

# THE COMMERCIAL CREW PROGRAM: CHALLENGES AND OPPORTUNITIES

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## HEARING

BEFORE THE  
SUBCOMMITTEE ON SPACE  
COMMITTEE ON SCIENCE, SPACE, AND  
TECHNOLOGY  
HOUSE OF REPRESENTATIVES  
ONE HUNDRED FOURTEENTH CONGRESS  
FIRST SESSION

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FEBRUARY 27, 2015

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**Serial No. 114-9**

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# **THE COMMERCIAL CREW PROGRAM: CHALLENGES AND OPPORTUNITIES**

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**FRIDAY, FEBRUARY 27, 2015**

HOUSE OF REPRESENTATIVES,  
SUBCOMMITTEE ON SPACE  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,  
*Washington, D.C.*

The Subcommittee met, pursuant to call, at 9:01 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Steven Palazzo [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas  
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas  
RANKING MEMBER

**Congress of the United States**  
**House of Representatives**  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
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**Subcommittee on Space**

***The Commercial Crew Program: Challenges and Opportunities***

Friday, February 27, 2015  
9:00 a.m. to 12:00 a.m.  
2318 Rayburn House Office Building

Witnesses

***Mr. Bill Gerstenmaier***, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration (NASA)

***Vice Admiral Joseph Dyer***, USN (Ret.), Chairman, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration (NASA)

***Mr. John Mulholland***, Vice President and Program Manager, Commercial Programs, The Boeing Company

***Dr. Garret Reisman***, Director, Crew Operations, Space Exploration Technologies Corporation

**U.S. House of Representatives  
Committee on Science, Space, and Technology  
Subcommittee on Space**

“The Commercial Crew Program: Challenges and Opportunities.”

**CHARTER**

Friday, February 27, 2015  
9:00 a.m. – 10:30 a.m.  
2318 Rayburn House Office Building

**Purpose**

At 9:00 a.m. on Friday, February 27, 2015 the House Science, Space, and Technology’s Subcommittee on Space will hold a hearing titled “The Commercial Crew Program: Challenges and Opportunities.” The purpose of this hearing is to review NASA’s efforts to develop and acquire safe, reliable, and affordable crew transfer services to the International Space Station (ISS). The Subcommittee will examine the progress of the Commercial Crew Program and its acquisition model, and future challenges for the program as the contractors move towards certification.

**Witnesses**

- **Mr. Bill Gerstenmaier**, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration (NASA)
- **Vice Admiral Joseph Dyer, USN (Ret.)**, Chairman, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration (NASA)
- **Mr. John Mulholland**, Vice President and Program Manager, Commercial Programs, The Boeing Company
- **Dr. Garrett Reisman**, Director, Crew Operations, Space Exploration Technologies Corporation

**Background**

The Commercial Crew Program (CCP) began, in its current form, in 2010 with President Obama’s announcement to cancel the Constellation program and develop a separate system to ferry astronauts to and from the International Space Station.<sup>1</sup> Congress authorized this new paradigm with the passage of the NASA Authorization Act of 2010.<sup>2</sup> NASA announced on September 16, 2014, that it would continue into the final phases of development, and ultimately human-rating certification, with two contractors, the Boeing Company (Boeing) and Space Exploration Technologies Corporation (SpaceX).<sup>3</sup> The third partner that was not chosen, Sierra Nevada Corporation, filed a protest with the Government Accountability Office (GAO) that was denied on January 5, 2015 clearing the way for NASA to continue with the program.<sup>4</sup>

<sup>1</sup> President’s Budget Request for the National Aeronautics and Space Administration, Fiscal Year 2011 <http://www.nasa.gov/news/budget/2011.html>

<sup>2</sup> National Aeronautics and Space Administration Authorization Act of 2010, P.L. 111-267, Sec. 402.

<sup>3</sup> Source Selection Statement for Commercial Crew Transportation Capability Contract (CCtCap), September 15, 2014 <http://www.nasa.gov/sites/default/files/files/CCtCap-Source-Selection-Statement-508.pdf>

<sup>4</sup> Sierra Nevada Bid Protest Decision, January 5, 2015, <http://www.gao.gov/assets/670/667979.pdf>

### ***Program Authorization***

The Commercial Crew Program was authorized in the NASA Authorization Act of 2008. Section 902 of the 2008 Act directs NASA to “enable a commercial means of providing crew transfer and crew rescue services for the International Space Station.” To achieve this goal, the bill directs that NASA-

- 1) make use of United States commercially provided International Space Station crew transfer and crew rescue services to the maximum extent practicable;*
- 2) limit, to the maximum extent practicable, the use of the Crew Exploration Vehicle to missions carrying astronauts beyond low Earth orbit once commercial crew transfer and crew rescue services that meet safety requirements become operational; and*
- 3) facilitate, to the maximum extent practicable, the transfer of NASA-developed technologies to potential United States commercial crew transfer and rescue service providers, consistent with United States law.<sup>5</sup>*

The 2008 Act also included a provision that provided congressional intent to NASA which prohibited the Administration from funding the Commercial Crew program at the expense of exploration programs.<sup>6</sup>

The NASA Authorization Act of 2010 continued this direction and included additional reporting requirements with regard to the safety of the systems under development. The Act required the Administration, “to provide independent assurance of flight safety and flight readiness before the authorization of United States government personnel to participate as crew onboard any commercial launch vehicle developed...”<sup>7</sup> Additionally, the Act directed the Administration to utilize the Orion crew vehicle as a backup should the Commercial Crew contractors were unable to fulfil the government’s needs requirements.<sup>8</sup>

### ***Program Structure and Schedule***

The hallmark of the commercial paradigm is what the Administration refers to as a “Commercial partnership,” meaning the partners contribute funding in addition to what the government contributes. This is in contrast to a traditional development project whereby the contractor is paid for all work performed at the behest of the government. This philosophical shift in acquisition strategy was accompanied by the increased use of a special procurement mechanism referred to as “Other Transaction Authority,” or OTA, for large developments. This authority was granted to NASA by the National Aeronautics and Space Act of 1958 (P.L. 85-568)<sup>9</sup> and permits NASA to enter into a “Space Act Agreement” for many purposes, including technology development.

The agency contends that the use of Space Act Agreements permits more flexibility than traditional Federal Acquisition Regulations (FAR) based development programs, specifically the ability of the government to share costs with the partners. In the Commercial Cargo development

<sup>5</sup> National Aeronautics and Space Administration Authorization Act of 2008, P.L. 110-422, Sec. 902(a).

<sup>6</sup> National Aeronautics and Space Administration Authorization Act of 2008, P.L. 110-422, Sec. 902(b).

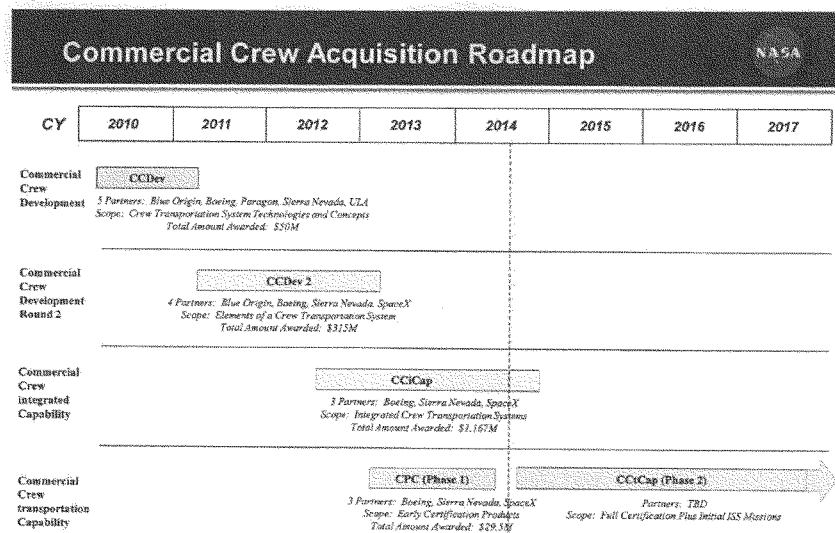
<sup>7</sup> National Aeronautics and Space Administration Authorization Act of 2010, P.L. 111-267, Sec. 403(b)(5).

<sup>8</sup> National Aeronautics and Space Administration Authorization Act of 2010, P.L. 111-267, Sec. 303(b)(3).

<sup>9</sup> National Aeronautics and Space Act of 1958, P.L. 85-568, Sec. 203.

program, this cost-share for the contractors was approximately 50 percent of the cost of the development.<sup>10</sup> It is unclear what that percentage is for the Commercial Crew Program, but NASA officials have testified before the Committee that the government is providing approximately 80-90 percent of the overall funding for the program.<sup>11</sup>

The program has three phases. The first two phases were referred to as Commercial Crew Development (CCDev) One and CCDev Two. Both phases were conducted under Space Act Agreements. The third phase was called Commercial Crew Integrated Capability (CCiCap) and was conducted under the final Space Act Agreement of the program. The final and current phase is called Commercial Crew Transportation Capability (CCtCap). The final phase was awarded last year to Boeing and SpaceX.<sup>12</sup> These two companies will proceed through the final design, development, testing, evaluation and human rating certifications under a traditional firm-fixed price contract. The purpose of CCtCap is to provide development funding to the contractors to mature their spacecraft designs to a point that they can be certified to fly astronauts to the ISS.



Although NASA will not fly astronauts on these systems until they have been certified for launch, the agency will need to procure launches before certification to allow the contractors lead-time to build the vehicles. Additionally, NASA may also include foreign astronauts on flights to the ISS based on existing or future agreements. The contractors will be required to

<sup>10</sup> NASA Office of the Inspector General, Commercial Cargo: NASA's Management of Commercial Orbital Transportation Services and ISS Commercial Resupply Contracts, Audit #IG-13-016 <http://oig.nasa.gov/audits/reports/FY13/IG-13-016.pdf>

<sup>11</sup> Verbal Testimony of Associate Administrator Bill Gerstenmaier before the House Science, Space and Technology Committee, September 14, 2012. <http://www.gpo.gov/fdsys/pkg/CHRG-112hhrg76234/html/CHRG-112hhrg76234.htm>

<sup>12</sup> See Attachment A

acquire a launch license from the FAA for all of their post-certification missions to the ISS. This is a change from historic human spaceflight launches in the past. For example Mercury, Gemini, Apollo, and Space Shuttle launches were not licensed by the FAA.

Contractor progress is measured by milestones that they must achieve throughout the contract period. The contractors are paid upon the completion of each of the milestones. There are a total of 41 certification milestones between the two contractors, 23 for Boeing and 18 for SpaceX.<sup>13</sup> After they have completed their milestones and they are certified by NASA as safe to fly astronauts to the ISS, the government will begin to procure flights from the contractor. The contracts allow the government to procure six flights from each partner for a total of 12 flights. However, the contract only guarantees that the government will purchase two post-certification missions to the ISS.

Based on the proposals and contracts from both contractors, NASA still anticipates a flight readiness of at least one partner by the end of 2017. Additionally, NASA estimates that if it uses all the potential flights it will not need to procure additional flights until 2023, one year before the Administration's current proposed end of life of the ISS.

#### ***Program Budget***

The President's budget request for this year includes \$1.24 billion for the Commercial Crew Program. This would be an increase of 54 percent over the appropriated funding for FY2015 (\$805 million). The Administration contends that without this funding, the government would be required to renegotiate their contracts with the providers which would delay flight readiness for the systems. The total potential values of these contracts are \$2.6 billion for SpaceX and \$4.2 billion for Boeing for a total potential value of \$6.8 billion over the life of the contracts. NASA has never completed an independent cost estimate of the Commercial Crew Development Program or the program estimates that the companies provided for their funding requirements.<sup>14</sup>

The NASA Authorization Act of 2010 authorized \$312 million, \$500 million, and \$500 million for the Commercial Crew Program for fiscal years 2011, 2012 and 2013 respectively. NASA has consistently requested more funding for Commercial Crew than the program has been authorized or previously appropriated.<sup>15</sup> Three years ago, the NASA Administrator testified before the Committee that the FY2013 request would put NASA "on track" for a commercial crew capability by 2017.<sup>16</sup> The actual appropriation for FY2013 was \$305 million less than the request. Two year ago, the Administrator testified to the Committee that NASA was still on track for a 2017 launch date, but full funding of the FY2014 request was "essential" to enabling

<sup>13</sup> Briefings provided by NASA to Committee staff, January 2015.

<sup>14</sup> NASA contracted with Booz/Allen/Hamilton to complete an independent cost assessment of the program which was released on March 1, 2013 and can be found here [http://www.nasa.gov/pdf/741617main\\_CCP-ICA-DRD-2c-Public-Releaseable-Final-Report-3-5-13-508.pdf](http://www.nasa.gov/pdf/741617main_CCP-ICA-DRD-2c-Public-Releaseable-Final-Report-3-5-13-508.pdf). However, as noted by the NASA Inspector General, "the assessment found that the estimates were optimistic, and that the Program was likely to experience cost growth. In addition, Booz Allen noted that without costs projected over the life of the Program, NASA officials will not be able to independently evaluate each partner's progress."

<sup>15</sup> FY2011 request: \$500 million. FY2011 actual: \$307 million. FY2012 request: \$850 million. FY2012 actual: \$392 million. FY2013 request: \$830 million. FY2013 actual: \$525 million. FY2014 request: \$821 million. FY2014 actual: \$696 million.

<sup>16</sup> Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration, statement before the House Committee on Science, Space, and Technology, March 7, 2012.

Commercial Crew access to the International Space Station by 2017.<sup>17</sup> The actual appropriation for FY2014 was \$125 million less than the request. The FY2016 NASA budget justification states that 2017 is still the target date for a Commercial Crew capability.

Funding history for the program is included below.

Budget Authority (\$ in millions)	Actual FY2013	Request FY2014	\$ Change	Actual FY2014	Request FY2015	\$ Change	Enacted FY2015	Request FY2016	\$ Change
Commercial Crew	525.0	821.4	296.4	696.0	848.3	152.3	805.0	1,243.8	438.8

Funding History \$ in millions	Program Phase					
	CCDev1	CCDev2	CCiCap	CPC1	CCtCap	Total
Paragon	1.40	-	-	-	-	1.40
United Launch Alliance	6.70	-	-	-	-	6.70
Blue Origin	3.70	22.00	-	-	-	25.70
Sierra Nevada	20.00	105.60	227.50	10.00	-	363.10
SpaceX	-	75.00	460.00	9.60	2,600.00*	3,144.60
Boeing	18.00	112.90	480.00	9.90	4,200.00*	4,820.80
Total Funding	49.80	315.50	1,167.50	29.50	6,800.00	8,362.30

Source - <http://www.nasa.gov/sites/default/files/files/CCiCapFactSheet.pdf>

\*Represents total potential value of the contract.

#### ***Aerospace Safety Advisory Panel (ASAP) Annual Report***

The Aerospace Safety Advisory Panel (ASAP) was created by Congress in 1968 after the tragic loss of three astronauts during a launch rehearsal test of Apollo 1.<sup>18</sup> The 1968 Act required the panel to "review safety studies and operations plans that are referred to it and shall make reports thereon, shall advise the Administrator with respect to the hazards of proposed operations and with respect to the adequacy of proposed or existing safety standards, and shall perform such other duties as the Administrator may request." In 2005, Congress amended the 1968 Act to require that ASAP report to Congress as well as the Administration. In compliance with this requirement, the panel produces an annual report. This year's report was transmitted to Congress on January 28, 2015.<sup>19</sup>

The report transmitted to Congress this year did not include a proper assessment of the Commercial Crew Program as it did with other large programs at NASA including the Space Launch System and Orion programs. The panel highlighted specific concerns with the Commercial Crew Program including concerns about the program's leadership at NASA Headquarters. The reports states that,

<sup>17</sup> Charles F. Bolden, Jr., Administrator, National Aeronautics and Space Administration, statement before the House Committee on Science, Technology, and Space, Subcommittee on Space, April 24, 2013.

<sup>18</sup> National Aeronautics and Space Administration Authorization Act of 1968 (P.L. 90-67) Sec. 6.

<sup>19</sup> 2014 Annual Report of the Aerospace Safety Advisory Panel  
[http://oair.hq.nasa.gov/asap/documents/2014\\_ASAP\\_Annual\\_Report.pdf](http://oair.hq.nasa.gov/asap/documents/2014_ASAP_Annual_Report.pdf)

*"The Commercial Crew Program (CCP) has been notably less forthcoming. This lack of transparency has been a concern for a number of years and, despite numerous discussions with the Director of Commercial Spaceflight Development (DCSD) and with senior leadership at NASA Headquarters, this less-than-candid and transparent communication with the ASAP regarding the CCP has persisted. Over the last several years, the DCSD has responded to ASAP's requests for information related to the plans on how commercial programs would be certified or how confidence would be gained on the safety of operations with a seamless set of constraints as to why the information could not be shared. These have ranged from "we're still defining the acquisition approach" to "that information is pre-decisional" to "the investigation is still being conducted" to "that's source selection sensitive information" to "a protest has been filed." While these statements are all true, these conditions should not be absolute barriers to sharing information related to certification and safety."*

This opacity was also noted by the Committee after recent requests for information from NASA.

<sup>20</sup> The ASAP report gives examples of how program leadership prevented candid discussions with the panel about the program;

*"Even when subordinates of the DCSD give briefings to the ASAP, there is often obvious concern about how to answer the Panel's questions. For example, the subordinate looking at the DCSD, apparently seeking permission and/or guidance prior to answering a probing question, may be a symptom of an environment where the culture is not one of openness and can lead to poor internal and external communication."*

Additionally, the panel concludes that the program leadership's actions may lead to the same type of problems identified by the Rogers Commission and Columbia Accident Investigation Board following the *Challenger* and *Columbia* tragedies respectively. The Panel notes that,

*"The actions of the DCSD in interacting with the ASAP, which were also noted during the development phase of the Commercial Cargo Program, have created a challenging environment that has the potential to increase risk. The Panel is concerned that this lack of candor is not limited to interactions with the ASAP and may extend to other internal and external stakeholders. This opacity and failure to engage in open and transparent communication is reminiscent of the problems that were explicitly identified by both the Rogers Commission and the Columbia Accident Investigation Board (CAIB) regarding causes of the Space Shuttle Challenger and Columbia mishaps respectively."*

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<sup>20</sup> Letter to Administrator Bolden from Science Committee Chairman Lamar Smith and Space Subcommittee Chairman Steven Palazzo, October 21, 2014.



**Key Questions**

1. Does NASA have the appropriate level of insight into the Commercial Crew contractors to be confident in the safety and reliability of the systems?
2. How has NASA responded to the ASAP report and what measures have been put into place to ensure the panel has insight into the human spaceflight programs at the agency?
3. What milestones or metrics can be used to judge the progress of the development of the crew systems?
4. What options does NASA have if one or both of the contractors drastically underbid their contract and cannot complete their milestones by 2017?
5. How will NASA ensure that the certification process for these systems will not deviate from known standards of safety and reliability?
6. What are the major challenges and risks facing the program and the contractors and how can those challenges and risks be mitigated?

Chairman PALAZZO. The Subcommittee on Space will come to order. Without objection, the Chair is authorized to declare recesses of the Subcommittee at any time. Good morning. Welcome to today's hearing, entitled "The Commercial Crew Program: Challenge and Opportunities". In front of you are packets containing the written testimony, biographies, and truth-in-testimony disclosures for today's witnesses. I recognize myself for five minutes for an opening statement.

I would like to welcome everyone to our hearing today, and I want to thank our witnesses for taking time to appear before the Committee. Today's hearing is a review of the Commercial Crew Program at NASA. This program holds the promise of tremendous value for both the taxpayer and the contractors, as long as the program is executed appropriately.

Last year NASA chose two partners to continue through the final phase of the program, Boeing and SpaceX. Known as CCtCap, or Commercial Crew Transportation Capability, this final phase will provide funding for the partners to complete testing of their systems. This is a critical phase in our Nation's efforts to develop and sustain assured U.S. human access to low-Earth orbit. To date, Congress and the Administration have not been able to reach consensus on the most efficient way to meet NASA's launch requirements. However, the promise of this capability, and new contracting structure, has allowed for guarded optimism.

The NASA Authorization Act of 2008 directed NASA to engage the private sector for access to the International Space Station, so long as it did not come at the expense of NASA's other exploration development programs. Similarly, the NASA Authorization Act of 2010 continued this direction, including reporting requirements related to safety, and directed NASA to ensure that the Orion vehicle was able to provide alternative means of delivering crew to the ISS in the event that partner supplied vehicles are unable to perform that function. NASA has done a lot to move the industry along in compliance with these laws. They have provided funding for early stage development, funding to mature spacecraft designs, funding to certify those designs, and ultimately they will provide a steady customer through the ISS program.

Previous testimony before this committee indicated that taxpayers will fund roughly 90 percent of the development of these capabilities, and then in turn pay once again for the services derived from those capabilities. In total, NASA has spent, or plans to spend, over \$8 billion on this initiative, which I believe represents a necessary investment, if managed effectively. In order to protect taxpayer interests, however, this level of investment by the taxpayer requires a similar level of transparency and accountability. To that end, it was concerning to read some of the findings made by the Aerospace Safety Advisory Panel, also known as ASAP, in its annual report this year. The ASAP is congressionally chartered to examine the culture of safety at NASA. It is required to provide advice to Congress, and to the administrator, measures that can be taken to improve safety at the agency.

This year, the ASAP was not able to complete their job insofar as it pertains to the Commercial Crew Program. According to the report, the Director of Commercial Space Flight Development at

NASA has provided excuses instead of information. This is described by the panel as a seamless set of constraints as to why information cannot be shared. Similarly, the report states this opacity and failure to engage in open and transparent communication is reminiscent of the problems that were explicitly identified by both the Rogers Commission and the Columbia Accident Investigation Board regarding causes of the Space Shuttle Challenger and Columbia mishaps, respectively. Unfortunately, this committee experienced similar issues when it attempted to get information on this program over the last year and a half.

I want to be crystal clear to our witnesses here today, and to the Administration, denying information to ASAP or Congress about the Commercial Crew Program is unacceptable when the hard-working American taxpayers are footing the bill for the program, and the safety of our astronauts is on the line. Congress and the American people deserve to have answers to the questions posed by ASAP. I am pleased to hear that NASA is now being more open, and I hope this trend continues.

Aside from the issues raised in the ASAP report, NASA must also address several outstanding questions as the program advances. The decision to use the Federal Acquisition Regulations to issue contracts for the final phase of the program was a welcome step from the Administration, and one that I endorse, but how will waivers to safety requirements from the Certification Products Contract phase be evaluated and issued? Given the delays in the Commercial Cargo Program, how will NASA maintain schedule discipline under the current crew contracts? Why can't a scaled back Orion launched on a Delta IV Heavy provide a redundant capability and competition to the Commercial Crew Program? What level of price competition exists in the program, now that we know the contractors' bids?

I raise these questions because I want the program to be successful. In these difficult budgetary times, NASA must concentrate its limited resources on meeting its core requirements, one of those being domestic human access to low-Earth orbit. I truly believe that we can come together to address these concerns in a constructive, bipartisan way so that we can once again launch American astronauts from American rockets from American soil. I look forward to hearing from our witnesses today.

[The prepared statement of Mr. Palazzo follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON SPACE  
CHAIRMAN STEVEN PALAZZO

Good morning. I would like to welcome everyone to our hearing today and I want to thank our witnesses for taking time to appear before the Committee.

Today's hearing is a review of the Commercial Crew Program at NASA. This program holds the promise of tremendous value for both the taxpayer and the contractors, as long as the program is executed appropriately.

Last year, NASA chose two partners to continue through the final phase of the program, Boeing and SpaceX. Known as CCtCap (Commercial Crew Transportation Capability), this final phase will provide funding for the partners to complete testing of their systems. This is a critical phase in our nation's efforts to develop and sustain assured U.S. human access to low-Earth orbit. To date, Congress and the Administration have not been able to reach consensus on the most efficient way to meet NASA's launch requirements. However, the promise of this capability and new contracting structure has allowed for guarded optimism.

The NASA Authorization Act of 2008 directed NASA to engage the private sector for access to the International Space Station (ISS) so long as it did not come at the expense of NASA's other exploration development programs. Similarly, the NASA Authorization Act of 2010 continued this direction, included reporting requirements related to safety, and directed NASA to ensure that the Orion vehicle was able to provide alternative means of delivering crew to the ISS in the event that partner-supplied vehicles are unable to perform that function.

NASA has done a lot to move the industry along in compliance with these laws. They have provided funding for early stage development, funding to mature spacecraft designs, funding to certify those designs, and ultimately they will provide a steady customer through the ISS program. Previous testimony before this Committee indicated that the taxpayer will fund roughly 90 percent of the development of these capabilities and then in-turn pay once again for the services derived from those capabilities. In total, NASA has spent, or plans to spend, over 8 billion dollars on this initiative, which I believe represents a necessary investment if managed effectively. In order to protect taxpayer interests, however, this level of investment by the taxpayer requires a similar level of transparency and accountability.

To that end, it was concerning to read some of the findings made by the Aerospace Safety Advisory Panel (ASAP) in its annual report this year. The ASAP is congressionally-chartered to examine the culture of safety at NASA. It is required to provide advice to Congress and to the Administrator on measures that can be taken to improve safety at the agency. This year, the ASAP was not able to complete their job insofar as it pertains to the Commercial Crew Program. According to the report, the Director of Commercial Spaceflight Development at NASA has provided excuses instead of information. This is described by the panel as a "seamless set of constraints as to why information cannot be shared." Similarly, the report states "This opacity and failure to engage in open and transparent communication is reminiscent of the problems that were explicitly identified by both the Rogers Commission and the Columbia Accident Investigation Board (CAIB) regarding causes of the Space Shuttle Challenger and Columbia mishaps respectively." Unfortunately, this Committee experienced similar issues when it attempted to get information on this program over the last year and a half.

I want to be crystal clear to our witnesses here today and to the Administration. Denying information to ASAP, or Congress, about the Commercial Crew Program is unacceptable when the hardworking American taxpayers are footing the bill for the program and the safety of our astronauts is on the line. Congress and the American people deserve to have answers to the questions posed by ASAP. I am pleased to hear that NASA is now being more open and I hope this trend continues.

Aside from the issues raised in the ASAP report, NASA must also address several outstanding questions as the program advances. The decision to use the Federal Acquisition Regulations to issue contracts for the final phase of the program was a welcome step from the Administration, and one that I endorsed, but how will waivers to safety requirements from the Certification Products Contracts phase be evaluated and issued? Given the delays in the commercial cargo program, how will NASA maintain schedule discipline under the current crew contracts? Why can't a scaled-back Orion launched on a Delta IV Heavy provide a redundant capability and competition to the commercial crew program? What level of price competition exists in the program now that we know the contractor's bids?

I raise these questions because I want the program to be successful. In these difficult budgetary times, NASA must concentrate its limited resources on meeting its core requirements - one of those being domestic human access to low-earth orbit. I truly believe that we can come together to address these concerns in a constructive bipartisan way so that we can once again launch American Astronauts on American Rockets, from American soil.

I look forward to hearing from our witnesses today.

Chairman PALAZZO. I now recognize the Ranking Member, Ms. Edwards, for an opening statement.

Ms. EDWARDS. Thank you, Mr. Chairman, and, of course, for as much time as I might consume, given that the clock was not running during your time. Good morning, and welcome to our distinguished panel of witnesses.

Mr. Chairman, I thank you for calling this hearing on the Commercial Crew Program, and the challenges and opportunities. There is no denying that NASA and its commercial partners have

taken great strides since commercial crew activities began about five years ago.

Last fall NASA, in partnership with two companies, Space Exploration Technologies—SpaceX—and the Boeing Corporation, established contracts to finalize designs, undertake full development, and carry out the milestones needed to complete NASA certification requirements to carry NASA, and NASA sponsored astronauts, to and from the International Space Station.

As I have recounted on other occasions, I used to be a skeptic of commercial crew and cargo transportation to support NASA requirements. I have evolved, but I still have questions. And while I am now supportive of the program, and industry's partnership with NASA, I remain committed to ensuring that these systems are safe. And as the title of the hearing states, there are both challenges and opportunities ahead.

First, the Commercial Cargo Transportation Program that is currently underway sheds light on some of those challenges. Initial operational flight showed up significantly later than initially anticipated, and a mishap last fall reminds us all that space flight, even in 2015, is indeed risky and hard, and when humans are involved, the stakes are immeasurably higher.

Secondly, as we will hear from Vice Admiral Dyer, and I—the concern that I share with the Chairman, the Commercial Crew Program's approach is to buy the commercial crew services, rather than make or manage a development program. This paradigm shift carries risks in and of itself, given that the services to be bought don't yet exist. In addition, the Aerospace Safety Advisory Panel—ASAP—which Vice Admiral Dyer chairs, has raised concerns about the transparency of the program in providing the panel, and Congress, with the information it needs to evaluate safety. As you know, Mr. Chairman, safety has, and will continue to be, a priority of this committee, and the NASA Authorization Act of 2015, I would add, the bipartisan Act passed by the House, directs that safety be the highest priority of the Commercial Crew Program.

Third, NASA is requesting \$1.2 billion for the Commercial Crew Program for Fiscal Year 2016. That is an increase of over \$400 million from the Fiscal Year 2015 enacted level. However, the Committee, despite having asked, has no independent external analysis by which to evaluate whether NASA's budget requests for the Commercial Crew Program are on target, and whether the amount the taxpayers are being asked to pay is too much, too little, or about right. We don't have any information. The NASA Authorization Act of 2015, again, directs NASA to provide that analysis. And while that isn't law yet, it is clear that, from a bipartisan perspective, we expect the Committee to be provided with that information.

I want NASA and its commercial partners to succeed so that NASA and the nation will regain human space flight access to low-Earth orbit once again. And I also want to understand what taxpayers are paying for, and the terms and the conditions involved. In particular, I look forward to hearing from our witnesses about several questions. One, how will NASA—SpaceX—and Boeing ensure safety and a safety culture throughout the development process in the operational space flights, once they are certified? What contingency plans will be in place, should commercial systems not

be available by the anticipated 2017 date, or should one provider need to stand down for an extended period of time? What is needed to appropriately communicate the risks involved in commercial human space flights to Congress, the public, and other stakeholders? And what are the policies in place for cost reimbursement, liability, and risk assumption regarding individual passengers that contractors could potentially carry on NASA sponsored missions to the ISS?

Before I close, Mr. Chairman, I want to note that, while the Commercial Crew Program is important, I hope that this committee will have the opportunity to discuss all of NASA's programs and plans that comprise its \$18 billion budget request for Fiscal Year 2016. I think we need to continue our tradition of inviting the NASA administrator to come in and testify on the agency's budget request, and I hope we can lock in a hearing in the near future.

Thank you, and I yield the balance of my time.

[The prepared statement of Ms. Edwards follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON SPACE  
RANKING MEMBER DONNA F. EDWARDS

Good Morning, and welcome to our distinguished panel of witnesses. Mr. Chairman, thank you for calling this hearing on The Commercial Crew Program: Challenges and Opportunities.

There is no denying that NASA and its commercial partners have taken great strides since commercial crew activities began about five years ago. Last Fall, NASA in partnership with two companies—Space Exploration Technologies and The Boeing Corporation—established contracts to finalize designs, undertake full development, and carry out the milestones needed to complete NASA's certification requirements to carry NASA and NASA-sponsored astronauts to and from the International Space Station.

As I have recounted on other occasions, I used to be a skeptic of commercial crew and cargo transportation to support NASA requirements. And while I am now supportive of the commercial space transportation industry's partnership with NASA, I remain committed to ensuring that these systems are safe.

As the title of the hearing states, there are both challenges and opportunities ahead. First, the commercial cargo transportation program that is currently underway sheds light on some of those challenges. Initial operational flights showed up significantly later than initially anticipated and a mishap last Fall reminds us that spaceflight is indeed risky and hard. When humans are involved, the stakes are immeasurably higher.

Secondly, as we'll hear from Admiral Dyer, the commercial crew program's approach is to "buy" the commercial crew services rather than make or manage a development program. This paradigm shift carries risk in and of itself, given that the services to be bought don't yet exist. In addition, the Aeronautics Safety Advisory Panel—ASAP—which Admiral Dyer chairs, has raised concerns about the transparency of the program in providing the Panel with the information it needs to evaluate safety. As you know, Mr. Chairman, safety has and will continue to be a priority of this Committee, and the NASA Authorization Act of 2015 directs that safety be the highest priority of the commercial crew program.

Third, NASA is requesting \$1.2 billion for the Commercial Crew Program for Fiscal Year 2016, an increase of over \$400 million from the FY 2015 enacted level. However, the Committee, despite having asked, has no independent external analysis by which to evaluate whether NASA's budget requests for the commercial crew program are on target, and whether the amount the taxpayers are being asked to pay is too much, too little, or about right. The NASA Authorization Act of 2015 directs NASA to provide that analysis.

I want NASA and its commercial partners to succeed so that NASA and the nation will regain human spaceflight access to low-Earth orbit once again.

Yet I also want to understand what the taxpayers are paying for and the terms and conditions involved. In particular, I look forward to hearing from our witnesses about:

- How will NASA, SpaceX, and Boeing ensure safety and a safety culture throughout the development process and the operational spaceflights, once they are certified?
- What contingency plans will be in place should commercial systems not be available by the anticipated 2017 date, or should one provider need to stand down for an extended period of time?
- What is needed to appropriately communicate the risks involved in commercial human spaceflight to Congress, the public, and other stakeholders?
- And what are the policies in place for cost reimbursement, liability, and risk assumption regarding individual “passengers” that contractors could potentially carry on NASA sponsored missions to the ISS?

Before I close, Mr. Chairman, I would like to note that while the Commercial Crew Program is important, I hope that this Committee will also have the opportunity to discuss all of NASA’s programs and plans that comprise its \$18 billion budget request for FY 2016. I think we need to continue our tradition of inviting the NASA Administrator to come in and testify on the agency’s budget request, and I hope we can lock in such a hearing in the near future.

Thank you and I yield back the balance of my time.

Chairman PALAZZO. Thank you, Ms. Edwards. I now recognize the Chairman of the full Committee, Mr. Smith.

Chairman SMITH. Thank you, Mr. Chairman. America has always been a Nation of innovators and explorers. We continue to remain on the forefront of new discoveries and technologies. Our history is filled with examples of entrepreneurs who pushed the boundaries of the possible. The Commercial Crew Program offers a new way to develop human rated systems for government access to space, with the goal, of course, of ending our dependence on Russia. Building on the Commercial Cargo Program could be an important change from traditional programs, but only if it is done correctly. Today the Subcommittee will examine the progress made in the Commercial Crew Program. This committee is dedicated to ensuring the government has safe, reliable, and affordable access to low-Earth orbit.

The U.S. currently pays Russia \$70 million a seat for access to the International Space Station. It should be a top priority to launch American astronauts on American rockets from American soil as soon as possible. American astronauts personify our nation’s pioneering spirit. They represent our leadership, as explorers, and agents of discovery. A great deal of trust has been placed in the commercial crew partners, Boeing and SpaceX, that are partnering with NASA to take our astronauts into space. This is an extraordinary responsibility for these companies. It is one that cannot be taken lightly.

It is absolutely imperative that we understand the gravity of what it means to carry our astronauts into space. This committee will continue to monitor whether the Commercial Crew Program will ensure safety, while also respecting cost and schedule constraints. We can only do this if NASA is open and transparent about the program. The Aerospace Safety Advisory Panel’s recent report highlights questions about NASA’s level of transparency. The Committee has encountered similar issues as well. For the sake of all who are working to make this program a success, I hope this will change.

I look forward to hearing from our witnesses today about their progress on these systems, and their ongoing relationship with NASA. Their insights into the program are invaluable to us. The

commercial space industry offers improvements to the quality of life for every person on the planet. The discoveries and applications that have come from space technology are numerous. Since the dawn of the Space Age, contractors and the private sector have played a central role in making our nation's aspirations a reality. The commercial space industry will ensure that America remains a world leader in space exploration.

Thank you, Mr. Chairman, and I will yield back.  
[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF FULL COMMITTEE  
CHAIRMAN LAMAR S. SMITH

Thank you Chairman Palazzo for holding this hearing. And I thank the witnesses for being here to share their expertise. America has always been a nation of innovators and explorers. We continue to remain on the forefront of new discoveries and technologies. Our history is filled with examples of entrepreneurs who pushed the boundaries of the possible.

The Commercial Crew Program offers a new way to develop human-rated systems for government access to space with the goal, of course, of ending our dependence on Russia. Building on the Commercial Cargo Program could be an important change from traditional programs, but only if it is done correctly.

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We can only do this if NASA is open and transparent about the program. The Aerospace Safety Advisory Panel's recent report highlights issues with NASA's level of transparency.

This Committee has encountered similar issues as well. For the sake of all who are working to make this program a success, I hope this will change going forward.

I look forward to hearing from our witnesses today about their progress on these systems and their ongoing relationship with NASA. Their insights into the program are invaluable to us.

The commercial space industry offers improvements to the quality of life for every person on the planet.

The discoveries and applications that have come from space technology are numerous. Since the dawn of the Space Age, contractors and the private sector have played a central role in making our nation's aspirations a reality.

The commercial space industry will ensure that America remains a world leader in space exploration.

Thank you Mr. Chairman, I yield back.

Chairman PALAZZO. If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I would like to introduce our witnesses. Mr. Bill Gerstenmaier is the Associate Administrator for the Human Exploration and Operations Mission Directorate at NASA. Vice Admiral Joseph Dyer is the Chairman of NASA's Aerospace Safety Advisory Panel, or ASAP. Mr. John Mulholland is the Vice President and Program Manager of Commercial Programs at the Boeing Com-



pany. And Dr. Garrett Reisman is Director of Crew Operations at the Space Exploration Technologies Corporation, or SpaceX.

In order to allow time for discussion, please limit your testimony to five minutes. Your entire written statement will be made part of the record.

I now recognize Mr. Gerstenmaier for five minutes to present his testimony.

**TESTIMONY OF MR. BILL GERSTENMAIER,  
ASSOCIATE ADMINISTRATOR,  
HUMAN EXPLORATION AND OPERATIONS  
MISSION DIRECTORATE,  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
(NASA)**

Mr. GERSTENMAIER. Thank you very much for allowing me to represent the teams that are heavily involved in the development of the crew transportation systems that will end our sole reliance on the Russian Soyuz for transportation to the ISS. This is a very important hearing, and a very important capability for the United States.

NASA has made tremendous progress in developing these capabilities. The work began under Space Act Agreements looking at generic capability, and transitioned to contracts for crew transportation to the ISS. The first phase of the Contract Certification Products, made tremendous progress in establishing clear requirements for the commercial providers at NASA. During this phase, the providers submitted alternate standards, hazard reports, certification plans, and verification plans for their crew transportation systems. The products were developed by the contractors, and heavily reviewed by NASA. It is important that this phase allowed the contractors to use their expertise and best practices, and submit alternate ways of developing and designing spacecraft using the latest standards.

I added two pie charts to my written testimony to highlight the significant amount and quality of work accomplished during this phase. The first pie chart shows the agency was able to accept 55 percent of the alternate standards as meeting or exceeding NASA's requirements. NASA only rejected five percent of the alternate standards proposed, but there is still open work to be done with the remaining 30 percent that were partially approved.

The second chart shows the variances. These are items where the contractors proposed an alternate method for hazard control, certification, or verification. This chart shows a significant amount of open work, with 53 percent of the variances needing additional definition and discussion. I see this as a big plus, and it allows the teams to know, prior to contract start, areas that will need work. It also is an area that we need to focus on and work over the next several weeks. This chart answers one of the Committee's pre-hearing questions, open work and risks. The work in preparation for the CCtCaP award has enabled the teams to understand the designs and risk areas, and will be a big advantage in achieving a safe system for crew transportation. Technically, the contract is off

to a very good start, however, development and flight of these systems will be complex and difficult activity for the teams.

The Commercial Crew Program has not received the funding requested in annual budgets. This underfunding has caused delays in program execution, and in past, forced NASA to continuous Space Act Agreements, as opposed to contracts, because of funding uncertainty. The budget appropriated in 2015 by Congress showed a commitment to the program, and allowed the agency to proceed with the current contracts. This Congressional support is greatly appreciated, and the program hopes to earn Congressional approval for the solid budget request that we have made in 2016. The budget request is anchored by negotiated firm-fixed-price contracts. Funding at these levels is required to end our sole reliance on Russians for crew transportation in a safe and timely manner.

In summary, the awarding of the contracts establishes the start of a new phase. Significant real progress continues to be made, as evidenced by the testimonies from Boeing and SpaceX. Despite the protested award, which limited communication, and made for a difficult contract start, work continued, and is accelerating. The decision, just like two contracts, was not an easy or trivial decision. The decision was carefully evaluated at contract selection, and the benefits of competition during the development phase was seen as necessary to allow for safe, timely, and cost-effective development. The decision was not simply to have competition, but was based on evaluating the details of the proposals, and making a selection decision that would provide best value to the U.S. government.

Developing new low-Earth orbit human transportation systems will not be an easy task. There will be challenges, and difficult decisions will need to be made. The entire agency, safety, engineering, crew health and safety organizations are actively engaged in this program. The support and interaction with the Aerospace Safety Advisory Panel (ASAP) will also be critical and important. The agency is working well with the FAA, and support for legislation on the government astronaut definition will be needed. The ISS will get a tremendous research benefit, 100 percent increase in crew research time, from the additional on orbit crew member provided by the system.

The Commercial Crew Transportation Program will take us all working together to ensure the next generation of U.S. LEO crew transportation systems are developed effectively and safely. Congressional support is absolutely required to develop safe and timely crew transportation systems. I look forward to your questions. Thank you.

[The prepared statement of Mr. Gerstenmaier follows:]

HOLD FOR RELEASE  
UNTIL PRESENTED  
BY WITNESS  
February 27, 2015

**Statement of  
William H. Gerstenmaier  
Associate Administrator for Human Exploration and Operations  
National Aeronautics and Space Administration**

**before the**

**Subcommittee on Space  
Committee on Science, Space and Technology  
U. S. House of Representatives**

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear before you today to discuss NASA's Commercial Crew Program (CCP). Over the past several years, NASA has made significant progress implementing its plan to develop the first ever commercially available American crew transportation system to low Earth orbit, with a goal of returning human spaceflight launches to U.S. soil by 2017 and ending our sole reliance on Russia. The recently awarded Commercial Crew Transportation Capabilities (CCtCap) contracts are the final phase of this development effort. U.S. crew transportation will allow the International Space Station (ISS) to increase the crew complement from six to seven enabling a substantial increase (~100 percent) in the amount of International Space Station (ISS) research that can be conducted, all the while reducing the costs the agency currently pays for transportation services.

**Background**

NASA's CCP is designed to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost-effective access to and from the ISS and low-Earth orbit. Throughout the process, both NASA and industry have invested time, money and other resources in the development of these commercial systems.

Through the CCP, NASA provides technical and financial support to industry partners during development of their crew transportation systems, and certifies them to carry NASA astronauts to and from ISS. Interaction between NASA and its commercial partners through each phase of the program has been excellent and will enable these new commercial systems to meet NASA's safety requirements.

Once complete, the crew transportation systems will support four NASA or NASA-sponsored crew on each flight, and provide emergency crew return, transport/return of pressurized ISS cargo, and crew safe haven while docked to ISS. The benefits of competition in implementing the CCP are numerous, as reinforced in statements by the

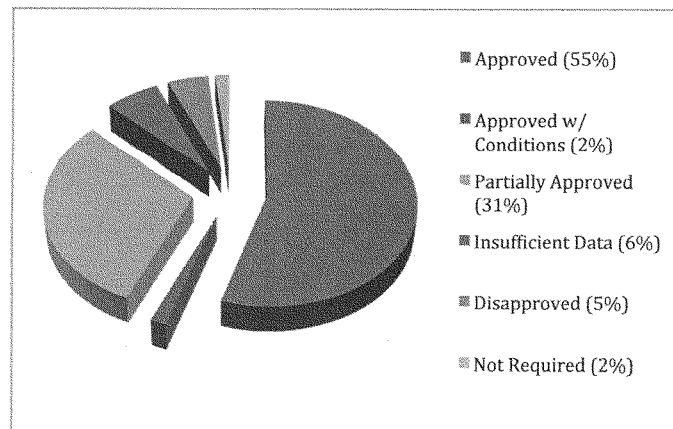
Government Accountability Office, Aerospace Safety Advisory Panel, and NASA Inspector General. Commercial Crew represents a significant endeavor in U.S. human spaceflight, with the goal of ending our sole reliance on foreign crew transportation to ISS, and certification of safe, reliable, and cost-effective U.S. commercial crew transportation systems. In addition, the approach NASA is taking with the CCP is helping to stimulate the growth of a new space transportation industry available to all potential customers, strengthening America's space industrial base and providing a catalyst for future business ventures to capitalize on affordable, globally competitive, U.S. space access.

#### **Certification Products Contracts (CPC)**

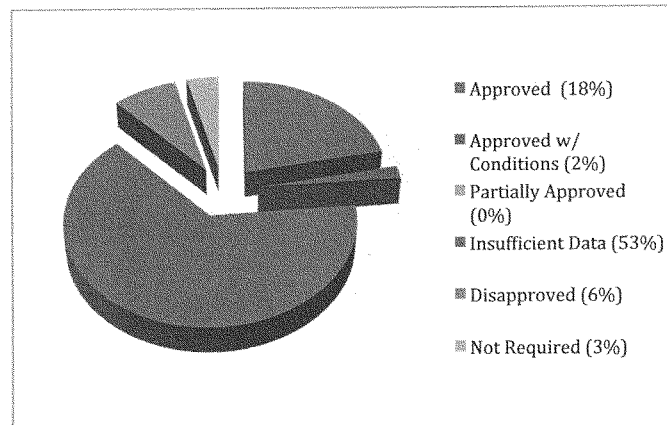
The first phase of the development effort was a series of competitively awarded Space Act Agreements, followed by Certification Products Contracts (CPC) competitively awarded to SpaceX, Boeing, and Sierra Nevada Corporation. The scope of the CPC contracts included submittal and technical disposition of specific, early development certification products. The CPC effort allowed potential providers to better understand and align with NASA human spaceflight requirements and gave NASA early insight into vehicle designs and approaches.

The companies submitted requests for alternate standards and variances to meeting NASA human spaceflight requirements. NASA's disposition of these requests is shown below.

Alternate Standard Dispositions under CPC



Variance Dispositions Under CPC



NASA's dispositions, with explanatory rationale, were provided to the companies. This feedback enabled our partners to make technical changes to better align their designs with NASA's requirements. The CPC phase also enabled NASA to examine the technical specifications and approaches that the companies were proposing to meet NASA's requirements. Understanding and agreeing on technical requirements is critical to developing a safe design. This phase shows tremendous progress in setting and understanding requirements. Overall, this phase of the contract was critical to allowing the contractors to understand the human rating requirements and NASA's understanding of how the contractors' approaches intend to meet those requirements. The number of variances from this phase with insufficient data shows the areas of concentration needed in the design phase.

#### **Commercial Crew Transportation Capability (CCtCap) Contracts**

CCP entered the development and certification phase with the award of Commercial Crew Transportation Capabilities contracts to SpaceX and Boeing. CCtCap will enable NASA to reach our goal of once again launching astronauts to the ISS from American soil.

In September 2014, after a highly competitive procurement and thorough evaluation process, NASA selected two providers, SpaceX and Boeing for the final development phase of the Commercial Crew Program, CCtCap. In selecting these companies, NASA evaluated the proposals for mission suitability, past performance, and price. NASA concluded that the proposals submitted by SpaceX and Boeing represented the best value

to the government. There was no ranking of awardees. NASA's rationale for these selections is described in detail in the *Source Selection Statement for Commercial Crew Transportation Capability Contract*, which can be found at <http://www.nasa.gov/sites/default/files/files/CCTCap-Source-Selection-Statement-508.pdf>.

The total potential contract value including certification, the maximum value for six post certification missions per company, and special studies is \$2.6 billion for SpaceX and \$4.2 billion for Boeing.<sup>1</sup>

These FAR-based contracts are designed to complete the NASA certification for human space transportation systems capable of carrying people to the ISS. Once certification is complete, NASA plans to use these systems to ferry astronauts to the ISS and return them safely to Earth. The contract scope of both contracts is the same, but because Boeing and SpaceX are using very different hardware, including launch vehicles, and are using different development, operational and management approaches, they have different prices for their respective integrated crew transportation systems.

The contracts include at least one crewed flight test per company with at least one NASA astronaut aboard to verify the fully integrated rocket and spacecraft system can launch, maneuver in orbit, and dock to the ISS, and to validate that all its systems perform as expected. Both companies proposed one uncrewed test flight to ISS prior to the crewed test flight. Once each company's test program has been completed successfully and its system achieves NASA certification, each contractor will conduct at least two, and as many as six, crewed missions to the ISS. These spacecraft also will serve as a lifeboat for astronauts aboard the ISS. If all 12 post certification missions are flown, these contracts can support the ISS crew transportation needs into 2023. NASA also anticipates having a Russian crew member on each U.S. commercial crew transportation flight and one astronaut will continue to fly on Soyuz. This is being done to insure that a U.S. and Russian crew member will remain on ISS in any contingency return of a vehicle. This will be accomplished on a no exchange of funds basis.

The SpaceX Crew Dragon and Boeing CST-100 will carry four crew members on each mission, which will enable the crew complement on the ISS to increase from six to seven crew members. As a result, the total crew research time on the orbiting laboratory can expand from 40 hours each week to 80 hours, enabling critical science investigations that increase our understanding of what it takes to live and work in space while also benefiting life on Earth.

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<sup>1</sup> After the awards were made, Sierra Nevada Corporation (SNC) filed a protest with the Government Accountability Office (GAO) on September 26, 2014. During this period, the case was under protective order and NASA was unable to publically release the rationale for the selection of the contracts as well as other details of the contracts. The GAO denied SNC's protest on January 5, 2015.

### **Safety**

Safety is an inherent aspect of NASA's strategy to develop a U.S. Commercial Crew space transportation capability. The first phase, the Certification Products Contracts is complete. During that phase, our industry partners made significant progress in honing their designs to meet our certification requirements, with explicit feedback from NASA on conformance.

The overarching objective of the second phase, the recently-awarded CCtCap contracts, is to ensure that NASA's human safety and certification requirements are met. The contracts include a robust insight clause, which will enable NASA to fully evaluate the company's designs to determine whether NASA's safety requirements are satisfactorily met. Defined milestones in the contracts enable NASA to incrementally assess the safety and performance of the systems through the certification process. In addition, the contracts include a comprehensive test program, including at least one crewed flight test to the ISS. The contract also includes a contract line item to add contractor-led studies, as needed, to provide extra analysis and possibly test in critical areas. The budget also includes funding for and fully involves NASA's technical authorities in the development process. This ensures that the entire NASA team is focused on this activity.

Simply put, crew safety is prioritized in the Commercial Crew Program. It is NASA's consistent and publicly stated position that any crew transportation systems selected and certified must meet the same rigorous safety standards as all human spaceflight programs in NASA.

### **CCtCap Milestones**

NASA measures partner progress against fixed-price milestones, based on performance of agreed upon entrance and success criteria. Although the content varies by partner, milestones are designed to demonstrate progress toward completing crew transportation system development such as risk reduction testing, design reviews, hardware development, and flight tests. The CCtCap Request for Proposals (RFP) listed five mandatory milestones for the development phase and five mandatory milestones associated with the post certification missions to ISS. The contractors added milestones beyond these minimum mandatory milestones. Boeing has 23 total milestones for the development phase and SpaceX has 18 milestones for this phase. The government pays for milestones only after completion. Criteria for successful completion of the milestones is negotiated prior to the milestone. NASA and the companies can mutually agree on changes to milestones, such as splitting contract milestones into smaller tasks with no price change. The total price for the sum of the smaller tasks will not exceed the total value of the original milestone. Payment for the milestone or smaller task will not be made until the agreed to criteria is met.

NASA and our industry partners are currently in the process of re-baselining the CCtCap schedule of milestones. It is likely that there will be a relatively large number of changes because the original contract milestones were established over a year ago when the

companies submitted their CCtCap proposals. These changes will not be indicative of poor contractor performance, but rather the significant maturity and advancement that has occurred on the partner designs since the proposals were submitted. In addition, these changes should not affect the total CCtCap contract costs or the FY 16 CCP budget request.

The goal outlined in the RFP is to complete certification in 2017. NASA and our partners are committed to that goal and have a plan to meet it, but we will not sacrifice safety of crew for that goal.

### **Recent Progress**

NASA's industry partners have made good progress under CCtCap.

Boeing completed the Certification Baseline Review in November 2014, which baselined a plan for achieving the certification of a commercial system to transport crew and cargo to/from the ISS. Also during November 2014, Boeing completed the Ground Segment Critical Design Review, which performed a review of crew and mission operations systems and ground systems for spacecraft assembly, integration, and test. In December 2014, Boeing completed the Phase II Safety Review Part B Integration System milestone.

Upcoming Boeing milestones include: an internal commercial crew transportation system Program Readiness Review, another Phase II Safety Review, and a Delta Integrated Critical Design Review.

SpaceX completed its Certification Baseline Review, which baselined the company's plan for achieving the certification of a commercial system to transport crew and cargo to/from the ISS.

Upcoming milestones include: a Pad abort test (performed under the CCiCap Space Act Agreement), an Avionics Test Best Activation milestone, and an In-Flight Abort Test (also under CCiCap).

It should be noted that these crew transportation systems are very complex and the development and test activity planned over the next three years will be extremely challenging. Most likely, many things will not go exactly as we and our partners plan. This is true of any spaceflight development activity.

### **Price Per Seat**

It is not possible to do a direct price comparison between Soyuz and Commercial Crew for crew transportation. Soyuz is purchased by the "crew seat" while Commercial Crew flights are purchased on a per mission basis which includes four seats and an additional 100kg of pressurized cargo. However, an equivalent seat price can be calculated for Commercial Crew using the prices established in the CCtCap contracts for the 4-seat configuration and excluding the price for the additional cargo. Using the pricing in the



CCtCap contracts for the 12 Post Certification Missions (6 per company) and assuming all 12 missions are purchased and flown at a rate of two per year, the average seat price is \$58 million per seat for Commercial Crew. The currently contracted seat price for Soyuz for 2017 is approximately \$76 million per seat. Soyuz seat pricing has been increasing at a rate of approximately 9 percent per year.

It should also be noted that, once both of these systems have been successfully completed, and including all previous commercial crew phases, the United States will have developed two new, independent, human space transportation systems for a cost of less than \$5B to the U.S. taxpayer.

### **Benefits of Competition**

American industrialization has long shown the benefits to customers of competitive markets, and NASA is capitalizing on that approach through the Commercial Crew Transportation Capability contracts. The Agency selected two independent systems designed by Boeing and SpaceX which, once certified, will add to the fleet of ships serving the ISS. Multiple awards maximizes meeting the program objectives, provides more options and flexibility for the Agency throughout contract performance, reduces overall risk to the program, and best ensures successfully accomplishing safe, reliable missions to the ISS.

While NASA is confident in the ability of the companies to perform, their designs are still not fully mature. Maintaining the benefits of competition during the rest of the development lifecycle and into initial services is critical to assuring safety by enabling redundant capabilities that will provide assured access to and from the ISS.

According to the Office of Inspector General: "Moving forward with a single company increases the risk that NASA could be left without a viable commercial option to transport crew to the ISS should issues arise that either significantly delay or render inoperable the selected company's systems." It is not in the best interests of NASA to put the Agency into a sole-source situation or to establish a monopoly on crew transportation.

In addition, selecting one company for a CCtCap award would not have accelerated the schedule. In NASA's RFP for CCtCap, the Agency requested proposals from industry for a crew transportation system "as soon as possible" and the companies proposed the optimum funding profile and technical schedule to complete their development as soon as possible.

### **FY 2016 Budget Request**

The FY 2016 budget request for Commercial Crew is \$1,243.8 billion, an increase of \$395.5 million above the FY 2015 request, and an increase of \$438.8 million above the FY 2015 enacted appropriation of \$805 million. This increase supports the contracts

awarded to two American companies and keeps us on track toward the goal of returning human spaceflight launches to U.S. soil by the end of 2017. The Commercial Crew Program budget request funds two total post certification missions. The ISS Program will fund all subsequent post certification missions.

The FY 2016 budget request for Commercial Crew is comprised of three components. The first and largest component is the cost of the CCtCap contract milestones. The milestones are contractual requirements that NASA has committed to paying once the companies successfully complete the milestones. The amounts of these contracts were identified when the proposals were selected for the CCtCap awards. The total cost for the development phase and two post certification missions for both contractors is ~\$3.9 billion. The second component is NASA program office costs, including civil servant labor, travel, etc. The budget for the program office support across the total activity is ~\$266 million. The third component is for Unfunded Future Expenses, risk reduction activities, additional tests, etc. The budget for these tasks is less than 5 percent of the total effort or \$198 million.

The \$805M appropriated for CCP in FY 2015 should be sufficient to fund the CCtCap contracts for the current fiscal year. If NASA does not receive the full requested funding for CCtCap in FY 2016 and beyond, NASA will have to adjust (delay) milestones for both partners proportionally and extend sole reliance on Russia for crew access to the ISS. The partners may request contract cost adjustments and the certification dates will be delayed.

### **Conclusion**

Human spaceflight is a very difficult endeavor and achieving commercial crew transportation will continue to be a challenge. However, NASA's successful developmental approach over the last several years has led to this final phase where we are ready to take the next step to enable U.S. commercial industry to fly crews to space, and once again launch our astronauts from America. Support for Commercial Crew at this time is critical for NASA to develop a safe, competitive, domestic program which will enable us to end our sole reliance upon the foreign governments for crew transportation by 2017 and to allow NASA to focus its exploration resources on expanding our human presence into destinations beyond low-Earth orbit. The Commercial Crew Program along with the Space Launch System and *Orion* program and daily operations on the International Space Station together make for a robust human spaceflight program for the nation – and are all critical components of our journey to Mars. NASA's human spaceflight team is ready for these challenges. Congressional support is critical.

Mr. Chairman, I would be happy to respond to any questions you or the other Members of the Committee may have.

**William H. Gerstenmaier**  
**Associate Administrator Human Exploration and Operations**



William H. Gerstenmaier, NASA Associate Administrator for the Human Exploration and Operations Directorate. Credit: NASA/Bill Ingalls. William H. Gerstenmaier is the associate administrator for the Human Exploration and Operations Directorate at NASA Headquarters in Washington, DC. In this position, Gerstenmaier provides strategic direction for all aspects of NASA's human exploration of space and cross-agency space support functions of space communications and space launch vehicles. He provides programmatic direction for the continued operation and utilization of the International Space Station, development of the Space Launch System and Orion spacecraft, and is providing strategic guidance and direction for the commercial crew and cargo programs that will provide logistics and crew transportation for the International Space Station.

Gerstenmaier began his NASA career in 1977 at the then Lewis Research Center in Cleveland, Ohio, performing aeronautical research. He was involved with the wind tunnel tests that were used to develop the calibration curves for the air data probes used during entry on the Space Shuttle.

Beginning in 1988, Gerstenmaier headed the Orbital Maneuvering Vehicle (OMV) Operations Office, Systems Division at the Johnson Space Center. He was responsible for all aspects of OMV operations at Johnson, including development of a ground control center and training facility for OMV, operations support to vehicle development, and personnel and procedures development to support OMV operations. Subsequently he headed the Space Shuttle/Space Station Freedom Assembly Operations Office, Operations Division. He was responsible for resolving technical assembly issues and developing assembly strategies.

Gerstenmaier also served as Shuttle/Mir Program operations manager. In this role, he was the primary interface to the Russian Space Agency for operational issues, negotiating all protocols used in support of operations during the Shuttle/Mir missions. In addition, he supported NASA 2 operations in Russia, from January through September 1996 including responsibility for daily activities, as well as the health and safety of the NASA crewmember on space station Mir. He scheduled science activities, public affairs activities, monitored Mir systems, and communicated with the NASA astronaut on Mir.

In 1998, Gerstenmaier was named manager, Space Shuttle Program Integration, responsible for the overall management, integration, and operations of the Space Shuttle Program. This included development and operations of all Space Shuttle elements, including the orbiter, external tank, solid rocket boosters, and Space Shuttle main engines, as well as the facilities required to support ground processing and flight operations.

In December 2000, Gerstenmaier was named deputy manager, International Space Station Program and two years later became manager. He was responsible for the day-to-day management, development, integration, and operation of the International Space Station. This included the design, manufacture, testing, and delivery of complex space flight hardware and software, and for its integration with the elements from the International Partners into a fully functional and operating International Space Station.

Named associate administrator for the Space Operations Directorate in 2005, Gerstenmaier directed the safe completion of the last 21 Space Shuttle missions that witnessed assembly complete of the International Space Station. During this time, he provided programmatic direction for the integration and operation of the International Space Station, space communications, and space launch vehicles.

Gerstenmaier received a bachelor of science in aeronautical engineering from Purdue University in 1977 and a master of science degree in mechanical engineering from the University of Toledo in 1981. In 1992 and 1993, he completed course work for a doctorate in dynamics and control with emphasis in propulsion at Purdue University.

Gerstenmaier is the recipient of numerous awards, including three NASA Certificates of Commendation, two NASA Exceptional Service Medals, a Senior NASA Outstanding Leadership Medal, the Meritorious Executive Presidential Rank Award, and Distinguish Executive Presidential Rank Award. He also was honored with an Outstanding Aerospace Engineer Award from Purdue University. Additionally, he was twice honored by Aviation Week and Space Technology for outstanding achievement in the field of space. His other awards include: the AIAA International Cooperation Award; the National Space Club Astronautics Engineer Award; National Space Club Von Braun Award; the Federation of Galaxy Explorers Space Leadership Award; AIAA International Award; the AIAA Fellow; Purdue University Distinguished Alumni Award; and Honored at Purdue as an Old Master in the Old Masters Program; recipient of the Rotary National Award for Space Achievement's National Space Trophy; Space Transportation Leadership Award; the AIAA von Braun Award for Excellence in Space Program Management; and the AIAA von Karman Lectureship in Astronautics.

Chairman PALAZZO. Thank you, Mr. Gerstenmaier.  
Now recognize Vice Vice Admiral Dyer for five minutes to present his testimony.

**TESTIMONY OF VICE ADMIRAL JOSEPH DYER,  
USN (RET.), CHAIRMAN,  
AEROSPACE SAFETY ADVISORY PANEL,  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
(NASA)**

Vice Admiral DYER. Thank you, Mr. Chairman, Ranking Member, Members of the Subcommittee. Thank you for the opportunity to discuss the Aerospace Safety Advisory Panel's 2014 activities and annual report. Mr. Chairman, I have limited the scope of my testimony to focus on the Commercial Crew Program. Ms. Edwards, I would note that both the Chairman and I are Southerners, and I would hope the clock wouldn't run during my testimony either.

The ASAP salutes NASA on the many accomplishments achieved during 2014. Among others, these include safe International Space Station operations, growing traction on the ESD program, and success in supporting ISS logistics via commercial cargo. The leadership and program management of the ISS is highlighted for its openness, transparency, and candor. The ISS culture is, we believe, a space flight exemplar.

In our 2014 report to the NASA administrator and the Congress, we noted that NASA is experienced and accomplished in space system procurement by making, managing, and buying. An example of making is a NASA custom produced satellite. An example of managing is a launch vehicle where NASA manages fulfillment of a performance spec often designed and generally produced by a contractor. An example of buying would be a commercial satellite launch service from a marketplace that has already established the bona fides of value, safety, and reliability.

The CCP program falls into a chasm between the deep insight of managing and that of buying a product already proven by broad market acceptance. With CCP NASA is operating at arm's length, and within a constrained budget. They are attempting to approach commercial crew transportation as buying a service, yet the maturity of the product may be more suitable for a managed development. Nevertheless, NASA is making laudable efforts to embrace this new model, but is trapped somewhere on a continuum between managing and buying.

The panel strongly believes that communications and transparency are necessary to ensure safety must be a central part of the program. Regrettably, the panel has been unable to offer any informed opinion regarding the adequacy of certification, or the sufficiency of safety in the Commercial Crew Program due to constraints placed on our access to needed information. Within CCP, candid, timely and transparent information has been insufficient. The lack of transparency has been a concern for a number of years, despite the discussions with the Director of Commercial Space Development, and with senior NASA officials at headquarters.

Those sets of constraints, Mr. Chairman, which you addressed as well, included a seamless series that began with the acquisition

strategy, is still being addressed, therefore, it can't be discussed. That information is pre-decisional. Responses had said the incident investigation is still being conducted, and we are not prepared to address. Next was that it was source selection sensitive, and lastly, a protest has been filed, and we are unable to address.

All these statements are true, but these should not have been absolute barriers to the sharing of information. The responses by the director have been a compilation of all the reasons information was withheld, rather than figuring out how to make things work. The ASAP members are, after all, special government employees. The panel is concerned that the lack of candor is not limited to interactions with the ASAP, but may extend to other internal and external stakeholders. This issue is reminiscent, we believe, of problems identified by both the Rogers Commission and the CAIB. NASA knows how to work in an open and transparent manner, and, as noted, the ISS is a great example. Going forward into 2015, the administrator has committed to making the changes necessary to resolve the situation.

Two other quick topics, Mr. Chairman, if I may? I would like to address budget and constancy of purpose. With regard to budget, the panel believes it is critically important to sustain sufficient funding for the CCP program to sustain competition. With regard to constancy of purpose, the panel notes that many NASA human space flight programs that have been initiated in the last 20 years have not been carried to completion. The ASAP appeals for constancy of purpose, and notices that the objective is both important and challenging when there is a change in leadership at the Congress or the White House. Thank you, Mr. Chairman.

[The prepared statement of Vice Vice Admiral Dyer follows:]

**Statement of Vice Admiral Joseph W. Dyer, USN (Retired)  
Chair National Aeronautics and Space Administration's Aerospace Safety Advisory Panel  
Before the Subcommittee on Space,  
Committee on Science, Space, and Technology  
U.S. House of Representatives**

Chairman Palazzo, Ranking Member Edwards and Members of the Subcommittee: Thank you for the opportunity to discuss the Aerospace Safety Advisory Panel's 2014 Activities and Annual Report. I've limited the scope of my testimony to focus primarily on the Commercial Crew Program.

The ASAP salutes NASA on the many accomplishments achieved during 2014. Among many others, these include safe International Space Station (ISS) operations, growing traction on the Exploration Systems Development (ESD) program, success in supporting ISS logistics via commercial cargo, and positive strides in infrastructure management. The leadership and program management of the ISS is highlighted for its openness, transparency, and candor. The ISS culture is a space flight exemplar.

In our 2014 Report to the NASA Administrator and the Congress, we noted that NASA is experienced and accomplished in procuring space systems by "making," "managing," and "buying." An example of "making" is NASA custom-produced satellites; an example of "managing" is launch vehicles, whereby a NASA program office manages fulfillment of a "performance spec," often designed and generally produced by a contractor; an example of "buying" is commercial satellite launch services, whereby NASA procures a service where the marketplace has established the bona fides of value, safety, and reliability.

The Commercial Crew Program (CCP) falls within a chasm between the deep insight of "managing" and that of "buying" a product proven by broad market acceptance. With the CCP, NASA is operating at relative arm's length while concurrently fostering the development of a commercial market. The distinctions between the three approaches often blur, but one usually dominates. NASA, within a constrained budget, is attempting to approach the commercial crew transportation requirement as "buying a service," yet the maturity of the product may be more suitable to a "managed" development. NASA is making a laudable effort to embrace this new business model but is caught somewhere in the transition between managing and buying.

The Panel strongly believes open communication and transparency are essential to ensuring the safety of the program as we go forward with such a construct. This raises the questions regarding safety. Regrettably, the Panel is unable to offer any informed opinion regarding the adequacy of the certification process or the sufficiency of safety in the Commercial Crew Program (CCP) due to constraints placed on access to needed information.

Within the CCP candid, timely, and transparent communication of risk has been insufficient. This lack of transparency has been a concern for a number of years and, despite numerous discussions with the Director of Commercial Spaceflight Development (DCSD) and with senior leadership at NASA Headquarters, this less-than-candid and -transparent communication with the ASAP regarding the CCP has persisted. Over the last several years, the DCSD has responded to ASAP's requests for information related to the plans on how commercial programs would be certified or how confidence would be gained on the safety of operations with a seamless set of constraints as to why the information could not be shared. These have ranged, in order of occurrence, from:

1. "We're still defining the acquisition approach" to
2. "That information is pre-decisional" to
3. "The investigation is still being conducted" to
4. "That's source selection sensitive information" to
5. "A protest has been filed."

While these statements are all true, these conditions should not have been absolute barriers to sharing information related to certification and safety. The responses by the DCSD have generally been a compilation of all the reasons cooperation was not possible rather than figuring out how to make things work. The ASAP members are, after all, special government employees.

The Panel is concerned that this lack of candor is not limited to interactions with the ASAP and may extend to other internal and external stakeholders. This issue is reminiscent of the problems that were explicitly identified by both the Rogers Commission and the Columbia Accident Investigation Board (CAIB) regarding causes of the Space Shuttle Challenger and Columbia mishaps respectively.

I would add, NASA knows how to work in an open and transparent way. Within NASA, there are outstanding examples of programs that have inculcated a culture of clear and candid communications. Their approach to accountability, good



systems engineering, and respect, both up and down the organization chart, would find strong favor with the authors of the Columbia Accident Investigation Board Report. As noted, ISS is a great example.

Going forward into 2015, the NASA Administrator has committed to making the changes necessary to resolve this situation and to ensuring these barriers are removed. Since the publication of our Annual Report, we are beginning to see improvements.

In the 2014 Annual Report to the NASA Administrator and to the Congress, we again highlighted the mismatch between the breadth of the Agency's undertakings and the funding available to execute them. The resources necessary to safely and efficiently accomplish the full scope of scientific discovery, aeronautics research, commercial space transportation, and further extending the Nation's reach into the solar system are insufficient. Especially, I highlight the importance of sufficiently funding the CCP to sustain competition. This is especially true as NASA has started developing the equipment that will carry Americans to Mars concurrently with extending the life of the International Space Station.

NASA's budget is insufficient to deliver all current undertakings with acceptable programmatic risk. History clearly shows programmatic risk precipitates tradeoffs that are not in support of good safety practice. The Panel highlights three possible methods to relieve this situation:

1. Prioritize and set aside programs, activities, and infrastructure of lesser import (i.e., do fewer things better);
2. Improve the utility of NASA's investment by completing programs of record versus the restarts that too often follow administration change (i.e., finish what is started); and
3. Form a lasting consensus among the Administration, the Congress, and NASA on a genuine, long-term mission and vision and provide the funding required to deliver it.

The Panel notes the many NASA human space flight programs that have been initiated in the last 20 years but not carried to completion. The ASAP appeals for "constancy of purpose" and observes this objective is both important and challenging when there is a change of leadership in either the Congress or the White House. Another threat to constancy of purpose is the reaction to inevitable failures along the way. Rather than canceling a program or coming to a prolonged standstill after a failure, an appropriate reaction—given constancy of purpose, a

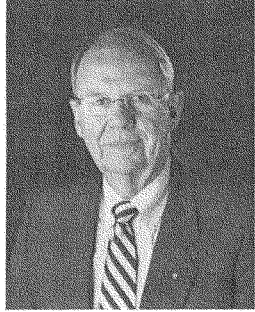
clear and well-articulated goal, transparently communicated risks and values, and mitigated or accepted risks—is to learn from the failure, fix any problem expeditiously and responsibly, and continue. The ASAP believes that this is the approach being taken with respect to the recent Cargo Resupply Services (CRS) launch failure and supports it.

The Panel notes NASA is doing a better job of communicating the risk inherent in space flight. The way the Agency communicated the danger Curiosity faced in landing on Mars is a good role model.

In closing, the Panel commends NASA's continued use of unfunded Space Act Agreements to stay engaged with the evolving, privately-funded commercial space companies including Sierra Nevada Corporation, Blue Origin, and Virgin Galactic, among others.

You may access the ASAP's 2014 report via:

[http://oiir.hq.nasa.gov/asap/documents/2014\\_ASAP\\_Annual\\_Report.pdf](http://oiir.hq.nasa.gov/asap/documents/2014_ASAP_Annual_Report.pdf)



**Vice Admiral Joseph W. Dyer, USN (Ret.)**

- Chair, Aerospace Safety Advisory Panel
- Former Chief Operating Officer and Chief Strategy Officer, iRobot Corporation
- Former Commander, Naval Air Systems Command

Vice Admiral (Ret.) Joseph W. Dyer is currently a consultant in the tech, aerospace, and defense markets. He operates at the intersection of technology, finance, and risk mitigation.

From 2003 through late 2012, he was an executive at iRobot Corporation serving consecutively as the President of the Government and Industrial Division, Chief Operating Officer, and as Chief Strategy Officer.

He served as Commander of the Naval Air Systems Command from June 2000 until his military retirement in July 2003. He previously was assigned as Commander of the Naval Air Warfare Center Aircraft Division at Patuxent River in July 1997 and a month later assumed additional responsibilities as the Assistant Commander for Research and Engineering of the Naval Air Systems Command.

From January 1994 to April 1997, Admiral Dyer served as F/A-18 Program Manager, leading engineering and manufacturing development efforts on the new F/A-18E/F, continued production and fleet support of the F/A-18C/D, and all F/A-18 foreign military sales. Under his management, the F/A-18 program won the Department of Defense Acquisition Excellence Award and the Order of Daedalian. Earlier in his career, he served as the Navy's Chief Test Pilot.

Vice Admiral Dyer is a graduate of North Carolina State University with a B.S. in chemical engineering and the Naval Postgraduate School, Monterey, California, with a degree in financial management.

He is an elected Fellow in the National Academy of Public Administration and the Society of Experimental Test Pilots. He was awarded the James H. Doolittle award in recognition of outstanding engineering achievement in aerospace.

Chairman PALAZZO. Thank you, Vice Admiral Dyer.  
I now recognize Mr. Mulholland for five minutes to present his testimony.

**TESTIMONY OF MR. JOHN MULHOLLAND,  
VICE PRESIDENT AND PROGRAM MANAGER,  
COMMERCIAL PROGRAMS, THE BOEING COMPANY**

Mr. MULHOLLAND. Chairman Palazzo, Ranking Member Edwards, welcome, Chairman Smith, Members of the Committee, on behalf of the Boeing Company, thank you for the opportunity to provide an update on Boeing's commercial crew transportation system. We are honored to be part of NASA's Commercial Crew Program to provide safe and reliable crew transportation to support the International Space Station mission. Boeing is the only provider to have closed NASA's commercial crew integrated capability contract on time, and to complete a successful critical design review. With that, we have laid the framework for completing our design during the current phase of the program, which was awarded last September.

Boeing's approach is a full service system, providing all elements needed to transport crew and cargo to and from low-Earth orbit, including the CST-100 spacecraft, spacecraft and launch vehicle integration and test, crew training and mission planning, cargo integration, mission operations, and crew and cargo recovery. In developing the Boeing system, we apply our unique integrated approach to meet NASA's human rating requirements, leveraging our space shuttle and ISS program experience and tools, along with our certification products, which are approved by NASA during the certification products contract. We continue to work diligently to maintain our planned schedule, completing the first two schedule milestones on time, and the first two of the next three part milestone.

We have made significant progress the first four months of the program. We have procured four Atlas V launch vehicles from United Launch Alliance for our two certification flight tests, and the first two service flights. Last week we held a formal groundbreaking with our partners to begin construction on the crew access tower for the Atlas V launch pad at Cape Canaveral. Work is underway on the Atlas V emergency detection system, part of the abort system that supports human rating of our integrated system.

Boeing and the Kennedy Space Center have completed handover of the former Orbital Processing Facility, OPF-3. Boeing has transformed it into a modernized state of the art facility that will support manufacturing, assembly, and integration and test for the CST-100 spacecraft. We have installed tooling, and have received and inspected more than 150 pieces of flight hardware on the way to assembling the CST-100 structural test article. Later this year, hardware for the qualification test vehicle will arrive, and after that the orbital and crude flight test vehicle hardware.

Other points of progress include system software and avionics development, along with development of our avionics and software integration lab. Wind tunnel testing and landing system testing is ongoing. Our space suit supplier has provided an innovative, safe,

and comfortable space suit prototype. And we are making significant progress with cabin interior design features.

Throughout 2015 and 2016 we will complete a number of key development tests and reviews. We are confident these milestones will show progress and completion of our structural test article and qualification test vehicle. Demonstration of flight hardware, acceptance of the mission control center, integrated simulation system, and completion of a service module hot fire launch abort test. We are on track for a pad abort test in early 2017 to fully check out the abort system, an un-crewed orbital flight test in spring of 2017, and our crewed flight test in the summer of 2017. After successfully achieving human rating certification, we will be prepared to fly the first service mission by the end of 2017.

As in most development programs, the Commercial Crew Program presents a number of technical and programmatic challenges. We are working proactively to meet these challenges. A key strength that Boeing provides to NASA is that we have depth in a wide range of engineering and manufacturing disciplines. We are able to apply those capabilities readily to achieve NASA's objective for safe crew access to ISS.

Commercial transportation to low-Earth orbit is the right solution to enable a robust portfolio of NASA programs in science and human space flight. The Commercial Crew Program provides safe and affordable transportation of our astronauts, helps stabilize our American human space flight work force, and frees up funding for NASA to invest in deep space exploration. Boeing is making substantial progress in our rigorous crew transportation development. Boeing is bringing the same quality to commercial space flight that we bring to our servicemen and women, NASA astronauts, and to the traveling public every day.

Thank you again for the opportunity to be here today, and I look forward to answering your questions.

[The prepared statement of Mr. Mulholland follows:]

**Testimony of John Mulholland**  
**Vice President and Program Manager, Commercial Programs**  
**Boeing Space Exploration**  
**February 27, 2015**

Chairman Palazzo, Ranking Member Edwards, and members of the Committee, on behalf of The Boeing Company, thank you for the opportunity to testify today to provide an update on Boeing's Commercial Crew Transportation System. We are honored to be part of NASA's Commercial Crew Program to provide safe and reliable crew transportation to support the International Space Station mission.

**Background**

This year, The Boeing Company enters its 100th year of developing human transportation systems. What began as a few airplanes flying mail routes on a small government contract has advanced to a thriving global enterprise serving the needs of millions of commercial airline passengers and servicemen and women around the world. Then and now, Boeing's success depends entirely upon the quality and safety of our products.

Our space experience extends to every human-rated system since the beginning of America's space program; from Mercury, Gemini, and Apollo to the Space Shuttle to the International Space Station.

As NASA continues to advance scientific research aboard ISS and extend exploration deeper into space with SLS and Orion, the Commercial Crew Program is pivotal to achieving NASA's human exploration vision within the economic constraints of a larger national agenda.

The Commercial Crew program's immediate purpose is to provide safe, reliable and affordable access to the International Space Station and low-Earth orbit and end America's reliance on Russian transportation for U.S. crews.

From the start of the first phase of the NASA Commercial Crew Development Program, CCDev, in 2009, Boeing implemented a robust program management approach, proven space flight systems and technology and a rigorous systems engineering development and certification approach to provide NASA and U.S. taxpayers with the most reliable solution to maintain schedule to meet NASA's mission.

This proven development process has led to Boeing successfully completing all phases of NASA's Commercial Crew program. We are proud to be the only Commercial Crew supplier to have closed NASA's Commercial Crew Integrated Capability contract on-time and the only supplier to successfully complete a Critical Design Review. This has laid the framework for completing our design during the current Commercial Crew Transportation Capability, CCtCap, phase of the program, which was awarded back in September.

In response to the request of the Committee, my testimony addresses a review of our Commercial Crew Transportation System capabilities, our progress, key milestones ahead, the challenges we face and risks we are mitigating as we prepare to certify and fly our system.

### **1. Review of Commercial Crew Transportation System capabilities, architecture and systems**

Boeing's simple design, using proven technologies to reduce system complexity, results in improved reliability and safety. It reduces development risk, improving predictability of cost and schedule. It also lowers overall cost. Our design will also support transportation services to other low-Earth orbit platforms, such as the commercial space station, planned by Bigelow Aerospace.

Our Commercial Crew Transportation System is a "full service" system. It provides all elements needed to transport crew and cargo to and from orbit, including crew training and mission planning; cargo integration; Crew Space Transportation (CST)-100 spacecraft assembly, integration and test; launch vehicle integration and testing; launch and mission operations; and crew and cargo recovery.

We apply an integrated approach to meet human rating requirements, leveraging our Space Shuttle and ISS program experience, along with our certification products approved by NASA during the Certification Products Contract, to continue guiding system development in compliance with NASA human rating requirements.

In our concept of operations, our CST-100 spacecraft launches from the Florida Space Coast on an Atlas V rocket, the most reliable rocket today with 100% success over 52 launches and counting. The fully autonomous CST-100 design is baselined for five passengers plus cargo, and can accommodate up to seven passengers or a mix of crew and cargo. After an eight-hour flight, the CST-100 capsule will rendezvous with a low-Earth orbit platform such as ISS. The capsule stays attached to the orbiting platform for up to seven months to serve as the crew's on-orbit "lifeboat." When it is time to return crew members to Earth, the capsule detaches from the space platform and re-enters the atmosphere behind the protection of an ablative heat shield. Boeing's CST-100 capsule is currently the only capsule being certified to land on land, which allows quick access to crews and valuable science. It uses a parachute and airbag landing system for comfortable deceleration. .

A land landing also increases reusability when compared with a water landing. The capsule can be refurbished and is reusable for up to 10 missions. The system does support water landings after pad or ascent aborts, targeted contingency landings, and emergency landings – providing additional measures of risk mitigation.

We have designed our capsule to be compatible with alternate launch vehicles. Once these launch vehicles have demonstrated sufficient technical and schedule reliability necessary for crewed flight, we maintain the ability to on-ramp them in our ongoing effort to drive life-cycle affordability.

### **2. Update of progress made**

We continue to work diligently to maintain our planned test flight schedule, despite a delay in contract award and subsequent stop-work associated with the protest denied by the Government

Accountability Office. Boeing has completed on schedule the first two milestones and the first two parts of a three-part third milestone.

Our first milestone, the Certification Baseline Review, was completed in October 2014, laying the ground work with NASA for our path to human-rated certification of our system.

The second milestone, the Ground Segment Critical Design Review, was completed in November. This was a review of the ground operations systems – including the facilities and processes for assembly, integration, and system test – as well as the mission operations systems – the control center, training systems and simulators and ground software that will be used to plan, train, and fly the crew.

The third milestone, the Phase II Safety Review, includes a review of Critical Design Review (CDR) level requirements and system architecture and design, with associated safety products to assess conformance with the certification process. It addresses updates to hazard reports/analyses including cause identification, development of controls, and specific safety verification methods. We completed the first two parts of this milestone in December and February, and the third part will follow in June.

The first four months of the program have seen significant progress in addition to the milestone-level accomplishments. Boeing has procured two Atlas V launch vehicles from United Launch Alliance for its two certification flight tests. Incidentally, the Atlas V that will launch the first uncrewed CST-100 test flight will be the 76th mission for the Atlas V family. The first crewed flight test of the CST-100 will fly on the 80th Atlas V mission.

Earlier this month, we began construction on the Crew Access Tower for the Atlas V launch pad at Space Launch Complex-41. The tower will be built off pad and assembled on pad between launches to maintain normal operations. The crew tower is needed to meet the requirements of a human-rated launch pad and will take approximately 18 months to complete.

Work is also underway on the Atlas V Emergency Detection System, part of the Abort System that supports human-rating of our integrated Commercial Crew Transportation System.

The former orbiter processing and engine maintenance shop, Orbiter Processing Facility (OPF)-3 at the Kennedy Space Center, has completed handover to Boeing and is now a modernized state-of-the-art facility that will support manufacturing, assembly, integration and test for the CST-100 spacecraft. We call the new facility the Commercial Crew and Cargo Production Facility, or C3PF. We have installed tooling, including the lower dome lift fixture and the upper and lower dome assembly jigs. We have received and inspected more than 150 pieces of flight hardware at C3PF so far. The hardware being delivered now will form the structural test article. Later this year, hardware for the qualification test vehicle will arrive, followed by the orbital and crewed flight test vehicle hardware.

System software and avionics development continues to advance, with recent release of software Engineering Release 4.0 and completion of early integration tests. We have progressed with



the development of our Avionics and Software Integration Laboratory (ASIL), finalizing the lab's layout and receiving from our suppliers a full ship set for ASIL system, flight and display computers.

We have completed additional Wind Tunnel Testing validating our addition of a perforated ring to eliminate launch buffeting in the integrated stack. Additional Wind Tunnel Tests have been completed to assess abort turn around performance, maneuvering jet interaction during abort and dynamic stability.

Landing system testing is also ongoing; we recently completed additional airbag water landing tests and a rapid inflation test.

Our space suit supplier has provided an innovative, safe and comfortable space suit prototype, and we are making significant progress with cabin interior design features. We continue to refine the human interface to our spacecraft and have defined all content for our remaining flight displays. We have completed key prototype evaluations for suit glove usability, keypad usability and suit helmet visor field of view.

With the completion of early CCtCap performance milestones and significant ongoing development testing, the team is working hard to finish the design. We previously completed multiple design analysis cycles in which we analyzed our design against NASA human-rating requirements. Now, under CCtCap, we have initiated the first Verification Analysis Cycle, working back in a closed-loop process to develop the objective evidence that will support certification of our baselined design to the NASA human-rating requirements.

Our approved certification plan follows a process very similar to the process that we followed for Space Shuttle, Space Station and is consistent with Boeing commercial programs, such as commercial airplanes and satellites.

### **3. Upcoming significant milestones**

Our efforts to date under CCtCap and prior contract phases come together next month in March with our fourth CCtCap milestone, a Delta Integrated Critical Design Review. In the Delta Integrated CDR, we'll review the baseline design established during the earlier CDR completed under CCiCap, as well as new design content, to demonstrate compliance of our integrated design across our system's launch, spacecraft and ground segments. The review will include hardware, software, facilities, support equipment and plans that satisfy system-level, segment-level and module-level requirements. The Delta Integrated CDR demonstrates that the design is mature enough to proceed to assembly, integration and test activities.

Over the remainder of 2015 and 2016, we will complete a number of key development tests and reviews. These milestones show progress in completion of our Structural Test Article and Qualification Test Vehicle, demonstration of flight software, acceptance of the Mission Control Center integrated simulation system, and completion of a Service Module hot fire launch abort test.

In late 2016, we will complete the formal NASA delivery milestone, ISS Design Certification Review (DCR), where we will demonstrate that our transportation system and operations meet all requirements, as defined in NASA's governing requirements documents [CCT-REQ-1130, ISS Crew Transportation and Services Requirements Document, and SSP 50808, ISS to Commercial Orbital Transportation Services (COTS) Interface Requirements Document (IRD)]. Successful completion of this milestone paves the way for our Flight Test Readiness Reviews.

We're on track for a pad abort test in early 2017, where we'll fully check the abort system as well as our uncrewed orbital flight test in spring 2017. The crewed flight test, which will have one Boeing test pilot and one NASA astronaut, will be in summer 2017. Test Readiness Review milestones precede both the orbital and crewed flight tests.

Following the crewed flight test, we will complete the Operational Readiness Review and Certification Review milestones in the fall. After we successfully achieve human rating Certification in the Certification Review, then the first services mission can begin as early as the end of 2017.

#### **4. Development program challenges and risk mitigation**

Like all development programs, the Commercial Crew Program presents a number of challenges, both technical and programmatic, which we are working proactively to mitigate. A key strength that Boeing provides to NASA is that we have a host of resources in a wide range of engineering and manufacturing disciplines, and we have applied this expertise early to drive resolution of emerging risks. This deep talent pool and ability to share lessons learned across a wide range of aerospace development and production programs has been instrumental in addressing and resolving risk to NASA's benefit.

Our final proposal submittal assumed an August 1<sup>st</sup> authority to proceed. The award date in September followed by the stop-work order due to the protest has created schedule pressures that our team is actively working to mitigate. We actively manage numerous Technical Performance Measures to ensure compliance with design requirements. An important aspect of our management approach is opportunity management. Risk management, done well, provides the benefit of achieving technical, schedule, and cost baselines. Our team puts the same focus on opportunity management, which provides the benefit of better-than-planned technical, schedule, and cost baselines. Our team has identified dozens of opportunity targets actively in work that will provide the benefit of improved technical and schedule performance.

We are currently at the peak of our development profile, manufacturing flight design hardware in support of component, system, and vehicle-level qualification testing. Adequate yearly funding is required to maintain our current cost and schedule baselines. Appropriations levels below the presidential budget request could significantly impact overall program cost and schedule.

As we work to expand the business base beyond the International Space Station, appropriate liability protections will be necessary to foster the market. We support a cap on liability for operators against Space Flight Participant legal claims for bodily injury, similar to liability caps that exists today to facilitate

the growth and expansion of many other industries. In fact, other transportation industries--such as the shipping, railroad, and aviation industries--currently benefit from statutory liability limitation.

In today's space transportation industry, under the CSLA regulatory regime, payload owners are required to waive legal claims against launch providers. We believe a similar construct, wherein a space flight participant shares the inherent risk of space flight with the operator through limitation of damages he or she may collect in the result of accident, simply makes sense. We must not allow potential legal claims to have a chilling effect on industry growth; to do so could force this new and exciting industry overseas. Implementation of a reasonable limit on financial recovery, rather than outright elimination of legal recourse, strikes a meaningful balance between the rights of space flight participants and facilitation of an emerging industry.

#### **Closing**

Commercial transportation to low-Earth orbit is the right solution to enable a robust portfolio of NASA programs in science and human space flight. The Commercial Crew program decreases transportation cost for our astronauts, increases our American space workforce and frees up funding for NASA to invest in deep space exploration.

Boeing is making strong progress in a rigorous development effort. Boeing is bringing the same quality to commercial space flight that that we bring to our servicemen and women, NASA astronauts and to the traveling public, every day. Thank you.

Thank you again for the opportunity to be here today.

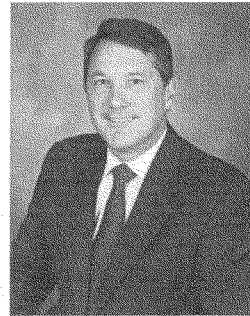


## Biography

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### JOHN P. MULHOLLAND

**Vice President and Program Manager  
Commercial Programs  
Space Exploration**



As Vice President and Program Manager, Commercial Programs, John Mulholland leads Boeing's commercial crew and cargo programs. Mulholland is responsible for the development of the company's fully integrated Commercial Crew Transportation System, comprised of the Crew Space Transportation (CST)-100 spacecraft, launch system, mission operations and ground systems. He also ensures that proven innovations and capabilities from across Boeing are used in development of space transportation vehicles to support NASA and other commercial customers.

Prior to his present position, Mulholland was the vice president and program manager for Boeing's Space Shuttle Program, responsible for overall direction and successful execution, from January 2008 to August 2011. Mulholland led Boeing in its role as the major subcontractor to United Space Alliance (USA) in support of its operations contract with NASA's Space Shuttle Program.

Prior to this position, Mulholland was the program director and chief engineer for Boeing's Space Shuttle Orbiter team. Mulholland was also responsible for resolving pre- and in-flight space shuttle engineering technical issues and maintaining the fleet's mission readiness.

Previously, he was a Boeing associate program director for Orbiter Vehicle Engineering where he led a team of about 400 employees in Huntington Beach, Calif.,

Houston, and Kennedy Space Center, Fla., responsible for space shuttle sustaining engineering, anomaly resolution and certification of flight readiness.

A NASA Exceptional Achievement Medal recipient, Mulholland was employed at NASA's White Sands Test Facility in New Mexico from 1986 to 1996 and was responsible for shuttle propulsion testing, including refurbishment of the orbiters' flight components. From 1996 to 2002, he was space shuttle deputy manager of operations and project engineer at NASA's Johnson Space Center (JSC) where he was responsible for orbiter vehicle modifications, flight and ground processing anomaly resolution, and flight preparation and vehicle modification processes.

Mulholland is a graduate of New Mexico State University with a Bachelor of Science in chemical engineering and a Master's degree in mechanical engineering.

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January 2015

Chairman PALAZZO. Thank you, Mr. Mulholland. I now recognize Dr. Reisman for five minutes to present his testimony.

**TESTIMONY OF DR. GARRETT REISMAN,  
DIRECTOR, CREW OPERATIONS,  
SPACE EXPLORATION TECHNOLOGIES CORPORATION**

Dr. REISMAN. Thank you, Chairman Palazzo, Chairman Smith, and Ranking Member Edwards. Thank you very much for inviting me here today to talk to you about SpaceX's progress under NASA's Commercial Crew Program. SpaceX is proud to be serving our nation's space program in a variety of ways. We are flying cargo missions today to the International Space Station using our Dragon spacecraft and our Falcon 9 launch vehicle. SpaceX currently offers the sole capability to return significant amounts of cargo to Earth from the ISS. We are also launching satellites for NASA and the Department of Defense, as well as the world's leading commercial satellite providers. To date, we have successfully launched the Falcon 9 15 times, and we have—and that includes six Dragon flights up to the ISS and back. Capitalizing on lessons learned from these missions, and from our partnership with NASA, the safest and most advanced human space flight systems ever seen are our objective.

Mr. Chairman, if I may, I would like to share a short video with you to provide a brief glimpse of SpaceX's manufacturing capabilities, hardware, and activities.

[Video shown.]

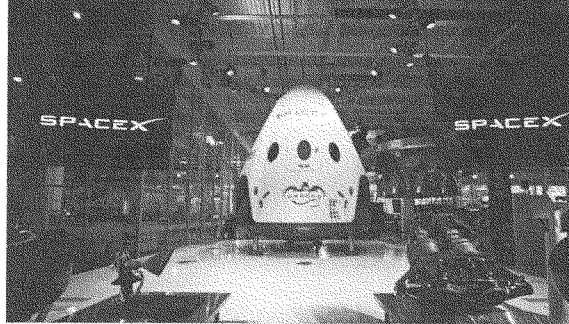
Mr. Chairman, human space flight is the reason that SpaceX was founded. Safe human space flight is of paramount importance to SpaceX, and also to me personally. Having been an astronaut at the time of the Columbia accident, I could tell you that I never want our country to have to experience a loss like that again. The safety and reliability that we have designed into the Falcon 9 and the Dragon reflect this longstanding intent. We are working steadily, thoughtfully, and efficiently with NASA to yield the safest and most reliable astronaut transportation system that the world has ever seen.

SpaceX believes that competition is critical to safe, timely, and assured access to space. The Aerospace Advisory Panel, the GAO, and NASA all agree that competition is an essential feature of this program. The value of redundant space transportation systems has also been repeatedly and recently demonstrated.

However, since 2011, the United States has depended entirely on Russia to transport our astronauts to the International Space Station. This is not a situation our great nation should accept. Together, we will fix this, and in only a few more years we will be launching once again Americans, on American rockets, from American soil. Your ongoing support is essential to restoring that capability by 2017.

Thank you for your contributions to the Commercial Crew Program, and to the American space exploration efforts. I am pleased to take any questions you might have.

[The prepared statement of Dr. Reisman follows:]



**STATEMENT OF  
GARRETT REISMAN  
DIRECTOR OF CREW OPERATIONS  
SPACE EXPLORATION TECHNOLOGIES CORP. (SPACEX)**

**BEFORE THE  
SUBCOMMITTEE ON SPACE  
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
U.S. HOUSE OF REPRESENTATIVES**

**February 27, 2015**

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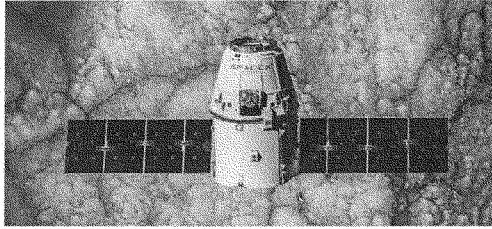
Chairman Palazzo, Ranking Member Edwards, and Members of the Subcommittee,

Thank you for the opportunity to participate in this important hearing. I also want to thank the Science, Space, and Technology Committee for its continued support for NASA's Commercial Crew Program. This innovative program will soon yield a critical outcome: the return of U.S. human spaceflight capability. To state the obvious, our current dependence on Russia to carry U.S. astronauts into space is unacceptable for numerous geopolitical, competitive, and financial reasons. Critically, American companies stand poised to fly American astronauts safely and reliably by 2017. Today, I am pleased to provide you with information regarding the status of SpaceX's efforts, technologies, schedule and remaining challenges as we move towards our first crewed mission to the International Space Station (ISS) under NASA's Commercial Crew Transportation Capabilities (CCtCap) program.

SpaceX is honored to have been selected by NASA as one of the two CCtCap awardees. Human spaceflight is the primary reason that SpaceX was founded in 2002; the safety and reliability technologies that we have designed and built into SpaceX launch vehicles and spacecraft reflect this long-standing intent. While there remain technological hurdles to overcome, we are working steadily, thoughtfully, and efficiently with NASA to yield the safest and most reliable astronaut transport system that the world has ever known.

## **1. SpaceX Background**

Thirteen years after SpaceX's founding, we are the fastest growing launch services company in the world with nearly 50 missions on manifest. Today, SpaceX is serving the Nation's space program in multiple respects, including cargo resupply missions to and from the ISS with the



Falcon 9 launch vehicle and Dragon spacecraft under NASA's Commercial Resupply Services (CRS) program. We have now successfully launched the Falcon 9 fifteen consecutive times, conducting missions for NASA, the Department of Defense, and the world's leading commercial satellite telecommunications companies. To date, the Dragon spacecraft has berthed with the ISS six times, carrying cargo and science payloads – including plants and live animals – and successfully returned critical science experiments and other cargo to Earth. Earlier this month we brought cargo back from the Space Station on a Dragon spacecraft and the very next day Falcon 9 launched a deep-space science payload for NASA, NOAA, and the Air Force.

As a commercial space transportation company, SpaceX is restoring America's competitive position in the global space launch market. We are recapturing market share that the U.S. long ago surrendered to our French, Russian, and Chinese competitors. This translates directly into jobs for Americans. With each Falcon 9 launch, for any of our customers, SpaceX demonstrates safety and reliability, which is critical for our NASA and national security customers. Each launch also demonstrates the best in U.S. high-tech engineering and manufacturing capabilities – all of SpaceX's design, development, engineering and manufacturing occur here in the United States. Every Falcon 9 launch vehicle (including engines and tanks) and Dragon spacecraft are made in America. We do not rely upon Russia for any element of the launch vehicle or spacecraft.

At SpaceX, we believe strongly in the value of competition. NASA has narrowed its crew transportation services providers to two companies that will compete for future astronaut launch opportunities. A competitive environment for the provision of launch services generally, and for astronaut carriage in particular, benefits of NASA and the country. Competition improves safety and provides the best outcome for the consumer – in this case, NASA and the American taxpayer. Indeed, the Aerospace Safety Advisory Panel's (ASAP) Annual Report for 2014 noted that it, "strongly supports NASA's decision to select two companies for the CCtCap contract" because "NASA will benefit from competition." Further, the ASAP correctly observed that, "the inherent dissimilar redundancy of these two systems means that a technical issue with one system will not preclude continued U.S. access to the ISS."

## **2. Crew Dragon and Falcon 9 System Overview**

SpaceX provides fully integrated, domestic human spaceflight capability for astronaut transport with all four major elements imbedded and integrated within the company – the Dragon spacecraft, Falcon 9 launch vehicle and their associated ground systems and mission operations.



America's astronauts will ride in Crew Dragon atop the Falcon 9 launch vehicle from the historic LC-39A launch pad at NASA's Kennedy Space Center. SpaceX is upgrading LC-39A to support several launches per year, including the Falcon Heavy launch vehicle. SpaceX will manage all crew launch and mission operations using an approach similar to the one that has resulted in 15 consecutive successful missions, including 6 Dragon cargo missions in partnership with NASA. Precision and rapid recovery operations will be executed in the water and on land, built on SpaceX's lessons learned from the ISS cargo program.

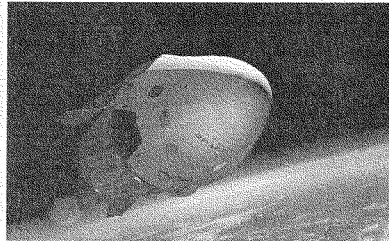
SpaceX's Crew Dragon and Falcon 9 integrated crew transportation system is designed to reduce complexity, enhance safety and increase reliability. For example, our system eliminates a separate launch abort tower that requires a critical jettison event on every mission. Crew Dragon is providing fault tolerance above and beyond NASA requirements in many instances. For example, the SuperDraco launch abort system (LAS), which is fully integrated into the spacecraft and includes an increased fault tolerance level to ultimately support a safe propulsive land-landing concept of operations. Additionally, the Cargo Dragon's deployable solar arrays have been eliminated to reduce the number of mechanisms on the vehicle and further increase reliability.

By developing, testing, manufacturing and integrating all elements of the commercial crew transportation system, SpaceX is able control all elements of the system to improve reliability, enhance safety and control schedule. To further improve safety and reliability, SpaceX places a very high value on our ability to 'test like you fly.'

### **3. Crew Dragon**

Crew Dragon is a free-flying, reusable spacecraft that will safely and efficiently carry the next generation of American astronauts to space. It is designed to fly up to seven astronauts to and from space beginning in 2017.

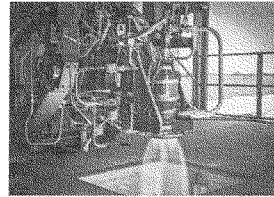
Crew Dragon was designed and is built and tested at SpaceX's facilities in partnership with NASA and thousands of American suppliers. It builds upon the success of Cargo Dragon, which has been carrying cargo to and from the ISS since 2012. While it employs key common elements with Cargo Dragon, the crew system has been designed to be more robust with key safety and reliability features that are described below.



Crew Dragon represents a significant step forward in space access. Leveraging the most advanced 21<sup>st</sup> century technologies, the Crew Dragon system also takes advantage of lessons learned over the history of human spaceflight. Crew Dragon is comprised of three main structural elements: the nosecone, which protects the vessel and the docking adaptor during ascent and reentry; the spacecraft, which houses the crew and pressurized cargo, as well as the service section (containing avionics, directional thrusters, parachutes, and other infrastructure); and the trunk, which will support Crew Dragon's solar arrays and radiators, as well as providing aerodynamic stability during aborts.

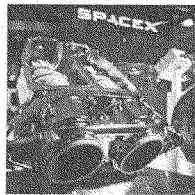
### 3.1 Crew Dragon Advanced Safety Systems

For the first time ever in human spaceflight, astronauts will have a dedicated system for escape in the event of a launch anomaly all the way through launch ascent to orbit. The spacecraft employs the SuperDraco launch abort system, which is capable of safely moving the Crew Dragon away from the launch vehicle at any point during ascent. In the past, astronauts could be pulled rapidly away to safety in the event of a launch vehicle anomaly only in the earliest stages of ascent. The Space Shuttle had no such safety system.



Crew Dragon's LAS relies on the 8 SuperDraco engines built into the spacecraft's sidewalls. Those engines produce up to 120,000 pounds of axial thrust. The LAS includes significant redundancy - it is a fault tolerant system that exceeds NASA requirements. While NASA does not mandate fault tolerance during an abort, Crew Dragon can suffer a failure within its system and still operate safely during the majority of the ascent. To demonstrate the capability and resiliency of this 21<sup>st</sup> century safety system, SpaceX will test Crew Dragon's escape capabilities during a unique pad abort test this spring and an in-flight abort test later this year.

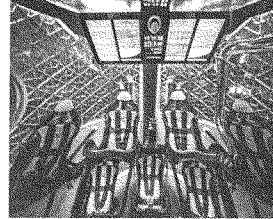
Crew Dragon's systems were designed with a critical focus on safety and reliability and provide a precision controlled reentry from space. Dragon's passively stable shape generates lift as it reenters the Earth's atmosphere supersonically. In addition to the 8 SuperDraco engines onboard Crew Dragon, its 16 Draco thrusters provide 2-fault tolerant roll control during reentry for precision guidance on course for a soft touchdown on land. Additionally, a movable ballast sled allows the angle of attack to be actively controlled during entry to further provide precision landing control. The Crew Dragon's SuperDraco engines are divided into four quads, each with two SuperDracos and 4 Draco engines. The SuperDracos will activate to provide precision land landing capability. Nominally, only two quads are used for on-orbit propellant with the Dracos and two quads are reserved for propulsive landing using the SuperDracos. For aborts or on-orbit faults, all four quads are available for Draco or SuperDraco operations, increasing flexibility, robustness, and performance in these critical situations. In the event of any anomalies with the propulsion system, Dragon retains its parachute capability for a soft water landing, a technology that has been demonstrated repeatedly via cargo missions.



Designed in partnership with NASA and fabricated by SpaceX, Crew Dragon's heat shield is made of PICA-X, a high-performance improvement on NASA's original phenolic impregnated carbon ablator (PICA). PICA-X is designed to withstand heat rates from a lunar return mission, which far exceed the requirements for a low-Earth orbit mission. It has been featured successfully on all of the Cargo Dragon missions. Crew Dragon incorporates an improved version of PICA-X, which better protects the spacecraft from the searing temperatures of reentry.

### **3.2 Crew Dragon Accommodations**

Crew Dragon has many innovative systems and features that complete the evolution of our currently operational cargo vehicle into a safe and reliable vehicle for human transport. These systems include seats, spacesuits, an environmental control and life support system, and crew displays and controls.

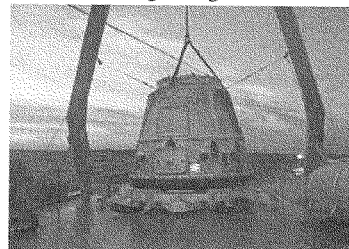


Crew Dragon will be capable of carrying seven crewmembers seated in two rows, a capability in excess of the NASA requirement to transport four crewmembers. Crew Dragon carries sufficient breathable gas stores to allow for a safe return to Earth in the event of a leak of up to an equivalent orifice of 0.25 inches in diameter. As an extra level of protection, the crew will wear SpaceX-designed spacesuits to protect them from a rapid cabin depressurization emergency event of even greater severity. The suits and the vehicle itself will be rated for operation at vacuum.

Crew Dragon features 21<sup>st</sup> century controls, including a modern touchscreen control panel to provide the crew with situational awareness and insight to the health and status of their vehicle as well as the ability to send critical commands to further guarantee crew safety in the event of contingencies. Using this interface, the crew will also have the ability to manually pilot Dragon even after two faults. Its environmental control and life support systems will provide the crew with fresh air ventilation, remove carbon dioxide, and control humidity and cabin pressure. Fire detection and suppression systems will protect the crew in the event of an emergency. Crew Dragon's seats are being designed with advanced occupant protections that draw on lessons learned from the Space Shuttle Columbia accident investigation reports, as well as the latest in automotive occupant protection technologies. Accommodations will also be provided for required food preparation and waste disposal.

### **3.3 Crew Dragon builds on ISS Cargo Services**

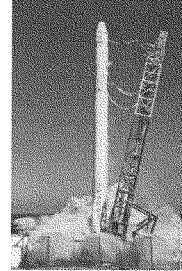
Falcon 9 and Dragon were conceived and architected with human spaceflight in mind. SpaceX undertook designs from inception to meet human certification requirements, including increased structural factors of safety, triple-string avionics, trajectories with acceleration limits within human safety limits, and many others. In fact, Dragon was originally designed to meet NASA's human engineering safety requirements in SSP 50808 because the Cargo Dragon flies in close proximity to the ISS and berths with the ISS. It also supports on-orbit crew habitation during cargo transfer operations. The commonality between the cargo and crew versions of Dragon allows for significant end-to-end flight heritage and operational experience to be gained on critical functions – including launch, navigation and control, thermal protection, thermal control, power generation and distribution, avionics, software, entry guidance and recovery – well before the first crew flight.



SpaceX's crew transportation development efforts build on the successful flight history of the Falcon 9 and Cargo Dragon currently operational under our CRS contract with NASA. SpaceX is collecting significant data and experience on the Falcon 9 and Dragon system through our CRS and other launch missions. Notably, the Cargo Dragon and Falcon 9 are scheduled to fly together at least 9 more times before the first Crew Dragon manned test flight in 2017. The Falcon 9 itself is scheduled to launch more than 50 times prior to the first Dragon crew mission. To date, 100 SpaceX Merlin 1D engines have been flown successfully on operational missions.

#### **4. Falcon 9**

Falcon 9 is an all-American rocket with a heritage of 15 consecutive successful flights. Falcon 9 features a simple two-stage design to minimize the number of stage separations. With 9 engines on the first stage, Falcon 9 has engine-out reliability during ascent. All of Falcon 9's structures, engines, separation systems, ground systems, and most of its avionics were designed, manufactured, and tested in the United States by SpaceX.



##### **4.1 Falcon 9 First Stage**

Falcon 9's first stage incorporates 9 Merlin engines. Merlin's thrust-to-weight ratio exceeds 150, making the Merlin the most efficient booster engine ever built, while still maintaining the structural and thermal safety margins needed to carry astronauts. The Merlin engines that power the first stage were developed and are manufactured in-house by SpaceX. SpaceX also produces Falcon 9's tanks, avionics and software in-house. The use of multiple clustered engines provides propulsion redundancy such that the first stage could suffer engine loss without causing a mission failure. This feature has not been present on any U.S. launch vehicle since the Saturn V moon rocket.

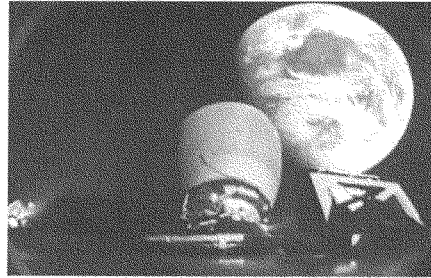
The 9 Merlin 1D engines are housed in Falcon 9's Octaweb thrust structure in a circular pattern with a single center engine. The layout provides individual protection for each engine, and further protects other engines in case of an engine failure. This design also allows the first stage to survive reentry and return to Earth post-launch, with the eventual goal of refurbishing and re-flying the stage. Though this capability may appear to be tangential to the crew program, since our CCtCap contract calls for brand-new vehicles for every crew mission, in order to survive the harsher environments of reentry, the first stage has been designed to be far more structurally robust than an ascent-only stage for the primary and critical ascent portion of the mission. This results in a safer and more robust launch vehicle for astronaut carriage.



After ignition, a hold-before-release system ensures that all engines are verified for full-thrust performance before the rocket is released for flight. That is, the rocket runs at full thrust and all systems are verified as green for launch before a mission proceeds. Only then, with thrust greater than five 747s at full power, the Merlin engines launch the rocket and its passengers to space.

#### **4.2 Falcon 9 Second Stage**

A single Merlin vacuum engine powers Falcon 9's second stage. The second stage engine ignites a few seconds after stage separation and can be restarted multiple times to place multiple payloads into different orbits. The second stage is made using most of the same tooling, materials, and manufacturing techniques as the first stage. This commonality yields significant design and manufacturing efficiencies. The commonality of the vacuum rated Merlin with its first stage variant is key to our high confidence in second stage reliability. Redundancy of critical components is included in the second stage engine design that exceeds even those present on the first stage engines. The helium spin start, pyrophoric igniter based engine architecture provides a very reliable means of ensuring engine start. Since the engine is designed to perform a number of restarts, for crew missions there is significant margin for the fluids required to perform a single start. Every Falcon 9 flight involves 10 similar engines that are acceptance-tested and operated in flight; therefore, Falcon 9 engines accrue flight heritage at a rapid clip that further distinguishes the Falcon 9 from its competitors.



#### **4.3 Falcon 9 Safety & Reliability**

An analysis of launch failure history between 1980 and 1999 by the Aerospace Corporation showed that the majority of known launch failures can be attributed to three causes: engine failure; stage-separation failure; and, to a much lesser degree, avionics failure. Accordingly, these three failure modes have been the focus of unrelenting attention at SpaceX. Falcon 9 is designed to have reliability in excess of NASA requirements and also achieve the stringent reliability requirements of other customers such as the U.S. Air Force's Evolved Expendable Launch Vehicle (EELV) program. With 9 Merlin engines clustered together to power Falcon 9's first stage, the vehicle is capable of sustaining engine failures and still completing its mission. From inception, Falcon 9's structure was designed with factors of safety required to human-rate the vehicle. Falcon 9 is an improved version of the architecture employed by the Saturn I and Saturn V rockets of the Apollo program.

To further improve safety and reliability, SpaceX places a very high value on the ability to 'test like you fly.' Every engine and every rocket stage is put through acceptance static fire testing at SpaceX's Rocket Development and Test facility in McGregor, Texas. Those tests use the actual avionics and software that will be used for flight, which allows system level assessments of a majority of the key flight systems in an integrated fashion. Prior to launch, a static fire test is performed with the fully integrated launch vehicle at the launch site. Static fire allows a complete

test of the vehicle, ground systems, and the interactions between the two. During static fire, SpaceX runs a launch countdown that fully tracks with launch day operations, cumulating with the launch vehicle achieving the level of thrust necessary to begin flight. At that point, SpaceX terminates thrust and safes the vehicle before reviewing the test data in preparation for launch.

With only 2 stages, Falcon 9 limits problems associated with separation events. The stage separation system features fault tolerant mechanisms that use pneumatics; this allows us to test the mechanics before we fly them, unlike traditional pyrotechnic systems.

SpaceX maximizes design and in-house production of much of Falcon 9's avionics, helping ensure compatibility among the rocket engines, propellant tanks, and electronics. Falcon 9's avionics and power architecture feature triple-string redundancy that is robust to failures during ascent. All critical control functions are designed to meet the high standards of reliability required to fly astronauts.

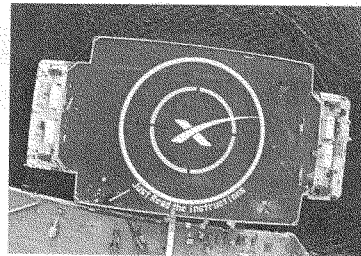
SpaceX utilizes an extensive instrumentation suite to gather data on all critical systems and validate prelaunch predictions on every flight. The combination of robust avionics, flight software, and extensive instrumentation allows us to implement crew ascent abort algorithms using demonstrated detection systems that have already been in use on every flight of Falcon 9. That capability is critical to astronaut safety.

Our Hawthorne, California, factory has a complete hardware simulator for avionics. By utilizing electronics identical to those on the rocket, the simulator allows SpaceX to check nominal and off-nominal flight sequences and validate the data that will be used to guide the rocket. The flight software is run on the actual launch vehicle to perform the same type of checks at the launch site prior to flight.

As mentioned above, SpaceX uses a hold-before-release system – a capability required by commercial airplanes, but not implemented on many launch vehicles. After the first stage engines ignite, Falcon 9 is held down and not released for flight until all propulsion and vehicle systems are confirmed to be operating normally. An automatic safe shutdown occurs and propellant is unloaded if any issues are detected.

#### **4.4 Falcon 9 Reusability Benefits Safety and Reliability**

SpaceX believes a fully and rapidly reusable rocket is the pivotal breakthrough needed to substantially reduce the cost of space access. While most rockets are designed to burn up on reentry, SpaceX rockets are designed not only to withstand reentry, but also to return to the launch pad for a vertical landing. Through reusability testing on the ground in McGregor, Texas, and in-flight testing, SpaceX is making great strides toward this goal. Although not required for crew missions, certain upgrades to the Falcon 9 first stage for return flight benefit the

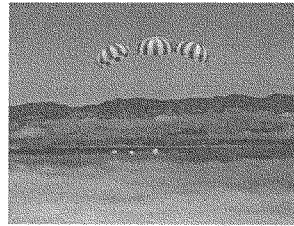


primary mission because a recoverable stage requires inherently higher levels of reliability. For example, Falcon 9 carries extra propellant to perform stage recovery and landing burns, which provides margin in excess of what a vehicle designed just for ascent can provide and can be used for the ascent portion of flight. SpaceX is also gaining key insights from our first stage recovery attempts regarding the reentry phase of spaceflight; those insights will inform our efforts to develop the safest possible systems.

## **5. Crew Transportation Development Overview**

SpaceX has partnered with NASA on crew transportation development efforts since 2011. By leveraging our existing vehicle designs and infrastructure, SpaceX has made significant progress on hardware development and testing under NASA's Commercial Crew Development II (CCDev2) and Commercial Crew Integrated Capability (CCiCap) programs. Through those programs, SpaceX accomplished development testing of our regeneratively-cooled, throttleable SuperDraco launch abort engines; composite overwrapped propellant and pressurant tanks to support the high thrust SuperDracos; structural qualification of the capsule primary structure; and fully integrated parachute system. The execution of the Pad Abort and In-flight Abort validation tests represent major milestones on the road to human spaceflight in the Crew Dragon spacecraft.

Since submitting the CCiCap proposal in January 2014, SpaceX has continued to enhance the Crew Dragon design to improve safety, operational flexibility, and reliability. These improvements include: the ability to perform precision propulsive land landing with full fault tolerance; increased propellant tank capacity for improved mission performance and to support propulsive landing; a movable ballast system to allow for high precision landings; life support system components moved from the trunk into the capsule service section to increase reliability; and consolidated avionics components to decrease complexity. The near doubling of the propellant tank capacity significantly increases the available impulse of the LAS allowing the capsule to travel further away from a failing launch vehicle. Additionally, the migration of life support consumables into the capsule allows the capsule to maintain pressure during the entire descent phase assuming a worst-case leak. Active center of gravity control allows for lift vector modulation for precise landings that ultimately enable fast access to the returning crew either on land or in the water.



Precision propulsive land landing will be certified in parallel with parachute to water landing for Crew Dragon. This will allow the teams to stay on schedule and ensure U.S. crew transportation safely and reliably in 2017. Land landing will become the baseline for the early post-certification missions; in the meantime, precision water landing under parachutes has been proposed as the baseline return and recovery approach for the first few flights of Crew Dragon. Parachute to water landing leverages SpaceX's excellent water recovery heritage, providing safe, fast, and reliable access to the crew. Per contract requirements, access to the crew will be provided within one hour of landing in the water and access to cargo within two hours of landing. Contingency plans involving multiple recovery vessels and locations will be fully implemented.

With each flight, the Falcon 9 launch vehicle also continues to undergo improvements to safety, reliability, and performance. The Falcon 9 will launch approximately 50 times before the first crew flight. As with the rest of the crew transportation system, SpaceX and NASA have been working closely throughout the commercial crew design, development and test programs to certify all launch vehicle designs and operations for astronaut safety and system reliability.

### 5.1 CCtCap Schedule and Challenges

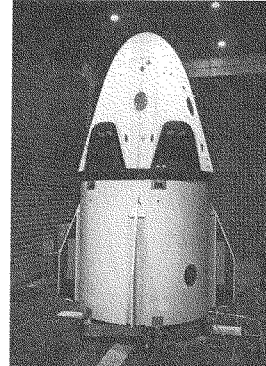
Subsequent to SpaceX's CCtCap award late last year, a program initiation meeting was held in October 2014, setting forth expectations, processes and deliverables. All targets were met leading up to the first major program milestone, the Certification Baseline Review (CBR), which was held in December 2014. The first Quarterly Program Review (QPR) was held in January 2015. Engineer-to-engineer engagement is now fully underway, with daily contact and various Technical Interchange Meetings (TIMs) already completed or planned. CCtCap contractual milestones appear immediately below. The majority of the CCtCap milestones shown below are hardware (versus paperwork) milestones; as such, the completion of each milestone represents significant forward progress.

Milestone	CLIN	Current Date
Certification Baseline Review (CBR) Complete	001	COMPLETE
Avionics Test Bed Activation	001	2015
Docking System Qualification Complete	001	2015
Launch Site Operational Readiness Review (LSORR)	001	2015
Initial Propulsion Module Testing Complete	001	2015
Delta Critical Design Review (dCDR)	001	2015
Propulsive Land Landing Test Complete	001	2015
Launch Site Operational Readiness Review (LSORR) for Crew	001	2016
ECLSS Integrated System Test	001	2016
Space Suit Qualification Testing Complete	001	2016
DM-1 Post Qualification Review (PQR) Complete	001	2016
Flight Test Without Crew Certification Review (FTCR)	001	2016
Demo Mission 1 Flight to ISS Without Crew	001	2016
Parachute Qualification Complete	001	2017
Design Certification Review (DCR)	001	2017
Flight Test Readiness Review (FTRR)	001	2017
Demo Mission 2 Flight to ISS With Crew	001	2017
Operations Readiness Review (ORR)	001	2017
Certification Review (CR)	001	2017

Over the next 10 months, our key focus is on the delta Critical Design Review (CDR) in December 2015. CDR represents a locked down baseline design after which there are no planned changes to the crew transportation architecture. All architecture trades will be closed at that time



with supporting development testing, and several components will already have proceeded through qualification testing, further reducing the risk of late breaking design changes. NASA and SpaceX are working closely in the time before CDR to ensure the smooth completion of the milestone and resolve any challenges early. The major items underway for the CDR are: aerodynamics database development, detailed loads analysis, development and qualification testing of avionics, propulsion and structures components, and crew training definition.



As we work toward the delta CDR, SpaceX will continue development testing of the SuperDraco LAS using a quarter section flight module at the SpaceX Rocket Development and Test facility in McGregor, Texas, to demonstrate full software and hardware-in-the-loop testing of the abort and landing system. Additionally, the flight capsule weldment design will be released and fabrication will begin this summer to support the first CCtCap demonstration mission in 2016. Another capsule weldment will be manufactured in short succession and populated with an entire environmental control and life support system to enable ground testing including various hardware and software failures and to ensure reliable crew life support system function during anomalies. Those tests will provide critical input for crew certification. Docking system qualification hardware is already in process to support full qualification testing utilizing two test units. One docking adapter will undergo complete environmental testing including vibration, thermal, and shock testing, while a second unit will be utilized for extensive docking simulations including a test at NASA's Johnson Space Center with a 6-degree of freedom simulator to minimize a docking issue with the ISS.

A key interim milestone is the Avionics Test Bed Activation in June 2015. The test bed will be comprised of a complete Crew Dragon avionics system and will be set up in SpaceX's state-of-the-art hardware-in-the-loop test facility. This important facility will be used to fully test all of Crew Dragon's computer systems to make sure that the spacecraft hardware and software is designed properly and is extremely robust and reliable. The tests will prove out communication between all major avionics components, including the flight computer, power unit, and vehicle device control unit. Our facility has a long heritage providing critical support to the development, test, and operations of all SpaceX flight systems.

To provide significantly increased NASA insight appropriate for a human spaceflight program, SpaceX and NASA have paired key program and technical leads as counterparts ensuring transparency, communication, fast problem solving, and early agreement on strategies and plans. Dozens of recurring forums and meetings have been established and are jointly led to keep the broader NASA and SpaceX community aware of progress and agreements as well as resolve questions and concerns. Program management leads from both NASA and SpaceX regularly evaluate the progress of insight and interaction to ensure program success.

One of the expected challenges in any program of this magnitude is aligning the schedule with the work ahead while providing sufficient NASA insight and interaction to certify a safe and reliable system. To this end, and in support of the reliability upgrades discussed, some milestones have been moved to ensure sufficient time is provided to develop and certify key systems.

Another challenge to the project's success is whether the program receives consistent and robust Congressional support and funding. The United States has been reliant on Russia for too long, and underfunding the Commercial Crew Program in fiscal year 2016 could further prolong that dependency. NASA is on course to achieve domestic astronaut carriage to the Space Station by 2017. Fully funding the commercial crew program to support the two awards is critical to maintaining that schedule, which will lead to an eventual reduction in spending as Soyuz flights are no longer needed by NASA. Underfunding of the Commercial Crew Program would effectively result in more taxpayer money being spent on Russia Soyuz services and delay the full utilization of the ISS.

## **5.2 Risk Management**

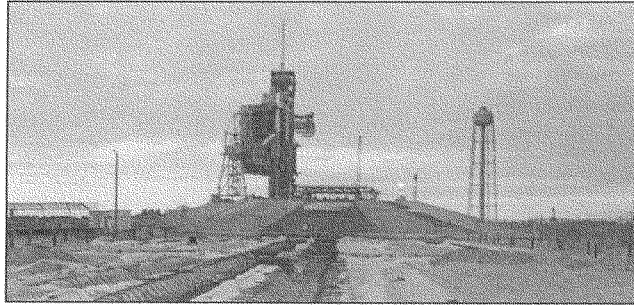
Key risk management and safety deliverables were provided early in the program and recently updated per NASA input. SpaceX and NASA held a hazard and safety planning meeting earlier this year to ensure that all hazard reports to the Safety Technical Review Board will be delivered prior to the system delta Critical Design Review. Safety and risk are closely tracked and managed at SpaceX through a well-established process leveraging our risk database, vigilance at all levels of the company, and a culture encouraging open discussion and risk mitigation. SpaceX provides NASA in-depth insight into this process.

The following focal areas have been identified: ensuring crew transportation capability certification in 2017; ensuring the timely development of all systems in advance of the delta Critical Design Review; and ensuring that NASA and SpaceX are in agreement on the interpretation and approach to meeting all technical and safety requirements. SpaceX acknowledges that certification of precision propulsive land landing is expected to take additional time; therefore, it will be done in parallel with precision water landing thus preventing this capability from delaying NASA's goal of completing certification in 2017. Remaining design trades are being closed by mid-2015; NASA and SpaceX are engaged in regular interaction and insight. In order to ensure agreement on requirements, the teams are leveraging the partnership to clarify requirement intent and, if needed, propose variances, jointly assess requirement change requests from NASA, and drive open issues to closure.

## **5.3 LC-39A Construction for Commercial Crew Launch**

SpaceX's crew transportation system will launch from the historic Apollo and Shuttle launch location, LC-39A on NASA's Kennedy Space Center. We have made excellent progress renovating the complex over the last year; construction will be completed by mid-2015. SpaceX is investing over \$60 million in LC-39A to modernize the complex for Crew Dragon, Falcon 9 and Falcon Heavy. Construction on the hangar has begun and will be completed later this year. Taking advantage of the existing launch tower, SpaceX will add a crew gantry access arm and

white room to allow for crew and cargo ingress to the vehicle. The existing Space Shuttle evacuation slide-wire basket system will also be re-purposed to provide a safe emergency egress for the Dragon crew in the event of an emergency on the pad that does not necessitate using the Crew Dragon's launch abort system.



#### **6. Conclusion**

Thank you again for the opportunity to provide an overview of SpaceX's efforts to provide American astronauts with safe and reliable transportation to space. It is our honor to work with NASA to end America's dependence on Russia for Space Station access and, most importantly, replace it with the safest and most reliable crewed transportation capability possible.

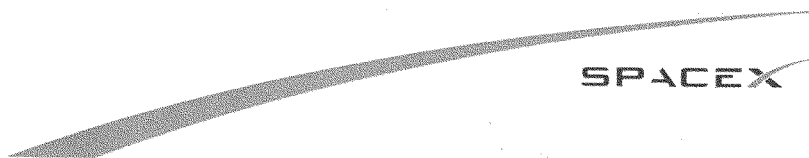


**Garrett Reisman**  
**Director of Crew Operations**

Garrett Reisman is responsible for working with NASA to prepare SpaceX's Falcon 9 rocket and Dragon spacecraft to carry astronauts. He was the SpaceX project manager for CCDev2 – a \$75 Million partnership with NASA to mature the Dragon Spacecraft launch abort system and crew accommodations. Reisman then became the SpaceX project manager for CCiCap – a \$460 Million partnership with NASA to complete the design of the Dragon-Falcon 9 crew vehicle, perform hardware testing, ensure astronaut safety and pave the way for NASA certification of the vehicle. Reisman is currently the Director of Crew Operations, responsible for all vehicle crew interfaces including displays, controls, space suits, human factors and crew health and medical issues.

Reisman came to SpaceX from NASA where he served as an astronaut starting in 1998. He has flown on two space shuttle missions, during which, he logged over 3 months in space including over 21 hours of extravehicular activity (EVA) in 3 spacewalks. Dr. Reisman served with both the Expedition-16 and the Expedition-17 crews as a Flight Engineer aboard the International Space Station.

Reisman holds a B.S. in Economics and a B.S. in Mechanical Engineering and Applied Mechanics from the University of Pennsylvania, an M.S. in Mechanical Engineering from the California Institute of Technology, and a Ph.D. in Mechanical Engineering from the California Institute of Technology. He is an FAA Certified Flight Instructor.



Chairman PALAZZO. Thank you, Dr. Reisman.

I thank the witnesses for their testimony. Members are reminded that Committee rules limit questioning to five minutes. The Chair recognizes himself for five minutes.

Mr. GERSTENMAIER, we are currently paying Russia \$76 million for a Soyuz seat to the ISS, which has historically increased nine percent per year. Your testimony states that the commercial crew prices will be roughly 50 million per seat, but that is hard to calculate an apples to apples comparison, because the commercial crew price includes some cargo. So my question is, does this \$58 million price also include the investments NASA has made in the CC Dev 1, CC Dev 2, CCiCap, and the CPC phases, or is this just CCtCap post-certification mission? I can't hear you.

Mr. GERSTENMAIER. The cost for commercial crew are just the costs associated with the post-certification mission activities. They do not include the developmental costs.

Chairman PALAZZO. What would the price per seat be if you included all development funding for the Commercial Crew Program.

Mr. GERSTENMAIER. Again, I can go ahead and do that calculation for you. I will take the question for the record.

Chairman PALAZZO. Ballpark?

Mr. GERSTENMAIER. We did the calculation the way we did because it is a fair comparison with the Soyuz. We didn't include the Soyuz development costs associated with the Soyuz vehicle in those numbers. So, it is the cost that NASA pays for the actual service we need to go to ISS. That is the reason we did the calculations the way we did.

Chairman PALAZZO. So you don't want to take a stab at—I mean, if you included the total development costs, would it be twice that of \$58 million? Is it twice that—what we are paying the Russians?

Mr. GERSTENMAIER. You could—

Chairman PALAZZO. Less than that?

Mr. GERSTENMAIER. It will be probably slightly more than the Russian seat price if you include the development cost in there. And we can do the calculation.

Chairman PALAZZO. All right. Thank you. Your testimony also states that you anticipate re-baselining the CCtCap schedule milestones, and that there will be a relatively large number of changes. Your statement also indicates that this will not affect contract costs.

So my questions are, will these milestone changes affect schedules? What—and while I am sure that all parties are very motivated to develop a capability as soon as possible, does NASA have any leverage in these contracts to ensure performance based on a schedule? For instance, if schedules are not met, or payment simply delayed until milestones are completed, are the payments lost, or are the payments scaled back?

Mr. GERSTENMAIER. Again, the payments will not be made until the milestones are satisfied, so those payments are essentially held back, in a sense, until those are met. I think the contractors can talk directly about where the schedules have moved and where the milestones are changing.

This is very typical in a contract startup, where you get the contractor on board, you go through, you evaluate the details of the

schedules. Many of the proposals were written about a year ago, so it is very appropriate for them to go ahead and see some updates in movement. We will continue to monitor the schedule.

You know, we were careful to make 2017 as a goal. We didn't want to make that as an absolute requirement, and the reason for that was purely safety. We felt that if we pushed too hard on schedule, we could sacrifice technical development. We could sacrifice safety to meet the date certain of 2017. So we will be cognizant of the date, we will move forward—as fast as we can, but we will also make sure that safety is present as we go forward.

Chairman PALAZZO. All right. Mr. Mulholland?

Mr. MULHOLLAND. Chairman, if I might add, our final proposal submittal to NASA assumed an August 1 authority to proceed, with the award near the end of September, and then subsequent protest. We re-baselined our proposal consistent with that approximate two month award delay. We did not want to compress our schedule, or take any technical risk at this time.

That said, we are working very diligently on several opportunities to try and accelerate that delivery. But at this point in the program, it did not make sense to do anything other than adjust our schedule consistent with the award date.

Chairman PALAZZO. Okay. Dr. Reisman, if you want to add anything?

Dr. REISMAN. Just to say, with regard to schedule, that we—after the original proposal was submitted, we continued to work diligently on our design, and we found ways, during the blackout period of the procurement, and during the protest, to make our vehicle better, safer, and more reliable.

And so that led to summary adjustment of some of the milestones, but I could tell you that we have a schedule that has been vetted by NASA, has been integrated upon with NASA, that has a margin built in to each milestone, and that has a significant amount of milestone—of margin to mean the ultimate goal of flying Americans in space in 2017. So we are confident that we are in a good position.

Chairman PALAZZO. All right. And, lastly, Dr. Gerstenmaier, several media outlets have recently reported that the Russian space agency is considering exiting the ISS partnership to support their own Space Station. According to the reports, this could include decoupling the Russian segments from the rest of the station, and continuing on their own. Do you have a response to these reports, and how would NASA respond in such a situation?

Mr. GERSTENMAIER. I think the details of those reports are basically that this would occur in 2024 or 2025, which is after the extension of the Space Station to the period of 2024, we have not heard anything officially from the Russians on their plans, but our understanding was, from the media reports, and from this internal meeting, that it was after 2024, so it would not have any impact to us through this period of ISS operations.

Chairman PALAZZO. All right. And after 2024, that is when you expect industry, or non-profits, or somebody else to assume operations of the International Space Station? But if Russia does decouple their segments from the International Space Station, is that—I mean, have you given any thought to how NASA would handle

that? Even though you may not be the operator at the time, I mean, how would that affect ISS operations for, you know, whatever group that does take it over?

Mr. GERSTENMAIER. We will continue to work those plans, but we have an ability to operate station without our Russian partners, if absolutely required.

Chairman PALAZZO. Okay. Well, thank you very much. I now recognize Ms. Edwards for her questions.

Ms. EDWARDS. Thank you very much, Mr. Chairman, and thank you to the witnesses today. As usual, we never have quite enough time to go into all the details, so please accept my apologies. And I just want to note, for the record, that many Democratic Members are not here today not because they are not concerned, but because a Democratic caucus meeting was called at 9 o'clock, at the time of this hearing, so we apologize for that.

I want to focus on Vice Admiral Dyer, in Mr. Gerstenmaier's prepared statements, he indicated that the Certification Products Contract efforts gave NASA an early insight into vehicle designs and approaches, and it would seem that access to the contractors' proposals for variances to meet the various safety requirements, and how NASA handled them, would be pieces of information that would be critical to ASAP's responsibilities in advising Congress.

In fact, in Mr. Gerstenmaier's statement, one point in particular stands out. He says, and I quote, "Overall, this phase of the contract was critical to allowing the contractors to understand the human rating requirements, and NASA's understanding of how the contractors' approaches intend to meet those requirements." And I want to know from Vice Admiral Dyer, were you aware of NASA's plans to assess contractor variance proposals, and did you request access to the variance proposals, and NASA's subsequent disposition?

Vice Admiral DYER. Yes, Madam Ranking Member. We were—we are aware. We have asked for that insight. We have not received it during the 2014 period. As I indicated in my testimony, General Bolden, the administrator at NASA, has indicated he is going to correct the situation. We are beginning to see the early stages of making that turn. We don't yet understand the waivers that have been granted, in terms of—beyond that which Mr. Gerstenmaier shared this morning.

Ms. EDWARDS. Excuse me—

Vice Admiral DYER. We look forward to—

Ms. EDWARDS. —would that—

Vice Admiral DYER. —that insight, but we don't have it yet.

Ms. EDWARDS. Would that—that information would, of course, help you, in terms of your advice both to the Congress, but also the, you know, the kind of partnership that is necessary from NASA, so that we can make sure that we really are paying attention to the safety concerns that all of us have expressed an interest in. And we all want to be on the same page about those things, isn't that right?

Vice Admiral DYER. You are absolutely right—

Ms. EDWARDS. Thank you.

Vice Admiral DYER. —and we look forward for that insight.

Ms. EDWARDS. Thank you. So I want to turn to Mr. Gerstenmaier, because I am—really, as I hear this, I am just incredibly dismayed about ASAP's difficulty in obtaining the kind of information that they need to advise the Congress. So, you know, and although I hear that there are conversations now about how that is going to happen, it still hasn't.

And so I want some assurance today, and I know the—all of the Committee, actually, wants the assurance today that ASAP will have full and unfettered access to contract information that is required to ensure document traceability of safety throughout the development and certification of commercial crew systems. And so can you give me that assurance today?

Mr. GERSTENMAIER. Yes. ASAP will have access to all the contract details associated with the variances and the other activities that could help them do their job.

Ms. EDWARDS. When?

Mr. GERSTENMAIER. We already did that in January. Vice Admiral Dyer can discuss the meeting we had in January with the ASAP panel. We are beginning to give all that data to them, and we will continue to give it to them.

Ms. EDWARDS. Okay. And so, I mean, when could we expect, if we were asking as a Committee, that ASAP would have what they need to date?

Mr. GERSTENMAIER. Immediately.

Ms. EDWARDS. Okay. We will be asking about that again. Mr. Mulholland—

Mr. GERSTENMAIER. And they have already received it in January, so they got a significant amount of information in January from the agency, and we will continue to give more as needed.

Ms. EDWARDS. Well, I look forward to both NASA and ASAP communicating with the Committee about what has been received in what timeline, and what remains to be received, so we would appreciate that.

Mr. Mulholland and Dr. Reisman, how will you ensure that NASA and ASAP don't encounter the same problems that ASAP has experienced in acquiring documents that are needed to evaluate safety?

Mr. MULHOLLAND. I think that is an extremely important position. I have the utmost respect for Vice Admiral Dyer, the ASAP mission. We have had two very successful meetings with ASAP in the last year, where we went through the details of our certification plans, validation plans. I was disappointed also to see the report, and the lack of information provided. In our meeting with ASAP just a couple weeks ago, I personally pledged to Vice Admiral Dyer that we would give him any and all information of our products, regardless of the ability of NASA to provide it to them.

Ms. EDWARDS. Dr. Reisman?

Dr. REISMAN. We have also been open to the ASAP. We have had them out to our facility in Hawthorne, and have a standing invitation to them to invite—to come by anytime. I think we are talking about August for another meeting just earlier today. But we are committed to full insight. We are drastically ramping up our activities in terms of insight for NASA, and creating complete transparency. We have established working forums, working groups.



Each SpaceX technical group has a weekly or biweekly meeting with their NASA counterparts, and communication is happening daily so that NASA knows exactly what we are doing, in terms of design and development. We have a buddy system, where everybody at SpaceX has a point of contact at NASA. We have deep facility and data access. So, really, we are being as transparent as we could possibly be.

Ms. EDWARDS. So—thank you very much, Mr. Chairman, for indulging me, and—so I appreciate that, the—and the relationship that our commercial partners have with NASA. I want that same relationship with ASAP, so that Congress has the ability to make sure that we can make determinations about how we are spending taxpayers' money, and about the progress of the program, and that we are continuing to stay focused on safety.

Thank you, Mr. Chairman.

Chairman PALAZZO. I now recognize Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman. And, again, I appreciate the leadership you and the Ranking Member are demonstrating by this hearing today, and the leadership you have taken in this job.

Let us see. Let me give this—the President has requested a 54 percent increase in the funding level for the Commercial Crew Program, so that is a \$1.24 billion request for 2016, versus \$850 million that was appropriated for 200—for 2015, so we have had this increase in the request.

I guess we should ask Mr. Gerstenmaier—now, if we don't get full funding, we have been hearing that the date for 2017 is at risk. We have heard that testimony several times. But yet, every year, we actually are spending less—we are appropriating less money than has been requested. Congress is appropriating less than what is requested, yet we are saying the 2017 date is at risk unless we meet these appropriations, but we are not doing it. Is the 2017 date at risk right now because of actions or inaction by Congress to fully appropriate the request of the Administration for the Commercial Crew Program?

Mr. GERSTENMAIER. Again, as I said in my written and oral statements, the problem with not getting appropriate funding in the past year has caused us to slip from earlier delivery dates, where we had planned to be earlier in 2015 and 2016, depending on which budget we submitted. Now we are saying 2017, the 805 that was provided this year, in 2015, is acceptable to continue to hold that date. It is consistent with the contracts. The funding that we need in 2016 is absolutely required to hold the 2017 date.

Mr. ROHRABACHER. Okay. So if we don't get the full amount that you have requested, which is \$1.24 billion, we could expect the date to slip?

Mr. GERSTENMAIER. Yes, the date will slip, and, more importantly, there is very important work that needs to be done in this near term timeframe that is important for both safety, and also important for the overall design of the vehicles. And without that funding, we will impact those other objectives, as well as just the date.

Mr. ROHRABACHER. Okay. So for every year that we let this slip, we are dependent on the Russians for the transportation at \$76

million per seat. So how much will it cost us extra if we are letting that date slip?

Mr. GERSTENMAIER. We use six seats per year, so you could do the math.

Mr. ROHRABACHER. So that is a very considerable price that we are paying, maybe more than even what—if we just go ahead and fund the program. I hope that that sinks into people's minds there. So—and so let us just—and let us also note—let us—we are depending on the goodwill of the Russians, and I want to note that they are showing goodwill. They could actually cut us off altogether, which is one other reason why we want to make sure that we—the crew program that we are talking about, that we get back in this business. So every year that we delay this, underfunding, we actually are paying the Russians an enormous amount for transportation. That needs to sink in.

Now, in terms of—how much would it cost, Mr. Gerstenmaier, if we were—we have heard the witnesses here from the two companies that are leading the way. They are point companies in this effort. How much more would it cost us if we were going about to achieve the same crew capabilities that we are trying to achieve, if we are going through the old process that NASA used to have in developing this type of technology? We have two private sector companies here. We know the cost of that. How much more or less would it cost if NASA would have gone through the old system, not the non-commercial system, as the admiral detail, the difference between what the commercial approach was, and the old NASA approach was?

Mr. GERSTENMAIER. I can't provide you a specific number, but is extremely more efficient to do it the way we are doing it today. And, again, the structured approach we have used, where we used Space Act Agreements first, and then we did the CPC portion of the contract. This contract is to save the agency a significant amount of funds over a typical procurement that we would have done from a basic kind of managed from the beginning type of activity with these providers.

Mr. ROHRABACHER. So, just in summary, Mr. Chairman, what we have, although we are looking at a major expense here, this is a lot less expensive to go with these private sector operations than if we went with the traditional way NASA would have gone about developing this same capability. Thank you very much.

Chairman PALAZZO. I now recognize Mr. Beyer.

Mr. BEYER. Thank you, Mr. Chairman. Three questions for you Mr. Gerstenmaier. First, after the Columbia Accident Investigation Board said that safety should be the highest priority, NASA's Astronaut office was more specific, urging that the next crewed spacecraft in a low-Earth orbit should have a Loss of Crew ratio of no more than 1 in 1,000. The Loss of Crew, loss of mission requirements for the commercial crew vehicles, are they still the 1 in 1,000? How do they compare with those for the Space Shuttle? And do you have the insight into the commercial crew contracts necessary to be assured that these vehicles meet the Loss of Crew, loss of mission requirements?

Mr. GERSTENMAIER. We have the appropriate insight to evaluate meeting our Loss of Crew and loss of mission requirements. I think

we also have the requirements in our contracts, in the 1130 set of documents that describe exactly the Loss of Crew numbers. They are not the 1 in 1,000 numbers that the crew requested. And we believe that that is not technically achievable. We think it is also very difficult to determine Loss of Crew precisely. There is a tremendous variance about that number. It is a very difficult number to calculate with any assurance of exactly what that number is. But we are very interested in keeping that number understood. We will review that again with the ASAP. We had discussions with them again in January about how we will meet those numbers and ensure we have crew safety.

The other big advantage of these systems is they have an abort system, which was not present on the Shuttle system. That allows for, essentially, the vehicles to abort if something occurs with the rocket underneath, which we did not have in the Shuttle program. And that gets factored in tangentially to the equation, but it is not directly in the calculation. Also, the capsules are safer to return, and require less stability during the return phase, which also makes them safer.

So there is inherent safety in both of these designs. Both companies are very focused on safety. We will meet the requirements that are specified across the agency.

Mr. BEYER. If 1 in 1,000, what the astronauts had requested, is not achievable, what is a number that you do use, and do think is achievable?

Mr. GERSTENMAIER. We have been using 1 in 500 for both ascent and entry, and it is the same for our exploration program, so the requirements for Loss of Crew is consistent across all agency programs on human space flight.

Mr. BEYER. Mr. Gerstenmaier, on the slippage issue, if, for some reason, SpaceX, Boeing is not able to perform by 2017, will you be able to extend the contract with Roscosmos? And I know there is three year lag times on some of that. Or are there any other reasons for continuing the contract with the Russians as backup?

Mr. GERSTENMAIER. We have recently done a synopsis to begin the investigation to see what our options for extending the Soyuz into 2017. We currently have Soyuz capability through calendar year 2017, with a return flight of our crews in the spring of 2018. We did that synopsis to begin the discussion with the Russians about acquiring additional Soyuz capability. We will continue that discussion over the next several months. But again, if you look at the timing, we need to make a decision with the Russians sometime this spring to have that assurance.

We think it is probably in our best interest, even if the calendar shows that we will be well completed in 2017, there is some advantage of having an overlap of both Soyuz capability and U.S. capability at the same time. Because we could get very late into flow on the launch pad, have a problem with the launch pad, or have a vehicle very late in the flow having a problem, and if we don't have a backup capability, we would be in the posture of having to de-crew the station. So we think it is in our interest to go pursue additional seats with the Russians. We will do that over the next several months.

Mr. BEYER. And is there any real wastage to have that overlap of taxpayer money, or NASA resources?

Mr. GERSTENMAIER. I believe we will use those Soyuz seats to our advantage. If the preference will be to fly the commercial providers as soon as they are ready, then we will use those Soyuz seat capabilities to the advantage—to give us additional research time on board station.

Mr. BEYER. All right. Thank you. And one last question. Every day I pick up the Post and read about Russia violating the terms of the cease fire in the Eastern Ukraine, the seizing of Crimea, the continued conflict there. The U.S. sanctions, and the sanctions from any European countries, are they affecting your relationship with the Soyuz at all?

Mr. GERSTENMAIER. No. To this point, we have a very strong relationship with the Russians. We work with them every day on board Space Station. Our teams are in constant communications back and forth. We have a team of roughly 20 to 30 U.S. citizens in Russia, constantly monitoring the Space Station activities, and the partnership at an engineering level, a technical level, and the program level has been very strong between the Russians and the—

Mr. BEYER. Okay.

Mr. GERSTENMAIER. —U.S. and NASA personnel.

Mr. BEYER. Thank you, Mr. Gerstenmaier. I yield back, Mr. Chair.

Chairman PALAZZO. I now recognize Mr. Lucas.

Mr. LUCAS. Thank you, Mr. Chairman. Vice Admiral Dyer, I could not help but listen with great intensity to your opening comments, and, of course, the questions so accurately raised by Ranking Member Edwards. Most of us on this panel—all of us on this mantle—panel remember the loss of the two shuttle crews. I suspect most of us remember the loss of the first Apollo crew many years ago, so sensitivity to safety and understanding that our astronauts are the most valuable piece of asset in the programs is of great importance to us.

Could you expand again for a moment about the challenges that the Aerospace Safety Advisory Panel faced in 2014 trying to access the information? Now, I know we have been given assurances here today that everything is available, but could you expand on for—that for just a moment?

Vice Admiral DYER. Yes, sir, I am happy to do so. It is, in my opinion, first and foremost a leadership level issue, below Mr. Gerstenmaier. It has been one that I have seen many times in my DOD experience, where an inexperienced program director, being perhaps right-hearted, but wrong-headed, believes that protecting the program from any criticism, or from any of those that might speak questioningly of it, is a first responsibility. It builds suspicion and distrust. It is not in the best interest of the program.

That is beginning to turn around, as Mr. Gerstenmaier said, but only after the issuance of our annual report. The first thing we received were gigabytes of data that I would describe as there is something important in there somewhere, why don't you see if you could find it? And we are following that up now with more detailed briefings, and the future is beginning to look better, but we can't

yet answer the question as to whether or not the certification process looks good and safe to us, and whether or not the path forward looks to be of good technical conscience. We will, but we are not there yet.

Mr. LUCAS. And the players that made it so challenging, 14 are still in place?

Vice Admiral DYER. They are.

Mr. LUCAS. I can assure you, Admiral, that the Committee will work with you to make sure that the panel's mission is completed, for the sake of all of our investments. With that thought, Mr. Chairman, I actually yield back.

Chairman PALAZZO. Thank you, Mr. Lucas. I now recognize Mr. Posey.

Mr. POSEY. Thank you, Mr. Chairman. Dr. Reisman, just curious about the extent to which NASA might impose safety requirements above the level of safety you would have if you did not have NASA oversight?

Dr. REISMAN. That is an interesting question. We—we have designed a vehicle, first and foremost, for what we think is safe, and what we think is the best possible design. We then make sure that we comply with NASA requirements, but often we exceed them, and one example is our launch abort system, which is—as Mr. Gerstenmaier pointed out, is an essential advantage over both of our vehicles, compared to the one I rode, the space shuttle.

Our launch abort system really has—the NASA requirement is not for fault tolerance, but we have made that launch abort system to be single fault tolerant, to make it even safer than it has to be per the requirements. So we look at—we make sure we meet the requirements, and we are committed to meeting NASA's safety requirements, but we are—we think it is prudent we go beyond them.

Mr. POSEY. Okay. Thank you. Mr. Gerstenmaier, what was the original cost of a seat on a Soyuz?

Mr. GERSTENMAIER. Soyuz seat price was—I don't remember what the original was. On the order of \$50 million or so.

Mr. POSEY. Okay. And how much is it exactly today?

Mr. GERSTENMAIER. Today it is \$76 million per seat.

Mr. POSEY. Okay. That is a pretty significant increase. Were those increases in cost, and I know they have gone up gradually, as I have seen—were they anticipated, were they agreed to in advance, or were they unilaterally set by the other side?

Mr. GERSTENMAIER. They were anticipated and negotiated with the Russians.

Mr. POSEY. Okay. And how much higher does this cost go?

Mr. GERSTENMAIER. Our historical increase has roughly been about nine percent per contract, and that was, again, fact-found on our side, where we looked at that compared to actual manufacturing costs, inflation, Dollar to Ruble conversions. All those went into those calculations, and the nine percent was seen as a reasonable kind of increase. And how can they go, I can't anticipate.

Mr. POSEY. Yeah, when will we expect the negotiations, or recalculation about the next increase?

Mr. GERSTENMAIER. We are in the process of doing that now. We started with a synopsis, of which we received comments back. We

are beginning discussions with the Russians on the contract, as I have just described to you.

Mr. POSEY. Okay. And when do we anticipate that will be complete?

Mr. GERSTENMAIER. It will probably be complete in the next several months.

Mr. POSEY. And we should look at probably a minimum of nine percent, so another \$7 million increase, minimum?

Mr. GERSTENMAIER. I think that is very reasonable.

Mr. POSEY. Okay. And then when is the next re-analysis scheduled after that?

Mr. GERSTENMAIER. We don't anticipate requiring any more additional seats after the seats we will acquire this time. We would anticipate acquiring six seats for 2018. We believe that provides sufficient overlap, as I described earlier.

Mr. POSEY. Thank you, Mr. Gerstenmaier. Mr. Mulholland, I understand that the CST-100 is designed to fly on multiple rockets. Can you discuss what makes the versatility possible, as well as what rockets it is capable of using, and why you chose the Atlas V as the launch vehicle?

Mr. MULHOLLAND. Absolutely. One of our original design parameters on the CST-100 was to design the spacecraft for all launch vehicles in this class to make it easier, if—in the event we needed to switch to another launch vehicle. We chose the Atlas V, obviously, because of its reliability. It has flown 52 times, with 100 percent mission success, unparalleled technical and schedule reliability.

But from day one we designed the CST-100 for launching on Delta. We have worked with SpaceX in the past to understand the loads of the Falcon 9, and we have also worked with emerging launch vehicle providers to ensure that we drive in long-term affordability through the entire life cycle of the program.

Mr. POSEY. Okay. Thank you, Mr. Chairman. I yield back.

Chairman PALAZZO. I now recognize Mr. Knight.

Mr. KNIGHT. Thank you, Mr. Chair, and thanks for having this today. I have just a couple quick questions. Mr. Gerstenmaier, on—as far as competition, we are having two companies involved. Can you give me kind of an idea how beneficial that is, having—competing for not just dollars, but competing for safety, competing for innovation? Can you give me an idea of where we are on that?

Mr. GERSTENMAIER. I think there is a tremendous benefit to the U.S. government, and to NASA, to have competition during this development phase, and it is much more than cost, as you described. You know, if we run into a problem or concern with the safety aspect, to not be totally reliant upon one contractor, and have the other one available to go ahead and continue is very important to us. If they run into a technical problem, maybe a manufacturing problem, parts delivery problem, or they have a test failure somewhere along the way, having another provider available to us to move forward and continue to keep progress heading towards commercial services is extremely important.

So there are numerous benefits along those lines during this development phase that keeps both companies at the top of their game, keeps innovation in the system, keeps making them want to

go ahead and make these milestones to keep moving forward. So it is extremely important to have competition during this development phase.

Mr. KNIGHT. And I think—let us see. I think, Vice Admiral Dyer, we were talking about the 1,000 to 1, or the 500 to 1, or maybe Mr. Gerstenmaier wants to weigh in on this. What are the Russians—when we are sending them up, what do we expect of them, or what kind of track record do they have? Are they on a 1,000 to 1, are they on a 500 to 1, or are they on less than that?

Vice Admiral DYER. Mr. Gerstenmaier will be better prepared to speak to the quantitative numbers. I will tell you that the Soyuz services do represent, given their years of support, and the numbers of missions that they have launched, it does represent a buy opportunity. It is market proven, and the bona fides of reliability, safety, have been demonstrated over time.

Mr. GERSTENMAIER. I would say that if you look at—their actual demonstrated reliability it is probably a little bit less than 1 in 500, from kind of a calculation standpoint. But then if you look at their actual demonstrated performance, it is fairly high. And the fact that, again, they have a pretty robust system overall, with a good design margin in it, and it has been demonstrated over the years. So, the—Soyuz again has the abort system on the spacecraft, much like the other providers. It is also a capsule design, with a proven, fairly simple re-entry capability.

So, it probably has a calculated number slightly less than what we will get with the commercial providers. But, from a demonstrated, and actually proven over the multiple years, it is probably slightly better.

Mr. KNIGHT. And I think you can hear from this panel, and from any American, that safety is the most paramount issue when we are talking about sending our young men and women into space. When we were talking about cost, it is about 77 now, and I guess the new contract will bump it up to about 84, and that would be comparing to 58 when the American companies are doing this.

We are not calculating in the development of the American companies, we are not calculating in all of the things that get us to that point where we are sending Americans into space, so it is a little apples to oranges when we are talking about tax dollars, but somewhere down the road those lines are going to meet, and the—or the American taxpayer is going to get a benefit. And so I would expect that that would be somewhere in the near future, five years into the program, or maybe even ten years into the program, so it will be beneficial to the taxpayer to do this. Also from a confidence standpoint, that we have American companies sending Americans into space, and we are backing the American dream of having space exploration.

So I yield back, Mr. Chair, and thank you very much.

Chairman PALAZZO. I now recognize Mr. Perlmutter.

Mr. PERLMUTTER. Thank you, Mr. Chairman, and thank you for indulging me, and letting me pass a couple times to listen to some of the questions and answers. I am new to this Committee. The acronyms are plentiful in your business, and I just wanted to have a chance to talk about, you know, from point of view—as a Member of Congress, safety issues, cost issues are going to be more up my

alley than the technical issues that you all are discussing. So let me get down to a couple questions that I have.

And the first is the safety issue. The Atlas V, I think, Mr. Mulholland, you said 52 missions, no failures. If, for some reason or other, Congress were to say, we are not dealing with any Russian engines from this point forward today, how long would it take us to come up with a new engine to power, say, the Atlas V, or some other rocket like that, to take on these missions?

Mr. MULHOLLAND. I would say ULA and the member companies of ULA are working diligently with Blue Origin, and also with AeroJet, to develop a replacement engine for the Atlas V.

Mr. PERLMUTTER. I hear you, but—and I am not trying to lead you down a path. It isn't like we could have an engine tomorrow.

Mr. MULHOLLAND. No.

Mr. PERLMUTTER. I mean, not even next year probably. Three or four years, right? Now I am trying to lead you down a path.

Mr. MULHOLLAND. No, it is, you know, ULA is on a plan for a 2019 re-engine of the Atlas V launch vehicle. The Air Force recently thought that that program would take seven to nine years. And so it is very important for us to make sure that we have a launch vehicle that is as robust and reliable as the Atlas V. There are other launch vehicles we could move to, such as the Delta, if we needed to. We were not given a bid for the Falcon 9 during this previous phase of the proposal, but we have had discussions with SpaceX, if they would be willing to provide a proposal. But incredibly important that we thoughtfully move through the ULA re-engine.

Mr. PERLMUTTER. So, I mean, basically you have got one path where you are developing other engines that would be American-made?

Mr. MULHOLLAND. Um-hum.

Mr. PERLMUTTER. At the same time, we have a reliable engine that has worked for us 52 times. And you can't just go cold turkey on that immediately and hope to move forward with these different programs we have in place, is that right?

Mr. MULHOLLAND. Correct.

Mr. PERLMUTTER. Okay. So, second question I have, and you all should know I am from Colorado, and I have certain companies in my state that are clearly interested in space exploration, and launches, and delivery, and all of that stuff. So, as I understand it, the Space Station has what I think Mr. Gerstenmaier, or somebody may have said, a—we expect a seven—well, a life through 2024. Yet the missions that you two, Boeing and SpaceX, have been given as part of your competition really go until 2023.

And I am just curious, and either—Mr. Gerstenmaier, you can answer, or, gentlemen, you can answer on behalf of your companies, am I now to take it that more or less competitive bids are over for any new kinds of commercial crew opportunities? And I am talking about the Dreamchaser, or whatever else might exist.

So, Mr. Gerstenmaier, you are looking pretty forlorn that nobody has asked you any questions for a while, so I will ask you.

Mr. GERSTENMAIER. We anticipate a competitive selection for services beyond the existing contracts. We have required a minimum purchase of two flights per contractor in this first contract,



and anything beyond that, we have the option of going and competitively selecting for future services to the Space Station.

Mr. PERLMUTTER. And gentlemen—Dr. Reisman, would you agree that you are in this to compete and to win, and you think that SpaceX can do that?

Dr. REISMAN. Absolutely. And I just wanted to add that, you know, John is talking about the possibility of making CST-100 compatible with the Falcon 9. We have had some discussion. I would put out there that the Falcon 9 is, in our opinion, the best way for the U.S. to wean itself off its Russian dependency. It is 100 percent American made. It has 15 consecutive flights, with 100 percent primary mission success. But by the time, in 2017, when we strap somebody in, we will be well over 50 missions, and so we will have the same type of flight heritage that the Atlas V has today.

It was designed from the beginning with human rating in mind. It has triple avionics streams, factors of safety of 1.4, so it meets all the human rating requirements. Now, I don't get a commission, so I can't sell you one of those today, and it is above my pay grade to talk about these types of strategic alliances, but I just wanted to say the Falcon 9, in my opinion, with all the issues we have out there, is certainly the best path forward for America, not only for NASA, but for Department of Defense, to break our dependency on the Russians.

Mr. PERLMUTTER. My time is expired, but if Mr. Mulholland wanted to respond, it is—I don't know. You—were you getting ready to say something?

Mr. MULHOLLAND. I think it is important, and obviously we work with and monitor the Falcon 9 performance as a launch vehicle buyer. It will be interesting to see, as—the Falcon 9 has gone through a couple of different design changes, and they are getting ready to go to larger engines, and so it will be interesting to see the stability and the scale as they perform. As Dr. Reisman mentioned, they expect to be over 50 missions by the time the launch services are provided, which would be a significant increase in their schedule reliability, to be able to achieve that number of missions per year.

And as they achieve that, and have that demonstrated reliability that you would need to put crew on it, obviously it could be considered as a launch vehicle—

Mr. PERLMUTTER. Okay. Thank you, and thank you, Mr. Chairman. I yield back.

Chairman PALAZZO. I now recognize Mr. Johnson.

Mr. JOHNSON. Thank you, Mr. Chairman. Mr. Gerstenmaier, real quick question starting off. You know, maintaining two partners in the program provides competition to price, and a redundant capability, but if Russia stopped providing Soyuz seats to NASA, could NASA accelerate the development of a domestic capability by focusing resources on one partner?

Mr. GERSTENMAIER. No, and the way the contract was awarded, or we put the proposal out, the stated requirement was we would select one or more providers, so that required both offerers to give us essentially their best schedule, and give us the best price, as an individual. There was no idea that we would pick two out of the selection. So they gave us the best schedules that they could give

us, and the best price at this award, assuming there might only be one winner out of this selection. So the current schedule we have is, I believe, the most aggressive schedule that we could get, and applying additional funds would not allow us to advance that date any earlier.

Mr. JOHNSON. Okay. Also, Mr. Gerstenmaier, the Commercial Crew Program is a new way of doing business that requires new processes for investigating mishaps or accidents. What has NASA done to prepare for any mishaps or accidents that may occur in the Commercial Crew Program?

Mr. GERSTENMAIER. Again, we would treat these as a major mishap. There is also a Congressional investigation that would probably be required and incurred for a loss of life associated with these programs. It would be similar to the kind of requirements we have had before for our human space flight programs, in terms of investigation and requirements following a mishap.

Mr. JOHNSON. So is it accurate to say, then, that procedures are in place to address investigations and oversight of investigations?

Mr. GERSTENMAIER. Those procedures are in place. We will review them again, probably along with the ASAP, and also with Congress, to make sure they are current and make sure they are up to date with where we stand today. But the processes and procedures we have in place today are the basis to start from. But like with any program, we can go back, reflect on them, look at them, and potentially improve and enhance them.

Mr. JOHNSON. Are they spelled out in the contracts? Are these procedures spelled out in the contracts with the partners?

Mr. GERSTENMAIER. I don't know if the accident procedures are called out specifically.

Mr. JOHNSON. Can you share those procedures with the Committee?

Mr. GERSTENMAIER. Sure.

Mr. JOHNSON. Can you point us to those?

Mr. GERSTENMAIER. Sure. They are available.

Mr. JOHNSON. Okay. Great. Mr. Gerstenmaier, the two contractors have proposed very different prices for accomplishing the goals and mission requirements set forth in their respective contracts. How do you account for this large discrepancy in development costs between the two competitors?

Mr. GERSTENMAIER. That question is better posed to them.

Mr. JOHNSON. Well, you are—but don't you work for NASA? Aren't you overseeing the contracts? Do you—

Mr. GERSTENMAIER. Yes, I am.

Mr. JOHNSON. Do you have a concern about the—

Mr. GERSTENMAIER. I have no concern—

Mr. JOHNSON. —costs?

Mr. GERSTENMAIER. —about the costs. We evaluated both costs to see if they were reasonable. We looked at the chance of default. We looked at them. They were reasonable, they were fully understandable to us, but the specifics of the differences we can understand. I can describe to you from a NASA perspective why they were there, but you have the luxury today of having both contractors here, and they can explain that to you in much more detail

from their perspective than I can from a NASA perspective. But——

Mr. JOHNSON. Well, let me ask a follow-on, then. If you were to use the same joint confidence level methodology for the Commercial Crew Program that you used for the cost-plus contracts for SLS and Orion, would you expect the outcome to resemble the contractor prices and schedules? Would you see any similarities?

Mr. GERSTENMAIER. We did an independent cost analysis, where we looked at the cost of what these contracts should cost, and we evaluated those against what the actual proposals were, and they were reasonable and consistent with what we could see.

Mr. JOHNSON. Have you done any—has NASA done—considered doing any JCLs on these contracts?

Mr. GERSTENMAIER. Right now we have firm fixed price contracts in place. We don't believe there is a need to do a JCL on a firm fixed price contract because that value has been given to us for the service we require, and it is a commitment by the contractors to deliver for that price.

Mr. JOHNSON. Okay. Mr. Mulholland and Dr. Reisman, what plan does each of your companies have to track and mitigate schedule and funding risks?

Mr. MULHOLLAND. Absolutely, and first, if I might go back to the cost question, and you talked about the different approaches of the two companies——

Mr. JOHNSON. I am out of time, so we will have to see if the Chairman will indulge, but we will see.

Mr. MULHOLLAND. Well——

Chairman PALAZZO. Go ahead, Bill.

Mr. JOHNSON. He wants—okay. Go ahead.

Chairman PALAZZO. Yes, please.

Mr. JOHNSON. Go ahead.

Mr. MULHOLLAND. I would say that, you know, there is a difference in approach. I think the only objective evidence is the NASA evaluation from the source board. Mr. Gerstenmaier put it in the record, and so the whole source selection statement is laid out, but there were many instances of statements about the increase in confidence that NASA has in the Boeing plan because of the detailed understanding of the certification requirements, in comparison to SpaceX, who did not demonstrate as good an understanding of the certification products, or have as effective systems for development of these key products.

And so it is, I think, that difference in approach. I mean, you have to remember that Boeing has been a partner with NASA in the development of every capsule that has taken domestic astronauts to space that this country has embarked on. And so it is that deep legacy, and knowledge of—and understanding of what it takes to design certified, and then field a human rated spacecraft.

Mr. JOHNSON. Right.

Mr. MULHOLLAND. And so a lot of focus, from our standpoint, on the robustness of the design, and the robustness of the processes needed to not only ensure safety in the design, but safety in operation through the life cycle.

Mr. JOHNSON. Okay. Thank you. Mr. Reisman, if you want to——

Dr. REISMAN. Well, John, I mean, it was a good qualitative answer, but I could tell you that if you looked in detail at the source selection official statement, that—you will see that we are—it was neck and neck when it came to technical mission suitability. There is a seven percent difference in the scores that were awarded, but there was a 70 percent difference in price.

And I could tell you that the reason for that—first of all, we are very happy with the \$2.6 billion that we did receive. That is every penny that we asked for. We have to—I should also point out that we have to meet the same contract requirements, the same objectives, and, most importantly, the same safety requirements that Boeing has to meet. So we have to do the same thing.

As far as why we are so much ahead, in terms of cost, is because we are so much ahead in terms of the development of the vehicle. We have a cargo vehicle today that is flying to the Space Station. We have a Falcon 9 that is already integrated with that vehicle. We have a mission control today that is controlling that integrated rocket and vehicle. We have the luxury of performing two major abort tests, two of the most difficult validation tests—hardware tests integrated under the CCiCap contract, and those abort tests are about to happen. In fact, the test article is at the Cape right now.

So we had a lot of runway behind us, and, at the same time, we are also very efficient. We are a vertically integrated company that does not have to pay subcontractors, upon subcontractors, upon subcontractors. So we have a lot of inherent efficiencies, and I think that explains the difference.

Mr. JOHNSON. Okay. All right. Well, thank you very much. Mr. Chairman, I yield back. Thanks.

Chairman PALAZZO. I now recognize Mr. Brooks.

Mr. BROOKS. Thank you, Mr. Chairman. Vice Admiral Dyer, the United States Government is working to replace the Russian RD-180 engine with a domestic alternative. Aside from the domestically sourced RS-68 used on the Delta IV launch vehicle, is there an alternative engine available today that could provide the same level of performance and reliability as the RD-180 engine?

Vice Admiral DYER. Mr. Brooks, as you heard from both the SpaceX representative and Boeing representatives, there are hard discussions to be made about domestic engines, both new ones, as well as extended use of the SpaceX engines, there is not currently a realistic path forward within the constraints of the schedules that we are talking about for commercial space, in my opinion.

Now, I will follow it up by saying we believe that the two contractors represent a great competitive portfolio. On the Boeing side, they have challenges of process innovation, cost, and finding a way to a new engine in time. On the SpaceX side, we would submit that the challenges are configuration, control, and design stability, as they find innovative and new ways of doing business with new equipment, but it is a great portfolio. An engine is critically important, but it is not, in my opinion, on the path between now and the end of ISS.

Mr. BROOKS. You have answered my second question to some degree, Vice Admiral Dyer, but if you would like to add anything additional to the second question, feel free. And after you have re-

sponded, Mr. Gerstenmaier, Mr. Mulholland, and Dr. Reisman, if you would like to share your insight, I would appreciate it. How important, then, is it for the United States Government to develop a domestic replacement for the RD-180?

Vice Admiral DYER. I think it is critically important for two reasons. For geopolitical reasons, to have an engine that is American made and unencumbered is important. And, perhaps it is a sin, but there is a prideful issue of American made that I think needs to be considered and addressed as well.

Mr. BROOKS. Would any of the other three like to add their insight? Mr. Gerstenmaier? No? Mr. Mulholland?

Mr. MULHOLLAND. You know, I would say it is important to have domestic capability over the long term ULA, and the member companies are actively pursuing it. But I would also like to add that the relationship that we have had with Russia in human space flight has been long lasting, and beneficial to both companies, and has allowed us, I think, a bridge to weather some difficult political situations that we have had globally. And so that relationship with Russia has been beneficial to us, and I believe will continue to do so.

Mr. BROOKS. Dr. Reisman?

Dr. REISMAN. I think a number of us have mentioned that, you know, we all think it is very important for this country to have assured access to space without being dependent on any other country, especially a country that is—we are having a difficult geopolitical situation with. And there are multiple ways you can go about doing that. You can start a development program for a brand new engine for—to replace rockets that are using Russian engines today in America.

But just—again, I want to emphasize we have a rocket that is 100 percent American, and it is standing by, ready to do these missions. We are going through the certification process with the Commercial Crew Program for human certification. We are also getting very, very close to completing certification with the Department of Defense for EELV. So we think we are standing by and ready to provide that capability for the country.

Mr. BROOKS. Thank you, Dr. Reisman. Vice Admiral Dyer, I have about a minute left. This question will be for you. Your recent report appears somewhat critical of NASA's transparency regarding the Commercial Crew Program. Did the issues for which the criticism was based extend to the contractors?

Vice Admiral DYER. NASA is the controller of information, and the nexus of many of our questions. The contractors have been open and sharing in showing us their facilities, sharing their designs with us, and sharing the questions that they have posed to NASA. Our questions, in terms of which waivers and deviations have been requested, how are they being filtered and sorted, which ones have been approved, and what is the thought process behind the approvals of those specific waivers?

Mr. BROOKS. Thank you, Vice Admiral Dyer, and thank you, Mr. Chairman. I yield back.

Chairman PALAZZO. Thank you. I—yeah, votes have been called. We never have enough time to ask all the questions that we want. This is a very important topic, not just to Congress, but definitely

to the American people, so I am going to open it up to one question per side, and I will start with Ms. Edwards.

Ms. EDWARDS. Thank you, and I will just be very brief. Mr. Gerstenmaier, I am just curious, because in—a couple of times in your testimony and your responses, you indicated a concern with slippage and budget, based on the fact that Congress hadn't provided the appropriations that were necessary. And I wonder if you share the concern that I have, that, if NASA were to come up—were to be able to do an effective independent cost analysis, that actually that could provide a better basis for making appropriations, but, in fact, that some of the concern with the appropriation has been that NASA hasn't been forthcoming in providing that kind of analysis.

And, indeed, in the 2015 Authorization Act that Mr. Palazzo and I moved forward, we require that kind of analysis. And so, I don't want to keep pointing fingers, but it would help to have that information in order for us to be the best advocates we can be for the kind of resources that you need. Would you be willing to do that?

Mr. GERSTENMAIER. Again, at this stage, we have definitized fixed-price contracts, and we would like to discuss those with you, show you the basis for those contracts, and show you the variance on those contracts. And that would essentially anchor any of our discussions for the budgets, and we could show you the other pieces around that.

So I don't—I am not sure that an independent cost model for a different acquisition approach, as we are doing with these commercial providers, provides any other insight, other than the specifics of the actual negotiated contract that we have. And we can show you the milestones and the details. We have already shared it with staff. We will continue to share that with staff as the basis for our budget.

So we will provide you with the information you need to understand the budget, and all its detail, and what it is based on, but it is actually anchored extremely heavily upon these actual negotiated contracts, and the milestones that were provided by both SpaceX and Boeing.

Ms. EDWARDS. And then, just in the time remaining—thank you, Mr. Gerstenmaier. In the time remaining, I just want to clarify that—both from Boeing and from SpaceX that, in terms of all of the development costs that have gone into the—your—both of your efforts, what percentage of that has been provided by taxpayers, and what percentage of that has been provided by you independently, as commercial companies?

Mr. MULHOLLAND. Ranking Member, I don't have that data readily available. I certainly will get that to you. I would say that NASA has paid the preponderance of the development cost, but Boeing has contributed significantly.

Dr. REISMAN. So I am going to, unfortunately, have to say the same thing. And I just asked the guys behind me, they don't know either, but—so we will get back to you on a precise number. But I can tell you that, similar to what John said, we have put—especially in the beginning, we put a lot of our own money in. We have our own skin in the game, but we have also enjoyed a lot of help from NASA, so—the exact numbers we will have to get back to you.

Ms. EDWARDS. It is important because, you know, the public believes that the work that you are undertaking now is entirely your own, and you are entirely footing the bill. We just saw a recent poll about that, which is actually undercutting our ability to make a sale that taxpayers need to continue to support NASA as an agency. And so it is a deep concern of mine that we have a public that believes, because you guys are very good at, you know, the promotion of your work, and it is exciting that it is all your skin in the game. And so why not just turn it all over to the private sector as though the taxpayer shouldn't meet any of that burden at all?

And my estimates, the estimates that I have, show that taxpayers have skin in the game to the tune of about 90 percent, and you all ten percent. And I don't have a problem with that, but I don't want anybody in the public going away believing that this is all commercial, and that taxpayers and NASA, therefore, don't need to be doing this work. And I thank you for your testimony.

Chairman PALAZZO. All right. Thank you, Ms. Edwards. Because of the lack of time, I am going to forego my question. I am going to submit questions for the record.

You know, there has been a lot of talk about what is actually the true cost per seat for sending American astronauts on American rockets back into space. Only time will tell, but the American people are really going to be the ones to decide how much are they willing to spend on maintaining—or not maintaining—but achieving American access to space, and also maintaining America's leadership in space. So, I want to thank the witnesses for their valuable testimony, and the Members for their questions. The record will remain open for two weeks for additional questions and written questions from Members. The witnesses are excused, and this hearing is adjourned.

[Whereupon, at 10:40 a.m., the Subcommittee was adjourned.]





## Appendix I

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### ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

*Responses by Mr. Bill Gerstenmaier*

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Mr. William Gerstenmaier, Associate Administrator, Human Exploration and Operations, National Aeronautics and Space Administration

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

QUESTION 1:

The process for a company to be certified to carry crew is quite extensive and requires substantial funding from the government. Is there a process for on-ramping new entrants for commercial crew?

ANSWER 1:

The Commercial Crew Transportation Capabilities (CCtCap) contracts contain a clause entitled “H.16, New Entrant.” This clause anticipates that other companies could develop a capability that meets NASA safety requirements. Because the exact circumstances are difficult to predict, the specific process that NASA would use to add a new entrant would be determined at the time we decided to seek new entrants.

QUESTION 1a:

How likely is it that you would re-compete the contract in the future?

ANSWER 1a:

NASA continues to plan for a subsequent International Space Station (ISS) crew transportation services contract (this would not be a “re-compete” of the current CCtCap contracts). The likelihood of this depends on several factors: the success of the current two partners, the maturity of the crew transportation market, and the lifetime of the ISS.

QUESTION 1b: How would that decision be made?

ANSWER 1b:

Agency management would consider the factors listed above as well as any other emerging areas of concern, and make the choice that would serve the best interests of the government at that time. Because this is some time in the future, it is difficult to be more specific at this time.

QUESTION 1c:

Would you permit other entrants to use the CPC option?

ANSWER 1c:

The use of a phased procurement approach, with CPC as Phase 1 and CCtCap as Phase 2, was a unique approach tailored to the circumstances of the Commercial Crew Program at that time. For either new entrants to CCtCap or a follow-on services contract, NASA would likely tailor its acquisition approach to the specific circumstances to best meet all requirements and objectives. It is unlikely that NASA would employ another phased procurement approach, but it cannot be ruled out at this time.

QUESTION 1d:

How would this impact the price the government pays for crew service?

ANSWER 1d:

While competition generally results in lower prices over time, the number of factors that could affect prices, both upward and downward, is large. Other customers, cost of materials, further technology developments, and other competitors could all vary and change the prices for ISS crew transportation services in the future.

QUESTION 1e:

How would this be impacted by if the Russian's decide to exit the ISS partnership?

ANSWER 1e:

It is very difficult to speculate on the net effect of a Russian exit from ISS on the prices of ISS crew transportation services.

QUESTION 2:

In your written testimony you stated that NASA will sponsor four NASA or NASA-sponsored crew on each mission.

- a. Can you please explain what you mean by "NASA-sponsored?" Does that include foreign astronauts?

ANSWER 2a:

"NASA-sponsored" crew is personnel assigned by NASA to be transported between Earth and the ISS in the crew transportation system. It could include foreign astronauts.

QUESTION 2b:

If you anticipate foreign astronauts will ride on these systems, will this be based on the existing ISS partnership responsibilities?

ANSWER 2b:

NASA anticipates having a Russian crewmember on each U.S. commercial crew transportation flight and one astronaut will continue to fly on Soyuz. This will be done to ensure that a U.S. and Russian crewmember will remain on ISS in any contingency return of a vehicle. NASA also has obligations under its international agreements to provide ISS transportation for Canadian, European, and Japanese crew. This will be accomplished on a no exchange of funds basis, based on the existing ISS partnership responsibilities.

QUESTION 2c:

If not, will NASA seek reimbursement for these seats?

ANSWER 2c:

See above. There will be no exchange of funds.

QUESTION 3:

Several of the ASAP's annual reports have highlighted weaknesses in NASA's insight into contractor work under the Commercial Crew program.

- a. What standards, mechanisms, or procedures do you have in place to ensure that NASA has adequate insight and oversight of these systems as they develop?

ANSWER 3a:

NASA relies upon the terms and conditions of contract clause H.15, Government Insight, to provide mechanisms and procedures for gaining insight into the ongoing development of a contractor's design. A brief quote from that clause states "The Contractor shall provide ... access to all Contractor activities ... under this contract." This is broad access that is fully adequate for NASA to monitor activities during performance. Each company's Insight Implementation Plan, a document the company prepares and NASA approves, provides more definition.

QUESTION 3b:

Is your oversight and insight authority codified in the CCtCap contracts and how is it enumerated?

ANSWER 3b:

Oversight authority is provided via contract clause E.2, Inspection of Services and Research and Development Work, in both CCtCap contracts. A brief quote from that clause states "The Government has the right to inspect and test all services and R&D work called for by contract, to

the extent practicable at all times and places during the term of the contract.” This broad authority should be adequate for all oversight activities.

Insight authority is provided via clause H.15, Government Insight, in both CCtCap contracts. That clause requires, in part, that, “The Contractor shall provide ... access to all Contractor activities ... under this contract.” This is broad access that is fully adequate for NASA to monitor activities during performance.

The contract also requires submission of specified data deliverables, reports, review packages and plans throughout contract performance to enable the Government to continuously monitor and assess contractor performance.

QUESTION 3c:

What enforcement mechanisms do you have to ensure compliance with these requirements?

ANSWER 3c:

The inspection clause allows for rejection of nonconforming services and R&D work, as well as re-performance, at no additional cost. Insight is performed prior to an oversight event such as inspection, to ensure that inadequate performance is identified as early as possible. Failure to provide adequate insight would result in rejection of the final work, giving contractors significant incentive to maximize insight as early as practicable.

QUESTION 3d:

What is the role of NASA’s Office of Safety and Mission Assurance?

ANSWER 3d:

The Office of Safety and Mission Assurance (OSMA) developed a major portion of the Commercial Crew Certification Requirements, including the human-rating requirements, to which the Agency will certify commercial vehicles as safe to fly U.S. and U.S.-sponsored astronauts. These requirements are specified in HEOMD-CSD-10001, Revision A, “Commercial Crew Transportation System Certification Requirements For NASA Low Earth Orbit Missions,” and are levied upon the Commercial Crew Program (CCP). Technical Authority representatives (includes OSMA, Office of the Chief Engineer, and Office of Chief, Health and Medical) are members of the CCP program boards and have a voice in decisions that affect crew safety. In addition, quality inspections are conducted or managed by OSMA representatives. These are the inspections that are anticipated by the inspections clause cited above.

QUESTION 4:

How will NASA ensure that the certification process for these systems will not deviate from known standards of safety and reliability, or at least the 50-plus years of safety culture that NASA has developed?

## ANSWER 4:

NASA's Commercial Crew Program has prioritized crew safety throughout its development and certification phases, including the Certification Products Contracts (CPC) and Commercial Crew Transportation Capability (CCtCap) contracts with industry. Our Commercial Crew partners have, and will continue to, put safety at the core of their designs. NASA is confident the insight and oversight requirements in the CCtCap contracts will ensure commercial crew transportation systems meet NASA's safety and certification requirements. Those requirements were established from the Agency's experience and expertise during more than 50 years of human spaceflight. NASA has worked carefully and diligently to assure our safety requirements span all mission phases and adequately address all credible hazards, including pad emergencies, in-flight aborts and emergency landings.

## QUESTION 5:

Has there been a situation in the past where NASA needed to use an enforcement mechanism to ensure one of the companies involved in the program complied with information or data requests from NASA?

## ANSWER 5:

There has never been a situation in the past where NASA needed to use an enforcement mechanism to ensure that a commercial crew company complied with a data request from NASA.

## QUESTION 5a:

How was that handled and did the company eventually comply with the request?

## ANSWER 5a:

See ANSWER #5 above.

## QUESTION 5b:

Has this occurred on the Commercial Cargo program?

## ANSWER 5b:

This has not occurred with Commercial Resupply Services (CRS).

## QUESTION 6:

The Commercial Crew Program is a new way of doing business that requires new processes for investigating mishaps or accidents. What has NASA done to prepare for any mishaps or accidents that may occur in the Commercial Crew program?

## ANSWER 6:

NASA, The Federal Aviation Administration (FAA), the Department of Defense (DoD) and the National Transportation Safety Board (NTSB) are jointly developing an integrated plan to manage accident investigations of commercial crew transportation systems. This investigation planning effort includes all mission phases including launch, orbital operations, ISS proximity operations, entry, and landing.

In June 2012, the NASA Associate Administrator for Human Exploration and Operations and the FAA Associate Administrator for Commercial Space Transportation signed a Memorandum of Understanding (MOU) for the achievement of mutual goals in human space transportation. This MOU memorializes the approach for our ongoing joint efforts to:

- provide a stable framework for the U.S. space launch industry;
- avoid conflicting requirements and mutual sets of standards;
- advance both public safety and crew safety; and
- advance the interests of NASA-certified U.S. commercial launch operators responsible for transporting U.S. and U.S. operating segment astronauts to the ISS.

Our relationship is further codified in the Commercial Crew Program Plan, CCT-PLN-1020, National Aeronautics and Space Administration (NASA) and Federal Aviation Administration Joint Program Management Plan (PMP) for the Commercial Crew Program (CCP), which details the partnership of these respective agencies during FAA licensed mission phases.

## QUESTION 6a:

Are specific procedures in place to address investigations and oversight of investigations?

## ANSWER 6a:

Contract clause H.26, Mishap Reporting, anticipates the processes to be used in the event of NASA-related mishaps during performance of the CCtCap contracts. In accordance with this clause, the contractor will conduct a mishap investigation, but will include NASA participation on the investigation. The companies are also obligated under this clause to provide personnel and data to support an independent NASA investigation.

## QUESTION 6b:

If these are not spelled out in the contracts, can you share those with the Committee for the record?

## ANSWER 6b:

See ANSWER #6 above.

## QUESTION 7:

The FAA and NTSB have uncertain authority to investigate space launch accidents. While the FAA will license the Commercial Crew launches, it does not investigate accidents and the NTSB has no legislative authority to investigate accidents involving space vehicles. How has NASA been working with FAA and NTSB to clarify the roles and responsibilities, if any, in the event of an accident? If so, how will those efforts conform to existing statutory requirements?

## ANSWER 7:

NASA, FAA, the DoD and NTSB are jointly developing an integrated plan to manage accident investigations of commercial crew transportation systems. This investigation planning effort includes all mission phases including launch, orbital operations, ISS proximity operations, entry, and landing. As the licensing authority, the FAA has responsibility for the launch, entry, and landing phases, with the NTSB taking the lead in its accident investigations. NASA will lead accident investigations for all other mission phases. NASA, FAA, NTSB and the Air Force have established a working group that is meeting monthly to ensure that roles and responsibilities are completely understood under all scenarios relating to potential accidents.

The organizations recognize the statutory responsibilities and limitations that Congress has set forth and are taking into account as plans are developed.

## QUESTION 8:

Are there any differences in transparency and documentation between the contractors either financially or technically?

## ANSWER 8:

In general, the contracts require the same documentation from each company during performance. Some differences occur because each company proposed unique technical reviews or milestone events and these represent their different levels of maturity and their internal processes. The specific documentation to be provided is described in the contract deliverables and in the milestone acceptance criteria. In both cases, the level of transparency and documentation is sufficient to verify compliance with all NASA safety and contract requirements.

## QUESTION 8a:

What access does each company provide NASA to key meetings?

## ANSWER 8a:

In general, the contracts require access that is adequate for NASA to verify compliance with contract technical requirements. Differences occur between the various meetings and between the two companies. Each company proposed unique technical reviews or milestone events and



these represent their different levels of maturity and their internal processes. The companies proposed how meetings would be conducted and, where NASA had concerns, those were resolved during contract discussions.

QUESTION 8b:

Comparatively, how does this affect NASA's confidence in safety, performance, program management, and reliability between the two contractors?

ANSWER 8b:

There is no real comparison. Both companies provide adequate access, transparency and documentation to permit NASA to verify compliance with safety, program management and reliability requirements.

QUESTION 9:

In the Commercial Cargo Program, up to 80 percent of the cost of a mission can be paid out to a contractor before the launch occurs. How are the payment schedules structured under CCtCap and how did NASA come to the decision to structure the payment schedules in that manner?

ANSWER 9:

NASA structured Post Certification Mission (PCM) payments to incorporate lessons learned during performance of the Commercial Resupply Contracts and the Launch Services Program. We included a variety of payment constraints to give us confidence that NASA would not overexpose itself prior to performance of either development activities or the individual PCM activity. For example, no more than two missions can be authorized before the contractor completes its Design Certification Review, a key development milestone. Also, PCMs 1 and 2 for each company have specific development requirements that must be met prior to NASA authorization of those missions.

For an individual mission, interim payments can be made up to 90 percent of the price of the mission prior to final payment after the completion of the mission. However, all interim payments are financing payments. These are subject to complete repayment if the contract is terminated for default. In the event of a failed mission, under clause H.21, Post Certification Mission Success Determination, the contractor is not paid the final 10 percent of the mission price and must return an additional 15 percent of the mission price previously paid.

QUESTION 10:

What, if any, NASA Civil Servant help and facilities access (outside of funded Space Act Agreements and contracts) is offered to the commercial cargo and crew companies?

## ANSWER 10:

In addition to funded Space Act agreements and contracts, NASA has provided support for development of commercial cargo and crew services through unfunded Space Act agreements and fully reimbursable Space Act agreements.

## QUESTION 10a:

What programs pay for these Civil Servants?

## ANSWER 10a:

For reimbursable Space Act Agreements, the companies pay for any NASA civil servant labor. For unfunded Space Act Agreements, it depends on the specific agreement.

## QUESTION 10b:

Do Exploration programs pay for any of them?

## ANSWER 10b:

The Commercial Crew Program is part of the Exploration appropriation account, but is separate from Exploration Systems Development (ESD). The 21<sup>st</sup> Century Space Launch Complex is part of the Space Operations appropriations account.

## QUESTION 10c:

Please provide the accounting of how much of this help is provided, by company, and what accounts the funding comes from.

## ANSWER 10c:

The Commercial Crew Program has spent less than \$2.5 million since inception on civil servant labor for unfunded Space Act Agreements. This civil servant labor was primarily for NASA insight and milestone approval. The breakout by company is provided below. However, the United Launch Alliance (ULA) number is overstated since it includes labor costs related to both the funded CCDev1 and unfunded CCDev2 Space Act Agreements with ULA.

	<u>\$ in Millions</u>
United Launch Services	1.4
Excalibur Almaz Inc	0.1
Alliant TechSystems	1.0
<u>Total</u>	<u>2.5</u>

QUESTION 11:

The Commercial Crew contracts are firm-fixed price and contract payments are based on the successful completion of milestones.

- a. In prior Commercial Crew development phases, how successful have the providers been at meeting their originally proposed milestones?

ANSWER 11a:

For the first round of Commercial Crew Development (CCDev), the period of performance for four of the five agreements was extended to enable the partners to complete their milestones. In CCDev 2, the period of performance for all four agreements was extended; and for CCIcap, the period of performance for all three agreements was extended.

QUESTION 11b:

Are there still outstanding milestones from the CCIcap phase and if so, please elaborate.

ANSWER 11b:

There are three SpaceX CCIcap remaining milestones: Milestone 12B: Dragon Primary Structure Qualification- Hatch Open Test, Milestone 13E: Delta Crew Vehicle Critical Design Review (CDR), and Milestone 14: In-Flight Abort Test. There are two Sierra Nevada CCIcap remaining milestones: Milestone 4B, ETA Flight Testing #2, and the recently added unfunded Milestone 41: Design Analysis Cycle-6 Closeout Review.

QUESTION 11c:

Were these delays caused by insufficient funding?

ANSWER 11c:

Insufficient funding was not included as a rationale from the partners for the request to delay any of the milestones listed above. However, insufficient funding did affect NASA's overall plan and schedule for the development of commercial crew capabilities.

QUESTION 11d:

What leverage does the government have to compel contractors to meet a schedule?

ANSWER 11d:

The previous phases of the Commercial Crew Program utilized Space Act Agreements (SAAs). These agreements were not for meeting NASA requirements; they were to assist the partner's

crew transportation system development efforts. If the partners delayed the completion of a milestone, NASA's milestone payment was similarly delayed. In extreme cases of non-performance under an SAA, NASA can terminate an agreement as was done with Rocketplane Kistler as part of the Commercial Orbital Transportation Services (COTS) agreements.

Under the current contract, the contractor is not paid for a milestone until it is completed. The contract also provides for an adjustment, in price or in other consideration to the Government, if the contractor delays a launch beyond the agreed grace period. The contract also may be terminated for default if the contractor fails to make progress in performance.

QUESTION 12:

What role did the White House Office of Management and Budget have in the selection process and decision on number of awardees during the selection process time frame?

ANSWER 12:

The White House Office of Management and Budget had no role in the selection process or the decision on the number of awardees during the selection process time frame.

QUESTION 13:

Congress and the Administration have, in the past, disagreed about proper funding levels and the acquisition strategy used by NASA for the Commercial Crew Program. This year's budget request includes yet another increase in funding.

- a. Why does the Administration continue to pursue acquisition and development strategies for the Commercial Crew Program beyond Authorized levels, or historical Appropriations?

ANSWER 13a:

NASA believes it is important for the successful operation and utilization of the ISS to have domestic crew transportation capability as soon as possible in order to reduce reliance on foreign entities and to no longer outsource jobs and taxpayer funds to other countries.

QUESTION 13b:

What are the down-select criteria if you don't get the funding you propose in the President's Budget Request?

ANSWER 13b:

The contract does not have any down-select criteria if appropriations are less than the President's Budget Request for CCP.

QUESTION 13c:

What measures are you going to employ that assure safe and reliable crew transportation if you down-select?

ANSWER 13c:

NASA does not intend to, and the contract does not provide for, down-select if appropriations are less than the President's Budget Request.

QUESTION 13d:

Why would NASA make multiple awards, if there was not enough money in the budget?

ANSWER 13d:

American industrialization has long shown the benefits to customers of competitive markets, and NASA is capitalizing on that approach through the Commercial Crew Transportation Capability contracts. The Agency selected two independent systems designed by Boeing and SpaceX that, once certified, will add to the fleet of ships serving the ISS. An approach employing multiple awards maximizes meeting the program objectives, provides more options and flexibility for the Agency throughout contract performance, reduces overall risk to the program, and best ensures successfully accomplishing safe, reliable missions to the ISS.

While NASA is confident in the ability of the companies to perform, their designs are still not fully mature. Maintaining the benefits of competition during the rest of the development lifecycle and into initial services is critical to assuring safety by enabling redundant capabilities that will provide assured access to and from the ISS.

According to the Office of Inspector General, "Moving forward with a single company increases the risk that NASA could be left without a viable commercial option to transport crew to the ISS should issues arise that either significantly delay or render inoperable the selected company's systems." It is not in the best interests of NASA to put the Agency into a sole-source situation or to establish a monopoly on crew transportation.

QUESTION 13e:

Do the CCtCap contract values align with the independent cost assessment conducted by Booz Allen Hamilton in 2013?

ANSWER 13e:

The total NASA crew transportation system development costs, including the CCtCap contract values and the prior CCiCap amounts, were, on average, 35 percent lower than the values established by the Booz Allen Hamilton independent cost assessment conducted in 2013.

## QUESTION 14:

Congress and the Administration have, in the past, disagreed about proper funding levels and the acquisition strategy used by NASA for the Commercial Crew Program. This year's budget request includes yet another increase in funding. What confidence do you have that Congress will depart from historical funding norms for this program?

## ANSWER 14:

NASA is optimistic that the Congress will agree with NASA that it is important for the successful operation and utilization of the ISS to have domestic crew transportation capability as soon as possible in order to reduce reliance on foreign entities and to no longer outsource jobs and taxpayer funds to other countries.

## QUESTION 14a:

Why does the Administration continue to pursue acquisition and development strategies for the Commercial Crew Program beyond Authorized levels, or historical Appropriations?

## ANSWER 14a:

The Administration and NASA believe it is important for the successful operation and utilization of the ISS to have domestic crew transportation capability as soon as possible in order to reduce reliance on foreign entities and to no longer outsource jobs and taxpayer funds to other countries.

## QUESTION 15:

The Certification Products Contract was meant to provide a structure whereby NASA and the potential contractors could develop standards to meet certification requirements. NASA's written testimony described the categories of alternate standards and variances to the original requirements but not the number of alternate standards.

- a. How many standards were presented to the contractors during CPC and how many of those were granted waivers for alternate standards or variances?

## ANSWER 15a:

For the Commercial Crew Program, there are slightly less than 100 documents of applicable standards for such things as workmanship, software development, and design strength standards for windows and glass. Variances that partners submitted could be to only one portion of one standards document, not necessarily the entire document. For all three CPC contractors, 87 requests for alternate standards were given some level of approval by NASA (i.e., Approved, Approved with Conditions, Partially Approved). Additionally, 17 variances were given some level of NASA approval during CPC. Boeing and SpaceX continue to develop their crew transportation system under their CCtCap contracts, and additional variance requests are anticipated as this process occurs.

QUESTION 15b:

How does this compare to traditional development programs?

ANSWER 15b:

The requirements set is significantly smaller for commercial crew than for a traditional government research and development effort. The applicable standards are very similar to those for other human space efforts.

QUESTION 16:

NASA provided a waiver to the FAR regulation for certified cost and pricing. How have the two companies responded to this lack of auditable spending?

ANSWER 16:

No waiver was necessary or provided for certified cost and pricing for the basic contract competition. Procurement regulations state that the government may not seek certified cost and pricing data in an environment of competition, which existed for CCtCap. The waiver NASA granted was for certified data on *modifications* only. We have not processed a modification with cost impact on either contract and do not have information concerning company responses to the waiver.

QUESTION 16a:

What level of insight do you have into the spending of taxpayer funds by each contractor?

ANSWER 16a:

The contract has fixed prices for the completion of development for each company's crew transportation system. We therefore know precisely how much taxpayer funds will be spent on the complete development of a new human-rated spacecraft. NASA has detailed requirements associated with the fixed price line items for the contracts. We therefore have complete insight into what will be delivered for the predetermined amount of dollars. This method of contracting is recommended by the FAR as the preferred contract method for the government, as it provides a known obligation of dollars for the agency and a defined deliverable from the partner. This is also the method NASA will use for acquiring the Post Certification Missions.

QUESTION 17:

What insight does NASA have to ensure that the variances and alternate standards granted during the CPC contract meet the original standards required by NASA?

ANSWER 17:

Prior to granting either alternate standards or variances to requirements, NASA performs a detailed analysis of the proposal from the contractor. We review how well the variance will meet the intent of the original language, albeit through a different mechanism. Commercial Crew Program engineers also study, report, discuss and determine any potential risk to crew safety, or to mission success that is encompassed by proposed alternate standards or variances, if any.

QUESTION 17a:

What quality control mechanisms are in place to provide sufficient data to the government to satisfy the original standards required by NASA?

ANSWER 17a:

NASA ensures compliance to all contract requirements through a combination of insight and oversight. Insight begins early in the development process and occurs often throughout the activity to allow NASA experts to understand deeply how the design will satisfy the requirements. For some of the NASA requirements, it is not possible to do this through inspection; it requires an understanding of how the company is going to build their spacecraft in order to know if it will be acceptable. This needs to be done before the design is complete. Oversight happens near the end of the process and is more akin to classic government inspection. This is a physical or analytical verification that the completed part or spacecraft meets the requirements.

QUESTION 18:

The CPC represents a new way of developing safety standards for human rated systems.

- a. What are the lessons learned from the experience and how do you intend to infuse those lessons into future projects?

ANSWER 18a:

The CPC effort allowed potential providers to better understand and align the design and operation of their vehicles with NASA human spaceflight requirements and gave NASA early insight into vehicle designs and approaches. The companies submitted requests for alternate standards and variances to meeting NASA human spaceflight requirements. NASA's dispositions, with explanatory rationale, were provided to the companies. This feedback enabled our partners to make technical changes to better align their designs with NASA's requirements. The CPC phase also enabled NASA to examine the technical specifications and approaches that the companies were proposing to meet NASA's requirements. Understanding and agreeing on technical requirements is critical to developing a safe design. Overall, this phase of the contract was important to enabling the partners to understand the human rating requirements and NASA's understanding of how the partners' approaches intend to meet those requirements.



## QUESTION 19:

NASA has historically conducted a flight readiness review prior to launches to facilitate a frank and open conversation about risks.

- a. Will the Commercial Crew program benefit from such a process?

## ANSWER 19a:

Yes, the Flight Readiness Review process will benefit CCP.

## QUESTION 19b:

If so, how will that occur?

## ANSWER 19b:

For crewed missions to the ISS, Flight Readiness Reviews (FRRs) will be conducted, with participation by the commercial partners, in accordance with the flight readiness process and baselined schedule. The purpose of the FRRs is to evaluate crew transportation system production and operation progress, technical issues and requirement deviations/waivers, and the closure of any actions and to grant "Authority-to-Proceed" to launch countdown. Upon the CCP's concurrence with the partner's determination of flight readiness, the CCP will develop a recommendation for flight readiness to be presented to the Agency governing councils, culminating at the NASA FRR.

The purpose of NASA FRR is to grant approval to the partner to proceed into launch countdown for a mission that transports NASA crew to the ISS. The FRR will also document the formal acceptance of risk by NASA and the partner. Upon successful completion of each FRR and closure of open work, NASA will grant Certification of Flight Readiness for the mission.

## QUESTION 19c:

If not, how will NASA ensure a similar level of candor among engineers, managers, and contractors?

## ANSWER 19c:

See ANSWER above.

## QUESTION 20:

NASA has had Loss of Crew and Loss of Mission (LOC/LOM) probability requirements for its crew vehicles in the past. These were based on Probabilistic Risk Analysis (PRA). After the Space Shuttle Columbia accident, these were put in place and intended to make sure the vehicle(s) that replaced the Shuttle were safer. What are the LOC/LOM requirements for

Commercial Crew vehicles and how are you verifying these requirements are being met and do you have the insight into the commercial crew contracts necessary to be assured these vehicles meet their LOC/LOM requirements?

ANSWER 20:

There are two LOC requirements for commercial crew transportation systems: (1) The overall LOC probability distribution for an ISS mission shall have a mean value no greater than 1 in 270; and, (2) The LOC probability distribution for the combined ascent and entry phases of an ISS mission shall have a mean value no greater than 1 in 500.

It should be noted that NASA recently clarified the allocation of LOC with the companies. The overall requirement of 1 in 270 did not change, but NASA allocated a portion of the requirement, 1 in 200, to the system design and the remaining portion of the LOC will be met with operational mitigations.

There is one LOM requirement: The LOM probability distribution for an ISS mission shall have a mean value of no greater than 1 in 55.

NASA will verify that these requirements are being met through a Probabilistic Safety Analysis (PSA). The PSA methodology shall be defined utilizing the methodology described in the CCtCap requirements documentation (i.e., CCT-PLN-1120) as a guide.

NASA will rely upon the terms and conditions of contract clause H.15, Government Insight, to provide the mechanisms and procedures for assuring that the vehicles meet NASA's LOC/LOM requirements. A brief quote from that clause states "The Contractor shall provide ... access to all Contractor activities ... under this contract." This is broad access that is fully adequate for NASA to monitor activities during performance.

QUESTION 20a:

How does safety certification of the commercial crew vehicles compare to what was done on the Space Shuttle?

ANSWER 20a:

Simply put, for ascent and entry, commercial crew transportation should be about twice as safe as Shuttle was at its end of life. Regarding the on-orbit piece, a commercial crew 6-month mission should be as safe as or safer than the Shuttle's 12-day mission to the ISS.

QUESTION 21:

The CCtCap Contract, unlike other major human-rated space systems, is a firm-fixed price contract. This is a new way of developing these types of systems.

- a. What happens if the contractors are unable to finish the work with the funding provided to them?

ANSWER 21a:

The CCtCap partners are obliged to complete the work under the contract for the price they have agreed upon. Should their internal costs exceed their earlier estimates, then the company's profit margin would begin to erode. Eventually, the company would complete the work at a loss. NASA reviewed the financial aspects of both companies and their CCtCap bids, and both companies proposed adequate margin to cover most plausible setbacks.

QUESTION 21b:

How do you track and mitigate this risk?

ANSWER 21b:

NASA requires the companies to report on their cost and schedule status on a quarterly basis. It is not necessary for NASA to mitigate this risk, as this is a contractor risk that both companies have mitigated with proposed margins.

QUESTION 22:

The Commercial Crew Program does not operate as a traditional development project. Without a baseline for cost and schedule that is independently verified, there is no way for Congress to measure progress of the systems other than public statements from NASA.

- a. What metrics is NASA using to ensure these systems stay on schedule?

ANSWER 22a:

NASA receives an updated integrated master schedule from each company on a monthly basis. Additionally, we require the companies to formally report on the status of their schedule on a quarterly basis. Finally, NASA independently calculates a Schedule Risk Analysis as part of the program's reporting to NASA Headquarters.

QUESTION 22b:

What prevents contractors from spending all of the money under contract and coming back to ask for more in order to complete the remaining milestones?

ANSWER 22b:

The contract terms and conditions require the companies to deliver the required deliverables and services for the prices negotiated. Failure to perform in accordance with the agreed upon terms is a breach of contract and grounds for a default termination.

QUESTION 22c:

Other than funding, what is your greatest risk to having at least one contractor ready to launch by 2017?

ANSWER 22c:

There are a number of technical challenges associated with the designs of both partner's crew transportation systems that may delay the goal of certification by 2017. CCP is a large, complex development effort whereby the partners are expected to conform to a set of requirements in a fixed price contract. Schedule delays are possible if there is a delay in certifying the partner's design. This could lead to late and expensive design changes by the partners to address an insufficient certification area. Also, a significant number of alternative standards and variances during CPC were not approved and contained forward work recommendations. This could result in delays to the Program schedule if shortcomings in the partner designs or standards are identified.

QUESTION 23:

The CCtCap contract awarded last year includes six post-certification missions. If NASA is able to certify both contractors for flight, what is the maximum period of the contracts and for how long could NASA get astronauts to and from the ISS on the existing contract?

ANSWER 23:

If all twelve post certification missions are flown, these contracts can support the ISS crew transportation needs into 2023.

QUESTION 24:

The CCtCap contracts provide NASA the ability to order additional data or studies from the contractors. What information do you expect to garner from these studies?

ANSWER 24:

When NASA created Contract Line Item Number (CLIN) 003, Special Studies, we anticipated a scenario in which a contractor meets all the written requirements for a piece of hardware, but NASA desires additional testing or analysis. Based on past experience, NASA experts may have concerns with the results of a contractor test, although the results are quantitatively acceptable. In this situation, we could use CLIN 003 to order and pay for an additional test to provide greater

data for understanding and accepting the contractor system. Additionally, we anticipated a situation in which an entirely unanticipated function or even mission arises well into the contract period of performance. NASA could use CLIN 003 to initiate a design study of the contractor's system to understand how or if that system could meet our emerging needs. CLIN 003 Special Studies is solely at the government's discretion and does not ever have to be used.

QUESTION 24a:

How do you ensure that all the data you need is available?

ANSWER 24a:

When the order is placed using CLIN 003, all data required to satisfy NASA's requirements will be defined as part of the order and this data will be included in the negotiated price for the Special Study task order.

QUESTION 25:

The FAA will be licensing NASA launches for human spaceflight missions for the first time with the Commercial Crew Program. Please describe the working relationship you have with FAA and how your rights and responsibilities are codified.

ANSWER 25:

NASA and FAA enjoy an extremely close working relationship through our respective implementing organizations as we jointly facilitate development of U.S commercial space transportation capabilities.

In June 2012, the NASA Associate Administrator for Human Exploration and Operations and the FAA Associate Administrator for Commercial Space Transportation signed a Memorandum of Understanding (MOU) for the achievement of mutual goals in human space transportation. This MOU memorializes the approach for our ongoing joint efforts to:

- provide a stable framework for the U.S. space launch industry;
- avoid conflicting requirements and mutual sets of standards;
- advance both public safety and crew safety; and,
- advance the interests of NASA-certified U.S. commercial launch operators responsible for transporting U.S. and U.S. operating segment astronauts to the ISS.

Our relationship is further codified in the Commercial Crew Program Plan, CCT-PLN-1020, National Aeronautics and Space Administration (NASA) and Federal Aviation Administration Joint Program Management Plan (PMP) for the Commercial Crew Program (CCP), which details the partnership of these respective agencies during FAA licensed mission phases.

## QUESTION 26:

The FAA and NASA have different requirements and responsibilities for launch and reentry. If NASA is prepared to launch or reenter a time-sensitive mission, but the FAA has not approved the requisite paperwork, how would such a dispute between the agencies be mediated? Is this included in a written agreement?

## ANSWER 26:

Cargo and crew missions to the International Space Station (ISS) require long-range planning involving a number of US and International Partner organizations. All flights to and from the ISS are time-sensitive, due to the nature of having a large fleet of crew and cargo visiting vehicles servicing the ISS. All flights are scheduled in advance of the current 180-day FAA licensing timeframe defined in Title 51 USC Chapter 509. Should an emergency occur, all responsible organizations make the maximum effort possible to increase the possibility of a positive outcome.

## QUESTION 27:

NASA and the FAA have officially requested a change to the Commercial Space Launch Act that would define a new category of "government astronauts" for the purposes of launching NASA Astronauts on the Commercial Crew systems. How important is the government astronaut change and what happens if the change isn't enacted in time for the Commercial Crew launches?

## ANSWER 27:

The requested Commercial Space Launch Act changes are extremely important as the United States moves closer to returning ISS crew missions back to American soil.

The FAA and NASA jointly request passage of the Government Astronaut Proposal because the current CSLA, as read to apply to astronauts on commercially licensed vehicles, raises several inconsistencies in the law and its application is unclear or contradictory with other laws and the International Space Station international agreements. NASA and FAA have faced challenges applying current law covering "spaceflight participants" to government employees (both civilian employees and military detailees) and to International Partner astronauts. At the same time, NASA and FAA are working very closely together to identify paths forward under current law. A legislative solution is requested to facilitate the efficient and complementary roles of NASA and the FAA to enable commercial human spaceflight with NASA ensuring its own crew safety and the FAA preserving public safety.

## QUESTION 27a:

Will NASA fly astronauts on these systems without the change?

ANSWER 27a:

It is unclear whether NASA would fly astronauts without this change. NASA would need to further evaluate the situation before we could say with certainty.

QUESTION 28:

The Commercial crew contracts are fixed price, and contract payments are based on the successful completion of milestones.

- a. In prior commercial crew development phases, how successful have the contractors been at meeting their originally proposed milestones?

ANSWER 28a:

For the first round of Commercial Crew Development (CCDev), the period of performance for four of the five agreements was extended to enable the partners to complete their milestones. In CCDev 2, the period of performance for all four agreements was extended; and for CCIcap, the period of performance for all three agreements was extended.

QUESTION 28b:

Are there still outstanding milestones from the CCIcap phase, and if so, please elaborate.

ANSWER 28b:

There are three SpaceX CCIcap remaining milestones: Milestone 12B: Dragon Primary Structure Qualification- Hatch Open Test, Milestone 13E: Delta Crew Vehicle Critical Design Review (CDR), and Milestone 14: In-Flight Abort Test. There are two Sierra Nevada CCIcap remaining milestones: Milestone 4B, ETA Flight Testing #2, and the recently added unfunded Milestone 41: Design Analysis Cycle-6 Closeout Review.

QUESTION 28c:

Please explain how contractors will be able to meet outstanding CCIcap milestones and at the same time meet the new CCtCap milestones without slipping schedule.

ANSWER 28c:

SpaceX is the only company that has both outstanding CCIcap milestones and CCtCap milestones, and the company has the responsibility to satisfy the acceptance criteria associated with all those milestones. NASA has confidence that SpaceX (and Boeing) understands the overall amount of work that needs to be performed. All NASA contractors have other contractual obligations, and each company must manage its workload appropriately.

## QUESTION 29:

The CCtCap contract does not require the contractors to be ready by a specific date; rather it is considered to be a “goal” for the program to be ready by 2017. What leverage does NASA have with the contractors to maintain schedules without compromising the quality or safety of the systems?

## ANSWER 29:

Although the CCtCap Request for Proposals (RFP) did not require a specific date, and requested proposed dates against NASA’s “goal” of 2017, the resulting contracts do contain specific dates for delivery. These contract delivery dates include the completion of human rating certification by 2017. Although the dates should be considered subject to the various contingencies that always occur in a complex development activity, payments are tied to the deliveries. This provides significant incentive for the companies to successfully perform against their agreed upon schedule.

## QUESTION 30:

The annual report of the ASAP identified specific concerns with the Director of Commercial Space Development at headquarters. The report specifically outlines a series of concerns about transparency and openness about risks in the program.

- a. Are you confident that you have insight into all areas of the program to which the ASAP has had difficulty gaining access?

## ANSWER 30a:

The contracts include a robust insight clause, which will enable NASA to fully evaluate company designs to determine whether NASA’s safety requirements are satisfactorily met. Defined milestones in the contracts enable NASA to incrementally assess the safety and performance of the systems through the certification process. In addition, the contracts include a comprehensive test program, including at least one crewed flight test to the ISS. The contract also includes a contract line item to add contractor-led studies, as needed, to provide extra analysis and possibly test in critical areas.

## QUESTION 30b:

What have you done to mitigate the concerns expressed by the ASAP in this report?

## ANSWER 30b:

To protect the integrity of the procurement process, the agency needed to control the data it released following award of the initial Certification Products Contracts and after the award of the follow-on CCtCap contracts. The CCtCap procurement blackout and protest period caused the agency to restrict data and product releases to all parties for an extended period of time of almost



one year. Protecting the procurement process helps ensure the best selection for the nation was made.

After the GAO protest was completed and the public decision was released in January 2015, NASA took immediate steps to inform its key stakeholders, Congress, the Aerospace Safety Advisory Panel (ASAP), and the public about Commercial Crew contract details.

- The CCtCap Source Selection Statement was posted on NASA's website.
- NASA provided detailed briefings to our Congressional oversight committees on the status and plans of the CCP, including in-depth descriptions of the CCtCap contracts.
- NASA provided two in-depth briefings to the ASAP. One on the status of the industry partners designs and technical risks and another on the overall progress of our industry partners and the CCP as a whole.
- NASA conducted a press conference regarding the CCtCap contracts, which included representatives from both industry partners.
- NASA has posted a public version of the CCtCap contracts on the NASA website.

Now that the constraints of the procurement process have been lifted, NASA plans to continue its information transparency initiatives and we are confident that this will provide all our oversight groups with sufficient insight into the human spaceflight programs at the agency.

QUESTION 30c:

Were you surprised by the concerns expressed in the report or did you anticipate their criticisms?

ANSWER 30c:

NASA has reviewed all formal ASAP documentation for 2014, including: the 2013 ASAP Annual Report, the ASAP 1<sup>st</sup> Quarter 2014 NASA Meeting Minutes, the ASAP 2<sup>nd</sup> Quarter 2014 NASA Meeting Minutes, the ASAP 3<sup>rd</sup> Quarter 2014 NASA Meeting Minutes, and the ASAP 4<sup>th</sup> Quarter 2014 NASA Meeting Minutes. There is no mention of lack of transparency or communication between CCP and ASAP in any of this documentation. In addition, the ASAP has made several recommendations to NASA regarding CCP over the years and no recommendation had to do with a lack of transparency or communication.

NASA has taken steps to address the concerns expressed by the ASAP (see ANSWER above) and the Agency is hopeful that its efforts will mitigate the ASAP's concerns.

QUESTION 30d:

What statute or legal precedent prohibits NASA from sharing information with ASAP staff (who are special government employees) or Congress?

ANSWER 30d:

There is an established legal and regulatory framework that controls access to information during the acquisition process. The purpose of such restrictions and conditions concerning the handling and dissemination of information is to preserve the integrity of the acquisition process. Under the Procurement Integrity Act, as stated in the Federal Acquisition Regulation (FAR), source selection and proposal information may not be disclosed to any person, even within an Agency, other than as authorized by implementing Agency regulations or procedures. In order to preserve the integrity of any acquisition, NASA procurement regulations and practices strictly limit disclosure of such information only to personnel involved with the procurement. Although the Procurement Integrity Act does not prohibit disclosure of source selection or proposal information to Congress, there sometimes are other legal or regulatory reasons that necessitate that NASA decline requests for procurement information at certain points in the acquisition cycle. For example, source selection information is not disclosed prior to the final selection decision. The selection decision might not be final if the source selection is challenged. Moreover, Court or GAO protective orders restrict disclosure of procurement information pending resolution of the litigation.

QUESTION 31:

Recent reports in the press have indicated that Russia intends to back away from the ISS program after 2020. We've heard a lot of rumors come out of Russia lately; many of them seem to be simply speculation rather than state-level decisions.

a. Can you explain the situation as you understand it?

ANSWER 31a:

Space cooperation has been a hallmark of US-Russia relations, including during the height of the Cold War, and most notably, over 14 years of continuous human presence on board the ISS. NASA has not received any official notification from the Government of Russia on any changes in our space cooperation at this time. Since the initial public declarations concerning Russia's participation on ISS, there have been multiple public indications that Russia will continue participating in the ISS program through 2024. Roscosmos has publicly commented that they expect to receive government authority later this summer to continue ISS beyond 2020.

QUESTION 31b:

How would Russia leaving the ISS partnership affect NASA's decision to extend ISS beyond 2020?

ANSWER 31b:

NASA is committed to continue ISS operations through at least 2024. If Russia should decide to discontinue its participation in the International Space Station (ISS) partnership, NASA and

Roscosmos would work that transition together to ensure that Station would continue to be operated safely and productively.

Currently, NASA is reliant on Roscosmos for crew transportation and rescue for the ISS. Beyond crew transportation and rescue, under the current ISS construct, NASA and Roscosmos are mutually reliant on one another for the life of the ISS. NASA will continue to need Russia-unique critical capabilities not currently available elsewhere, such as: propellant and propulsion, systems for desaturation of the rate gyros, reboost, phasing burns and debris avoidance maneuvers; redundant life support for U.S. systems; sustaining engineering for the Russian-built, U.S.-owned Functional Cargo Block (FGB); goods and services related to Russian Segment systems training for on-orbit ISS operations; supplies and sustaining engineering on the Russian-built toilet in the non-Russian segment; and potential de-orbit assistance. Roscosmos will continue to need NASA capabilities including: electrical power for Russian core systems and payloads; redundant life support for Russian systems; attitude control; communications downlink telemetry and commanding to augment limited Russian ground site coverage; and training for non-Russian Segment operations.

If the Russians decided to withdraw from the ISS after 2020, NASA would require lead-time and resources to develop those capabilities for which we are currently reliant on Roscosmos.

QUESTION 31c:

How would this impact the Commercial Crew program, since launch is currently scheduled for 2017? Would NASA continue developing a system to only operate for three years?

ANSWER 31c:

NASA is committed to continue ISS operations through at least 2024. If Russia were to discontinue participation in the ISS, NASA would work with Roscosmos and our other international partners to ensure a transition that allows for continued safe and productive operations on Station. With necessary lead-time and resources to develop capabilities for which we are currently reliant on Roscosmos, including crew transportation and rescue, NASA could continue ISS operations beyond 2020. The Commercial Crew program, therefore, will play a critical role in providing crew transportation and rescue capabilities for the Station prior to and beyond the 2020 timeframe, and would be even more critical if Russia were to discontinue participation in the ISS.

QUESTION 32:

The Administration has proposed extending the life of the International Space Station to 2024. While Congress has yet to approve this extension, to what extent was the decision to extend the ISS affected by the late launch readiness estimates of the Commercial Crew contractors?

## ANSWER 32:

The decision to extend the ISS was not based on the readiness of commercial providers. The ISS is a unique facility that offers enormous scientific and societal benefits, only one of which is encouraging commercial development in low-Earth orbit (LEO). The Administration's proposal to extend its life until at least 2024 will allow the maximization of its potential, deliver critical benefits to our Nation and the world, and maintain American leadership in space including the following.

- Extension will allow NASA to complete necessary research activities aboard the ISS in support of planned long-duration human missions beyond low-Earth orbit.
- Extending ISS until 2024 will give us the necessary time to bring technologies and spacecraft systems necessary for humans to safely and productively operate in deep space to maturity.
- ISS extension will extend the broader flow of societal benefits from research on the Station.
- ISS extension will give NASA and its private-sector partners time to more fully transition to a commercial space industry including the transportation of cargo and crew to other low-Earth-orbit commercial platforms.
- Ensuring the stability and availability of the ISS through 2024 will instill confidence in the science community that the ISS platform will be available for important, long-term research endeavors.

Extending the ISS will also help cement continuing U.S. leadership in human spaceflight going forward. Station is a clear demonstration of the benefits to humankind that can be achieved through peaceful global cooperation. It is important to keep this partnership intact, with America as its leader. Leadership in space brings with it economic growth, technological prowess, and national pride, and contributes to American global leadership more broadly.

## QUESTION 32a:

Would the Administration consider proposing an extension beyond 2024 if the Commercial Crew contractors were delayed beyond 2017?

## ANSWER 32a:

Please see ANSWER to Question #32, above. If the Administration proposes extension of ISS beyond 2024, it would likely be based on consideration of a variety of factors.

QUESTION 32b:

How is the decision to re-compete the Commercial Crew contracts affected by the life of the station?

ANSWER 32b:

If all twelve post certification missions are flown, the CCtCap contracts can support the ISS crew transportation needs into 2023. If the ISS lifetime is beyond this date, a follow-on contract of ISS crew transportation services is expected to be required.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Mr. William Gerstenmaier, Associate Administrator, Human Exploration and Operations, National Aeronautics and Space Administration

Questions submitted by Rep. Brian Babin

**QUESTION 1:**

Under the CCtCap contract, both Commercial Crew providers will bring their spacecraft online for manned flights by 2017. Although the companies are each expected to achieve the same level of technological maturity and conduct the same number of test flights, SpaceX’s \$2.6B award is significantly less than Boeing’s \$4.2B award. Would each of you - NASA Space X and Boeing - address why you believe there is such a significant disparity in the contracts?

**ANSWER 1:**

NASA provided a single set of requirements for the crew transportation system development, certification, and services. Because Boeing and SpaceX are using very different hardware and are using different development, operational, and management approaches, they have different prices for their respective integrated crew transportation solutions. For example, SpaceX is using the Falcon 9 rocket booster and Boeing is using the Atlas 5. Almost all of the other major subsystems are different between the two company’s solutions. In addition, the maximum contract values include six (6) Post Certification Missions (PCMs). SpaceX and Boeing will charge different rates for these missions and differences in price between the PCMs get magnified when calculating the maximum contract value.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Mr. William Gerstenmaier, Associate Administrator, Human Exploration and Operations, National Aeronautics and Space Administration

Questions submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology

**QUESTION 1:**

You state in your prepared statement that the overarching objective of the CCtCap contracts is to ensure that NASA's human safety and certification requirements are met. You go on to say that the insight clause will enable NASA to fully evaluate the company's designs to determine whether NASA's safety requirements are satisfactorily met and that defined milestones in the contracts enable NASA to incrementally assess the safety and performance of the systems through the certification process.

- a. What specific activities do you plan to undertake, and what data will you require the companies to provide?

**ANSWER 1a:**

Certification of a spaceflight system to transport NASA personnel to/from the International Space Station (ISS) consists of the following four separate functions: 1) validation of the technical and performance requirements/standards; 2) verification of compliance with those requirements/standards; 3) consideration of relevant operational experience; and 4) acceptance of residual technical risk due to hazards, waivers, non-compliances, etc.

NASA will collectively evaluate crew transportation system design changes, manufacturing (or refurbishment) process changes, and testing changes to verify the mission falls within the bounds of the system certification and that anomalies from previous missions have been addressed. NASA will decide, based on the flight readiness certification and residual risk posture, whether to authorize NASA crew to fly on the crew transportation system. During the operations/services phase, NASA will monitor the safety performance by evaluating the risk based on the significance of observed anomalies, and by updating its independent assessments of safety performance to ensure safety requirements continue to be met and there is an established process for continuous improvement towards achievement of the safety goal.

The NASA Program Manager will develop a Certification Package as described in the Commercial Crew Program (CCP) requirements documentation. The form of the Certification Package is a compilation of pertinent plans and documents, plus presentation material, to help guide reviewers through the package. The package collectively illustrates, with supporting evidence, that the system has met the technical requirements and is safe to carry NASA crewmembers.

QUESTION 1b:

How do you plan to engage the ASAP in your ongoing safety assessment, and have you discussed this plan with the ASAP?

ANSWER 1b:

At a minimum, CCP will brief the ASAP on a quarterly basis on the status, plans, progress, and issues associated with the Program. In addition, for unique issues of high relevance to the ASAP, CCP will engage with the ASAP as was done in January 2015 after the CCtCap protest had been resolved whereby the Program briefed the ASAP on the status of the partner's designs and technical risks.

QUESTION 1c:

How do you plan to factor in ASAP's analyses in your incremental assessments?

ANSWER 1c:

NASA will respond to any and all ASAP analyses of CCP plans and assessments.

QUESTION 2:

What recourse does the government have if contractors cannot complete the CCtCap milestones under the budget established in the firm-fixed price contract, or if contractors seek to eliminate requirements in order to meet the firm-fixed price they agreed to in the contract?

ANSWER 2:

The Government may terminate the contract for default if a contractor fails to perform in accordance with the terms of the contract. Our policy is to identify performance issues early, and take proactive steps to ensure that the contractor is successful in accomplishing the contract. NASA has carefully evaluated the prices the companies proposed to ensure that it is possible to execute the contract at those prices. Additionally, the use of interim financing milestones will provide early warning if a company is having difficulty meeting the requirements. At that time, NASA could either work with the company, providing our technical expertise to assist in overcoming technical obstacles, or cease financial payments.

Under a fixed price contract, the requirements and the prices are tightly bound to one another. The elimination or reduction of a contract requirement is a change to the contract and would therefore be subject to negotiation of a downward adjustment in contract price, or some other equitable consideration from the contractor.

QUESTION 3:

Based on NASA's assessment of the contractors' proposals, is the 2017 date the "most likely" date for initiation of commercial crew services to the ISS, or is it a "best case"? What is the "most likely" date, based on NASA's analyses?



ANSWER 3:

NASA has reviewed the partners' proposed schedules and concurs with them. The partners' schedules both show certification dates for their systems in the latter part of 2017.

QUESTION 4:

NASA is planning to extend the Soyuz service contract through 2018. Are there other reasons for extending the Soyuz contract even if U.S. commercial crew systems become available? If so, what are they?

ANSWER 4:

NASA does not plan to purchase additional Soyuz seats after U.S. commercial crew services are operational. However, the Agency may utilize these procured seats as a backup transportation option to augment future ISS operations and research, which may result in adjustments to the period of performance. There may be a period of time during which crew transportation and rescue services provided by Russian and U.S. vehicles may overlap while U.S. providers demonstrate their capability both in terms of safety of flight and production requirements/timelines, and to ensure no gap in services.

QUESTION 4a:

Should one or both of the commercial providers need to stand down on launches for a period of time, as currently being experienced with Orbital ATK's Antares, how could the Soyuz be a viable backup in light of the stated three year lead time to procure additional Soyuz services?

ANSWER 4a:

Please see response above to Question #4. Having more than one domestic capability will provide the advantages of keeping costs low through competition and ensuring that if one vendor's vehicle is grounded due to an anomaly, NASA would still retain a domestic option for the transport of its astronauts to the ISS.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

**“The Commercial Crew Program: Challenges and Opportunities”**

Questions for the record, Mr. William Gerstenmaier, Associate Administrator, Human Exploration and Operations, National Aeronautics and Space Administration

Questions submitted by Rep. Donna Edwards, Ranking Member, Subcommittee on Space

**QUESTION 1:**

Your prepared statement indicates that once each contractor’s test program has been completed successfully and its system achieves NASA certification, each contractor will conduct at least two, and as many as six, crewed missions to the ISS. You go on to say that if all 12 post certification missions are flown, the CCtCap contracts can support the ISS crew transportation needs into 2023. That nearly brings us to the proposed end of the ISS operational lifetime in 2024.

- a. Do you foresee competing a separate commercial crew services contract, as you had planned and announced? If not, what would be the reason for not doing so?

**ANSWER 1a:**

NASA continues to plan for a follow-on ISS crew transportation services contract. The likelihood of this depends on several factors: the success of the current two partners, the maturity of the crew transportation market, and the lifetime of the ISS.

**QUESTION 1b:**

If you were to use CCtCap contract options for fulfilling ISS transportation service requirements until 2023, would there be any “on ramp” opportunities for non-CCtCap companies to demonstrate that they can safely and cost-effectively meet NASA’s requirements? If so, when, and what specific opportunities do you envision?

**ANSWER 1b:**

The CCtCap contracts contain a clause entitled “H.16, New Entrant.” This clause anticipates that other companies could develop a capability that meets NASA safety requirements. Because the exact circumstances are difficult to predict, the process that NASA would use to add a new entrant would be determined at the time we decided to seek new entrants.

**QUESTION 2:**

What specific steps is NASA taking to ensure that ASAP’s ability to advise the Congress on the safety of NASA systems, including commercial crew transportation systems, is never again limited as a result of NASA’s refusal to provide necessary information?

## ANSWER 2:

To protect the integrity of the procurement process, the Agency needed to control the data it released following award of the initial Certification Products Contracts and after the award of the follow-on CCtCap contracts. The CCtCap procurement blackout and protest period caused the Agency to restrict data and product releases to all parties for an extended period of time of almost one year. Protecting the procurement process helps ensure the best selection for the nation was made.

After the GAO protest process was completed and the public decision was released in January 2015, NASA took immediate steps to inform its key stakeholders, Congress, the Aerospace Safety Advisory Panel (ASAP), and the public about Commercial Crew contract details.

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- NASA conducted a press conference regarding the CCtCap contracts, which included representatives from both industry partners.
- NASA has posted a public version of the CCtCap contracts on the NASA website.

Now that the constraints of the procurement process and litigation have been lifted, NASA plans to continue its information transparency initiatives and we are confident that this will provide all our oversight groups with sufficient insight into the human spaceflight programs at the Agency.

## QUESTION 3:

How does NASA plan to deal with an accident involving a commercial crew transportation system carrying NASA astronauts? How has NASA defined the roles and responsibilities among the FAA, NASA, the U.S. Air Force, the National Transportation Safety Board (NTSB), and the commercial contractor? What entity would be accountable for issuing recommended actions and which individual would be accountable for ensuring recommended actions have been addressed? What data is NASA requiring the contractors to maintain to aid in the investigation of any accident?

## ANSWER 3:

NASA, FAA, the DoD and NTSB are jointly developing an integrated plan to manage accident investigations of commercial crew transportation systems. This investigation planning effort includes all mission phases including launch, orbital operations, ISS proximity operations, entry, and landing. As the licensing authority, the FAA has responsibility for the launch, entry, and landing phases, with the NTSB taking the lead in its accident investigations. NASA will lead accident investigations for all other mission phases. NASA, FAA, NTSB and the Air Force have

established a working group that is meeting monthly to ensure that roles and responsibilities are completely understood under all scenarios relating to potential accidents.

The organizations recognize the statutory responsibilities and limitations that Congress has set forth and are taking into account as plans are developed.

Recommended actions stemming from accident investigations will be issued as follows:

1. Per Title 51 USC 50905, FAA may suspend the operator's commercial license and issue regulations that restrict or prohibit design features that are found to have resulted in the accident.
2. NASA may modify our CCtCap contracts to include any recommended actions stemming from the accident investigation, and conduct nominal re-verification of impacted subsystems prior to resuming NASA crew flights.

Per contract requirements, NASA's commercial crew contractors are responsible for conducting a mishap investigation, including allowing NASA participation and making all data and reports available to NASA. The contractor also is obligated to provide personnel support and data to support an independent NASA investigation. These are outlined in CCtCap contract clause H.26, Mishap Reporting.

#### QUESTION 4:

What are NASA's policies on including a non-government "passenger" on a NASA crew rotation mission to the ISS? What would be NASA's involvement in evaluating the risks to the ISS, providing training related to a stay on the ISS, providing food, water and other supplies?

#### ANSWER 4:

NASA has not fully developed all its policies concerning non-NASA passengers on a commercial crew flight. We have laid out procedures and some requirements in the CCtCap contracts under clause H.23, Non-NASA Passengers, Cargo and Payloads. In general terms, NASA will only authorize a passenger if the passenger can be accommodated consistent with our obligations to ISS International Partners, all applicable laws, regulations or requirements, and without interference to NASA's mission or cost to NASA. There are other rights that NASA has reserved in the clause, such as a unilateral right to revoke our decision, the need for insurance, and the need to meet NASA medical requirements, among others.

- a. Will the costs of these and any other NASA services required to accommodate a "passenger" on the ISS be reimbursed to NASA? If not, why not?

#### ANSWER 4a:

We anticipate that NASA and the partner will negotiate an overall agreement on the conduct of a post certification mission. This includes price and schedule of the basic mission as well as the inclusion of any non-NASA passengers and cargo. The contract clause specifies that flying non-NASA passengers must be at no cost to NASA.

QUESTION 4b:

Who will pay for the transport of the “passenger” to the ISS?

ANSWER 4b:

See the above full discussion of how the impacts of a non-NASA passenger would be resolved.

QUESTION 4c:

What is the availability of crew rescue services for a non-government “passenger” staying on the ISS?

ANSWER 4c:

No special crew rescue services would be acquired for non-NASA passengers. The existing emergency plans can easily accommodate the inclusion of an additional person.

QUESTION 4d:

What would happen if the non-government “passenger” required emergency departure from the ISS? Would other crew members need to cut short their mission?

ANSWER 4d:

The detailed mission rules on how to respond to various emergencies that could occur during a mission have not been developed yet.

QUESTION 5:

Can the CST-100 and/or Dragon 2 be used to boost the ISS as is being done with the Soyuz? If not, what options does NASA have for reboosting the Station once NASA discontinues its Soyuz contract with Roscosmos, or should Russia discontinue its partnership with the ISS as has been discussed for post-2024?

ANSWER 5:

The ISS is re-boosted by the Russian Segment Service Module and Progress vehicles, not the Soyuz. At the March 2015 Soyuz launch that began the one-year mission of astronaut Scott Kelly and cosmonaut Mikhail Kornienko, the new head of Roscosmos affirmed the agency’s commitment to the ISS partnership and positive inclination toward operation of the ISS through 2024. Though unlikely, if Russia should decide to discontinue its participation in the ISS partnership after that point, NASA and Roscosmos would work that transition together to ensure that Station would continue to be operated safely and productively.

## QUESTION 6:

Have you given a formal Authority to Proceed (ATP) to Boeing for a Post-Certification Mission? If so, what was the date of the ATP? If not, when will that ATP occur? Based on that ATP date, what date is Boeing projecting that the spacecraft and launch vehicle will be ready for its first PCM?

## ANSWER 6:

NASA provided Authority to Proceed to Boeing for their first Post Certification Mission on May 22, 2015. The Boeing contract provides substantial flexibility on dates so far in advance of launch. The final launch date for the PCM task order could vary over time, but is tentatively set for December 2017.

## QUESTION 7:

Have you given a formal Authority to Proceed (ATP) to SpaceX for a Post-Certification Mission? If so, what was the date of the ATP? If not, when will ATP occur? Based on that ATP date, what date is SpaceX projecting that the spacecraft and launch vehicle will be ready for its first PCM?

## ANSWER 7:

No Authority to Proceed has been given to SpaceX for a Post Certification Mission at this time. We anticipate that ATP for their first PCM could be given to SpaceX by the end of the year. The SpaceX contract states that they need at least 24 months to produce a PCM. The final negotiated date for the PCM task order could vary from this, based on the SpaceX proposal and subsequent negotiation with NASA.

## QUESTION 8:

Your contracts with commercial providers specify that they shall meet an overall Loss of Crew (LOC) probability distribution of no greater than 1 in 270 for an ISS mission and a combined LOC probability distribution for the ascent and entry phases of a mean value no greater than 1 in 500. Your contracts also require that the Loss of Mission (LOM) probability distribution for an ISS mission have a mean value no greater than 1 in 55. What was the basis of the LOC/LOM requirements, and how will you determine contractor compliance?

## ANSWER 8:

The current CCP LOC requirement was derived based on Constellation program requirements. The Constellation program LOC requirement was roughly based on targeted improvements from Shuttle.

NASA will verify that these requirements are being met through a Probabilistic Safety Analysis (PSA). The PSA methodology shall be defined utilizing the methodology described in the CCtCap requirements documentation (i.e., CCT-PLN-1120) as a guide.

QUESTION 8a:

With an LOM of 1 in 55, what impact would a loss of mission have on the ability to maintain a full crew complement on the ISS?

ANSWER 8a:

Having more than one domestic capability will help ensure that if one vendor's vehicle is grounded due to an anomaly, NASA would still retain a domestic option for the transport of its astronauts to the ISS.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Mr. William Gerstenmaier, Associate Administrator, Human  
Exploration and Operations, National Aeronautics and Space Administration

Questions submitted by Rep. Ami Bera

Regarding the current ISS Commercial Resupply Services (CRS) contracts with SpaceX and Orbital ATK:

QUESTION 1:

How much funding has been provided to each contractor and what is their respective total contract value?

ANSWER 1:

The Not-To-Exceed value for each contract is \$3.1B and the status (as of March 27, 2015) is provided below:

	Paid Thru 2/28/2015	Current Contract Value	Percent Paid of Contract Value
Orbital ATK	\$ 1,372,356,619	\$ 2,190,696,530	63 percent
SpaceX	\$ 1,286,944,243	\$ 2,171,996,302	59 percent
Total	\$ 2,659,300,861	\$ 4,362,692,832	

QUESTION 2:

So what percentage of total contract value does this funding represent for each?

ANSWER 2:

See ANSWER # 1 above.

QUESTION 3:

How many metric tons of cargo have been delivered to ISS by SpaceX and Orbital– ATK respectively, and what percentage of their respective 20 metric ton requirement has been fulfilled?



ANSWER 3:

Under the Commercial Resupply Services (CRS) contracts, SpaceX has delivered approximately 10.7 metric tons to ISS, while Orbital has delivered approximately 3.8 metric tons. NASA estimates that SpaceX has flown at least 44 percent of its total contracted CRS upmass and Orbital has flown 21 percent of its total contracted upmass.

QUESTION 4:

Why have you provided such high amounts of advance payments to each contractor for unfulfilled cargo delivery, and will such practices be carried over to the commercial crew program?

ANSWER 4:

As outlined in the commercial resupply services contract, NASA pays for cargo mission preparation milestones as milestones are completed. Milestone payments paying portions of the contracted price is an appropriate practice because launch vehicles are not a high-rate production type of activity and much work is done over many months and years to prepare for a single launch event. Launch is much more than just the effort seen on launch day; the performance criteria for a launch milestone includes various preparation activities and concludes with intentional ignition and liftoff of the launch vehicle. If a mission is not completed, NASA withholds the mission completion milestone, as outlined in the contract. This final milestone payment represents some of the contractor's remaining costs and a large portion of any profit; thus the contractor is incentivized to provide a successful launch service.

In the Commercial Crew Transportation Capability (CCtCap) contracts, NASA structured mission payments to incorporate lessons learned during performance of the Commercial Resupply Contracts. For an individual mission, interim payments up to 90 percent of the price of the mission can be made prior to the final payment that occurs after the completion of the mission. However, all interim payments are financing payments. These are subject to complete repayment in the event of a termination for default. Should an unsuccessful mission occur (but not a default termination), under clause H.21, Post Certification Mission Success Determination, the contractor is not paid the final 10 percent of the mission price and must return an additional 15 percent of the mission price previously paid..

QUESTION 5:

The hearing charter notes the following with respect to the 2008 Authorization Act, which authorized the Commercial Crew Program:

*The 2008 Act also included a provision that provided congressional intent to NASA which prohibited the Administration from funding the Commercial Crew program at the expense of exploration programs.*

Do you believe that NASA's, hence the Nation's, deep space exploration program and funding for that program has been negatively impacted by the efforts and funding that NASA has put forth to bring the Commercial Crew Program on line?

ANSWER 5:

Since FY2010, deep space exploration programs have been funded at levels above the Administration's request and the Commercial Crew Program has been funded at levels below the Administration's request.

*Responses by Vice Admiral Joseph Dyer*

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Vice Admiral Joseph Dyer, Chairman, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

1. Has NASA provided sufficient information to the ASAP about the processes in place should an accident or mishap occur in the Commercial Crew Program?
  - a. Have you been able to analyze these plans and come to any conclusions as to their efficacy?
  - b. If you have, what judgment has the ASAP made about them?

**Response:** To date, NASA has not provided detailed information about the processes for an accident or mishap occurring during the Commercial Crew Program (CCP). However, this is an important area of interest for the ASAP, and we look forward to discussing it with NASA as plans are developed. One potential area of concern relates to the requirement in the NASA Authorization Act of 2005 for a Presidential Commission to investigate accidents involving human space flights being conducted under a government contract. Should that requirement result in an extended hiatus of human space flights (such as what occurred after the Challenger and Columbia accidents), that would clearly have a significant negative impact on continuing operations of the International Space Station (ISS).

2. Are there any differences in transparency and documentation between the contractors either financially or technically?
  - a. What access does each company provide NASA to key meetings?

**Response:** As noted in the ASAP 2014 Annual Report, the Panel’s insight into the communication and working relationship between NASA and Boeing and NASA and SpaceX has been veiled by NASA’s CCP. To say it very plainly, the Panel has had very little insight into the interface, including verification, validation, waivers, and certifications on the CCP. Relying on the commitment of the NASA Administrator, the Panel believes better understanding will be forthcoming during the second half of the year.

- b. Comparatively, how does this affect NASA’s confidence in safety, performance, program management, and reliability between the two contractors?

**Response:** The CCP reports good confidence with regard to safety, performance, program management, and reliability with the two contractors. The Panel is seeking, and has been promised, the access and insight to verify this confidence.

3. What insight does NASA have to ensure that the variances and alternate standards granted during the CPC contract meet the original standards required by NASA?

**Response:** It is our understanding that for each alternate standard and variance proposed, the contractor's method of compliance was reviewed by the cognizant technical authority and evaluated. Not all proposed alternatives were approved; some have required adjustments on the part of the contractor, and some are still being negotiated. To date, we have not yet been able to fully review the certification plan and all of the provided deviations and waivers. NASA has promised to provide this information in the near future.

- a. What quality control mechanisms are in place to provide sufficient data to the government to satisfy the original standards required by NASA?

**Response:** The ASAP's understanding is that NASA has not completed analysis of the proposed variances and alternate standards, and has, in some cases, needed additional information to do so. As stated above, the review mechanism requires that the use of any alternative standard, process for validation, or change/variance to specification numbers be approved by NASA. In these cases, the proposed variance would be evaluated by appropriate technical experts within the Agency who would render a decision on the acceptability of that alternative standard, level, or specification requirement. This would be formally documented by the approval of a deviation or waiver that becomes part of the permanent project record. Generally speaking, such one-to-one review system for each individual change would be adequate if the total number and the extent of those changes were small. However, the numbers of requested changes quoted for the Certification Products Contract (CPC) are not small; hence, the ASAP remains concerned with the integrated effect of all of those changes taken together in a single design. This issue forms part of our requested discussions with the Program at future meetings.

4. Please share the ASAP's view on the use of the CPC for exchange of technical data and alternate standards or variances to standards. Was this process sufficient to allow NASA adequate insight that would be similar to traditional development programs?

**Response:** In most developmental programs, the fundamental design document is the specification, typically approved (if not generated) by the Government and provided to the contractor. This lists the primary requirements of the system. It is then is "expanded" down into all of the lower level requirements that would govern the performance of subsystems and components. This aggregated data base would show the dependence or independence of each performance requirement and from where it was derived, leading up to the top level total system requirements. This requirements data base is typically tracked and managed via commercial software data base tools. If the contractor requests either a variance in the level of any specified performance or a waiver of some feature or test, the change can be easily traced to any subsequent negative impacts in other areas. In complex systems, this tracking is invaluable, because the various subsystems almost always affect each other in their performance.

While the individual variances (deviations or waivers) were submitted to NASA and technically reviewed, the ASAP does not have any insight into whether or not the impact of any granted change on other systems was evaluated. We have been told that a considerable number of changes and alternate standards were requested. While we have been assured that each one of these was assessed, the question regarding any integrated effect of those changes remains to be seen, at least by the ASAP. We are pursuing this issue as part of our current effort to gain insight into the CPC. The Agency has arranged for presentations on this and other aspects of certification at our May and possibly future meetings.

Without more detailed information on the extent, detail, completeness, and subsequent evaluation of the submittals, we cannot say definitively if this process was sufficient. However, we hope to be able to form a position on that in the near future.

5. NASA has had Loss of Crew and Loss of Mission (LOC/LOM) probability requirements for its crew vehicles in the past. These were based on Probabilistic Risk Analysis (PRA). After the Space Shuttle Columbia accident, these were put in place and intended to make sure the vehicle(s) that replaced the Shuttle were safer. Are you satisfied that these requirements are in place?

**Response:** Yes, LOC/LOM requirements are in place. NASA originally placed a requirement on the commercial crew providers to meet the same LOC probability as the Exploration Systems Development system. This probability was 1 in 270, or about 0.4 percent chance per mission of LOC, based solely on analytical projections. This number was chosen by NASA for all of its crewed missions to be approximately three times better than actual flight experience with the Space Shuttle. This was an attempt to ensure that the systems are at least "as safe as the Space Shuttle" even after hazards not predicted by prior analyses are factored in. However, it must be noted that recently NASA has relaxed the LOC requirement for the vehicle design for Commercial Crew ISS missions to 1 in 200 because of difficulties the commercial providers were having meeting the on-orbit portion of the mission LOC risk. At a future date, NASA will evaluate whether they can regain some of the lost safety through on-orbit, extravehicular activity (EVA) vehicle inspections or other operational controls.

- a. What is your understanding of the relative safety in these terms between the two commercial crew vehicles?

**Response:** The Panel cannot comment at this time about the relative safety of the two providers because we are just beginning to gain insight into their designs.

- b. How does safety certification of the commercial crew vehicles compare to what was done on the Space Shuttle?

**Response:** The Panel has not yet reviewed the certification plans of the two providers; therefore, we cannot compare them to processes used on the Space Shuttle.

6. The working relationship between the FAA and NASA on licensing the launch and re-entry of Commercial Crew flights is a new one. What insight does the ASAP have into this relationship and the agreements that have been signed by the parties involved? Do you believe the rights and responsibilities of each has been sufficiently explained and delineated?

**Response:** There are two key agreements between NASA and the FAA related to commercial crew flights. A Memorandum of Understanding on the achievement of mutual goals in human space transportation was signed June 4, 2012. It established the intent for all operational ISS crew launches to be licensed for public safety by the FAA. The Joint Program Management Plan for the Commercial Crew Program, signed on April 23, 2014, describes the roles and responsibilities of the two organizations for these missions. Although there is still much work to be done, both NASA and the FAA seem pleased by the status of their partnership. At this point, the ASAP is comfortable that the rights and responsibilities of each agency have been explained and delineated; however, we will continue to monitor their progress in resolving the remaining issues.

7. The ASAP has voiced concerns relative to the less-than-candid and transparent communication regarding the commercial crew program. Please explain if this lack of transparency is an indication of NASA's lack of insight into the contractor designs, or a lack of transparency between NASA and the ASAP?

**Response:** The lack of transparency stemmed from less than candid and open communication from NASA's Director of Commercial Spaceflight Development, whose actions have obscured the Panel's understanding of NASA's insight into the execution of the CCP.

8. Your recent report is critical of NASA's transparency regarding the Commercial Crew Program. Did these issues extend to the contractors?

**Response:** The ASAP cannot answer this question with confidence at this time. As more information is made available to the ASAP by the CCP, we expect to be able to assess these items.

- a. How does this affect your relative confidence in each of their vehicle certification approaches?

**Response:** At the present time, the ASAP is not able to answer this question, because we have not been given sufficient information to form a well-informed opinion. We are encouraged that recent interactions with NASA with respect to the

CCP suggest that we may be able to furnish such an evaluation in the upcoming months.

- b. How does this affect your relative confidence in the safety of the vehicles in transporting astronauts?

**Response:** Due to the reasons given in 8(a) above, the ASAP's relative confidence is unchanged from what was indicated in our Annual report and our testimony in February.

- c. What is your relative confidence in their predicted launch manifests?

**Response:** As documented in the 2014 ASAP Annual Report, the projected flight schedule has not accurately predicted the flight rate as actually flown. This is not a new phenomenon and was also typical of the Space Shuttle Program and other similar programs. We would not be surprised if the launch schedule as currently stated experiences slips, which has been the case in the past.

- d. Please compare and contrast their management and organizational approaches and discipline.

**Response:** It is clear to the ASAP that the various organizations are different in their approaches. These differences underscore the need for NASA to be thoughtful and clear to all parties regarding the requirements that must be satisfied and how this determination will be made. Due to the dearth of information furnished to us by NASA, we cannot offer further comment on the topic at this time but hope to be able to do so in the future. As noted in our 2014 Annual Report, the inherent dissimilar redundancy of these two systems means that a technical issue with one system will not preclude continued U.S. access to the ISS.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Vice Admiral Joseph Dyer, Chairman, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration

Questions submitted by Rep. Mo Brooks

1. In its Annual Report for 2014, the Aerospace Safety Advisory Panel, which you chaired, states the following:

“The Panel was pleased to note an innovative and successful approach to managing the limited infrastructure maintenance budget at MSFC. An individual with a strong program management background has been placed in charge of facilities management and is applying classical program management techniques to optimizing the use of available resources. Through such techniques as ‘repair by replacement’ and prioritizing facilities maintenance in line with mission priorities, MSFC is actually reducing its deferred maintenance backlog. While NASA as a whole clearly has a serious budgetary facility-maintenance shortfall, including significant environmental cleanup needs, the techniques being used at MSFC to optimize limited resources are applauded, are exemplary, and should be expanded throughout the Agency.”[1]

In what specific ways could NASA expand MSFC’s “exemplary” program management techniques throughout the agency?

**Response:** There are a number of steps NASA could take. Documenting the processes, techniques, and lessons learned at Marshall Space Flight Center (MSFC) and promulgating them to other NASA centers is one way to expand the MSFC experience. Using NASA’s emerging Chief Information Office (CIO)/knowledge management initiative could greatly facilitate this expansion. While processes, lessons learned, and training can impact the success of an approach like MSFC’s, the greatest impact on how a program is being run is the people leading it. Selecting the right people, such as those with strong program management expertise, would be an important step. Having a strong resource of qualified individuals groomed through deliberate mentorship and succession programs could help produce the high-caliber managers and leaders we commented on at MFSC.

An alternative might be to broaden the responsibility of the individual managing the MSFC facilities to include all NASA facilities.



**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Vice Admiral Joseph Dyer, Chairman, Aerospace Safety Advisory  
Panel, National Aeronautics and Space Administration

Questions submitted by Rep. Brian Babin

1. Under the CCtCap contract, both Commercial Crew providers will bring their spacecraft online for manned flights by 2017. Although the companies are each expected to achieve the same level of technological maturity and conduct the same number of test flights, SpaceX's \$2.6 billion award is significantly less than Boeing's \$4.2 billion award. Would each of you - NASA Space X and Boeing - address why you believe there is such a significant disparity in the contracts?

**Response:** The cost and associated contract awards to Boeing and SpaceX reflect the different histories, processes, cultures, and financial responsibilities of the two companies.

Boeing has a hundred years of aviation experience. The processes Boeing has developed over these many years are thorough but complex; further, they are proven capable but expensive. Additionally, Boeing is a publically traded company with fiduciary responsibilities to their shareholders. Boeing's challenge is to reduce cost and increase design and testing speed.

SpaceX is a young, innovative, and aggressive company that is bringing new ways of doing business into NASA. It is a privately held company and operates without the regulatory and fiduciary responsibilities of a public company. SpaceX challenges are to stabilize design, manage configuration, and confidently estimate costs. It must demonstrate that speed and cost reduction can coexist with safety.

The two companies' different financial responsibilities are reflected in the fixed-price contracts' risk mitigations. Another element driving cost differential is the cost of launch vehicles (Atlas 5 and Falcon 9) for two test flights (one with crew) and six ISS missions.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Vice Admiral Joseph Dyer, Chairman, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration

Questions submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology

- In your view, has NASA made safety or cost the most important criterion in developing the commercial crew vehicles?

**Response:** It is the view of the ASAP that NASA leadership is making safety an important criterion, but is balancing safety risk with cost in the development of commercial crew vehicles.

- How effectively are NASA and the commercial providers establishing a safety culture that works across the government-industry partnership of the Commercial Crew Program and that also reflects the Columbia Accident Investigation’s findings and recommendations? What more needs to be done? Have you been given enough access to date to be able to answer with confidence?

**Response:** As stated in our Annual Report, the ASAP has not been given adequate information to be able to confidently form an opinion as to the safety of the Commercial Crew Program (CCP) from a technical perspective. There are indications that NASA is moving to rectify this situation, and we should be in a better position to comment later this year.

Similarly, with specific regard to the establishment of a culture of safety across the government-industry partnership, the ASAP has not been given information upon which to form an opinion. Unlike technically related issues, it is not clear that NASA even intends to collect information related to answering the question of culture of safety across the government-industry continuum. This is a socio-technical issue and not explicitly within the scope of the CCP endeavor.

- What specifically does NASA need to do to ensure that the constraints on ASAP’s access to information are eliminated?

**Response:** NASA needs to follow through on its pledge of unfettered access to information. Initial indications are positive, but this process is only just beginning.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Vice Admiral Joseph Dyer, Chairman, Aerospace Safety Advisory Panel, National Aeronautics and Space Administration

Questions submitted by Rep. Donna Edwards, Ranking Member, Subcommittee on Space

- NASA’s “Integrated Crew Transportation System (CTS) Requirements document CCT-REQ-1130 Rev C” specifies the requirements for Loss of Crew (LOC) and Loss of Mission (LOM) probabilities that the CCtCap contractors are required to meet. Specifically, the document specifies that the crew transportation systems shall meet an overall LOC probability distribution for an ISS mission of a mean value no greater than 1 in 270. The LOC probability distribution for the combined ascent and entry phases must have a mean value no greater than 1 in 500. In addition, the LOM probability distribution for an ISS mission must have a mean value not greater than 1 in 55.

- Are you satisfied with NASA’s LOC/LOM requirements that are in place in the contracts for the Commercial Crew Program? Do you have the insight you need to verify that these requirements are being met? How do they compare with the recommendations of the Columbia Accident Investigation Board?

**Response:** Because of the increased safety of the modern technology now available and the inherent safety advantages of the available architectures, including the availability of abort systems, the ASAP encouraged NASA to set a more challenging Loss of Crew (LOC) requirement for all of its crewed missions. However, NASA’s assessment was that a higher level of safety was not achievable, primarily due to the threat posed on orbit by Micrometeoroid and Orbital Debris (MMOD).

- What are your perspectives on the commercial crew LOC/LOM requirements, in light of the retrospective analysis on Space Shuttle LOC risk discussed in the ASAP’s 2014 and 2013 Annual Reports?

**Response:** The retrospective analysis of the Space Shuttle risk estimates, as well the ASAP’s own experience with other *a priori* analyses of complex systems, both indicate that such analyses often significantly underestimate actual failure rates experienced in actual use. The reason for this is that many hazards that eventually manifest in fielded systems cannot be properly identified and accurately assessed during the design phase. These are sometimes referred to as “unknown unknowns.” If they could be identified, they would be designed out of the system. To accommodate this known underestimation of risk, prudent designers establish requirements for a higher level of safety than they are truly willing to accept.

- In your view, has NASA made safety or cost the most important criterion in developing the commercial crew vehicles?

**Response:** It is the ASAP's view that NASA leadership is making safety an important criterion, but is balancing safety risk with cost in the development of commercial crew vehicles.

- How do major changes in the design and operation of the commercial crew launch vehicle/crew capsule affect the vehicle's risk assessment? Are you satisfied that NASA has a process for recertification if such design changes take place?

**Response:** Major changes in the design and operation of a commercial crew launch vehicle/crew capsule would significantly affect the vehicle's risk assessment. Even minor changes in the design or operation of a complex system can have profound impact on the safety performance of that system. This is one reason why Management of Change, rigorous Configuration Control, and continual reassessments of the operational environment are critical parts of a robust safety program. The ASAP has not yet had an opportunity to evaluate how these program elements will be accomplished for the commercial crew systems. In addition, we do not have any information at this time on the process for recertification if such design changes take place and cannot comment on this.

- I have no doubt that Mr. Gerstenmaier will ensure that commercial crew systems are safe and meet NASA's certification requirements before allowing NASA astronauts to fly aboard those systems. That said, I am interested in your perspective as a safety expert and chair of the ASAP, on NASA's three-fold role as bill payer, safety certifier, and user of commercial crew services. Would you see any inadvertent conflict of interest in the Commercial Crew Program having all of these roles?

**Response:** A similar observation could be made for the FAA, which holds a dual role: (1) as regulator of the air industry and maintaining its safety standards, and (2) one of its charter roles to "...encourage aviation". NASA is properly using its role as the user of commercial services to encourage commercial industry to venture into the high risk area of space business. It is arguable if, left to conventional investment parameters, significant commercial investment would have taken place. By being able to offer the potential of contracting for services, NASA was able to incentivize key industrial partners to first invest in creating commercial cargo and now invest in commercial crew capability. However, if NASA maintains the part of certifier, it will need to transition into the role of a regulatory agency. NASA has never had this role in its history and could be expected to have some transition difficulties along the way. Given what we know at this point, NASA has seemed to uphold its support for both existing regulations and safety practices and has imposed those on the contractors providing the

systems. We have been assured these deviations/waivers have been undertaken with appropriate review and consideration of safety implications.

While the ASAP still lacks full information, the situation is progressing well and the Agency is arranging to bring the Panel up to speed. Assuming that considerations for safety are being applied consistently in all cases, we would expect that its role as both certifier and user of the final systems will provide acceptable answers.

- In its 2012 Annual Report, your Panel cautioned against the use of a firm-fixed contract for the development phase of the Commercial Crew Program. Specifically, your report said:

*The ASAP strongly believes that a cost type contract is appropriate for Phase 2. Fixed-price type contracts are appropriate for low-risk undertakings where the requirements are clearly understood by both the government and the contractor.*

NASA proceeded with a firm-fixed price procurement despite the high-risk nature of commercial crew development.

- How can Congress ensure that the pressure of performing on a firm-fixed price contract doesn't inadvertently lead to an erosion of safety during the development and certification phases? Similarly, how do we ensure that pressure to meet an arbitrary schedule doesn't lead to an erosion of safety?
- Although the initial financial risk is clearly on the contractors' shoulders, should Congress be concerned if either or both cannot deliver at the contracted for prices?
- What would be the implications of NASA or a commercial crew contractor seeking to reduce requirements in order to maintain a firm-fixed price environment?

**Response:** The caution the ASAP presented in its 2012 Annual Report was based on the ASAP members' extensive experience with development programs throughout their careers--in particular, the firm fixed price (FFP) contracting done on Department of Defense (DOD) programs of the 1980's, 1990's and 2000's. In addition, the Federal Acquisition Regulation (FAR) is clear that contract type determination should be based on an analysis of programmatic risk. Where the requirement, technology, or processes are not well defined, the FAR and lessons learned indicate a cost-plus contract is appropriate. To address the entire foregoing question and to provide true mitigations, NASA would be wise to review the lessons learned from other FFP development initiatives, particularly those of the DOD. Program examples do exist where FFP contracts were used successfully in a development phase. Key elements of success in these examples were: understanding the key/critical requirements, reducing risk by dividing the program schedule into shorter performance periods, and having experienced people on the government and contractor sides leading and managing the program. It remains to be seen if NASA's CCP has command of these elements and can deliver without significant scope expansion, contract changes and associated cost growth. At the same time, the CCP must ensure design compromises do not degrade safety. The ASAP will continue to encourage NASA to use lessons learned to mitigate the risks and the potential consequences of using FFP

contracts in its development programs. The ASAP believes NASA is heeding this encouragement but is eager to see more definitive mitigations.

- Has ASAP evaluated NASA's and the contractors' plans and policies for handling the risks of a potential "passenger" on a NASA-sponsored ISS crew rotation mission? If so, are the plans for risk mitigation adequate? If not, what is needed to address any potential risks?

**Response:** To date, the ASAP has had extremely limited insight to the plans and policies for handling Commercial Crew Program (CCP) risks on a NASA-sponsored ISS rotation mission. The information we had at the time of our 2014 Annual Report lacked the sufficiency and cohesiveness to form an objective opinion. We are just now beginning to receive additional information. The ASAP has not been apprised of plans for handling the risks of a potential "passenger" on a NASA-sponsored crew rotation mission.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

“The Commercial Crew Program: Challenges and Opportunities”

Questions for the record, Vice Admiral Joseph Dyer, Chairman, Aerospace Safety Advisory  
Panel, National Aeronautics and Space Administration

Questions submitted by Rep. Ami Bera

1. Do you believe that NASA’s Commercial Crew Program has adequate insight, oversight and transparency into the design, reliability, hazard analyses, and mission assurance aspects of SpaceX’s and Boeing’s respective programs? Do the respective providers differ in the amount of insight/oversight and transparency they provide?

**Response:** As noted in the ASAP 2014 Annual Report, the Panel is unable to offer any informed opinion regarding the adequacy of the certification process or the sufficiency of safety in the Commercial Crew Program (CCP) due to constraints on access to needed information.

2. If not, what should be done to ensure that we are not wasting tax-payers’ money on human launch systems that may not work or create tragic losses of human life?

**Response:** Until the ASAP gains more information on the CCP, the Panel cannot provide an informed and objective answer to this question at this time.

3. The hearing charter notes the following with respect to the 2008 Authorization Act , which authorized the Commercial Crew Program:

*The 2008 Act also included a provision that provided congressional intent to NASA which prohibited the Administration from funding the Commercial Crew program at the expense of exploration programs.*

Question: Do you believe that NASA’s, hence the Nation’s, deep space exploration program and funding for that program has been negatively impacted by the efforts and funding that NASA has put forth to bring the Commercial Crew Program on line?

**Response:** In the past several annual reports, the Panel has highlighted the mismatch between the breadth of the Agency’s undertakings and the funding available to execute them. The resources necessary to safely and efficiently accomplish the full scope of scientific discovery, aeronautics research, and further extending the Nation’s reach into the solar system are insufficient. This is especially true as NASA has started developing the equipment that will carry Americans to Mars concurrently with extending the life of the ISS. To answer your specific question, it is our opinion that the recent appropriations for both the CCP and for Exploration Systems Development

(ESD) have been less than optimum for maximum efficiency and effectiveness. From a workforce allocation perspective, the Panel does not believe the CCP has negatively impacted ESD.



*Responses by Mr. John Mulholland*

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

"The Commercial Crew Program: Challenges and Opportunities"

Questions for the record, Mr. John Mulholland, Vice President and Program Manager,  
Commercial Programs, The Boeing Company

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

1. How has NASA communicated with you about the processes in place should an accident or mishap occur? Is the communication between the government and your company sufficient to satisfy any concerns you have about what would happen in the event of an accident or mishap? Has your company been included in planning for these types of incidents?

NASA communicates the processes in place should an accident or mishap occur through Commercial Crew Program planning and requirements documents, such as CCT-PLN-1010, *Mishap Preparedness and Contingency Plan for Commercial Crew Program*. In addition, clause H.26 in the CCtCap contract levies requirements associated with Mishap Reporting, and Boeing provides and manages a Mishap Reporting and Investigation Plan and process that are in accordance with Clause H.26 Mishap Reporting. Our Insight Implementation approach and continuous communications with NASA throughout the development program, at both the technical and program management levels, provide confidence in our ability to work together to implement the approaches outlined in our plans.

2. The "commercial" paradigm is a different way of contracting and development that NASA has not used for major human-rated spacecraft. What level of insight are you giving NASA and ASAP into your safety process, and input data and calculations for the Loss of Crew and Loss of Mission probabilities. What are your probabilities for these compared to the requirement?
  - a. How do you recertify your vehicle safety after major design changes?

We have met with the ASAP when requested and we will continue to do so throughout our development and test program, providing information on our plans, approaches, and results and responding to the panel's questions.

As part of the CCtCap acquisition process NASA required and Boeing provided an Insight Implementation Plan that describes the broad access we provide NASA to our people, processes, data, and facilities. The Insight Implementation Plan establishes processes for exchanging information on all aspects of the program, including safety processes, to ensure that the benefits of both NASA and Boeing technical expertise and experience are brought to bear on our Commercial Crew Transportation System development and operations. Boeing enables NASA insight through access to facilities, personnel, activities, and data. We ensure NASA personnel and support services contractors can perform their insight, Government Quality Assurance functions, and Joint Test Team participation responsibilities as defined in clause H.15, Government Insight. Our approach to offering NASA insight into our Commercial Crew

Transportation System development and certification activities continues to provide the transparency, cooperative environment, and project culture that we have provided on the prior CCDev, CCDev2, and CCiCap program phases. As part of the NASA Insight approach, NASA has visibility into our Loss of Crew and Loss of Mission probabilities as we continue to refine our design during the development program to meet the NASA requirement.

a. Certification of our system occurs after the design has been finalized and flight tests have been completed, so we do not anticipate major design changes after certification. Throughout the development process, Boeing uses a rigorous closed-loop system to manage the configuration baseline.

3. What lessons learned have you garnered from the CPC process that you would offer on future responses to competitive government contracts? Would you expect to infuse lessons learned from this process on future procurements?

Two key lessons learned from the CPC process are (1) the value of NASA's specific documented feedback in their responses to our interim and final product submittals, and (2) the benefit of submitting robust certification products in order to maximize the opportunity for this feedback. We submitted alternate standards and all known variances for NASA disposition, enabling us to understand with specificity the areas required for forward work to ensure our design will meet NASA human rating certification requirements. The maturity and level of detail in our verification and certification plans enabled NASA feedback at a higher level of refinement and ensures that we have a consistent shared understanding of the verification and certification processes ahead to ensure NASA confidence in using our transportation system.

Our approach to the acquisition process includes identification of lessons learned, and the NASA acquisition de-brief process provides an opportunity for an exchange with NASA on lessons learned during the acquisition.

4. The Certification Products Contract process that your company went through was a new way of exchanging technical data between offerors and the government for a development program. Please share your thoughts on this process and what you believe the end result was for your program.

The NASA CPC acquisition process enabled interim and final submittals of alternate standards, hazard reports, our verification plan and our certification plan, with the opportunity for NASA to assess and disposition these products. NASA feedback during CPC provided an effective mechanism for Boeing to ensure our design and our verification and certification planning met NASA requirements. CPC also provided an effective mechanism, in conjunction with the CCiCap acquisition, for NASA to incorporate specific effort associated with these product dispositions into the CCiCap contract Statement of Work. The end result for our program was specific feedback and dispositioning from NASA, with clearly defined Statement of Work commitments in the contract for forward work to ensure our design meets NASA requirements and our verification and certification approaches will result in achieving human rating certification.

5. What plan does your company have to track and mitigate schedule and funding risks?
  - a. How do you share those risks and tracking tools with NASA?

Boeing tracks and mitigates schedule and cost performance as part of our ongoing program management approach that has been in place throughout our participation in the Commercial Crew Program. Our program management processes are in place to ensure technical, schedule, and cost performance – including rigorous risk and opportunity management. These processes include tracking performance to our Integrated Master Schedule, monitoring earned value, and identifying risks and opportunities and managing them to closure. We conduct weekly Boeing Program Management Reviews where we monitor performance and make decisions to ensure we meet contracted, fixed price performance milestones per plan. NASA sees technical and schedule performance metrics in regular Quarterly Program Reviews, and weekly and monthly joint program leadership meetings provide an opportunity for early visibility into any performance risks or issues. Cost reporting to NASA is not required given the fixed price contracting relationship, but Boeing carefully monitors progress within agreed-to costs.

6. Your company will receive a launch license for every Commercial Crew launch that you conduct. How has NASA, FAA, FCC, and the NTSB interacted with you so far in preparing for these launches?
  - a. Is it clear to your company who is in charge and when?
  - b. Do you have any concerns about the authorities claimed by the FAA, FCC, and NTSB?
  - c. If there is a discrepancy between requirements for obtaining a launch license and a NASA requirement, has it been made clear to you whose guidance you should follow?
  - d. What procedures have been enumerated to you to explain the dividing lines of authority between NASA and the FAA?

Through active participation in the FAA Commercial Space Transportation Advisory Committee (COMSTAC) as well as ongoing technical interchange with these government agencies, Boeing remains apprised of and provides feedback to regulations relevant to Commercial Crew Program missions. The inter-agency and industry community is working effectively to ensure clarity of roles, requirements, authority, and interrelationships and we are actively engaged to ensure we understand these requirements now and as they are further refined throughout our development program and preparations for missions. We have held coordination meetings and discussions with the controlling agencies for our launch and landing sites. We understand the FAA licensing process per Section 413.7 of the FAA's commercial licensing regulations for applicable launch and reentry operations. We are executing FAA licensing data development up to the point of submittal for our orbital and crewed flight tests even though FAA licensing is not required (these missions are conducted under NASA authority). Our adherence to Post Certification Mission procedures and FAA licensing processes, along with the requirements of other government agencies, provides operations validation, reduces risk to operational readiness, and supports certification.

Our Boeing CCtCap team includes United Launch Alliance, which has an ongoing relationship with government agencies associated with launch licensing and conduct for many government and commercial missions, as well as NASA Flight Operations Directorate,

which has significant experience working with these government agencies over many NASA crew and cargo missions. This experience has been beneficial throughout our planning to date and will support our successful inter-agency coordination throughout flight testing and post certification missions.

We do not have concerns about the various regulatory agencies acting in harmony to facilitate commercial human space flight. Although there is some overlap in responsibilities, the agencies are working together to resolve areas which may be regulated by multiple government stakeholders.

Our CCtCap contract clearly states our pre-certification missions are under the cognizance of NASA; post certification missions will be licensed under CSLA. The FAA and NASA appear to be cooperating on licensing of these flights; the 2012 MOU between FAA and NASA provides a broad framework for cooperative efforts addressing both technical and government oversight issues.

We have observed the regulators and government customers of future commercial human space flights are sensitive to their potential impact upon industry and are working together to minimize impact of multiple agency involvement.

7. The Commercial Space Launch Act governs the licensing and regulatory authority of the FAA. What changes to the CSLA would you like to see for the Commercial Crew Program to work as intended?
  - a. Have you identified any risks that could be mitigated by changes to the law?

We would like to see multi-year enactment of CSLA indemnification to ensure continuation of the mature liability risk regime currently in place for commercial launch and re-entry activities and the protection it affords. Recently, CSLA indemnification is enacted annually, adding significant risk to industry forward business planning since the indemnification is a common assumption for insurance acquisition and risk management activities of commercial operators. GAO has previously opined that the indemnification is important for the U.S. to maintain a viable competitive posture against foreign competition; we agree with their findings.

In addition, we recommend amendment of the CSLA to include liability limitation for space flight participant (SFP) recovery against operators, designers, and manufacturers against bodily injury claims. Currently, SFPs are required to waive bodily injury claims against the Government, but not against commercial entities. The potential for these claims has a chilling effect on industry development.

As history demonstrates, high net worth individuals are the pioneers of commercial use of new transportation systems. The well-to-do took the initial journeys on railcars, owned the first automobiles, and were the first to fly in commercial aircraft between continents. Space transportation is no different; however claims from high net worth individuals or their heirs must be bounded in order for business to assess risk of potential claims in formulation of business cases.

We recognize that any waiver or cap upon claims must be considered carefully; we should not take lightly removal of an important individual right. However, a blanket prohibition on SFP claims is not necessary to achieve this objective; industry can be held to account up to a reasonable damage cap without significant negative impact. The goal is not to provide industry with a “free ride” but rather establish parameters within which industry can make prudent investment and operation decisions in this emerging business.

We believe a reasonable cap on SFP claims--for example, of \$10M--for bodily injury damages provides a balance of protection for space transportation customer safety and facilitation of this emerging business. Industry will remain responsible for product safety, but unbounded potential SFP claims would no longer represent a significant roadblock to commercial space transportation industry growth. Although we do recognize SFPs will abdicate high dollar claims under a liability cap, the initial SFPs of commercial space flight represent a wealthy class of plaintiffs who arguably don't require protection of law to ensure their legal rights are maintained. Minimization, not elimination, of SFP bodily injury claims provides a fair and equitable path forward for all stakeholders involved. The SFPs themselves will benefit from lower overall transportation prices since industry will not be required to raise prices in order to address unbounded claims risk.

We note that any liability limitation for SFP claims must be provided in Federal law to ensure consistency in legal application since multiple State laws could be involved in SFP claims by individuals or their heirs.

We encourage legislators to act in order to enhance the competitiveness of domestic industry against foreign providers, whose pricing does not include risk mitigation due to legal legislative liability relief. US industry must enjoy an equal playing field in this new market to ensure the industry is not abdicated to foreign competition simply due to excessive liability risks not addressed by a mature risk management legal and regulatory regime.

- 8 NASA and the FAA have officially requested a change to the Commercial Space Launch Act that would define a new category of "government astronauts" for the purposes of launching NASA Astronauts on the Commercial Crew systems. How important is the government astronaut change and what happens if the change isn't enacted in time for the Commercial Crew launches?
  - a. Will your company fly NASA astronauts without this change?
  - b. Do you recommend alternate legislative text, or a different approach or solution?

Boeing will fly NASA crew on our Commercial Crew Transportation System per our CCtCap contract, and we support changes in crew terminology that NASA and the FAA jointly agree are needed. We support the language and believe its clarification is beneficial to eliminate uncertainty in the administration of any claims by individuals classified as Government astronauts.

- 9 The launch readiness goal for the Commercial Crew Program is 2017. How would you evaluate the likelihood that your company will meet that goal?
  - a. How do you evaluate your progress towards that goal?

Based on steady progress to an achievable program plan as proposed under CCtCap, Boeing anticipates meeting the NASA goal of launching in 2017. We monitor our progress regularly at a weekly program management review, assessing technical and schedule progress and making any needed adjustments to ensure we meet our agreed-to performance milestones. *See also the program management process details in response to question 5.*

Boeing has human spaceflight experience and skills from our work on the Space Shuttle Program and the International Space Station Program that we are applying to development and operations planning for our Commercial Crew Transportation System. That expertise gives us a high confidence in meeting NASA's human rating certification requirements. That experience is essential for identifying any issues early in the development process to enable adjustments without impacting our ability to deliver a safe, certified human space flight system on schedule.

b. What is the highest risk to meeting that goal that you are tracking?

Like most development programs, the Commercial Crew Program presents technical and program risks which we work proactively to mitigate. A key strength that Boeing provides to NASA is that we have a host of resources in a wide range of engineering and manufacturing disciplines, and we are able to apply those capabilities readily to NASA's benefit. While the NASA acquisition approach, progressing through CCDev, CCDev2, CCiCap, CPC, and now CCtCap, had the advantage of enabling technical risk reduction, it has resulted in delayed orders to suppliers and caused some concurrency in the program schedule that added risk. Boeing addressed this schedule and technical risk in our proposal with the addition of a third crew module to mitigate development testing risk. The delayed award and protest-related stopwork order exacerbated the supplier phasing issue. We continue to apply a program management focus to identifying opportunities to build schedule margin and protect for potential downstream issues.

- c. If it is funding, would you contribute additional corporate funding to the partnership to meet the 2017 goal?
- d. Previous NASA testimony indicated that they expect to fund 90 percent of the development costs for commercial crew contractors. Are you willing to make this partnership more equitable to maintain the 2017 launch date?

Per the terms of our fixed price CCtCap contract, Boeing is committed to complete our CCtCap performance work statement at the contracted price. At this juncture, we could not speculate on the viability of future additional private investment augmentation of NASA funding. Such investment would require calculation of a business case.

Nevertheless, our company is "bullish" on this new emerging market and is optimistic about the timely establishment of three critical legislative and legal constructs: First, a risk management and liability regime addressing the carriage of humans vice cargo or satellites; second, continued Government facilitation of the market through investment and prudent contracting practices, and third, establishment of appropriate safety standards imposed by regulation in the near future in order to deter high-risk entrants into the market.

10. The ASAP identified some concerns with the Commercial Crew Program that involved outside stakeholders. Specifically, the report noted a concern that the lack of candor and transparency in the program may extend outside NASA. Do you agree with the ASAP's assessment?
  - a. What changes would you like to see in communication with NASA that would be helpful for alleviating this concern?

Boeing has been, and will continue to be, forthcoming with the ASAP in responding to requests for information needed for their independent assessment. We are not privy to all conversations concerning the Commercial Crew Program, but have not encountered lack of candor or transparency in NASA's or FAA's efforts in furtherance of the commercial crew program. As we move through our development program, we will continue our engagement with ASAP to ensure fulfillment of their critical mission.

11. The International Space Station has not been extended by Congress yet; however the Administration has proposed to extend to 2024. How much of your business plan for recouping investments in Commercial Crew is predicated on the extension of the life of the Station to 2024 or beyond? Would you continue with the Commercial Crew Program if the ISS is not extended?

Our multi-phase business plan is based on continued ISS operations through 2024 and beyond. We have implemented a program plan for CCtCap that ensures our partnership with NASA through all missions contemplated under the CCtCap program period of performance. Because there are no firm commitments for other low Earth orbit destinations prior to 2024, we rely on NASA as the primary customer/market to close our business plan. In the event a decision was made to not extend ISS through at least 2024, we would evaluate the impact to our business plan given an updated market assessment for that timeframe and determine the best path forward.

Of course, transportation systems and destination platforms are both necessary for a successful human space industry. Development of commercial crew transportation systems helps fulfill NASA's charter—in the NASA act of 1958—to commercialize space. Destinations are part of the fulfillment of this objective. Thus, we encourage NASA and the Government to facilitate the development and operation of platforms as well as transportation systems.

NASA has a working model for acquisitions necessary to facilitate establishment of industry capabilities for commercialization of space. This model, established for commercial crew transportation, can be leveraged into achievement of the objective of platform commercialization. In addition, there are several different models for extended use of ISS with various levels of Government involvement. Overall, we are optimistic that once commercial crew transportation is established and on the way to becoming a mature capability, platform investment, both Government and private, will be the next step towards commercialization of space.

12. What assurances can you provide to Congress that Boeing will not seek additional funding in order to provide commercial crew access to ISS by 2017?

Boeing accepted performance risk for the CCtCap contract through proposing and accepting award of a fixed price contract against a pre-defined set of requirements and agreed upon work scope with NASA. Boeing is contractually obligated to develop and certify our Commercial Crew Transportation System for services in 2017 at our proposed fixed price, with 100 percent of any cost overruns falling upon Boeing.

Boeing's obligation to complete the work within the proposed fixed price assumes NASA does not implement changes to the contract which make system design and development more expensive. The CCtCap contract includes a provision for additional funding on a limited basis only if NASA changes requirements and/or work scope and authorizes Boeing effort to respond to the NASA requested changes.



**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

"The Commercial Crew Program: Challenges and Opportunities"

Questions for the record, Mr. John Mulholland, Vice President and Program Manager,  
Commercial Programs, The Boeing Company

Questions submitted by Rep. Brian Babin

- 1 Under the CCtCap contract, both Commercial Crew providers will bring their spacecraft online for manned flights by 2017. Although the companies are each expected to achieve the same level of technological maturity and conduct the same number of test flights, SpaceX's \$2.6 billion award is significantly less than Boeing's \$4.2 billion award. Would each of you - NASA Space X and Boeing - address why you believe there is such a significant disparity in the contracts?

Comparison of contract value requires an understanding of prior Commercial Crew and also Cargo Resupply Services acquisitions. SpaceX has received ~\$2B to design, develop, certify, and launch cargo missions and that they have continually redesigned their system to increase performance and capability to align with the original contractual commitments. Therefore, SpaceX funding received under COTS and CRS should be included in consideration of total development cost comparisons. When taken in total context, the Space X development costs are much higher than the \$2.1B evaluated price and \$2.6B maximum price of CCtCap. In addition, Boeing's evaluated price for CCtCap—the price used by NASA in the source selection process—was approximately \$3B, compared to the maximum value that was stated as \$4.2B.

The CCtCap award values also reflect a difference in approaches between the two providers. Boeing's rigorous closed-loop development approach and our use of highly reliable, flight proven systems provided by world-class aerospace industry partners – including the ULA Atlas V launch system – were evaluated by NASA as providing the best value to the government. NASA recognizes that the Government's "best deal" when acquiring goods or services isn't always just the lowest cost provider.

In sum, although Boeing and Space X bid to the same set of requirements in CCtCap, the difference in contract price reflects differences in the effort proposed for fulfillment of those requirements. Identical requirements neither mandate nor indicate identical effort, and stakeholders should not make the erroneous assumption that contractors will merely meet and not exceed NASA's requirement.

As reflected in NASA's source selection documentation, Boeing's approach minimizes performance, cost, and schedule risk; utilizes proven and low-risk products and technology anticipated to result in a highly reliable and safe system, and is based upon previous successful space act agreement performance. Boeing also proposed use of proven processes and procedures, as well as robust testing protocols. These examples reflect that Boeing is not merely meeting, but is rather exceeding, CCtCap requirements. We encourage stakeholders to examine NASA's source selection document, which highlights the logic for selection of Boeing's proposal despite higher evaluated costs. Boeing's

approach provides the best value to the Government despite higher evaluated cost, and NASA's justification for selection of the Boeing approach was reviewed and confirmed by GAO.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

"The Commercial Crew Program: Challenges and Opportunities"

Questions for the record, Mr. John Mulholland, Vice President and Program Manager,  
Commercial Programs, The Boeing Company

Questions submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science,  
Space, and Technology

- How confident are you that Boeing can make the proposed 2017 date for operational commercial crew transportation services? What is the basis for your confidence and what key assumptions underlie your projection? What do you consider to be the primary risks to that date?

Based on steady progress to an achievable program plan as proposed under CCtCap, Boeing anticipates meeting the NASA goal of launching in 2017. We monitor our progress regularly at a weekly program management review, assessing technical and schedule progress and making any needed adjustments to ensure we meet our agreed-to performance milestones.

Boeing has human spaceflight experience and skills from our work on the Space Shuttle Program and the International Space Station Program that we are applying to development and operations planning for our Commercial Crew Transportation System. That expertise gives us a high confidence in meeting NASA's human rating certification requirements. That experience is essential for identifying any issues early in the development process to enable adjustments without impacting our ability to deliver a safe, certified human space flight system on schedule.

Like most development programs, the Commercial Crew Program presents technical and program risks which we work proactively to mitigate. A key strength that Boeing provides to NASA is that we have a host of resources in a wide range of engineering and manufacturing disciplines, and we are able to apply those capabilities readily to NASA's benefit. While the NASA acquisition approach, progressing through CCDev, CCDev2, CCiCap, CPC, and now CCtCap, had the advantage of enabling technical risk reduction, it has resulted in delayed orders to suppliers and caused some concurrency in the program schedule that added risk. Boeing addressed this schedule and technical risk in our proposal with the addition of a third crew module to mitigate development testing risk. The delayed award and protest-related stopwork order exacerbated the supplier phasing issue. We continue to apply a program management focus to identifying opportunities to build schedule margin and protect for potential downstream issues.

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE**

"The Commercial Crew Program: Challenges and Opportunities"

Questions for the record, Mr. John Mulholland, Vice President and Program Manager,  
Commercial Programs, The Boeing Company

Questions submitted by Rep. Donna Edwards, Ranking Member, Subcommittee on Space

- How is Boeing satisfying NASA's contracted LOC/LOM requirements? What level of insight is Boeing giving NASA and ASAP into the safety process, and what input data and calculations is Boeing providing for NASA and ASAP's assessment of those LOC/LOM probabilities? How do Boeing's LOC/LOM probabilities compare to the CCtCap requirement?

We have met with the ASAP when requested and we will continue to do so throughout our development and test program, providing information on our plans, approaches, and results and responding to the panel's questions.

As part of the CCtCap acquisition process NASA required and Boeing provided an Insight Implementation Plan that describes the broad access we provide NASA to our people, processes, data, and facilities. The Insight Implementation Plan establishes processes for exchanging information on all aspects of the program, including safety processes, to ensure that the benefits of both NASA and Boeing technical expertise and experience are brought to bear on our Commercial Crew Transportation System development and operations. Boeing enables NASA insight through access to facilities, personnel, activities, and data. We ensure NASA personnel and support services contractors can perform their insight, Government Quality Assurance functions, and Joint Test Team participation responsibilities as defined in clause H.15, Government Insight. Our approach to offering NASA insight into our Commercial Crew Transportation System development and certification activities continues to provide the transparency, cooperative environment, and project culture that we have provided on the prior CCDev, CCDev2, and CCiCap program phases. As part of the NASA Insight approach, NASA has visibility into our Loss of Crew and Loss of Mission probabilities as we continue to refine our design during the development program to meet the NASA requirement.

Certification of our system occurs after the design has been finalized and flight tests have been completed, so we do not anticipate major design changes after certification. Throughout the development process, Boeing uses a rigorous closed-loop system to manage the configuration baseline.

- What is your interpretation of Boeing's role and responsibilities regarding accident investigation? Have you been given clear direction as to how Boeing would interact with FAA, NASA, the U.S. Air Force, and the NTSB, and what data you will need to be able to provide?

NASA communicates the processes in place should an accident or mishap occur through Commercial Crew Program planning and requirements documents, such as CCT-PLN-1010, *Mishap Preparedness and Contingency Plan for Commercial Crew Program*. In addition, clause H.26 in the CCtCap contract levies requirements associated with Mishap Reporting, and Boeing provides and manages a Mishap Reporting and Investigation Plan and process that are in accordance with Clause H.26 Mishap Reporting. Our Insight Implementation approach and continuous communications with NASA throughout the development program, at both the technical and program management levels, provide confidence in our ability to work together to implement the approaches outlined in our plans.

Through active participation in the FAA Commercial Space Transportation Advisory Committee (COMSTAC) as well as ongoing technical interchange with these government agencies, Boeing remains apprised of and provides feedback to regulations relevant to Commercial Crew Program missions. The inter-agency and industry community is working effectively to ensure clarity of roles, requirements, authority, and interrelationships and we are actively engaged to ensure we understand these requirements now and as they are further refined throughout our development program and preparations for missions. We have held coordination meetings and discussions with the controlling agencies for our launch and landing sites. We understand the FAA licensing process per Section 413.7 of the FAA's commercial licensing regulations for applicable launch and reentry operations. We are executing FAA licensing data development up to the point of submittal for our orbital and crewed flight tests even though FAA licensing is not required (these missions are conducted under NASA authority). Our adherence to Post Certification Mission procedures and FAA licensing processes, along with the requirements of other government agencies, provides operations validation, reduces risk to operational readiness, and supports certification.

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We do not have concerns about the various regulatory agencies acting in harmony to facilitate commercial human space flight. Although there is some overlap in responsibilities, the agencies are working together to resolve areas which may be regulated by multiple government stakeholders.

Our CCtCap contract clearly states our pre-certification missions are under the cognizance of NASA; post certification missions will be licensed under CSLA. The FAA and NASA appear to be cooperating on licensing of these flights; the 2012 MOU between FAA and NASA provides a broad framework for cooperative efforts addressing both technical and government oversight issues.

We have observed the regulators and government customers of future commercial human space flights are sensitive to their potential impact upon industry and are working together to minimize impact of multiple agency involvement.

- I understand that the CCtCap contract foresees the possibility of NASA agreeing to allow Boeing to include potential non-NASA "passengers" on future rides to the ISS on your respective spacecraft. How important is this aspect of the contract to Boeing? Is this a "nice-to-have" or is it an important component of your business plan?
  - o What is your understanding of how insurance liability would apply to non-NASA "passengers" and how the cost to NASA of their transport to and from the ISS and their stay on the ISS would be compensated?
  - o In the event a non-NASA "passenger" causes damage to the ISS during his or her stay, what is your understanding of the insurance requirements that would cover that situation?

Boeing sees CCtCap contract provisions for including non-NASA passengers as a great opportunity to facilitate the NASA vision to foster a commercial market in low Earth orbit. We see the addition of commercial, non-NASA transportation services as a growth opportunity for our commercial program.

Our approach to including private passengers on CCtCap missions follows the provisions for non-NASA passengers established by NASA in CCtCap contract clause H.23 Non-NASA Passengers, Cargo and Payloads, which includes a sub-section specifically addressing liability and insurance.

However, as we have previously mentioned, the bodily injury liability of SFPs is currently not limited by law. As discussed in our answer to question #7, mitigation of liabilities associated with the carriage of high net worth individuals is a deterrent to growth of the SFP market. We hope Congress intervenes to assist industry in further growth of this market.

*Responses by Dr. Garrett Reisman*

**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
SUBCOMMITTEE ON SPACE  
“The Commercial Crew Program: Challenges and Opportunities”**

Responses to questions for the record provided by:

**Dr. Garrett Reisman, Director, Crew Operations, Space Exploration Technologies Corp.**

April 6, 2015

Questions submitted by Rep. Steven Palazzo, Chairman, Subcommittee on Space

- 1. How has NASA communicated with you about the processes in place should an accident or mishap occur? Is the communication between the government and your company sufficient to satisfy any concerns you have about what would happen in the event of an accident or mishap? Has your company been included in planning or these types of incidents?**

NASA has provided accident and mishap process information. The processes are set forth in contract clauses and referenced documents in the commercial crew prime contract (CCtCap), as well as prior Space Act Agreements with SpaceX. These clauses and reference documents adequately describe NASA’s processes and SpaceX obligations with regards to an accident or mishap; the agency works in close partnership with our company, and no concerns have arisen at this time.

- 2. The “commercial” paradigm is a different way of contracting and development that NASA has not used for major human-rated spacecraft. What level of insight are you giving NASA and ASAP into your safety process, and input data and calculations for the Loss of Crew and Loss of Mission probabilities? What are your probabilities for these compared to the requirement?**

Safety processes have been documented thoroughly and provided to NASA on multiple intervals during the CCiCap contract performance period and now in the context of the CCtCap contract. The most recent version was submitted for NASA approval at the Certification Baseline Review (CBR) under the newly awarded CCtCap contract. NASA is the direct interface with ASAP, with SpaceX as the contractor. SpaceX has hosted ASAP in the past, and has planned for a mid-2015 interface with ASAP.

At each quarterly meeting, NASA is briefed on top technical, safety, and schedule risks. NASA and SpaceX safety engineers hold weekly Safety and Mission Assurance meetings wherein issues and processes are discussed, as well as the schedule of safety-related analyses.

SpaceX is actively working with NASA on the analysis technique to ensure a robust approach to LOC/LOM probability analysis. SpaceX intends to meet the contractually required LOC/LOM. We are working steadily, thoughtfully, and efficiently with NASA to yield the safest and most reliable astronaut transportation system ever built.

**a. How do you recertify your vehicle safety after major design changes?**

Any major design changes following the Critical Design Review would be tracked in the SpaceX Change Management database, at which time the Mission Assurance and Safety group is automatically alerted. In turn, this group makes corresponding updates to the probabilistic safety analysis, as required. NASA has insight throughout this process. After any design change, affected requirements will be identified and a delta certification of those requirements will be completed to NASA's satisfaction before flight.

**3. What lessons learned have you garnered from the CPC process that you would offer on future responses to competitive government contracts? Would you expect to infuse lessons learned from this process on future procurements?**

See Response to Question 4, below. Yes, SpaceX would expect to apply lessons learned from this process on future FAR-based procurements.

**4. The CPC process that your company went through was a new way of exchanging technical data between offerors and the government for a development program. Please share your thoughts on this process and what you believe the end result was for your program.**

The CPC process was valuable, allowing SpaceX to make progress on some of the core elements of NASA certification of our vehicles. Chiefly, CPC required us to deliver a master Verification and Validation (V&V) Plan and Certification Plan, and allowed us to engage NASA in formulating Phase 1 Hazard Reports and getting feedback on their quality and depth. Additionally, it allowed NASA to understand, through variance and alternate standards submissions, which requirements SpaceX might need to better understand and accommodate, or where SpaceX had an alternate or preferable approach to meeting those requirements. Collectively, these exchanges of technical data, and the insight and discussion that accompanied them, allowed SpaceX to improve its offering to the Government. Further, the exchanges helped us to understand NASA's expectations ahead of development, such that we could properly cost and schedule the development, test, and certification phases.

**5. What plan does your company have to track and mitigate schedule and funding risks?**

Financial and schedule status, along with risks and mitigations, are reported to NASA each quarter. Regardless, we regularly assess all programs, including Commercial Crew, to identify schedule, funding, and other possible risks. Our Mission Assurance team in conjunction with the Finance team evaluates all potential risks. Mitigations and impacts are identified, and our Mission Assurance team actively tracks the status of mitigations and drives implementation and risk reduction. Schedule risk is mitigated by incorporating margin and reserve into our Integrated Master Schedule, which is delivered monthly to NASA for review. Lifecycle cost risk is mitigated by designing the Crew Dragon-Falcon 9 System to leverage common design and operational elements from CRS cargo missions and commercial satellite launches which benefit from the control provided by our vertically integrated production processes supported by a diverse U.S. supplier base with very limited international dependencies.



**a. How do you share those risks and tracking tools with NASA?**

NASA has been provided full access to our risk database, where all risk records for the Commercial Crew Program contracts are recorded. Further, NASA participates in our weekly Risk Boards and the agency is briefed on a status of all of our risks on a regular basis, both at the Crew Quarterlies and when requested, or when a significant risk arises. Integrated Master Schedule updates are delivered monthly to NASA.

**6. Your company will receive a launch license for every Commercial Crew launch that you conduct. How has NASA, FAA, FCC, USAF and the NTSB interacted with you so far in preparing for these launches?**

For the Post Certification Missions (PCM), SpaceX will build on our experience with the NASA Commercial Resupply Services (CRS) missions that are FAA licensed. For those missions, SpaceX is responsible for working with NASA, FAA, FCC, and USAF in order to license and conduct our launch in accordance with those agencies' roles and responsibilities. This process has functioned well to date. We understand that the NTSB's involvement will be in accordance with the agreement between the NTSB and FAA in connection with investigations associated with commercial space launch activities.

**a. Is it clear to your company who is in charge and when?**

The CCtCap contract distinguishes between the pre- and post-certification for FAA licensing. The pre-certification demonstration missions are not FAA licensed, while all of the post-certification missions will be FAA licensed. Other than the distinction for FAA licensing, under clause H.18 of the CCtCap contract, the Contractor is responsible for obtaining and maintaining the necessary licenses, permits and clearances, as required, from the Department of Transportation, Department of Commerce, Department of Defense, NASA and other Governmental agencies for the flight tests and Post Certification Missions.

**b. Do you have any concerns about the authorities claimed by the FAA, FCC, and NTSB?**

We do not currently have concerns.

**c. If there is a discrepancy between requirements for obtaining a launch license and a NASA requirement, has it been made clear to you whose guidance you should follow?**

NASA's requirements are contract-based. FAA licensing is regulation-based. There is no direct conflict perceived at this time: however, given the hybrid nature of certain launches (that is, commercial style launches for government customers) there must be certainty regarding the amounts of third party insurance required or advisable for those launches. SpaceX has had good experiences working with various agencies through the NASA CRS missions. In cases where an agency's role was not clear, we have been able to successfully work with NASA and the FAA to resolve ambiguities.

**d. What procedures have been enumerated to you to explain the dividing lines of authority between NASA and the FAA?**

The delineation between Pre- and Post-Certification Missions in the CCtCap contract establishes the initial dividing line. Subsequently, NASA's requirements are contract-based. FAA licensing is regulation-based. There is no direct conflict perceived at this time.

**7. The Commercial Space Launch Act governs the licensing and regulatory authority of the FAA. What changes to the CSLA would you like to see for the Commercial Crew Program to work as intended?**

SpaceX recommends that the CSLA be amended to account for the carriage of "government astronauts" on FAA licensed launches as discussed in the question below. SpaceX also recommends permanently extending the CSLAA indemnification regime. By requiring FAA licenses for the Post-Certification Missions under CCtCap, NASA and the Contractors rely in part on the CSLAA indemnification regime for defining liability and insurance requirements.

**a. Have you identified any risks that could be mitigated by changes to the law?**

Providing clarity regarding NASA astronauts and extending the indemnification regime would mitigate risks related to liability.

**8. NASA and the FAA have officially requested a change to the CSLAA that would define a new category of "government astronauts" for the purposes of launching NASA astronauts on the Commercial Crew systems. How important is the government astronaut change and what happens if the change isn't enacted in time for the Commercial crew launches?**

The CCtCap contract that SpaceX signed with NASA distinguishes "government astronauts" from Spaceflight Participants and Crew. This redounds to the benefit of the astronauts. This change adds clarity for a category of participants with respect to liability.

**a. Will your company fly NASA astronauts without this change?**

Yes. As noted above, SpaceX has already contractually agreed under CCtCap to fly NASA astronauts as "government astronauts."

**b. Do you recommend alternate legislative text, or a different approach or solution?**

We welcome the opportunity to work with the Committee on legislative text to codify "government astronauts" as a separate category from crew and spaceflight participants.

**9. The launch readiness goal for the CCP is 2017. How would you evaluate the likelihood that your company will meet that goal?**

We are making excellent progress toward launch readiness in 2017; at this time, we project a very high likelihood of meeting that goal.

**a. How do you evaluate your progress towards that goal?**

We regularly evaluate progress toward launch readiness within our Integrated Master Schedule, assessing status based on inputs from all key task and milestone owners.

**b. What is the highest risk to meeting that goal that you are tracking?**

The greatest external risk to meeting launch readiness in 2017 is interruption or diminishment of Government funding for the CCtCap program. Within the program, the greatest risk is ensuring a timely complete of validation and verification events to support certification of the design.

**c. If it is funding, would you contribute additional corporate funding to the partnership to meet the 2017 goal?**

The CCtCap contract is firm fixed price. We are therefore prepared to provide additional funding if our costs exceed the contractual projections, assuming that the program requirements have remained stable.

**d. Previous NASA testimony indicated that they expect to fund 90 percent of the development costs for commercial crew contractors. Are you willing to make this partnership more equitable to maintain the 2017 launch date?**

We believe the partnership is equitable, with SpaceX providing significant developmental funding against a firm fixed price (FFP) offering, and therefore taking on the risk of costs exceeding the FFP incremental payments.

**10. The ASAP identified some concerns with the Commercial Crew Program that involved outside stakeholders. Specifically, the report noted a concern that the lack of candor and transparency in the program may extend outside NASA. Do you agree with the ASAP's assessment?**

Our relationships with NASA have been characterized by transparency and candid communication. We provide open and direct working insight to NASA on a daily basis, and jointly exchange summary insight and assessment weekly, monthly, and quarterly. We maintain an open relationship with ASAP and periodically host them at our facility for program reviews, including an upcoming meeting this year in August 2015.

**a. What changes would you like to see in communication with NASA that would be helpful for alleviating this concern?**

SpaceX is pleased to support NASA and the ASAP's efforts to achieve an appropriate level of communication as we develop the safest crew transportation systems ever flown. SpaceX has no comment on how NASA should interface with the ASAP.

**11. The ISS has not been extended by Congress yet; however, the Administration has proposed to extend to 2024. How much of your business plan for recouping investments in Commercial Crew is predicated on the extension of the life of the Station to 2024 or beyond? Would you continue with the Commercial Crew Program if the ISS is not extended?**

SpaceX anticipates that our current contract will be profitable with no investments remaining to be recouped after completion of the CCtCap program; our business plan is not predicated on the ISS extension to 2024. SpaceX offers the same launch vehicle that will be used for commercial crew services to a wide range of U.S. Government and traditional commercial customers; therefore, our business model is not premised on the Commercial Crew program alone. We would continue with the Commercial Crew Program if the ISS is not extended.

**12. What assurances can you provide to Congress that SpaceX will not seek additional funding in order to provide commercial crew access to ISS by 2017?**

We have executed a firm fixed price contract, and do not anticipate any need for any additional funding absent changes in the CCtCap contract requirements.

**13. Please provide funding levels associated with contracts outlined on page 2 of your truth-in-testimony form submitted in advance of this hearing.**

- Commercial Crew Transportation Services (CCtCap) — NASA, \$1.1 billion
- Certification Products Contract (CPC) — NASA, \$9.6 million
- Orbital-Suborbital Program 3 (OSP-3) — USAF, \$250 million
- EELV Early Integration Studies (EIS) — USAF, \$4.3 million
- Leading Edge Integration (LEI) — NRO, \$5.4 million
- Falcon 9 v.1.1 Launch System Certification Cooperative Research and Development Agreement (EELV CRADA) — USAF, no government funding
- Cadet Summer Research Program Cooperative Research and Development Agreement (CSRP CRADA) — USAF, no government funding
- Unfixed Firm Fixed-Price Letter Contract, TO-128 CLA 2014, SpaceX CLA (subcontractor to The Boeing Company), unfixed letter contract
- Firm-Fixed Price Subcontract Launch Reservation Agreement – Single Launch (subcontractor to Northrup Grumman Systems Corporation), reservation agreement, pricing to be determined.
- Falcon 9 Launch Services Agreement – Single Launch (subcontractor to Ball Aerospace & Technologies Corp.), undisclosed.

Questions submitted by Rep. Brian Babin

- 1. Under the CCtCap contract, both Commercial Crew providers will bring their spacecraft online for manned flights by 2017. Although the companies are each expected to achieve the same level of technological maturity and conduct the same number of test flights, SpaceX's \$2.6 billion award is significantly less than Boeing's \$4.2 billion award. Would each of you – NASA SpaceX and Boeing – address why you believe there is such a significant disparity in the contracts?**

Award amounts reflect the amount of funding required by each provider to meet proposal requirements, plus a reasonable profit. Award amounts are not a factor of merit, but efficiencies. NASA fully funded SpaceX's proposal based on our stated funding needs to meet the proposal requirements. We are very confident that we can accomplish the contract requirements and bring back American crew capability in the amount we proposed. As noted in the GAO decision dated January 5, 2015, there was only a 7% difference in the mission suitability scores for SpaceX and Boeing in NASA's final CCtCap proposal evaluation but the evaluated price for Boeing was 72% higher than that for SpaceX. As the question highlights, SpaceX will be meeting all the same mandatory milestones, certification requirements, safety requirements and providing the same capabilities as Boeing, but for \$1.6 billion less.

Questions submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology

- 1. How confident are you in SpaceX making the proposed 2017 date for operational commercial crew transportation services? What is the basis for your confidence and what key assumptions underlie your projections? What do you consider to be the primary risks to that date?**

We are making excellent progress toward launch readiness in 2017 and have a very high likelihood of meeting that goal assuming that requirements remain stable. Since SpaceX is already flying an operational cargo version of our Dragon spacecraft and Falcon 9 launch vehicle, schedule risk due to technical integration issues is significantly mitigated. To ensure schedule discipline, we regularly evaluate progress toward launch readiness within our Integrated Master Schedule, assessing status based on inputs from all key task and milestone owners.

Our Integrated Master Schedule is highly detailed and includes all major tasks and milestones toward launch readiness. By assessing schedule progress with monthly input from the task owners, we are able to maintain ongoing confidence in the schedule and mitigate any areas of concern. Margin is built into the schedule protecting launch readiness in 2017. Key assumptions to our projections include consistent program funding from the Government and ongoing success in design validation and verification in partnership with NASA.

The greatest external risk to meeting launch readiness in 2017 is interruption or diminishment of Government funding for the program. Within the program, the greatest risk is ensuring a timely completion of validation and verification events to support certification of the design.

Questions submitted by Rep. Donna Edwards, Ranking Member, Subcommittee on Space

- 1. How is SpaceX satisfying NASA's contractual LOC/LOM requirements? What level of insight is SpaceX giving NASA and ASAP into the safety process, and what input data and calculations is SpaceX providing for NASA and ASAP's assessment of those LOC/LOM probabilities? How do SpaceX's LOC/LOM probabilities compare to the CCtCap requirement?**

SpaceX is actively working with NASA on the analysis technique to ensure a robust approach to LOC/LOM probability analysis. SpaceX intends to meet the contractually required LOC/LOM. We are working steadily, thoughtfully, and efficiently with NASA to yield the safest and most reliable astronaut transportation system ever built.

Safety processes have been documented thoroughly and provided to NASA on multiple intervals during the CCiCap contract performance period and now in the context of the CCtCap contract. The most recent version was submitted for NASA approval at the Certification Baseline Review (CBR) under the newly awarded CCtCap contract. NASA is the direct interface with ASAP, with SpaceX as the contractor. SpaceX has hosted ASAP in the past, and has planned for a mid-2015 interface with ASAP.

At each quarterly meeting and milestone, NASA is briefed on top technical, safety, and schedule risks. NASA and SpaceX safety engineers hold weekly Safety and Mission Assurance meetings wherein issues and processes are discussed, as well as the schedule of safety-related analyses.

- 2. What is your interpretation of SpaceX's role and responsibilities regarding accident investigation? Have you been given clear directions as to how SpaceX would interact with FAA, NASA, the U.S. Air Force, and the NTSB, and what data you will need to be able to provide?**

For the Post Certification Missions (PCM), SpaceX will build on our experience with the NASA Commercial Resupply Services (CRS) missions that are FAA licensed. For those missions, SpaceX is responsible for working with NASA, FAA, FCC, and USAF in order to license and conduct our launch in accordance with those agencies' roles and responsibilities. We understand that the NTSB's involvement will be in accordance with the agreement between the NTSB and FAA in connection with investigations associated with commercial space launch activities.

In an accident investigation, we understand how we would interact with FAA, NASA, the U.S. Air Force, and the NTSB.

**3. The CCtCap foresees the possibility of NASA agreeing to allow SpaceX to include potential non-NASA “passengers” on future rides to the ISS on your respective spacecraft. How important is this aspect of the contract to SpaceX? Is this a “nice-to-have” or is it an important component of your business plan?**

SpaceX has no intention of carrying non-NASA passengers at this time, as it adds tremendous mission complexity and is not needed by SpaceX for additional revenue. The SpaceX offering needs no additional funding that would be gained from this activity. Our mission pricing codified in our CCtCap contract is not based or contingent upon any revenue generated by non-NASA “passengers”.

**a. What is your understanding of how insurance liability would apply to non-NASA “passengers” and how the cost to NASA of their transport to and from the ISS and their stay on the ISS would be compensated?**

SpaceX has no intention of carrying non-NASA “passengers” on any NASA mission to the ISS. Nonetheless, clause H.23 “Non-NASA Passengers, Cargo and Payloads” of the CCtCap contract addresses the applicability of insurance and liability to Passengers as well as the cost to NASA. That clause requires the Contractor to “extend section (c) of clause H.5, NFS 1852.228-76 Cross-Waiver Of Liability For International Space Station Activities (Oct 2012) (Deviation), to Passengers by requiring them to waive any and all claims against the entities listed in section (c)(1) of that clause”. The parties listed in (c)(1) of H.5 are those who are “party to an Agreement involving activities in connection with the ISS” and “a Partner State, including the United States,” as well as the related entities and employees of parties within the two categories listed here. Further, CCtCap requires that the Contractor “require Passengers to maintain insurance covering damage to or loss of any property or injury or death of any person on the ISS or in the CTS resulting from any action, negligence, or failure to act by the Passenger.”

With regard to the cost to NASA for Passengers, clause H.23(b) states:

The Contractor acknowledges and agrees that any decision to authorize the manifest of a Passenger(s) or non-NASA Cargo or Payload in response to a task order proposal shall be a unilateral determination at NASA’s sole discretion. NASA retains the right to revoke its prior approval of a Passenger(s) or non-NASA Cargo or Payload at any time prior to launch of the Post Certification Mission. NASA shall not be responsible for any costs, liabilities or obligations incurred by the Contractor to manifest a Passenger(s) or non-NASA Cargo or Payload; NASA shall not be responsible for any costs, liabilities or obligations incurred by the Contractor should NASA revoke its prior approval of Passenger(s) or non-NASA Cargo or Payload.

Clause H.23(c) outlines the process for the Contractor to propose flying a Passenger or non-NASA cargo or payloads on a Post Certification Mission. That proposal must be at no cost to NASA and include the “non-NASA mission requirements, if any, and price adjustment or other consideration to be received by NASA.” The contract states that the Contractor is “responsible for the costs of and ensuring completion of all necessary training in accordance with FAA license requirements and NASA requirements, including all training required for the Crew Transportation System and for the ISS, even if such training is provided by NASA.”



- b. In the event a non-NASA “passenger” causes damage to the ISS during his or her stay, what is your understanding of the insurance requirements that would cover that situation?**

As noted in the response above, clause H.23 of the CCtCap contract states, “The Contractor shall require Passengers to maintain insurance covering damage to or loss of any property or injury or death of any person on the ISS or in the CTS resulting from any action, negligence, or failure to act by the Passenger.”

Questions submitted by Rep. Ami Bera

1. SpaceX originally planned to perform the pad abort test and in-flight abort test of its Dragon version 2 capsule (under CCiCap) in the 3<sup>rd</sup> quarter of 2014. We are now well into the first quarter of 2015, the CCtCap contract has been awarded and is underway, and we still have not seen either abort test from the earlier contract. Why are the abort tests being delayed?

The pad and in-flight abort tests are the integrated tests of state of the art crew safety systems. We are taking the time necessary to ensure test and system success, carefully resolving any issues. We continue to maintain significant margin between the projected abort test dates and impacts to commercial crew launch readiness in 2017.

2. Is SpaceX delaying the in-flight abort test to wait for a F9 first stage to be recovered from a launch in 2015, refurbished, and then re-used for the in-flight abort test? What is your contingency plan if the recovery of a first stage is not executed in the near future?

No. The in-flight abort test has a dedicated Falcon 9 first stage.

3. The hearing charter notes the following with respect to the 2008 Authorization Act, which authorized the CCP: *“The 2008 Act also included a provision that provided congressional intent to NASA which prohibited the Administration from funding the Commercial Crew Program at the expense of exploration programs.”* Do you believe that NASA’s, hence the Nation’s, deep space program and funding for that program has been negatively impacted by the efforts and funding that NASA has put forth to bring the Commercial Crew Program on line?

No. Quite the opposite; the Commercial Crew Program (CCP) has provided NASA the opportunity to leverage public-private partnerships and firm, fixed price contracts to develop an American human spaceflight capability in a safe and efficient manner. The CCP has progressed at a fraction of the tax dollars being spent on deep space programs. But for NASA’s use of a more commercial, cost-effective model for developing a crew transportation systems, the agency would not be able to accomplish all of its exploration goals. Further, the alternative to the CCP program is continued reliance on Russia for crewed missions at ever-increasing prices.

planetary systems, and of life itself - beyond what either telescope on its own would be capable of doing.”

QUESTION 4:

Is there a plan to overlap JWST with other science missions and observatories in the study of dark matter?

ANSWER 4:

As mentioned in question 3, JWST is designed to be complementary to existing and future ground-based facilities, making observations that are not possible from the ground. However, JWST and other telescopes cannot directly see "dark matter," the unseen matter that makes up a large fraction of the mass of galaxies and clusters of galaxies, but JWST will be able to measure its effects. One of the best ways to measure mass is through the gravitational lens effect. As described by Einstein's General Relativity theory, a light beam passing near a large mass will be slightly deflected, because space-time is disturbed by the presence of mass. By taking pictures of distant galaxies behind nearby galaxies, astronomers can calculate the total amount of mass in the foreground galaxies by measuring the disturbances in the background galaxies. Because astronomers can see how much mass is present in stars in the foreground galaxies they can then calculate how much of the total mass is missing, which is presumed to be in the dark matter. JWST will be particularly well-suited for this type of measurement, because its very sharp images will allow very small disturbances to be measured, and because it can see so deep into space, giving it access to many more background galaxies to measure disturbances caused by this gravitational lensing effect. Also, JWST will observe many facets of galaxy evolution and scientists will be able to compare these observations to theories of the role that dark matter played in that process, leading to greater understanding of the amount and nature of the dark matter in galaxies.

Although this is not widely recognized, the universe would not have galaxies and stars today without dark matter. The dark matter has the gravity that causes the primordial gases to flow together and make galaxies and then stars. So we owe our existence to the dark matter, even though we can barely detect its presence today, and have never found a single particle of it in a laboratory. JWST's ability to study the history of galaxy formation will be a strong test of this idea.



## Appendix II

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ADDITIONAL MATERIAL FOR THE RECORD

STATEMENT SUBMITTED BY FULL COMMITTEE RANKING MEMBER  
EDDIE BERNICE JOHNSON

Good morning. I would like to welcome each of our witnesses to today's hearing. The topic of today's hearing is an important one as it presages a new chapter in NASA's human spaceflight activities.

Now almost halfway through this decade, substantial progress can be seen. The International Space Station was completed in 2010 and continues to show great promise as an orbital laboratory. NASA has started to build the next deep space exploration system of the future with the building blocks of the Space Launch System (SLS) and Orion crewed vehicle.

With the Space Shuttle retired, cargo resupply of the ISS is being turned over to two commercial providers, albeit a success made possible through substantial NASA financial investment and technical transfer. And, as we will hear today, NASA is working with Boeing and SpaceX to develop of future crewed commercial orbital transportation services to the Space Station.

This laudable progress is a testament to the hard work and perseverance by the NASA federal workforce and its industry partners. In the process, NASA has learned new ways of doing things and is adopting some of industry's best practices.

Yet, we should not lose sight of the fact that routine access to space is hard. Nor should we forget the painful lessons NASA has learned along the way to mitigate the risks of sending humans beyond the confines of Earth's surface.

This Committee has followed the many twists and turns NASA took in getting to this point with its Commercial Crew Program. Various contractual vehicles were used, and I will not take the time here to recount the Committee's concerns about inadequate insight into contractor designs and conformance with NASA safety requirements.

On one hand, I am somewhat comforted that Mr. Gerstenmaier is at the helm and feel confident in his commitment to fly NASA astronauts on commercial transportation systems only when safety has been demonstrated.

On the other hand, I am not comfortable, nor am I pleased, that the Aerospace Safety Advisory Board known as ASAP, Congress's safety adviser, was denied access to key information before contracts were awarded. Indeed, the Commercial Crew Program's denial caused the Panel Chairman to state in the ASAP's 2014 Annual Report that "the Panel is unable to offer any informed opinion regarding the adequacy of the certification process or the sufficiency of safety in the Commercial Crew Program (CCP) due to constraints on access to needed information."

Clearly, this is troublesome.

If NASA is to convince Congress that the two commercial crew transportation systems are safe, it must provide ASAP with information, by which the Panel can make objective assessments.

Mr. Chairman, I recognize that NASA and its two contractors have much work to do. The nation needs their important contributions to the space program.

I hope we can continue this dialogue through future hearings as part of the open communications that must form the basis of trust and transparency in this government-industry partnership.  
Thank you Mr. Chairman and I yield back.

