itself is not privy to the details of the Soyuz vehicles, we have

gained confidence that NASA officials are taking reasonable steps to gain the required insight.

Question. Are you suggesting that the Aerospace Safety Advisory Panel is completely satisfied, whether by any independent analysis or direct assessment, that the crew vehicle on which the United States will rely for its only human access to space for the next 5 to 7 years is “safe enough” for us to be comfortable in accepting that reliance?

Answer. As explained above, the Panel’s assessment has been of the NASA processes used to gain confidence in the Soyuz system. While we cannot independently validate the safety of the Soyuz, we are aware of no issues that lead to significant concern at this time.

Question. A full one-third of the last six Soyuz flights returning to Earth, have experienced “unexplained anomalies.” In two cases, the vehicles returned in a steeper-than-normal trajectory and experienced erratic movement during re-entry, caused by an improper separation of the descent module from the rest of the spacecraft. The crews were subjected to much higher gravity loads—if not dangerously high, at least uncomfortably high, from all reports. In another previous case, there was minor disturbance caused by what was reportedly the uneven packing and mounting of waste materials in the upper module, before it separated from the descent module. In none of these cases do we know for sure what took place. Steps have been taken to try to avoid what is thought to be the problem, but it has not been verified.

If this were to happen with the space shuttle, what would be the result? Wouldn’t it be necessary to ground the fleet until the cause was determined and repairs or adjustments made? Why is this acceptable for continued U.S. reliance on the Soyuz?

Answer. Both the shuttle and the Soyuz flight teams examine each and every anomaly that occurs on their system on each flight. Just as they do for shuttle anomaly assessments, senior NASA officials sat with their Russian counterparts during the assessments for the problems described above. They reported to us that similar rigorous assessment techniques were used in both countries. Most probable causes have been identified and steps taken to prevent recurrence. It is worth noting that these anomalies demonstrated one of the unique safety features of the Soyuz design: its inherent reentry aerodynamic stability that does not rely on complex guidance components to maintain alignment during reentry.

Question. If at any time in the next 5 to 7 years something more serious were to happen during a Soyuz descent, and if it were serious enough to force the grounding of the Soyuz fleet for an extended period of time (a year or more), it might be necessary, due to the on-orbit limits of the Soyuz, for the six crew members still on board the space station to have to abandon the space station—using the same kind of vehicle which had experienced the problem which forced the grounding of the fleet.

Has your panel considered such a possibility? Could that possibly be considered a “wise” or “safe” choice for this Nation to make, to have placed our astronauts—and our partners’ astronauts—in that position?

Answer. This is one of the risks that the Panel will be evaluating in the coming months. As I stated in my testimony, there is an increased risk of forced station abandonment once we are limited to a single means of ISS crew access. The steps being taken to minimize this risk will be examined, as will the impact of such a potential abandonment, both on the crew and the danger an abandoned ISS might pose to those on the ground.

ASAP CHARTER

Question. I have expressed some concerns I have about the thoroughness and appropriateness of some of the statements made in previous reports by your Panel. The Aerospace Safety Advisory Panel (ASAP) operates under the Federal Advisory Committee Act (FACA). That act imposes a requirement on the Committees of Jurisdiction to make a continuing review of the activities of each advisory committee under its jurisdiction to determine whether such advisory committee should be “abolished or merged with any other advisory committee, or whether the responsibilities of such advisory committee should be revised.” In addition, the Charter of the ASAP states that it is to advise the NASA Administrator and the Congress.”

Based on your experience on the Panel, do you believe there is any sense that there should be greater interaction between the appropriate congressional committees and the Panel, beyond simply briefing the Congress on its annual reports?

Answer. The Panel, as currently constituted, is a strategic resource for Congress and NASA focused on processes, plans, and policies that are necessary to maximize safety rather than the detail design assessments of hardware. While the results of our deliberations are shared freely with both NASA and Congress, it must be re-

membered that since we only meet formally four times a year, the availability of material that would be of interest to the committees is somewhat limited. We have quickly responded to all requests for support from both NASA and Congress and will happily do so for any in the future.

Question. Would that include a practice of briefing the Congress before publicly releasing the annual report, which the panel failed to do in releasing the Report for 2009?

Answer. Our annual report is based directly on the results of our quarterly reviews which are specific and readily available. Due to the time sensitivity of many of these subjects, I suggest that an ongoing dialog concerning questions members may have about these reports may be of more value.

QUESTIONS SUBMITTED BY SENATOR THAD COCHRAN

Question. I think our memories of the Challenger and the Columbia remind us of the risks our Astronauts willingly accept, just as Administrator Bolden did when he piloted the Discovery to deliver the Hubble telescope to space exactly 20 years ago this Saturday, April 24. I know NASA continues to look for ways to reduce the frequency of accidents. In your role as a NASA safety expert, could you help me understand to what degree and in what ways does robust engine testing minimize the risk of future accidents and ensure that our brave Astronauts come home safely?

Answer. The propulsion component of any space transportation system is one of the most critical pieces of hardware for a safe and successful mission. It is the source of the most significant risks of catastrophic failure during launch. In the case of either solid or liquid rockets, testing is one of the most basic validation techniques to show that the systems analysis and safety studies are accurate and correct. For the case of solids, no test of the actual rocket that will be on the vehicle can be accomplished (it has only a one-time use), however testing must be done on a statistically significant sample to prove that our safety analysis is valid. On liquid or multi-use propulsion, we have the advantage of actually firing the engine which will be on the vehicle and then examining its condition after such a trial firing. This provides an extra margin of safety for engines of this type. There is no question, in either case, that testing both in development and in production/operations where possible provides a fundamental mechanism to validate safety assessments and performance analysis. Vigorous and extensive testing of rocket motors was one of the touchstones of Dr. Wernher von Braun's approach to development of human rated rockets like the Saturn V.

Question. President Obama's new plan calls for the use of contractor owned and operated launches for the first time ever. His critics have said that the private sector cannot provide the level of safety that has been provided by NASA. The first time a commercial launch company experiences a significant accident, scrutiny of NASA for releasing direct control of launch activities and the President's plan will be jeopardized. Understanding that NASA already places great value on safety do you believe that NASA will need to place an even greater emphasis on commercial engine testing and safety to ensure the chances of such an accident are minimized.

Answer. While the already high degree of emphasis on safety may not change under the proposed new acquisition strategy, the techniques for ensuring the safety of the vehicles carrying our astronauts certainly will. The classical acquisition strategy of direct and detailed NASA involvement in every step of space vehicle design provides NASA with deep insight into the design features, potential failure modes, robustness, and reliability of the systems and their components. This deep insight may not be available with commercial providers who independently develop systems using their own procedures, approaches, and experience base. The current NASA work process will have to be replaced with a different approach that has not yet been developed. This approach may well include significantly more test and demonstration of safety critical components such as engines.

SUBCOMMITTEE RECESS

Senator MIKULSKI. This subcommittee stands in recess until Thursday, April 29 at 10 a.m., when we will take the testimony of Attorney General Eric Holder.

The subcommittee stands in recess.

[Whereupon, at 11:50 a.m., Thursday, April 22, the subcommittee was recessed, to reconvene at 10 a.m., Thursday, April 29.]