LESSONS FROM THE SOYUZ ROCKET FAILURE AND RETURN TO FLIGHT

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

WEDNESDAY, OCTOBER 12, 2011

Serial No. 112–43

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PRINTING OFFICE

70–589PDF WASHINGTON : 2011

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HON. RALPH M. HALL, Texas, *Chair*

F. JAMES SENSENBRENNER, JR., Wisconsin
LAMAR S. SMITH, Texas
DANA ROHRABACHER, California
ROSCOE G. BARTLETT, Maryland
FRANK D. LUCAS, Oklahoma
JUDY BIGGERT, Illinois
W. TODD AKIN, Missouri
RANDY NEUGEBAUER, Texas
MICHAEL T. McCAUL, Texas
PAUL C. BROUN, Georgia
SANDY ADAMS, Florida
BENJAMIN QUAYLE, Arizona
CHARLES J. "CHUCK" FLEISCHMANN, Tennessee
E. SCOTT RIGELL, Virginia
STEVEN M. PALAZZO, Mississippi
MO BROOKS, Alabama
ANDY HARRIS, Maryland
RANDY HULTGREN, Illinois
CHIP CRAVAACK, Minnesota
LARRY BUCSHON, Indiana
DAN BENISHEK, Michigan
VACANCY

EDDIE BERNICE JOHNSON, Texas
JERRY F. COSTELLO, Illinois
LYNN C. WOOLSEY, California
ZOE LOFGREN, California
BRAD MILLER, North Carolina
DANIEL LIPINSKI, Illinois
GABRIELLE GIFFORDS, Arizona
DONNA F. EDWARDS, Maryland
MARCIA L. FUDGE, Ohio
BEN R. LUJÁN, New Mexico
PAUL D. TONKO, New York
JERRY McNERNEY, California
JOHN P. SARBANES, Maryland
TERRI A. SEWELL, Alabama
FREDERICA S. WILSON, Florida
HANSEN CLARKE, Michigan

SUBCOMMITTEE ON SPACE AND AERONAUTICS

HON. STEVEN M. PALAZZO, Mississippi, *Chair*

F. JAMES SENSENBRENNER JR., Wisconsin
LAMAR S. SMITH, Texas
DANA ROHRABACHER, California
FRANK D. LUCAS, Oklahoma
W. TODD AKIN, Missouri
MICHAEL T. McCAUL, Texas
SANDY ADAMS, Florida
E. SCOTT RIGELL, Virginia
MO BROOKS, Alabama
RALPH M. HALL, Texas

GABRIELLE GIFFORDS, Arizona
MARCIA L. FUDGE, Ohio
JERRY F. COSTELLO, Illinois
TERRI A. SEWELL, Alabama
DONNA F. EDWARDS, Maryland
FREDERICA S. WILSON, Florida

EDDIE BERNICE JOHNSON, Texas

CONTENTS

Wednesday, October 12, 2011

LESSONS FROM THE SOYUZ ROCKET FAILURE AND RETURN TO FLIGHT

WEDNESDAY, OCTOBER 12, 2011

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 2:03 p.m., in Room 2318 of the Rayburn House Office Building, Hon. Steven Palazzo [Chairman of the Subcommittee] presiding.

Ralph Hall, Texas
Chairman

Eddie Bernice Johnson, Texas
Ranking Member

U.S. House of Representatives
Committee on Science, Space, and Technology
Suite 2321 Rayburn House Office Building
Washington, DC 20515-6301
(202) 225-6371

Subcommittee on Space and Aeronautics

The International Space Station: Lessons from the Soyuz Rocket Failure and Return to Flight

Wednesday, October 12, 2011
2:00 p.m.-4:00 p.m.
2318 Rayburn House Office Building

Witnesses

Mr. William H. Gerstenmaier
Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration

Lieutenant General Thomas P. Stafford, USAF (Ret)
Chairman, International Space Station Advisory Committee

Vice Admiral Joseph W. Dyer, USN (Ret)
Chairman, Aerospace Safety Advisory

HEARING CHARTER

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON SPACE AND AERONAUTICS U.S. HOUSE OF REPRESENTATIVES

The International Space Station: Lessons from the Soyuz Rocket Failure and Return to Flight

WEDNESDAY, OCTOBER 12, 2011
2:00 P.M.—4:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Introduction

On August 24, 2011, a Russian Progress unmanned cargo vehicle carrying supplies to the International Space Station (ISS) crashed during launch from the Baikonur Space Center, Kazakhstan. The crash was caused by a malfunction of the Soyuz-U third stage booster, which is nearly identical to the Soyuz-FG booster used to launch astronaut crews in the Soyuz capsule to the ISS. As a result, use of the Soyuz launch vehicle for astronaut transportation to the ISS has been suspended until the Russian Federal Space Agency (Roscosmos) completes its failure investigation, and the international partners reach agreement on recertification and return-to-flight plans. Both NASA and Roscosmos would like to launch two unmanned Soyuz boosters before recertifying the system to fly humans.

The launch failure highlights the risks of dependence on non-U.S. means for the strategically important capability of access to space. Since the termination of the Space Shuttle program, the Soyuz rocket with its Soyuz crew capsule is the only way to transport NASA and international partner crews to the ISS. The Soyuz crew capsule also serves as a lifeboat for ISS crews. Even with the shuttle (which could only stay at the ISS for about two weeks), ISS crews relied on the Soyuz capsule to serve as a lifeboat in the event of an emergency to return to Earth.

The purpose of the hearing is to review the impacts of the Soyuz launch vehicle failure on the safe operation and utilization of the ISS, the current status of the Roscosmos' accident investigation, recertification and return-to-flight plans, and the implications of de-crewing the ISS. The hearing will also examine the basis for NASA's decision to resume use of the Soyuz for transportation of its astronauts, including the advice it is receiving from external advisory bodies.

Witnesses

- **Mr. William H. Gerstenmaier**, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration
- **Lieutenant General Thomas P. Stafford, USAF (Ret.)**, Chairman, International Space Station Advisory Committee
- **Vice Admiral Joseph W. Dyer, USN (Ret.)**, Chairman, Aerospace Safety Advisory Panel

Overarching Questions and Concerns

- What is the status of Roscosmos' Soyuz launch vehicle failure investigations, and what are the milestones for the Soyuz return-to-flight activities?
- How much insight and influence do NASA and the Aerospace Safety Advisory Panel have into the Russian return-to-flight plans?
- What are the effects of a reduced three-person crew on ISS operations and scientific utilization?
- What are the contingency plans of NASA and the international partners if there are further delays in the Soyuz return-to-flight efforts?
- If the ISS is fully de-crewed in November, can it be maintained in a safe condition and for how long?
- What are the biggest risks associated with a de-crewed station?

Background and Timelines (All dates in Kazakhstan time)

August 24—The Russian Progress 44 unmanned cargo vehicle crashed during launch from the Baikonur Space Center in Kazakhstan. Roscosmos initiated an investigation into the cause of the Soyuz-U third stage failure.

August 29—Roscosmos attributed the Soyuz-U third stage failure to a malfunction in the engine's gas generator. The cause of the malfunctioning gas generator was not announced. However, the commission concluded the reason for the failure was specific to that engine and not a fleet-wide problem. Since the Soyuz rocket design has flown over a thousand successful flights, the malfunction was presumed to be caused by human error in the manufacturing or assembly process.

Russian news reports cited possible reasons for a decline in quality and workmanship as low salaries, an aging workforce, and lack of investment, coupled with an increased workload that requires manufacturing four Soyuz spacecraft per year to support a six-person ISS crew (during the Shuttle program only two Soyuz per year were required).

As a result of two unrelated failures of military satellite launches in December 2010 and February 2011, Roscosmos's chief Anatoly Perminov was forced to resign and Russian news media reported that a number of other senior space industry officials were fired. On September 22, 2011, the Russian News and Information Agency, RIA Novosti, reported that the recent failed launches were a reflection of the agency's management problems and quoted the new head of Roscosmos, Vladimir Popovkin saying, "We have found the causes [of the failures] and we are trying to identify the people who are responsible . . . But the troubles go much deeper to the level of management and control within the organization." Russian Prime Minister Vladimir Putin has ordered tougher quality controls of all Russian space hardware, including a quality review of all hardware currently in Roscosmos' possession.

Crew Rotation

The immediate issue facing the ISS crew is not lack of supplies. The recent—and final—Space Shuttle mission (STS–135) delivered enough to support a six-person crew through next year without being resupplied. However, the limiting factor governing the crew time on ISS is the certified lifetime of the Soyuz capsules that are docked to the station. Soyuz capsules are certified to spend no more than 200 days attached to the ISS because the peroxide thruster system degrades over time. The second issue affecting crew time on ISS are the lighting conditions and weather at the Soyuz landing site in Kazakhstan. The times when a Soyuz capsule can land are dictated by its path over the landing site and the weather conditions at the landing site. Severe weather exists across much of Kazakhstan during the winter months from December to February, making recovery impossible. There are extended periods of time when the orbit only passes over the landing site in darkness, which also make recovery impossible.

The dates governing the landing decisions are as follows:

September 19 to October 27—Period of darkness at the Soyuz landing site.
October 16—200-day certification limit of first Soyuz capsule (TMA–21).
November 22 to December 27—Period of darkness at the Soyuz landing site.
December 24—200-day certification limit of second Soyuz capsule (TMA–02M).

Space Station Is Partially De-Crewed

September 16—As a result of balancing the above requirements, the first Soyuz capsule (TMA–21) returned to Earth with American crewmember Ron Garan, and Russian crewmembers Andrei Borisenko, and Alexander Samokutyayev.

The other three crewmembers, Russian Sergei Volkov, American Mike Fossum, and Japanese Satoshi Furukawa, remain on the ISS with the second Soyuz capsule.

October 2—An unmanned Soyuz-2 rocket, which is similar but not identical to the one that failed in August, successfully launched a GLONASS-M navigation satellite from Russia's Plesetsk launch site. This was one of two uncrewed Soyuz rockets that Roscosmos is using to recertify the rocket for crew.

October 30—Planned launch of the unmanned Soyuz/Progress 45P to ISS from Baikonur Space Center, Kazakhstan. Again, this version of the Soyuz launch vehicle is similar, but not identical to the failed Soyuz-FG used for crew.

This would be the second of two unmanned Soyuz flights paving the way for the first crewed launch since the original failure.

November 14—Planned launch of the first crewed Soyuz (28S) since the accident. This mission would carry American crewmember Dan Burbank, and Russian crewmembers Anatoly Ivanishin and Anton Shkaplerov to the ISS on November 16th, restoring the crew size back up to six persons for only one week.

November 22—Planned landing of the second ISS-based Soyuz capsule (27S) carrying Russian Sergei Volkov, American Mike Fossum, and Japanese Satoshi Furukawa. This landing is timed to occur before the beginning of the darkness period.

De-Crewing the Space Station

If the November 14th launch is successful, the ISS would be left with three new crewmembers. If the November 14th launch is delayed, the ISS will be de-crewed, in which case it will be operated autonomously from the ground.

December 26—Planned launch of Soyuz 29S with three crewmembers. If the ISS is de-crewed in November, this will be the first opportunity to return crew to the ISS.

January 26, 2012—Planned launch of an unmanned Progress 46 resupply craft.

March 30—Planned launch of Soyuz 30S with a three-person crew.

Potential Effects of De-Crewing the Space Station

As mentioned above, if Roscosmos is unable to resume Soyuz flights by the middle of November, NASA will have to de-crew the ISS. NASA has contingency plans in place to configure ISS for extended autonomous operations without crew. In that case, NASA claims the ISS could be autonomously operated from the ground. According to NASA, the ISS has sufficient propellant aboard to maintain a stable orbit for an extended time. Prior to de-crewing, the habitation and research modules would need to be isolated and the structural hooks holding the unmanned Progress supply vehicles would need to be undone so that Progress vehicles could be undocked and docked autonomously. Debris avoidance maneuvers and reboosting could be accomplished from the ground.

Potential Effects on Research From De-Crewing the Space Station

The biomedical and human physiology research is among the most important for understanding and mitigating the effects of long-duration space flight necessary to enable exploration missions to destinations beyond low Earth orbit. This is the research that is most dramatically affected by de-crewing the ISS because this research depends collecting samples and data from crewmembers. On the current Expedition 28 there were more than 25 different investigations into human physiology. If the ISS must be de-crewed many of the biomedical projects that depend on multiple crew samples will be adversely impacted. Further, unanticipated malfunctions that require real-time diagnosis and repair will also be impacted by reduced crew size.

Chairman PALAZZO. The Subcommittee on Space and Aeronautics will come to order. Good afternoon, and welcome to today's hearing entitled, "The International Space Station: Lessons from the Soyuz Rocket Failure and Return to Flight." In front of you are packets containing the written testimony, biographies, and truth in testimony disclosures for today's witness panel.

I now recognize myself for five minutes for an opening statement.

Today's hearing has been called to examine the consequences of the August 24 launch failure of a Russian Progress cargo vehicle carrying supplies to the International Space Station and the implications of the failure on ISS operations. The Progress launch vehicle is very similar to those used to carry astronauts in a Soyuz capsule to the ISS, and for at least the next five years the Soyuz launch system and crew capsule is the only means of ferrying astronauts to and from the station.

Our dependence on the Russians should come as no surprise to anyone in this room. In the aftermath of the Columbia shuttle accident, the previous Administration proposed retiring the Shuttle and developing a follow-on system that we all knew as Constellation. Two different Congresses approved this plan in NASA authorization bills that were passed in 2005 and 2008.

In order to make the transition as affordable as possible, the Shuttle was to be retired first and the funds freed up from that program would then be applied to developing the Constellation launchers and crew capsule, and as a part of that transition it was clearly acknowledged that NASA would be fully reliant on the Russian Soyuz to carry astronauts to and from Station until we had a successor system developed. It would appear, however, that we may well end up being dependent on the Russians for more years than was originally anticipated as a result of the struggles between this Administration and Congress following the cancellation of the Constellation Program.

It is perhaps an ugly coincidence that one month following the Shuttle's final flight the Progress accident occurred, forcing Roscosmos and its supplier-base to re-examine their designs and quality assurance programs to account for the third-stage failure. I am hopeful our witnesses will be able to shed light on the accident investigation board's findings, the degree of insight offered by Roscosmos into the workings and deliberations of the accident investigation board, and offer their views about Russia's plans for recertifying the launcher.

The failure also caused NASA to contemplate the real possibility that ISS would have to be de-crewed if there were any extended delays in understanding and resolving the root causes of the accident.

While I understand that ISS can safely operate without crew aboard, there is always the risk of the unknown system failure, or worse, a debris hit that damages the integrity of the habitation modules. And after some point in time the capability of safely returning a crew may become more and more in doubt depending on the overall performance of the Station's array of systems.

Finally, I would note that construction of the Station was only recently completed. It has a finite lifetime of useful service before its systems become too unreliable and difficult to maintain. Thus, it is imperative that we take advantage of as many capabilities before maintenance becomes a major concern.

I want to welcome our guests for taking time from their busy schedules to appear before us today. I realize any appearance before a Congressional panel entails considerable time and effort, and I want you to know that your expertise and wisdom will be very helpful to this Committee and Congress.

Mr. Gerstenmaier, I want you to know that we are looking forward to your oral statement to answer the questions posed in our letter of invitation for today's hearing. I understand you were traveling internationally last week and weren't available to help draft the written testimony, while it provided information about the ISS's ability to operate without crew aboard it was not responsive to questions regarding the Progress failure and recovery plan. I am counting on your oral statement to fill in the missing details.

My thanks, again, to our witnesses. At this point I yield any remaining time I have to the chairman of the Science Committee, Mr. Hall, for any comments he might have.

[The prepared statement of Mr. Palazzo follows:]

PREPARED STATEMENT OF SUBCOMMITTEE CHAIRMAN STEVEN M. PALAZZO

Good afternoon. Today's hearing has been called to examine the consequences of the August 24 launch failure of a Russian Progress cargo vehicle carrying supplies to the International Space Station, and the implications of the failure on ISS operations. The Progress launch vehicle is very similar to those used to carry astronauts in a Soyuz capsule to ISS, and for at least the next five years, the Soyuz launch system and crew capsule is the only means of ferrying astronauts to and from station.

Our dependence on the Russians should come as no surprise to anyone in this room. In the aftermath of the Columbia shuttle accident, the previous Administration proposed retiring the Shuttle and developing a follow-on system that we all knew as Constellation. Two different Congresses approved this plan in NASA authorization bills that were passed in 2005 and 2008.

In order to make the transition as affordable as possible, the Shuttle was to be retired first and the funds freed up from that program would then be applied to developing the Constellation launchers and crew capsule. And as part of that transition, it was clearly acknowledged that NASA would be fully reliant on the Russian Soyuz to carry astronauts to and from station until we had a successor system developed. It would appear, however, that we may well end up being dependent on the Russians for more years than was originally anticipated as a result of struggles between this Administration and Congress following the cancellation of the Constellation program.

It's perhaps an ugly coincidence that one month following the Shuttle's final flight, the Progress accident occurred, forcing Roscosmos and its supplier-base to reexamine their designs and quality assurance programs to account for the third-stage failure. I am hopeful our witnesses will be able to shed light on the accident investigation board's findings, the degree of insight offered by Roscosmos into the workings and deliberations of the accident investigation board, and offer their views about Russia's plans for re-certifying the launcher.

The failure also caused NASA to contemplate the real possibility that the ISS would have to be de-crewed if there were any extended delays in understanding and resolving the root causes of the accident.

While I understand that ISS can safely operate without crew aboard, there is always the risk of the unknown system failure, or worse, a debris hit that damages the integrity of the habitation modules. And after some point in time, the capability of safely returning a crew may become more and more in doubt, depending on the overall performance of the station's array of systems.

Finally, I would note that construction of the station was only recently completed; it has a finite lifetime of useful service before its systems become too unreliable and difficult to maintain. Thus it is imperative that we take advantage of its many capabilities before maintenance becomes a major concern.

I want to welcome our guests for taking time from their busy schedules to appear before us today. I realize any appearance before a Congressional panel entails considerable time and effort, and I want you to know that your expertise and wisdom will be very helpful to this Committee and Congress.

Mr. Gerstenmaier, I want you to know that we're looking forward to your oral statement to answer the questions posed in our letter of invitation for today's hearing. I understand you were traveling internationally last week and weren't available to help draft the written testimony, which, while it provided information about the ISS's ability to operate without crew aboard, was not responsive to questions regarding the Progress failure and recovery plan. I am counting on your oral statement to fill in the missing details.

My thanks again to our witnesses.

Mr. HALL. Thank you, Mr. Chairman, and I thank you for calling this hearing, and my thanks to the witnesses. A special thanks to Bill Gerstenmaier, who will be introduced later. He has been here many times, and he is as knowledgeable as anybody I know. He knows everything that goes on at NASA, and he has had very good testimony, and Admiral Dyer, of course, is a long-time friend and Aerospace Safety Advisory. He is very valuable to us.

I just want to say a word or so, Mr. Chairman, if I might; you are going to introduce Tom Stafford, but I just want to say that I am really honored to have him here. He is here as the Chairman of the International Space Station Advisory Committee. One of the greatest things I know about him right now is that he is this year's winner of the prestigious Wright Brothers Memorial trophy, and that is really something.

Less than a month ago on September 21, General Stafford was named the recipient by the National Aeronautics Association in recognition of his, "pioneering achievements that have led the way to the Moon, to great international cooperation in space, and to a safer America," and he will formally be presented with the award at the Wright Memorial Dinner December 16 at the Washington Hilton Hotel, and I surely hope that I can be there with him.

Mr. Chairman, General Stafford has been a fighter pilot, a test pilot, astronaut, author, advisor to federal agencies, advisor to U.S. presidents. He commanded Gemini 9, further refining NASA's knowledge of rendezvous techniques that were later used on Apollo. He served as commander of Apollo 10, the first flight of the lunar module to the Moon, performed the first rendezvous around the Moon, and performed the entire lunar landing except for the actual landing.

I am proud to have him as a friend. I have been at his home. He has a son at Southern Methodist University, about 30 minutes from my home, and I hope to get to visit with him some and be as courteous to him as that whole family was to me when I was in your home, General. I thank you for that and for being recipient of this year's Wright Brothers Memorial trophy.

If I have any time left, I yield it to either my friend Sandy Adams, or I yield it back, and she can get her own. I am trying to do some good for her any chance I get.

[The prepared statement of Mr. Hall follows:]

PREPARED STATEMENT OF CHAIRMAN RALPH M. HALL

Mr. Palazzo, thank you for calling this afternoon's important hearing, and my thanks, too, to our witnesses for taking time from their busy schedules to be here.

The International Space Station is the centerpiece of NASA's human space flight program for the foreseeable future, and its capability to host a wide array of microgravity research has the potential to develop fundamentally new discoveries in biology, material sciences, and space physics.

Despite the tremendous successes of building and manning a station over the past decade, getting astronauts and cargo reliably and safely to and from the ISS has never been without significant risk. To their credit, NASA and its international partners have made the launches look routine, but as the August 24 failure of the Progress vehicle clearly showed, launching to orbit is still fraught with perils.

As the only means of ferrying astronauts to and from station for at least the next five years, it is incumbent on the Russians and NASA to ensure they have addressed the root cause of the Progress failure, and more importantly, to put safeguards in place to prevent future occurrences.

My thanks again to everyone for being here. I look forward to hearing your opening statements.

I yield back my time.

Chairman PALAZZO. Thank you, Mr. Hall, and Mrs. Adams will have time in a moment.

The chair now recognizes Mr. Costello for an opening statement.

Mr. COSTELLO. Mr. Chairman, thank you, and I thank you for calling the hearing today. I welcome all of our witnesses who will testify before the Subcommittee today, and I am looking forward to hearing their testimony and answering a few of our questions.

I am also pleased that the STS–135 crew is here today as well for the hearing, and I had the opportunity to visit with them earlier today. I want to recognize Sandra Magnus in particular, who is from my hometown of Belleville, Illinois. She attended the junior high school where my wife was first a teacher and eventually the principal. She also attended our district community college that my wife is president of now. So we know her whole family, and in fact, she has relatives who live three doors down from me in my home in Belleville. So it is good to see them here today, and we compliment you on your service and a successful mission.

With the retirement of the Space Shuttle, NASA is now fully dependent on Russia for transportation services to the ISS for at least the next five years until U.S. commercial crew services are available. A few weeks ago the risks associated with that dependence were clear when Russia experienced two back-to-back launch failures, including the malfunction in the upper stage of a Soyuz rocket transporting cargo to the ISS.

A few weeks ago our Russian partners identified the cause of these failures and set a date to resume manned flights. NASA and its international partners are confident that the necessary steps are being taken to correct these malfunctions. We must use this opportunity to learn from these failures and plan for the future.

Specifically, I would like to hear from our witnesses on two issues. One, does NASA have adequate insight into the investigation conducted by the Russian authorities to make informed decisions about resuming Soyuz use and how we can build on that information and share that information in the future?

Second, how will NASA and the external safety bodies work together to enhance the safety of crew and cargo transport operations in the future?

Mr. Chairman, I especially want to know as we transition from relying on our international partners to using commercial providers what the assessment is of our witnesses here today.

I welcome our panel of witnesses, look forward to hearing their testimony, and hearing their answers to the questions that we will pose to them. Thank you.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF ACTING RANKING MEMBER JERRY F. COSTELLO

Mr. Chairman, thank you for holding today's hearing to receive testimony on the impacts ofthe Soyuz launch vehicle failure to the International Space Station (ISS).

With the retirement of the Space Shuttle, NASA is now fully dependent on Russia for transportation services to the ISS for at least the next five years, until U.S. commercial crew services are available. A few weeks ago, the risks associated with that dependence were clear when Russia experienced two back-to-back launch failures, including a malfunction in the upper stage of a Soyuz rocket transportiug cargo to the ISS.

A few weeks ago, our Russian partner identified the cause of these failures and set a date to resume manned flights. NASA and its international partners are confident tbat the necessary steps are being taken to correct these malfunctions.

We must use this opportnnity to learn from these failures and plan for the future. Specifically, I would like to hear from our witnesses on two issues.

First, does NASA have adequate insight into the investigations conducted by Russian authorities to make informed decisions about resuming Soyuz use and how can we build that information sharing in the future.

Second, how will NASA and external safety bodies work together to enhance the safety of crew and cargo transport operations in the future, especially as we transition from relying on our international partners to using commercial providers .

I welcome our panel of witnesses and look forward to their testimony. I yield back the balance of my time.

Chairman PALAZZO. Thank you, Mr. Costello. 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 witness panel, but before doing so I want to recognize four very special guests sitting in the audience. We have with us today the crew of STS–135 who flew on the Shuttle Atlantis for the final Shuttle mission flown by NASA. They launched on July 8 from Kennedy Space Center carrying supplies, logistics, and spare parts to sustain ISS through the months and years ahead.

I would like to ask each crew member to rise as I read your name. Chris Ferguson, mission commander. STS–135 was his third space flight mission; Doug Hurley, pilot, his second space flight mission; Rex Walheim, mission specialist, his third mission; and Sandy Magnus, mission specialist, and her third mission.

We are honored and proud to have you join us. Thanks to you all and thank you for your service to our country and the space program. Thank you.

Our first witness will be Mr. William Gerstenmaier, NASA Associate Administrator for Human Exploration and Operations Mission Directorate. Mr. Gerstenmaier began his career at NASA in 1977, after graduating from Purdue University with a Bachelor of Science degree in aeronautical engineering. During his tenure at NASA, Mr. Gerstenmaier has led a number of activities associated with the Shuttle, International Space Station, and the Shuttle-Mir Program. He was program manager of the ISS office at the Johnson Space Center and most recently served as associate administrator for space operations prior to the summer's reorganization. Mr. Gerstenmaier has received a number of awards at NASA, including the Presidential Rank Award for meritorious executives. We are delighted to have you with us here today.

Our second witness was already aptly introduced by Chairman Hall, so we will move onto our third witness and our final witness, who will be Vice Admiral Joseph Dyer, Chairman of the Aerospace Safety Advisory Panel which was created by Congress in 1968, to advise the Administrator and Congress on matters related to hazards of facilities, operations, and safety standards. Admiral Dyer graduated from North Carolina State University with a degree in chemical engineering, earned his wings as a naval aviator, and through the course of his career served as the Navy's chief test pilot, Commander of the Naval Air Warfare Center, Aircraft Division, F–18 Program Manager, and as Commander of the Naval Air Systems Command. Today Admiral Dyer serves as Chief Operating Officer of the iRobot Corporation. Admiral, it is good to have you join us here today.

As our witnesses should know, spoken testimony is limited to five minutes each, after which the members of the committee will have five minutes each to ask questions.

I now recognize our first witness, Mr. William Gerstenmaier, Associate Administrator of the Human Exploration and Operations Mission Directorate of NASA.

STATEMENT OF MR. WILLIAM H. GERSTENMAIER, ASSOCIATE ADMINISTRATOR, HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. GERSTENMAIER. Thank you, Mr. Chairman and Members of the Subcommittee. Thank you for the opportunity to appear before you today to discuss the status of the International Space Station Program and in particular the recent Progress 44 anomaly.

On August 24 of this year our Progress cargo ship was lost when the upper stage of its launch vehicle shut down before reaching orbital velocity. Our Russian partners formed a commission to investigate the anomaly and, as has been the case with previous investigations, have kept NASA well informed about the progress of their review.

I have traveled to Russia along with the ISS program manager and met personally with the chairman of the Russian Commission to discuss their findings and conclusions. The launch vehicle involved, which is used for both Progress and Soyuz spacecraft, is a highly-reliable booster based on a design that has been flying for many decades. NASA is confident that our Russian partners identified the most likely failure cause and have a sound return-to-flight plan.

The Russian Failure Investigation Commission has identified low fuel feed to the gas generator as the cause of the emergency shutdown of the 44 Progress third-stage engine due to off-nominal engine performance. The most likely cause of this anomaly is contamination in the fuel lines to the gas generator or in the stabilizer valve. The contamination most likely was introduced in a post-engine hot fire acceptance test inspections.

The Russian Federal Space Agency, Roscosmos, and its contractors have a plan in place to validate engines for the near-term launches, including improving quality control process such as adding additional inspectors and videotaping critical actions related to component assembly.

Roscosmos has shared its data with NASA. NASA has formed an independent U.S. team to look at the information provided by the Russians. The NASA independent team agrees with the Russian Commission conclusions regarding a likely cause of the engine shutdown and the corrective actions. This NASA team out-briefed their findings to the safety community and the rest of the NASA engineering staff today.

As part of its efforts to resolve the Progress anomaly, the Russians returned 18 upper-stage engines to the factory for inspection and test firings. So far they have not found any issues with these engines. The engines that are slated to be used for the next Progress flight, as well as the next two Soyuz flights, have been built using the new quality control processes and are not part of the 18 returned engines.

The ISS partnership has developed a new manifest plan that provides for the launch of 45 Progress on the 30th of October and Soyuz 28 on November 14, which will have five days of handover between the 27 Soyuz crew and the 28 Soyuz crew members. The 27 Soyuz crew is scheduled to return on November 22.

While the need to de-crew or remove the crew from ISS is remote, NASA nonetheless has a set of procedures in place for this case. The crew has performed several onboard reconfigurations and maintenance tasks to better prepare the ISS for this unlikely contingency. The current three-person crew onboard the ISS is in no danger, and the station itself can be flown un-crewed from mission control. Over the long term, the crew has a key role to play in maintenance of systems onboard the ISS as astronauts address anomalies and perform repairs to critical ISS systems both inside and outside the vehicle.

Research is continuing with the three-person crew, and although the number of investigations that are being performed is less than with six crew, quality research is still being done every day. If the ISS needed to be de-crewed, the largest impact would obviously be to crew-tended research.

In conclusion, the ISS Program has been successful in large part because of the flexibility and resourcefulness of the partnership in adapting to changes in environments and challenges. The ISS represents an unparalleled capability for human space-based research. Its facilities can support research in the areas of high-energy particle physics, Earth remote sensing, geophysics, protein crystallization, human physiology, radiation, plant and cultivation experiments, fluids and combustion material science, and biology.

ISS will continue to help NASA prepare for the next steps in human exploration, steps that will take astronauts beyond low-earth orbit to destinations such as asteroids, the Moon, and Mars. NASA anticipates that many investigations conducted aboard the ISS will have application to terrestrial medicine as well. For example, the growing senior population may benefit from experiments in the areas of bone and muscle health, immunology, and from the advancement of new diagnostic systems.

There are many challenges ahead, some anticipated and some not. The recent loss of the Progress was an example of the latter. However, the ISS partnership was prepared. The final Shuttle flight, STS–135, and the detailed logistics planning over the past year provided the margin that prevented the loss from having immediate logistical consequences. The Russians are preparing for return to flight. The program team is now also working aggressively to bring onboard the new domestic commercial cargo providers. None of this is easy. NASA will need your help in ensuring that the team is allowed to do its work with full support.

The support provided by Congress for STS–135 is an example of the larger team all working together. If we continue to work together, the ISS will remain an amazing facility that yields remarkable results to further benefit the world.

Mr. Chairman, I have submitted a more detailed written statement, and I will be happy to answer any of your questions as we go through the hearing. Thank you.

[The prepared statement of Mr. Gerstenmaier follows:]

PREPARED STATEMENT OF MR. WILLIAM H. GERSTENMAIER, ASSOCIATE ADMINISTRATOR, HUMAN EXPLORATION AND OPERATIONS MISSION DIRECTORATE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear before you today to discuss the status of the International Space Station (ISS) Program. This has been a remarkable year, as we have completed assembling and outfitting of the U.S. On-orbit Segment (USOS) of the ISS, allowing us to focus on full utilization of the Station's research capabilities; taken key steps in moving forward into the future of exploration beyond Low Earth Orbit (LEO); celebrated the 50th anniversary of human spaceflight; and witnessed the successful conclusion of the historic Space Shuttle Program. Today, I would like to provide you with information on the current health of the ISS, our plans for transporting cargo and crew to Station, our efforts to promote ISS as a National Laboratory, and research being done aboard Station that will support the Nation's exploration goals.

International Space Station—USOS Assembly Complete and Research-Ready

The ISS is the culmination of the efforts of the United States and its Canadian, European, Japanese, and Russian partners to work together to construct a highly complex and capable spacecraft with components built in many nations around the globe, launched from four different space centers, and assembled on orbit by astronauts conducting over 160 spacewalks. It represents an unparalleled capability for human space-based research. The STS–135 mission, flown by Space Shuttle Atlantis in July of this year, marked the conclusion of the successful Space Shuttle Program after 30 years of flight, as well as the completion of major assembly and outfitting activities on the ISS. The Station, including its large solar arrays, spans the area of a U.S. football field, including the end zones, and weighs over 860,000 pounds, not including visiting vehicles. The complex has more livable room than a conventional five-bedroom house, and has two bathrooms, a fitness center, a 360-degree bay window, and, most importantly, state-of-the-art scientific research facilities. These research facilities can support a large variety of research disciplines. Examples include high-energy particle physics, Earth remote sensing and geophysics experiments, protein crystallization experiments, human physiology research (including bone and muscle research), radiation research, plant and cultivation experiments, combustion research, fluid research, materials science experiments, and biological investigations. Since November 2, 2001, when the crew of Expedition 1 docked with the ISS, the Station has been visited by more than 200 people, and has been continuously crewed for almost 11 years. By way of comparison, the first U.S. space station, Skylab, hosted three crews—a total of nine people—with the longest mission duration being 84 days.

Beyond being a feat of unparalleled engineering and construction, as well as international collaboration, the ISS is a place to learn how to live and work in space over a long period of time. It is a place to conduct research and development (R&D) that cannot be pursued on Earth due to our gravitational field. The three major science laboratories aboard the ISS—the U.S. Destiny, European Columbus, and Japanese Kibo facilities, and external test beds—enable astronauts to conduct a wide variety of experiments in the unique, microgravity and ultra-vacuum environment of LEO. It is important to note that the Station supports R&D across an array of disciplines, including biology and biotechnology, Earth science, space science, human research, physical and materials science, and technology development. This means that R&D conducted aboard Station holds out the promise of new discoveries not only in areas directly related to NASA's exploration efforts, but in fields that have terrestrial applications, as well. The ISS will provide these opportunities to scientists and technologists through at least 2020.

In addition to the direct research benefits to be gained by the ISS as a National Laboratory, this innovative arrangement also supports NASA's effort to promote the development of a LEO space economy. National Lab partners can use the unique microgravity environment of space and the advanced research facilities aboard Station to enable investigations that may give them the edge in the global competition to develop valuable, high technology products and services. Furthermore, the demand for access to the ISS will support the providers of commercial crew and cargo systems. Both of these aspects of the ISS as a National Laboratory will help establish and demonstrate the market for research in LEO beyond the requirements of NASA.

Supporting Assets—the Current Cargo and Crew Vehicles of the ISS

In order to realize the full potential of the ISS' capabilities, the platform is serviced by a fleet of operational international vehicles, and the U.S. cargo vehicles are in the final stages of development to help ensure robust operations. U.S. commercial crew transportation is being advanced with the recent release of a draft Request for Proposals (RFP) for the integrated design phase of the Commercial Crew Program. The international spacecraft currently include the Russian Soyuz crew transport, the Russian Progress cargo vehicle, the Japanese H–II Transfer Vehicle (HTV), and the European Automated Transfer Vehicle (ATV).

- The Soyuz spacecraft, an evolutionary development of a vehicle that has been flying since 1967, provides transportation to and from the ISS for the Expedition crews. Soyuz also has the capability to remain docked to the Station for the six-month periods required to support these crews, providing an on-orbit rescue capability in the event of a contingency aboard the ISS. The Station can host six crewmembers on long-duration missions with the support of two Soyuz spacecraft.
- The uncrewed Progress cargo vehicle is closely related to the Soyuz, and is used to resupply the ISS with dry cargo, propellant, water, and gas; it is also used to boost the orbit of the ISS and control the orientation of the Station. At the end of its mission, Progress is filled with trash, undocks from the ISS, and is incinerated in Earth's atmosphere in a controlled re-entry.
- The HTV can carry dry cargo, gas and water to ISS, and has both pressurized and unpressurized cargo carriage capability. Like the Progress, HTV can also provide trash removal at the end of its mission.
- The ATV can carry dry cargo, atmospheric gas, water and propellant, and also provide trash removal at the end of its mission. As with the Progress, the ATV can boost the Station's orbit and control the orientation of the ISS.

The ISS is a highly robust platform for scientific research and technology development. This is due in part to the design of the Station itself and its ability to be operated from the ground. In addition, the ISS has been well provisioned by pre-positioning of key spares and supplies on ISS by the Space Shuttle, and will be supported by the current fleet of vehicles available to provide cargo and crew transportation. With the retirement of the Shuttle, the United States is temporarily without a domestic vehicle for carrying crew or cargo to the ISS. (Even when the Shuttle was transporting crew to the ISS, NASA still needed the Russian Soyuz to serve as a crew rescue vehicle.) NASA and its commercial partners are working to field the next American spacecraft to service the Station, helping to ensure that its full potential can be realized.

ISS Robustness and Possibility of Un-Crewed Operations

Since its inception, the ISS has been designed and built to be operated without onboard crew, to be crew-tended, and to be permanently crewed. Critical systems that are required to maintain a stable orbit, such as guidance, navigation and control, and communications, are multi-failure tolerant and have dissimilar redundancy across the U.S. and Russian elements. This active control architecture provides for robust and failure-tolerant operations that do not require crew intervention, as the Station can be commanded through both the U.S. and Russian Mission Control Centers. Other systems, such as power generation and thermal systems, are also failure tolerant and have excess capacity to accommodate off-nominal or failure conditions. Under most operating conditions, the crew is not required to maintain the Station in orbit and, much like robotic spacecraft, the ISS is operated exclusively by ground control. The crew is normally active in maintaining crew systems such as exercise equipment and life support systems; however, these systems are not required during extended un-crewed operations.

Over the long term, the on-orbit crew has a key role to play in maintenance of the systems aboard ISS, as astronauts can address anomalies and perform repairs to critical ISS systems—both inside and outside the vehicle. In the summer of 2010, a coolant pump module on the exterior of the Station failed. The module was critical to the full operation of the ISS, as it was used to move ammonia through the Station's thermal control system, enabling the dissipation of heat that would otherwise force the shut-down of various systems. Spacewalking astronauts were on hand to remove the faulty module and replace it with a new pump, thus ensuring continued nominal operations.

On August 24 of this year, a Progress cargo ship was lost when the upper stage of its launch vehicle shut down before reaching orbital velocity. Our Russian partners formed a commission to investigate the anomaly, and—as has been the case with previous investigations—have kept NASA well informed about the progress of their review. The launch vehicle involved, which is used for both Progress and Soyuz spacecraft, is a highly reliable booster based on a design that has been flying for many decades. NASA is confident that our Russian partner will resolve the root cause of the accident and safely return the Soyuz booster to flight.

While the need to de-crew is not anticipated, NASA has a set of standard procedures in place for de-crewing the Station, should it become necessary to return the Soyuz currently on orbit before the next mission is flown. NASA is once again reviewing these procedures to ensure they are optimized for the current configuration of, and situation on, ISS. While this is not a likely scenario, NASA is nonetheless prepared for the contingency. It should be noted that the current three-person crew aboard ISS is in no danger, and that the Station itself can be flown, uncrewed, from mission control. While human-tended research would have to cease until crew were able to return to the Station, a number of experiments could be run autonomously, including the recently-installed Alpha Magnetic Spectrometer (AMS) experiment. The design of ISS and its control interfaces help ensure the maintenance and operation of the laboratory.

With the recent Progress launch failure, the ISS Partners began preparations for the possibility of short-term de-crewing the Station in the event that the Soyuz 27 crewmembers would have to leave the ISS untended on their return to Earth on November 22, 2011. The plan includes such items as closing module hatches, stowing equipment, configuring systems such as Environmental Control and Life Support System (ECLSS) for re-crewing, and providing additional cross-strapping between power and command and control systems. Since Expedition 1 in November 2000, the ISS has been prepared for short-term uncrewed operations 22 times due to extravehicular activities (EVA) operations during the period of two-crew (post-Columbia) and Soyuz relocations. In addition, plans are also in place for long-term uncrewed operations in the remote event of an extended gap in crew transfer capabilities. These plans are codified in the Flight Rules and include such crew actions as reconfiguring elements and distributed systems, checking switch positions and resetting limit set-points, topping off or draining fluids, inspecting seals, disposing of batteries, repositioning equipment necessary to re-crewing, and environmental sampling. These procedures have been established for every domestic and international element in the ISS configuration.

Since the return of the Soyuz 26 crewmembers in September of this year, the ISS has been occupied by three crewmembers. Lessons learned on how to operate the ISS in a reduced crew capacity after the Columbia accident have been incorporated into NASA's planning. As a result, during the current three-crew operations period, the crew is able to meet utilization objectives that were previously planned. In the event of an actual de-crewing, scientific results that require crew action would be secured in a recoverable configuration prior to departure. Additionally, utilization that does not require crew action, such as the AMS, will continue as normal.

On September 15, 2011, the ISS Partners held a Space Station Control Board meeting to baseline a new Progress and Soyuz flight plan based on the results of the Russian commission that was chartered to investigate the root cause of the Progress failure and to recommend recovery and remediation activities. The new plan provides for the launch of Soyuz 28 on November 14, 2011, which will allow approximately five days of handover between the 27S and 28S crewmembers. With the successful execution of the new flight plan, de-crewing the Station is considered unlikely.

The Shape of Things to Come—U.S. Commercial Cargo and Crew Transportation Services for the ISS

The ISS Program has made LEO a venue for international cooperation in the construction and operation of large space structures and for R&D across many disciplines. Now, the Station will also serve to promote the growth of a LEO space economy by operating as a customer and a destination for U.S. companies capable of transporting of crew and cargo into orbit.

In the area of commercial cargo transportation, NASA has implemented a two-phased approach for developing and procuring services: Commercial Orbital Transportation Services (COTS) to develop and demonstrate commercial cargo transportation systems; and Commercial Resupply Services (CRS) to procure cargo resupply services to and from the ISS.

Commercial Orbital Transportation Services

As part of COTS, NASA has partnerships with Space Exploration Technologies, Inc. (SpaceX) and Orbital Sciences Corporation (Orbital) using funded Space Act Agreements (SAAs). These agreements include a schedule of fixed payment performance milestones culminating in a demonstration mission to the ISS that includes vehicle launch, spacecraft rendezvous, ISS berthing, and re-entry for disposal or return safely to Earth.

Both COTS partners continue to make progress in developing and demonstrating their systems.

- On December 8, 2010, SpaceX successfully completed their first COTS demonstration flight, by launch of the Falcon 9 booster with Dragon spacecraft, separation of the Dragon spacecraft, completion of two orbits, orbital maneuvering and control, reentry, parachute descent, and spacecraft recovery after splashdown. NASA is reviewing a SpaceX proposal to combine the flight test objectives of the second and third demonstration flights into a single mission.
- The pad complex at Wallops Flight Facility in Virginia is being readied for the start of tests of the Taurus II vehicle, and the first hot-fire test on the pad is on track for November/December 2011. Orbital is currently performing first-stage integration and check-out, and beginning the process of mating the engines to the stage in preparation for hot-fire testing. The first flight is still on target by the end of this year.

Commercial Resupply Services

On December 23, 2008, NASA awarded CRS contracts to Orbital and SpaceX for the delivery of cargo to the ISS after the retirement of the Shuttle. NASA anticipates that both providers will have their systems operational in 2012.

- NASA ordered 12 CRS flights from SpaceX. The first SpaceX CRS flight is scheduled for Spring 2012, and the company is slated to fly three CRS missions each fiscal year from 2012 through 2015. The January 2012 date is dependent on SpaceX's successful completion of its COTS demo flight(s).
- NASA ordered eight CRS flights from Orbital. The first Orbital CRS flight is scheduled for winter 2012 and the company is slated to fly two CRS missions each fiscal year from 2012 through 2015.

NASA is pleased with the steady progress both companies continue to make in their cargo development efforts. We need to anticipate the inevitable start-up challenges associated with a technologically ambitious endeavor. Both NASA and these providers have spent many years preparing for the full utilization phase of ISS. Now is the time when we will begin to see the fruits of this planning and development. NASA is engaged in ISS utilization and with the help and dedication of these providers; ISS will be more extensively utilized and positioned to demonstrate the benefits of space-based R&D more widely to the world.

Commercial Crew Development (CCDev)

In the area of commercial crew transportation, NASA investments have been aimed at stimulating efforts within the private sector to develop and demonstrate human spaceflight capabilities through the CCDev initiative. Since 2009, NASA has conducted two CCDev rounds, soliciting proposals from U.S. industry participants to further advance commercial crew space transportation system concepts and mature the design and development of elements of the system, such as launch vehicles and spacecraft. The first round of CCDev awarded five funded Space Act Agreements (SAAs) in February 2010, which concluded in the first quarter of 2011. Awardees were Blue Origin, the Boeing Company, Paragon Space Development Corporation, Sierra Nevada Corporation, and United Launch Alliance (ULA). During the second CCDev competition, NASA awarded four funded SAAs that are currently being executed with the following industry partners:

- Blue Origin's work involves risk-reduction activities related to development of a Crew Transportation System (CTS) comprised of a reusable biconic Space Vehicle (SV) launched first on an Atlas V launch vehicle and then on Blue Origin's own Reusable Booster System (RBS). They are working to mature their SV design through Systems Requirements Review (SRR), mature the Pusher Escape System, and accelerate engine development for the RBS.
- The Boeing Company is maturing their commercial crew transportation system through Preliminary Design Review (PDR) and performing development tests. Boeing's system concept is a capsule-based spacecraft reusable for up to 10 missions that is compatible with multiple launch vehicles. Boeing's effort will include launch abort engine fabrication and static test fire, landing air bag drop demonstration, wind tunnel testing, parachute drop tests, Service Module Propellant Tank Development Test, and Launch Vehicle Emergency Detection System/Avionics System Integration Facility Interface Simulation Test.
- Sierra Nevada Corporation (SNC) is maturing their commercial crew transportation system, the Dream Chaser, through PDR with some subsystems to Critical Design Review (CDR). The Dream Chaser is a reusable, piloted lifting body, derived from NASA HL–20 that will be launched on an Atlas V launch vehicle. SNC's effort also includes fabrication of an atmospheric flight test vehicle, conducting analysis and risk mitigation, and conducting hardware testing.
- SpaceX is maturing their flight-proven Falcon 9/Dragon transportation system focusing on developing an integrated, side-mounted Launch Abort System (LAS). The uncrewed version of Dragon is already being demonstrated as part of COTS, and will be used operationally as part of the CRS effort. Their crew transportation system is based on the existing Falcon 9 launch vehicle and Dragon spacecraft which have been designed since inception for crew carriage with relatively minimal modification. The LAS, an essential safety-critical system, represents the longest-lead portion of the Falcon 9/Dragon transportation system to prepare for crew carriage.

In addition to the four funded agreements mentioned above, NASA has also signed SAAs that execute without funding with two companies: Alliant Techsystems, Inc. (ATK) and ULA. The ATK agreement is to advance the company's Liberty launch vehicle concept. The ULA agreement is to accelerate the potential use of the Atlas V as part of a commercial crew transportation system.

Commercial Crew Program

On September 19, 2011, NASA released a draft RFP that outlines a contract to provide a complete end-to-end design, including spacecraft, launch vehicles, launch services, ground and mission operations and recovery. This draft RFP is for what NASA had been referring to as "CCDev 3." However, the Agency is no longer using that term because NASA is not doing a third round of SAAs modeled after the original CCDev agreements. Instead, NASA's strategy has evolved into an overall hybrid structure over the lifecycle of the program, building on the progress made by the SAAs and transitioning into a series of competitively awarded contracts. NASA has formulated its approach specifically to reduce overspecification of requirements and to implement the lessons learned throughout the Agency's history regarding requirements control. Further NASA is making considerable effort to alleviate some of the administration burdens to industry associated with contracts as well as working to maximize benefits such as commercial retention of IP rights, etc. The draft RFP for this contract is for the integrated design phase of the Commercial Crew Program. NASA plans to release the final RFP for this effort by the end of 2011, and anticipates that one or more operational commercial crew systems will be available for the transportation of astronauts to and from the ISS—as well as the provision of rescue services—by the middle of this decade. Success of this program would also end the outsourcing of work to foreign providers. Together with the capabilities to explore deep space provided by the Space Launch System and the Multi-Purpose Crew Vehicle, NASA looks forward to moving forward on its robust, comprehensive U.S. human spaceflight program. NASA is mindful that reductions from the President's FY 2012 requested funding level would affect our ability to successfully implement this program and its procurement strategy, and could leave us dependent on foreign transportation services for a longer period of time at a cost of at least $480 million per year. The success of this program will ensure that U.S. companies will provide these services and create good-paying American jobs.

NASA's efforts to assist in the development of U.S. commercial cargo and crew vehicles represent a new way of doing business for the Agency. Using this approach, we plan to procure domestic crew transportation services—rather than own and operate vehicles or procure services from an international partner—to support the ISS. By providing the foundation on which private industry can build, the Agency will also encourage the use of these systems by other customers as well.

Frontiers of R&D—the ISS as a National Laboratory

In the NASA Authorization Act of 2005 (P.L. 109–155), Congress designated the U.S. segment of the ISS as a National Laboratory, and directed the Administrator to seek to increase the utilization of the ISS by other Federal entities and the private sector. NASA has made great strides in its effort to engage other organizations in the ISS program, and the Agency now has Memoranda of Understanding with five federal agencies and SAAs with nine companies and universities; they include:

- National Institutes of Health—Nine participating institutes
- Department of Energy—Implementing Arrangement for 10-year deployment of the Alpha Magnetic Spectrometer (AMS)
- National Science Foundation—Interest in free-flying nanosat deployments from ISS visiting vehicles and external instruments
- U.S. Department of Agriculture—Plant and animal sciences and applications
- Department of Defense—Engineering research and defense sciences
- Bioserve Space Technologies, University of Colorado, Boulder—Limited flight opportunities on final Shuttle flights to enable National Lab pathfinder payloads
- Astrogenetix, Astrotech International, Inc.—Vaccine development for bacterial pathogens
- Ad Astra Rocket Company—Demonstration of VASIMR© propulsion technology
- NANORACKS, LLC—Nanoscale payload accommodations hardware for pressurized operations
- Zero Gravity, Inc.—Proof-of-concept for accelerated plant cultivar development
- Boeing Aerospace—Proof-of-concept for software interface system to allow users to use their lab control systems with on-board experiments
- Louisiana State University—Continuation of previously awarded peer reviewed research in miscible fluids behavior in microgravity

NASA is exploring additional opportunities with other organizations.

In the NASA Authorization Act of 2010 (P.L. 111–267), Congress directed that the Agency enter into a cooperative agreement with a not-for-profit organization to manage the activities of the ISS National Laboratory. To this end, NASA issued a cooperative agreement notice on February 14, 2011, and on August 31, 2011, the Agency finalized a cooperative agreement with the Center for the Advancement of Science in Space (CASIS) to manage the portion of the ISS that operates as a U.S. National Laboratory. CASIS will be located in the Space Life Sciences Laboratory at Kennedy Space Center in Florida. The independent, nonprofit research management organization will help ensure the Station's unique capabilities are available to the broadest possible cross-section of U.S. scientific, technological and industrial communities.

CASIS will develop and manage a varied R&D portfolio based on U.S. national needs for basic and applied research; establish a marketplace to facilitate matching research pathways with qualified funding sources; and stimulate interest in using the national lab for research and technology demonstrations and as a platform for science, technology, engineering and mathematics education. The goal is to support, promote and accelerate innovations and new discoveries in science, engineering and technology that will improve life on Earth.

Preparing for the Next Giant Leap—Supporting Beyond-LEO Exploration

While the ISS offers extraordinary opportunities for advancing science and technology to other U.S. Government agencies, non-profit research foundations, and private firms, it will also continue to meet NASA's mission objective to prepare for the next steps in human space exploration—steps which will take astronauts beyond LEO to destinations such as the asteroids, the Moon, and eventually, Mars.

The ISS is NASA's only long-duration flight analog for future human lunar outpost missions and Mars transit missions. It provides an invaluable laboratory for research with direct application to the exploration requirements that address human risks associated with deep space missions. It is the only space-based multinational research and technology test-bed available to identify and quantify risks to human health and performance, identify and validate potential risk mitigation techniques, and develop countermeasures for future human exploration.

The ISS research portfolio includes human research and the development of countermeasures to reduce the deleterious effects of microgravity for long-duration exploration missions. ISS crews are conducting human medical research to develop knowledge in the areas of clinical medicine, human physiology, cardiovascular research, bone and muscle health, neurovestibular medicine, diagnostic instruments and sensors, advanced ultrasound, exercise and pharmacological countermeasures, food and nutrition, immunology and infection, exercise systems, and human behavior and performance. While this research is aimed at enabling astronauts to push the boundaries of exploration beyond LEO, NASA anticipates that many investigations conducted aboard ISS will have application to terrestrial medicine as well. For example, the growing senior population may benefit from experiments in the areas of bone and muscle health, immunology, and from the development of advanced diagnostic systems.

In the physical and biological sciences arena, the ISS is using microgravity conditions to understand the effect of the microgravity environment on fluid physics, combustion science and materials processing, as well as environmental control and fire safety technologies. The ISS also provides a test-bed for studying, developing, and testing new technologies for use in future exploration missions. Finally, Station is an available platform for observing the Earth and can support educational activities, including observations and investigations which allow students and the public to connect with the ISS mission and inspire students to excel in science, technology, engineering, and math.

Conclusion

From September 2000 to October 2010, 1,149 investigations were conducted aboard the ISS. These included U.S., International Partner, and National Laboratory Pathfinder investigations. This research involved 1,600 scientists and has already resulted in more than 310 scientific publications. Station has now entered its intensive research phase, and this phase will continue through at least 2020.

The ISS Program has been successful in large part because of the flexibility and resourcefulness of the Partnership in adapting to changing environments and challenges. NASA will pursue its exploration-related research at the same time that we are progressing to expand the use of the ISS to other Government agencies as well as commercial users—the National Laboratory effort is key to this expansion of U.S. research utilization aboard the Station. The ISS Program is also important to the development of commercial transportation services that can serve Government and non-government users in the new space economy, and vice versa. Finally, Station is an invaluable training ground for the next generation of space explorers and researchers. NASA is proud of the work the Agency and its International Partners have done in designing and assembling the ISS on orbit; Station represents a tremendous engineering achievement. However, this is only the beginning of the Program's accomplishments, and NASA looks forward to continuing work with our Partners to ensure that this remarkable research asset is available to scientists working in many disciplines for years to come.

There are many challenges ahead, some anticipated and some not. The recent loss of Progress was the latter. However, the ISS Partnership was prepared. The final Shuttle flight, STS–135, and the detailed logistics planning over the past year provided the margin that prevented the loss from having immediate logistical consequences. The Program is busy preparing and optimizing for the next contingency.

The Russians are preparing for return to flight and working to make the Soyuz booster system more reliable. The Program team is also working aggressively to bring on board the new domestic commercial cargo providers. None of this is easy. NASA will need your help in ensuring that the team is allowed to do its work with full support. If we all work together, the ISS will continue to be an amazing facility that yields remarkable results and further benefits for the world.

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

Chairman PALAZZO. Thank you, Mr. Gerstenmaier.

I now recognize our second witness, Lieutenant General Thomas Stafford, United States Air Force, Retired, and current Chairman of the International Space Station Advisory Committee.

STATEMENT OF LIEUTENANT GENERAL THOMAS P. STAFFORD, USAF (RET.), CHAIRMAN, INTERNATIONAL SPACE STATION ADVISORY COMMITTEE

Lieutenant General STAFFORD. Chairman Palazzo, Ranking Member Costello, Chairman Hall, distinguished Members of the Committee, thank you for the opportunity to once again express my personal views and concerns at this hearing to review the impacts of the recent Soyuz launch vehicle failure on the safe operation and utilization of the International Space Station. I will attempt to answer the questions specifically provided by your letter of invitation from the standpoint of my position as the Chairman of the ISS Advisory Committee and former astronaut.

As you know, I have had the unique experience of working with the Russians during the era of the Soviet Union as a member of the Apollo-Soyuz Test Project. As an American astronaut, I joined with our Russian colleagues, and I was afforded a unique opportunity to view their space program up close alongside their best engineers and their technicians.

As a result of that joint successful effort, NASA and Roscosmos were able to join again to operate together in space with the Shuttle-Mir Program culminating in our successful partnership on the International Space Station. Throughout that long partnership, I continued to observe and assess the Russian Space Program and am delighted to share my thoughts.

The question is “How has the overall operation of the ISS been impacted by the loss of the Soyuz launch vehicle?” If the proposed launch schedules of the Soyuz U that carries the Progress and the Soyuz FG for the crew vehicles are realized, the long-term effects on the ISS will be minimal. The last few Space Shuttle flights, and especially STS–135, were able to deliver consumables, spares, utilization hardware, and samples to provide margin through calendar year 2012.

The biggest concern at this time is the ability to return to the full complement of six crewpersons onboard the ISS as soon as possible to maximize the utilization for the United States. The Soyuz FG booster used to launch the Soyuz TMA crew vehicles is a variant of the Soyuz U, which experienced the failure, and its launch resumptions will depend on the successful launch of Progress 45P on October 30, 2011, as Mr. Gerstenmaier has outlined. If that launch is successful, and I have every confidence that it will be successful, the next crew will be launched on or about November the

13th, and the ISS will return to six-person crew on December 26, 2011.

The next question for your view is “Is Russia’s return to flight adequate, effort adequate, and what do you consider the top risks to operational status?” With regards to the adequacy of the Russian return to flight effort, I have not received briefings on the activity or results of the Russian Investigation Commission concerning this recent failure. However, Mr. Gerstenmaier recently received the briefings from the Russian experts in Moscow, and I feel the best use of our time would be for Mr. Gerstenmaier to respond to that question.

I would like to comment on the reliability of the RD–0110 engines used on those upper stages of the Soyuz launch vehicle. Out of a block of six engines, five are flown and one is test run on a normal third-stage burn duration of approximately 240 seconds and then inspected. And prior to this first failure, there has been a total of over 1,800 RD–0110 engines that have flown and an additional 360 engines that have undergone the 240-second test run. This equates to a total of 2,160 RD–0110 engines that have been successfully operated.

Although not directly involved in this investigation, I would like to share a perspective of the program. In 1999, I was asked by the administrator of NASA and the head of Roscosmos to engage in a full understanding of the Proton second-stage engine failure that had two Proton failures in a row, and the next one up would be our Service Module, which is the key to the ISS as far as the controllability.

Specifically, we wanted to have the co-chairs of the U.S. and the Russian Commission review this rocket engine failure, including corrective action to be taken, safety, reliability, quality assurance processes which were to be implemented prior to that Proton launch. The trust and respect we had developed through our years of our Joint Commission work resulted in a very thorough, open, and comprehensive briefing on the failure of the Russian Proton vehicle, in the investigation process, and in the correction.

I think it is very significant that we were taken to Voronezh; we were the first Americans, I think, ever to visit there and possibly the first foreigners. They have showed us the production line, the actual drawings of the spacecraft, and they showed the actual engine they had recovered, the failure modes occurred there, and also they ran one to simulate that. So that was very unique. They were very open in the corrective action, and fortunately, all those Protons that work for the Space Station put the elements up there correctly.

So after nearly 40 years of continuous and close working relationship with the Russians and their space program, I can attest to their thorough and complete approach to problem solving and their robust manufacturing.

The last question, I will go ahead very rapidly, contingency plan adequate to ensure safe operations for the ISS. NASA already has exercised the first steps of the contingency plan. The plan was defined and formalized as a result of the Columbia accident investigation, so the ISS program is well versed in dealing with this type of contingency.

And, Mr. Chairman, in addition to the comments I have just given, I would like to submit for the record written statement and Attachment A, a summary of the Commercial Re-Supply Services Review recently conducted by the ISS Advisory Committee and the Aerospace Safety Advisory Panel. This review was co-chaired by Admiral Dyer and myself at the request of Mr. Gerstenmaier to review the status of these two CRS contractors, Orbital Sciences Corporation and the Space Exploration Technology Corporation.

Mr. Chairman, thank you and the Committee for giving me the opportunity to be here today, and I will be available for any questions.

[Attachment A may be found in Appendix 2.]

[The prepared statement of Lieutenant General Stafford follows:]

PREPARED STATEMENT OF LIEUTENANT GENERAL THOMAS P. STAFFORD, USAF (RET.), CHAIRMAN, INTERNATIONAL SPACE STATION ADVISORY COMMITTEE

Thank you, Chairman Palazzo, Ranking Member Costello, and Full Committee Chairman Hall for that warm introduction, and to the Committee for the opportunity to once again express my personal views and concerns at this hearing to review the impacts of the recent Soyuz launch vehicle failure on the safe operation and utilization of the International Space Station (ISS). I will attempt to answer the questions provided in your letter of invitation from the standpoint of my position as the advisory committee chairman and former astronaut. As you all know, I have had the unique experience of working with the Russians during the era of the Soviet Union as a member of the Apollo-Soyuz Test Program. As an American astronaut, I joined with our Russian colleagues and was afforded an opportunity to view their space program up close alongside their best engineers and technicians. As a result of that successful joint program, NASA and ROSCOSMOS were able to join again to operate together in space with the Shuttle-MIR program culminating in our successful partnership on ISS. Throughout that long partnership, I continued to observe and assess the Russian space program and am delighted to share my thoughts.

If the proposed launch schedules of the Soyuz U and Soyuz FG launch vehicles are realized, the long-term affect on the ISS operation will be relatively minor. The last few Space Shuttle flights, and especially STS–135 were able to deliver consumables, spares, utilization hardware and samples to provide margin through CY 2012. The bigger concern at this time is the ability to return to a full complement of six crewpersons onboard the ISS as soon as possible to maximize utilization for the United States. The Soyuz FG booster used to launch the Soyuz TMA crew vehicles is a variant of the Soyuz U which experienced the failure, and its launch resumption will be dependent on the successful Soyuz U launch of Progress 45P on October 30th. If that launch is successful—and I have every confidence it will be—the next crew will be launched to the ISS on or about the 13th of November and the ISS will return to six-person crew on 26 December, 2011.

With regard to the adequacy of the Russian return to flight effort, I have not received briefings on the activity or results of the Russian Investigation Commission regarding the recent (24 August 2011) failure of the Soyuz U carrying the Progress M–13M/45P logistics vehicle. However, Mr. Gerstenmaier recently received these briefings from the Russian experts in Moscow, and I feel the best use of our time today would be for me to yield the response of this question to him. I would like to comment on the reliability history of the RD–0110 engines used on the Soyuz launch vehicles. Out of a block of six engines, five are flown and one is test run for the full nominal third-stage burn duration of 240 seconds, and then inspected. Prior to this first failure, there have been a total of 1,800 RD–0110 engines that have flown, and an additional 360 that have undergone the 240-second test run. This equates to a total of 2,160 RD–0110 engines that have been successfully operated. Although not directly involved in this investigation, I would like to share a perspective. In 1999 I was asked by the Administrators of NASA and Roscosmos to engage in a full understanding of the Proton launch failure investigation. Specifically, to have the Joint U.S.-Russian Commission, which I co-chair, review the completed Russian investigation on the causes for the Proton booster rocket failures in 1999. This included the corrective action to be taken, and the safety, reliability, and quality assurance processes which were to be implemented for the Service Module

(1R) launch vehicle. The trust and respect we had developed through our years of Joint Commission work resulted in very thorough, open, and comprehensive briefings on the failure of the Russian Proton launch vehicle, in the investigation process, in the corrective actions taken to preclude a repeat of the failure, and of the extensive retesting of hardware to be used for flight.

With nearly 40 years of continuous and close working relationship with the Russians and their space program, I can attest to their thorough and complete approach to problem solving, and to their robust manufacturing and test program philosophy.

As for the impact to the U.S. associated with the Soyuz launch vehicle not being able to return to flight, I would submit that today, there is no other vehicle in the world capable of delivering crews to the ISS other than the Soyuz TMA crew spacecraft.

In response to your question regarding contingency plans, the answer is yes, and in fact NASA is already exercising the first steps of the contingency plan. This plan was refined and formalized as a result of the Columbia accident investigation so the ISS program is well versed in dealing with this type of contingency. The ISS can be maintained in orbit without a crew for a time. The critical systems for ensuring safe operation of the ISS are all able to be controlled from the ground and designed with robust redundancy should an anomaly occur. It is my opinion that at this time adequate contingency plans are in place to ensure the continued safe operation of the ISS.

Mr. Chairman, in addition to the comments I have just given, I would like to submit for the record, as Attachment A, a summary of the Commercial Resupply Services review recently conducted by the ISS Advisory Committee and the Aerospace Safety Advisory Panel. This review was Co-Chaired by Vice Admiral Dyer and myself at the request of the Associate Administrator for Space Flight Operations Mission Directorate, to review the status of the two Commercial Resupply Services (CRS) contractors for the ISS—Orbital Sciences Corporation (Orbital) and Space Exploration Technologies Corporation (SpaceX). The focus of this meeting was the status of the SpaceX "Dragon" and the Orbital "Cygnus" logistics vehicles.

Mr. Chairman, I thank you and the Committee for giving me this opportunity, and thank you for all you do to advance American human space flight.

Chairman PALAZZO. For your statements for the record without objection, so ordered, and thank you for your testimony.

I now recognize our final witness, Vice Admiral Joseph Dyer of the United States Navy, retired, and current Chairman, Aerospace Safety Advisory Panel.

STATEMENT OF VICE ADMIRAL JOSEPH W. DYER, USN (RET.), CHAIRMAN, AEROSPACE SAFETY ADVISORY

Admiral DYER. Thank you, Chairman Palazzo and Acting Ranking Member Costello. It is a pleasure today to represent the perspective of the Aerospace Safety Advisory Panel. Given that Mr. Gerstenmaier and General Stafford have to a large extent covered the details of your questions and given the fact that I am from North Carolina and speak with that kind of speed, I will abbreviate and summarize my remarks.

I would add that the panel reconstituted in 2003 and changed to the NASA Authorization Act in 2005, has us reporting both to the Administrator of NASA and to the Congress. So we are happy to be here today in keeping with that—the second part of our charter and direction.

I would offer an important caveat much as General Stafford did. While the panel follows the safety aspects of joint Russian and U.S. space activities, we have had no direct contact with the Russian Space Program. Our insight and information comes from NASA and is by definition second hand. With that said, we view the information related to Russian operations as creditable and of high fidelity.

We do follow NASA's analysis and decision making regarding the cooperative program with the Russians. This includes activity related to the resumption of the Soyuz flight and U.S. astronaut transport to the International Space Station.

The ASAP's role in monitoring safety issues arriving from cargo and crew and re-supply has been the focus of the panel certainly over the last two years, and you will find it addressed in our annual reports, which I have included with our written statement. But it has been especially the focus since the retirement of the Space Shuttle. In fact, we have had panel members at the SpaceX facility earlier this month, and we will be visiting with the Orbital folks out near Dulles Airport here in Washington at the end of this week.

With regard to return to flight, we share the perspective that you have heard from both General Stafford and Mr. Gerstenmaier, but I would especially like to highlight the very positive relationship that Bill Gerstenmaier has built in his dealings with the Russians. To a very great extent this relationship building has enabled NASA's timely understanding of the Russian investigative status, and we are confident that the two launches anticipated, one of Progress and one of—the Soyuz launch hopefully in mid-November, will put the current issues to rest and return us to a steady-state operation.

Likewise, we believe that the issue associated with the third stage of the Progress engine is a quality statement rather than a design flaw, and we note that the Russians have put in place significant quality control processes and activities.

We likewise have no concerns with regard to the reduction of crew aboard ISS. We would note that following the report for an extended period of time, when the Shuttle was down, the Station was operated with only two people aboard, and that we have had six only since improvements to the life support systems.

It is a tribute to the Soyuz System and its unusual reliability that the risk of running out of shelf life while docked to the ISS has not been an active topic with the ASAP. To put that in simpler terms, we miss it. The ability to get to higher orbit and to get an extended period of operation, even in an unmanned status if necessary, for one year to as much as two years is noted with some good comfort.

In summary, sir, the ASAP has been and continues to be actively engaged in safety issues arriving from the full spectrum of crew and cargo, including both commercial space as well as the Soyuz activity. Via NASA, the ASAP is monitoring the progress being made in return to Soyuz flights and the ability to support both crew and logistics. We should all say thank you to the crew of 135 for their laying up of stores aboard the Station and, from a logistics perspective, the ability of the Station to operate until at least the end of next calendar year.

Two prime safety concerns, potentially flowing from a disruption of the Soyuz Transport System, the first is the risk to the public of an unplanned or uncontrolled ISS de-orbit and associated debris. The second is the loss of Station due to stability control and the de-manning of those folks necessary to provide onboard maintenance. Both risks have been mitigated, and the Station has potential, we believe, to operate very safely.

The information provided by the NASA Human Exploration and Operations Mission Directorate indicates that the Russians have been forthcoming with engineering analysis, safety, and mission assurance information related to the return of flight and the Soyuz status. It is the sharing and transparency that is necessary, and if sustained, it should be sufficient to support a decision to resume astronaut transportation hopefully by the end of November.

The ASAP's engagement with anomalies in the Russian Systems have, as I indicated, been second hand, but we follow it closely and find general comfort and a way forward.

Thank you, sir.

[The prepared statement of Admiral Dyer follows:]

PREPARED STATEMENT OF VICE ADMIRAL JOSEPH W. DYER, USN (RET.), CHAIRMAN, AEROSPACE SAFETY ADVISORY

Chairman Palazzo, Acting Ranking Member Costello, and distinguished Members, thank you for the opportunity to appear before you today. As requested, I would like to present the NASA Aerospace Safety Advisory Panel's (ASAP's) perspective regarding "The International Space Station: Lessons from the Soyuz Rocket Failure and Return to Flight."

The Aerospace Safety Advisory Panel (ASAP) was originally established under Section 6 of the NASA Authorization Act, 1968 (42 U.S.C. § 2477). In 2005, the ASAP authority was modified under Section 106 of the NASA Authorization Act of 2005 (P.L. 109–155).

The ASAP's charge is, among other things, to advise the NASA Administrator and the Congress with respect to the hazards of proposed or existing facilities and proposed operations with respect to the adequacy of proposed or existing safety standards, and with respect to management and culture related to safety.

The panel comprises individuals with deep knowledge and broad experience in the safety aspects of major technical undertakings. Membership includes individuals with backgrounds in government, commercial industry and some with combined leadership experience in both camps. The panel members' biographies can be found via *www.hq.nasa.gov/asap/bios*.

I must first offer a caveat—while the panel follows safety aspects of joint Russian-U.S. space activities, we have had no direct contact with the Russian Space Program. Our insight and information comes from NASA and is by definition "second hand." With that said, we view the information related to Russian operations we receive as creditable and high fidelity.

We do follow NASA's analysis and decision making regarding the cooperative program with the Russians; this includes the activity relating to resumption of the Soyuz flights for U.S. astronauts' transport to the International Space Station.

ASAP's Role in Monitoring Safety Issues Arising From Cargo and Crew Resupply to the International Space Station (ISS)

The ASAP closely examines activities associate with the ISS and has addressed both crew and cargo commercial transport in our last two annual reports. I've included those reports in our written submission. Over the years, NASA has sharpened and improved its risk management processes. With the advent of commercial space, the ability of NASA to effectively understand and manage the total scope of risk becomes much more difficult. Timely insight in the face of contractual and intellectual property constraints will be critical moving to the future. To believe that commercial space flight removes risk from NASA's programs is, at best, wishful thinking. Since the Shuttles' last flight, commercial transport and associated risks have been the centerpiece of the panel's focus. In our latest engagement, members of the panel visited the SpaceX facilities during the first week of October and we will spend this coming Friday with Orbital.

ASAP and the Soyuz Return to Flight

On 24 August 2011, Russian Progress M–12M launched for the International Space Station (ISS). The third stage of Progress' Soyuz-U rocket failed and prevented the rocket from achieving orbit. The failure grounded both the Soyuz-U rockets used to launch cargo, and the Soyuz-FG rockets used to launch crews to the ISS, since both rockets share very similar third stages.

NASA's Human Exploration and Operations Missions Directorate has conscientiously communicated with the ASAP following the August incident. We've always found that communication to be forthright and transparent; NASA has shared their evolving understanding and has not been reluctant to share both what is known and unknown. We take faith in what we've heard and note the trusting relationship Mr. Gerstenmaier has built with the Russians. To a great extent this relationship building has enabled NASA's timely understanding of the Russian Investigation status. It appears to the ASAP that the cause of the third-stage failure has been identified, is being verified, and actions are underway for a safe return to flight in time to preclude a de-crewing of the ISS. The Russians plan to launch another Progress mission on or about 30 Oct. If successful in verifying fixes to the 24 August failure, NASA and the Russians anticipate a 13 November Soyuz to the ISS. A November success will put to rest the current predicament.

Our understanding of the third-stage engine's failure mode involves the normally fuel rich Gas Generator mixture which powers the engine turbine. A blockage in the fuel line appears to have reduced fuel flow by 30%, creating an oxygen-rich mixture that caused the Gas Generator to speed up and eventually burn through its exhaust duct. Engine controllers sensed the pressure dropping and opened the oxygen flow, further exacerbating the problem. We note that this engine was designed in the 1950s and uses a mechanical fuel balancing system that has advantages as well as disadvantages compared to digital systems used in engines being designed today.

The above failure mode is clearly a quality escapement, rather than a design flaw. We understand that the Russians have added significant quality control processes to prevent a fuel system contamination recurrence that was experienced on the last flight. They have two and three independent inspectors checking each operation and are videotaping every step in the process to ensure it is done correctly. NASA sent a team to Russia to monitor the successful test of an engine returned from a third-stage assembly. They will conduct a formal Flight Readiness Review before the next Progress and Soyuz launches to formalize the agency's review of the investigation and readiness for flight. The ASAP will closely monitor these reviews.

We note that thankfully, unlike the Space Shuttle, Soyuz has an abort capability. This capability is available throughout its launch trajectory. While it would have been "exciting," it is believed that this system is capable of recovering a crew in the event of an engine failure such as experienced on the last Progress launch. We've also been impressed with the contingency planning NASA and the Russian Space Agency have undertaken to mitigate the risk to the ISS and to the public if it is necessary to de-crew the station.

NASA Consultation With ASAP Following Flight Anomalies

Since the ASAP was reconstituted in 2003, the ASAP has been deeply involved with each grounding incident and closely engaged in all significant technical and programmatic issues affecting operations. You may recall that the Return to Flight Committee formed following the conclusion of the Columbia Accident Investigation Board handed off outside oversight to the ASAP prior to resuming Space Shuttle operations. Then, as now, we have been routinely invited to participate in the Flight Readiness Reviews and other decision forums. The panel has been included in the dialogue on all serious anomalies—sometimes via NASA's invitation and sometimes at our own insistence. We have rarely found fault with NASA's communications and on those rare occasions when information was slow in coming, we've had strong support from the Administrator to gain the access and insight we believe necessary. This has never been better than with the current Administrator, Mr. Bolden. He was, after all, an ASAP member prior to his appointment.

Safety Concerns Resulting From Reduction in Crew Aboard the ISS

We are confident the ISS and crew aboard can operate safely with only three crew members and note this was the norm prior to life support system improvements which allowed the crew size to grow to six. During the time the Shuttle was grounded following the Columbia accident, the crew size was at two. While the day-to-day experimentation and work ancillary to operating the station may be impacted, a crew of three can safely fly.

Likewise, the necessary stores and supplies required for extended operation are aboard, and we believe the station could operate with a reduced crew of three until late calendar year 2012.

The Soyuz capsule left docked aboard the ISS provides the crew return mechanism and serves as a "life boat" for recovery in the event of emergency. It is not logistics but the 200-day "use by" requirement of the of the docked Soyuz capsule that is the critical factor in the potential necessity to remove the crew and to leave the ISS unmanned. (Specifically, it is hydrogen peroxide propellant which is running out of life.) The delay in the planned Soyuz flights means that the capsule docked at the ISS is at risk of aging out before a replacement capsule can be transported to station. The U.S. policy has been to never leave a crew on board Station without a rescue vehicle that is fully certified and ready to use. This would require sending the last three crew members home and leaving Station without crew if a replacement Soyuz and crew is not launched before approximately mid-November. It is a tribute to the Soyuz system's usual reliability that the risk of running out of "shelf life" while docked to the ISS was not an active topic at NASA nor was it an ASAP focus. A more prophylactic and energetic risk assessment would have been helpful. To put that in simpler terms—we (the ASAP) miss it.

NASA's ISS Contingency Plans

NASA and the Russian Space Agency have developed a number of plans which have potential to both protect the public from an unplanned and potentially uncontrolled de-orbit and sustain the ISS life on orbit.

Luckily, it would take multiple malfunctions to cause serious problems for an unmanned Station. An example would be loss of cooling on BOTH the U.S. and Russian sides of the station, which could then cause loss of gyroscopes and the resulting loss of attitude control. NASA is working under the assumption that loss of attitude control would be catastrophic, but it may not be, as there are some recovery techniques that may be available, depending on the Station's response. The Probabilistic Risk Assessment for the Station tells us that having crew on board is an important mitigator for such hypothetical failures.

NASA already has contingency plans in place that would respond to the first signs of loss of redundancy in the critical systems by boosting the ISS to a higher orbit. This would buy additional time to respond to a potential loss of the remaining critical systems. At the existing orbit, they believe they would have approximately one year to respond to a station anomaly before it reentered the atmosphere. With the additional orbit boost that would be implemented, they believe they can extend this window to somewhere from 18 to 24 months.

The ASAP has previously identified to NASA the desirability of formalizing the approaches that could be used in the future to safely deorbit the ISS whenever that might eventually become necessary, whether at end of mission or upon an anomaly before that time. NASA is working with the Russians to formalize plans for such an eventuality.

NASA and our Russian partners have spent over a month meticulously going over exactly how to leave the Station configured if they must de-crew. They have looked at all systems and maintenance issues. They have gone through each and every Orbital Replacement Unit and identified its condition and optimum configuration. They're treating this as a real possibility. As AA Bill Gerstenmaier often says, "they hope for the best, but plan for the worst."

Summary

In summary:

- The ASAP has been, and continues to be actively engaged in safety issues arising from cargo and crew resupply to the ISS.
- Via NASA, the ASAP is monitoring the progress being made in returning the Soyuz to flight status and enabling the Russians to provide crew and logistics transport to the ISS.
- The ASAP, reconstituted in 2003, has been closely consulted regarding decisions on resuming missions following a flight anomaly.
- The two prime safety concerns, potentially flowing from a disruption of Soyuz transport capability, are, (1) Risk to the public from an unplanned and uncontrolled ISS deorbit and associated debris; and (2) risk of loss of the Station due to stability control failure following de-manning and the lack of crew to provide maintenance support. Both risks are mitigated given the ability to position the station in a higher orbit (and thereby buying time to find a solution) and the nominal ability to control station stability from the ground.
- Information provided to the ASAP by NASA's Human Exploration and Operations Missions Directorate indicates the Russians have been forthcoming with

the engineering analysis, safety and mission assurance information related to the efforts to return Soyuz to flight status. If the sharing and transparency is sustained, it should be sufficient to support a decision to resume the astronauts' transport to the ISS. Collectively, NASA and the Russians are hoping for the best but preparing for the worst.

- The ASAP's engagement with anomalies in the Russian System have been "second hand" via NASA's Human Exploration and Operations Missions Directorate and not "first person" as is the case with NASA and commercial space contractors.

I thank you for the opportunity to testify today.

Chairman PALAZZO. Thank you. I thank the panel for their testimony. I would like to remind Members that Committee rules limit questioning to five minutes.

The Chair will at this point open the round of questions. The Chair recognizes himself for five minutes.

Pretty much I am going to share many of the same concerns that Mr. Costello addressed in his opening statement. Mr. Gerstenmaier, Lieutenant General Stafford, and Vice Admiral Dyer, can you elaborate on the level of insight and influence that NASA and the Aerospace Safety Advisory Panel have into Russian return to flight plans? You all kind of touched on that, so you don't really have to spend much time but just touch on it again.

Mr. GERSTENMAIER. What we have done within NASA is myself and the program manager, we both went to Russia, and we had first-hand interchange with the Commission that the Russians put in place to do the failure investigation. They showed us detailed plots, diagrams, their logic for why they thought the most likely failure was what it was, and they also explained to us other items on the fault tree or other potential causes and why those were not considered credible in their mind. They spent several hours with us in a detailed discussion and review of that information.

We then took that information back with us to the U.S. We formed a team of experts from the Marshall Spaceflight Center who do rocket propulsion tests. We brought in our safety personnel, we brought in our engineering personnel, we provided them with that information, and they took essentially an independent look at that same information and their understanding of the Russian engines from essentially the open source information that is available on those engines, and they did kind of a background check to make sure that the conclusions the Russians were drawing were reasonable, and we agreed with those. We completed that review today within the agency, and we agree with the basic Russian finding. So that is the level of insight we have.

We also had a team of experts that got to go to the Voronezh engine manufacturing facility, and they got to actually watch an engine test firing of 280 seconds. It was an engine that was returned from the field, and they actually got to witness that engine testing and the test firing and interact with the personnel that actually manufacturers the engines.

So we have very good insight into the Russian system and their anomaly investigation, and it is pretty much standard with what we would do of an investigation of this type.

Lieutenant General STAFFORD. Mr. Chairman, as Mr. Gerstenmaier has outlined, with respect to the recovery from this incident follows the same type that we went into great detail on the Proton failure, and the Advisory Committee monitors through the program office, and Mr. Gerstenmaier, the activities there, and then once a week General Joe Engle, who is a technical advisor for the committee, has a joint conference call with people from Roscosmos and our counterparts there.

So we are kept advised on a weekly basis of that, but the lead for this goes back to the program office, and from all the details we have seen before and being in the manufacturing plant. You have in-depth committees that can review this, experts that go through it, and this is the same as what we observed as before, sir.

Chairman PALAZZO. Do you see any weaknesses in the process, or do you have any suggestions on how we might be able to improve the process?

Mr. GERSTENMAIER. Again, I think we have a very strong relationship with the Russians. If there is something that we needed to do differently or we wanted them to run an extra test, we have the ability to request that of the Russians and to get their cooperation. They don't necessarily have to agree with our activities, but I think if we have pretty strong technical rationale, they would agree to do additional testing or additional investigations based on what we saw.

So I think it is a pretty good relationship back and forth. Again, we have been given access to what we need to see. We got to see the information that we needed to make sure that we have the knowledge to go ahead and proceed, but ultimately the Russians are the experts in this area. It is their engines, it is their design. We have insight into that, but we ultimately have to rely upon the Russians basic analysis.

Lieutenant General STAFFORD. Mr. Chairman, I see at this time no apparent weaknesses in what the Russians are doing. Again, this is based on the experience I have had with them over the years and the information we received from the program office and Mr. Gerstenmaier and our contacts.

Admiral DYER. Mr. Chairman, the insight afforded the ASAP as an outside advisory panel is as it should be. We have been supported strongly by the Administrator, and I would point out that the Administrator was a prior member of the ASAP before taking over the leadership at NASA. So as you would perhaps expect, we have had the very strongest support and deepest insight that we might need.

By way of reference, the ASAP members will be participants in the flight readiness review where NASA makes the final decision to go forward with future Soyuz operations.

Chairman PALAZZO. Thank you. I now recognize the Ranking Member, Mr. Costello.

Mr. COSTELLO. Thank you, Mr. Chairman.

The title of this hearing, of course, is Lessons from the Rocket Failure and Return to Flight. With the fact in mind that we are moving, NASA is moving to commercial, let me ask a couple of questions for the record, Admiral Dyer.

I understand from your testimony that ASAP members have not met with Russian spaceflight officials and that you have not visited their spaceflight facilities. Is that correct?

Admiral DYER. That is correct, sir. As I indicated, our insight is second hand but, we believe, of high fidelity.

Mr. COSTELLO. Okay. My concern is, as we move forward to going to a commercial partnership, that we have an independent source and an independent review, and as I understand from your testimony today that basically what you and your ASAP members are basing your information, solely on what is coming from NASA, and you really do not have an independent source to verify what NASA is telling you. Is that correct?

Admiral DYER. That is correct, sir.

Mr. COSTELLO. Does that concern you for the future, and I would throw this question out to all of the witnesses here today. Should there be an independent source that is verifying as we go forward with commercial spaceflight and a partnership with the commercial folks?

Admiral DYER. Well, the ASAP's insight into space activities, operation facilities, et cetera, has been deepest with the NASA programs of record. It is very deep, and it is a close focus of ours with regard to commercial space activities from U.S. firms. It is really uniquely the Russian activity, complicated by sovereign nation and distance, where we lack direct insight, sir.

Mr. COSTELLO. And I trust that the information that we are getting from NASA concerning this investigation and, again, we are looking for lessons learned so that we can move forward when we partner with the commercial side that we have learned lessons, and we, in fact, can know as we are going forward what we are doing and the mistakes that have been made and what should be corrected.

But let me throw out to General Stafford, should there be an independent review or an independent source other than just NASA?

Lieutenant General STAFFORD. Well, Mr. Costello, in the past I have given my opinion that the independent committee that I have had the honor to chair has been a very positive with its inputs to NASA and helped them in the solving of problems, particularly at the start of this program to get it going forward, and we give our opinion.

In fact, Mr. Gerstenmaier, I would like to compliment Mr. Gerstenmaier. It was the result of this committee observing the way that the program had slipped out that it was unanimous from our opinion, we had told Mr. Gerstenmaier nearly 2–1/2 years ago, three years ago, that we thought it was a requirement that those two shuttles that were there as contingency should be flown because without those shuttles, we could be in high risk of not maintaining six persons onboard that Station.

And finally, I told Mr. Gerstenmaier that it is our opinion that within 12 to 18 months after the last shuttle would fly we would have a higher risk by far of maintaining six people. So I appreciate the help that Mr. Gerstenmaier did and what this committee did with the 2008, Authorization Act and also what Admiral Dyer said, thank the crew again that is here for flying that mission because right now if those two shuttles hadn't gone, we would have been very short on supplies.

Mr. COSTELLO. General Stafford and Admiral Dyer, let me ask overall what commercial issues need to be resolved before any commercial crew vehicles can be baselined for ISS use?

Lieutenant General STAFFORD. Well, this is a very in-depth detail. I don't know that we could cover it in this period of time, Mr. Costello. To meet all the requirements for safe operation there is going to be a very detailed effort, and there is already, I think, in-depth discussion that it should be conducted under the Federal Acquisition Requirements, which I certainly agree with.

Then there is the other issue about, "commercial." Is there a market out there? I know that Mr. Mike Hawes when he was at NASA had the Aerospace Corporation conduct a study that looked at the market that would be out there, and I have not read the study. I have seen the executive summary, but they said that basically the government was the market, and so that becomes a question about commercial.

Mr. COSTELLO. Thank you. Mr. Chairman, thank you very much.

Chairman PALAZZO. Thank you. I now recognize Chairman Hall.

Mr. HALL. Thank you, sir. I guess I would ask Mr. Gerstenmaier, in your view, has ramping up the Soyuz System to accommodate four missions a year put any stress on the Russians, and if so, kind of tell us something about that.

Mr. GERSTENMAIER. Again, I think the increase in flight rate on the Russian side has put some scheduling pressure on the Russians to deliver these flights. We have been watching that activity to make sure that there is nothing that is a problem to us. We specifically even looked at this particular problem with the Progress to make sure that there wasn't systemic problems or a problem that occurred from the fact that they are increasing the flight rate.

And I would add one other clarification to the previous answer was the ASAP doesn't have an interface to the Russians, but General Stafford interfaces with Raikunov of the Russian Space Agency, and that is an independent check where they can actually get data independent of the NASA team on the Russian failures and insights.

So there is an independent source available to NASA through Tom's meeting and the group that he chairs as the ISS Safety Task Force.

But your point, I think, is a consideration we need to watch. We see no evidence of the schedule concerns with the Soyuz increase, but it is something we need to continue to watch and get a good handle on.

Mr. HALL. How much continuing to watch can we do? If we put a lot of stress on them, do you think there is any chance of them upping their charge to us?

Mr. GERSTENMAIER. We have negotiated those prices, and those prices are fixed, and they are in place. The Russians have decided to go ahead and build a backup Soyuz vehicle and a backup Progress vehicle. So they recognize that there could be a problem in their supply line, and they wanted to have one additional vehicle available to support. So on their own they have gone ahead and funded the addition of an additional Soyuz as a backup and an additional Progress vehicle as a backup as well.

So, again, they look at the overall operational scenario. They look at where there needs to be margin, and on their own they added some margin to make sure there is enough robustness to keep the Space Station fully occupied and fully functional.

Mr. HALL. Thank you, sir. I yield back my time.

Chairman PALAZZO. I now recognize Ms. Adams from Florida.

Mrs. ADAMS. Thank you, Mr. Chairman.

Mr. Gerstenmaier, I want to make sure I understand just where our human spaceflight is and go from there. Just so we have our baseline. At this moment there is no American access to the ISS via American rocket built by an American workforce to bring American astronauts to and from the Station. We will not have this capability for at least a couple of years, probably longer, and our great hope is at this point a rocket that just crashed landed due to some error in the manufacture of the rocket. Does that about sum it up?

Mr. GERSTENMAIER. That is the current status.

Mrs. ADAMS. I have a few questions, and I want to run through them quickly so that I can get them all. The hearing has focused on problems associated with U.S. relying on Russian providers to transport our astronauts. I am wondering if there is a lesson to be learned here about reliance on foreign providers now that NASA has settled on a plan for our Next Generation Human Spaceflight systems.

For example, shouldn't the final SLS design and procurement decisions favor as much as possible U.S.-made systems and components so we don't get into a situation where a failure or problem with a foreign company can impede the development and operation of the SLS?

Mr. GERSTENMAIER. I think the important consideration is to have a similar backup capability for those critical functions. As when we had the Columbia tragedy, it was extremely important that the Soyuz was there and able to back up the loss of ability to transport crew to and from Space Station. The Soyuz backed that up and allowed us to keep two crew members onboard Space Station, keep Space Station functional during a very critical period of its time.

So I agree with the idea of the dysfunctional redundancy, and we can do that a variety of different ways.

Mrs. ADAMS. On the cover of *Space News* this week is a story about delays of the launch of the test flights for the Falcon 9 and Taurus 2. Can you explain the reasons for these delays and what NASA is doing to facilitate a quick return to reliable launch schedules for both of these providers?

Mr. GERSTENMAIER. Yeah. Both of those providers are new entrants into the cargo world. They are going through normal startup transience that typically aerospace companies go through as they bring a new system online. In the case of Orbital, they are building a new launch site at Wallops. There is some startup transience associated with that, getting the new systems in place. They have also experienced an engine failure that they had to work through and understand the consequence of that engine failure.

In the case of the SpaceX Corporation, they are going through some software testing that is discovering some concerns. They recently completed some thermal vacuum testing which was very highly successful. They are doing some electromagnetic interference investigations and some other testing. There are minor problems being identified with those. With software, they are discovering some problems that are normal, but they are normal transience that we would expect to see in that development activity.

And as we have discussed earlier, the reason we requested, and luckily got, STS–135 was it gave us some margin so we have a period of time for these new commercial cargo providers to come on line. They have until the end, basically, of 2012, to deliver cargo. We think there is plenty of time in the overall system. We want them to be ready to fly when they are ready to fly. We don't want to put pressure on them and force them to fly before they are ready to fly.

Mrs. ADAMS. So NASA is working with them?

Mr. GERSTENMAIER. We are working with them very closely to work these issues out and get ready to go fly.

Mrs. ADAMS. On September 21, DOD released its annual industrial capabilities report to Congress. On page 31 of this report, DOD devotes an entire section of NASA disruptions to the space industrial base, claiming that the present cancellation of the Constellation Program has significantly interrupted the industrial base. The report goes on to say that NASA had 29 percent of the entire 2009 space budget for the Federal Government. Obviously reliable support to the International Space Station ensures continued support to our national security asset like the rocket industrial base. What is NASA doing to mitigate this national security risk?

Mr. GERSTENMAIER. Specifically the plans we have released for the space launch system, the heavy-lift launch vehicle, and the Orion multi-purpose crew vehicle, both of those plans will help stabilize that market. It will allow our contractors to understand what our plans are, what hardware we want to build, and they can make the appropriate facilities and personnel decisions to support that.

Mrs. ADAMS. And we were happy to finally see those released, that released information.

Ambassador Bono was in Florida yesterday, and he said, "From California to Florida the space industry is strong and growing." My constituents are still waiting for the shorter space gap the President promised at a campaign stop on August 2, 2008, in Titusville.

Can you give me some examples of where in Florida the space industry is growing and strong?

Mr. GERSTENMAIER. Again, we are moving out on the SLS and the MPCV Orion as we have talked about. We are in doing some initial welding of the Orion capsule, which will be the test vehicle, which will be flown from Florida. So we are starting to move out on some of those activities. The mobile launch platform, which was built——

Mrs. ADAMS. So they have started. We are just not up to where we need to be. Correct?

Mr. GERSTENMAIER. We are beginning that process and working through the development activities associated with both of those vehicles, and it involves the testing and operations in Florida.

Mrs. ADAMS. My time has expired.

Chairman PALAZZO. I now recognize Mr. Rohrabacher from California.

Mr. ROHRABACHER. I thank you very much, Mr. Chairman, and let me get a couple of things straight.

Now, the SLS, when is that scheduled to be complete?

Mr. GERSTENMAIER. Its initial test flight will be 2017, December.

Mr. ROHRABACHER. When will it be, actually be prepared for a mission?

Mr. GERSTENMAIER. We had the ability to support a crewed mission in 2021, with the current——

Mr. ROHRABACHER. 2021, and at this point, please correct me if I am mistaken, but the Space Station is not supposed to be actually functioning in 2021, is it?

Mr. GERSTENMAIER. Both of those systems are geared for beyond low-earth orbit. They are not geared for low-earth orbit. We are looking to commercial transportation for——

Mr. ROHRABACHER. Right.

Mr. GERSTENMAIER. [continuing]. Both cargo this year and commercial crew in the 2015, 2016 timeframe.

Mr. ROHRABACHER. So all of this talk—I think in the public there has been a mistaken impression that the SLS, this huge mega rocket that is being built, will have something to do with supplying Space Station, and in reality it has nothing to do with Space Station.

Mr. GERSTENMAIER. Its goal is to be used beyond low-earth orbit for exploration activities——

Mr. ROHRABACHER. Right.

Mr. GERSTENMAIER [continuing]. Beyond low earth.

Mr. ROHRABACHER. Right. So would you characterize the Russians—we depended on Space Shuttle, and Space Shuttle is gone, and since we lost Shuttle, have the Russians been basically operating in good faith with us, would you say?

Mr. GERSTENMAIER. Yes.

Mr. ROHRABACHER. Would the panel agree with that? They could have raised the rates on us if they wanted to play hardball. Is that right, General?

Lieutenant General STAFFORD. Mr. Rohrabacher, from the interface I have had with them and the independent committee, they have been operating in good faith, and one issue came up about raising the price. Again, our commission never gets involved with contracts, but the American dollar, unfortunately, has been getting weaker, and the Russian ruble has been getting stronger. So that would account for some of it.

Mr. ROHRABACHER. I see, and I think we should note that the Russians have not taken advantage of the situation that they could well have taken advantage of, and the Russians are one component in a competitive field, meaning once we have our other private sector groups, whether it is SpaceX or others involved, the Russians will still be there as an option. Isn't that the case? As we look forward right now, we are at a very delicate moment which the Russians are not taking advantage of to bleed us, but in the future when we have Falcon 9 or whatever, we will have some real competition up there for whatever projects are in low-earth orbit, however.

And let me ask about—now—don't we have Russian engines in Atlas?

Mr. GERSTENMAIER. That is correct. The RD–180 engine is in the Atlas 5.

Mr. ROHRABACHER. Okay. So we actually have been working very closely with them, probably more than most Americans understand.

Let me ask you about that; can you explain the difference between the contract with the Russian Soyuz cargo contract and the standard launch services contract for unmanned launches? Is there some difference between these contracts with what the Russians will get and what our own people will get?

Mr. GERSTENMAIER. For cargo, we have no contracts with the Russians for cargo. We previously had purchased some cargo space on Progresses, but we no longer do that. We are now committed fully to the commercial U.S.-based cargo systems to provide the cargo needs for ISS.

Mr. ROHRABACHER. Okay, and do you expect that once we have these commercial alternatives that we expect to come online, will they be in competition with Russian launch services?

Mr. GERSTENMAIER. Again, I think we will have both needs. They will still want to continue to fly their crew to Space Station, so they will continue to fly Soyuz crew capsules to deliver Russian crew members. We will be flying our U.S. crew members and European partners and Japanese partners and Canadian partners on commercial U.S. crew transportation systems.

So I would say they are not in competition. There is a need for both of those two vehicles to fly to Space Station.

Mr. ROHRABACHER. All right. Yes, sir, General?

Lieutenant General STAFFORD. Mr. Rohrabacher, one thing you brought up I think is a good point. When you talked about the need for other requirements for cargo, say low-earth orbit or even geosynchronous, and when you are looking at commodities, we are in a globalization type of era, and what we are faced with, sir, is the technicians in Samara where they build the Soyuz booster, they made $700 or $800 a month. The engineers make approximately $1,100 to $1,300 a month. I do not know what the Chinese make, sir, but I would assume it is probably a little bit less than that, and so when you have to compare that for somebody that is just independently wanting cargo lifted into space and wants to have a reliable vehicle, they would probably go for the lowest cost. And that is what unfortunately we are faced with.

As an example, Mr. Rohrabacher, I talked to Dr. Tom Young who used to be the president of Martin Corporation, now Lockheed Martin, and when the expendable, the evolved and expendable launch vehicle, the ELV, the Atlas and the Delta, were started, Martin forecast 30 to 35 vehicles a year that would be flown East and West Coast total.

Mr. ROHRABACHER. Uh-huh.

Lieutenant General STAFFORD. McDonnell Douglas forecasts for their Delta 4 medium and heavy would be 30 to 35 flown. Again, most of those, Mr. Rohrabacher, would be commercial. And today at this time, unfortunately, the United States government has to subsidize ULA about $1.3 billion a year just for infrastructure.

Then they have the opportunity to buy the booster, and today total out of East and West Coast between the Atlas and the Delta, sir, there is about seven to eight vehicles flown a year. So their forecasts were off about 85 percent.

Mr. ROHRABACHER. I know I have overextended my limit. Just one last thought and that is as we move forward, it seems to me that we will have projects like we have with the Station where the Russians have their own part, responsibility, and we have our responsibility, and that works with us and, for example, clearing debris or trying to deal with near-earth objects or some of the other space-related projects that we should be addressing and have not been addressing for a number of years.

So thank you very much, Mr. Chairman.

Chairman PALAZZO. I now recognize Ms. Edwards from Maryland.

Ms. EDWARDS. Thank you very much, also, for your indulgence while I got myself together, and I know Mr. Rohrabacher would always fill in time for me. I appreciate that.

I really appreciate this hearing because it is a reminder that when I first joined this Committee when I came in 2008, and we began really looking seriously at the prospect of losing Shuttle capacity, these are many of the same questions that were raised about reliability, about our international partners, and about safety considerations and what we would do to try to make up for the fact that we didn't have our own Shuttle capacity.

And so as we sit here today I am always in a mode of what are the lessons that we have really learned from this, and what do we need to know going into the future because it does raise some really serious concerns that not only do we not have our own capacity, but we are relying on partners who had some mishaps, and I wonder about our capacity to really examine those mishaps, to examine what that means for our serving capacity for the International Space Station, and to see for ourselves what it is that we can learn in terms of our relationship with our international partners.

And so, Admiral Dyer, General Stafford, I think you know that when you investigate anomalies and mishaps, when we have had government launch vehicles, the U.S. government has the capacity to maintain and access documentation on parts, on testing, on quality control when they are investigating, and then, of course, we in Congress have the ability to look in the public view about these mishaps. We often issue reports when we have had problems internally at NASA, and I guess I want to know what the capacity is if a mishap failure anomaly were to occur on a commercial vehicle for transporting NASA crew or cargo, and what information and documentation NASA would need to obtain from commercial companies in order to evaluate the safety of return to flight plans, ensure confidence that the root cause of any mishap had been identified and resolved, and to make a decision about how and when to resume flight operations.

Are there things about what we have learned over the last couple of months that help us in that direction?

Admiral DYER. That is an excellent question and an important one. We are already seeing in this developmental phase with commercial space how important transparency is. One, I think, should expect it, given that it is taxpayer's dollars paying a tremendous amount of the freight, but certainly transparency on behalf of the commercial companies will be a good step forward but probably not a sufficient one.

This does open a question to what on the panel we call acquisition strategy. Acquisition strategy closely links to safety because if you run out of money or you run out of time, you start to run out of the margin that is a contributor——

Ms. EDWARDS. Uh-huh.

Admiral DYER [continuing]. In many good cases to safety. So as we go forward with the plan of a fixed price contract, it is important that those things be considered. As we look at the estimated costs and whether we will be able to support competition, all these things are a part of this, and that insight that you referenced needs to be part of the calculus going forward.

Ms. EDWARDS. Let me just ask this. I mean, do we know if that kind of data are being kept now with companies and how much of that is not proprietary so that if something were to happen that NASA really has a capacity, if it, as though it had had the problem or failure itself, to investigate in the most thorough way?

Admiral DYER. I think there are different answers with different companies as to the maturity of the processes in place to maintain the data. The question of accessing it, whether it needs to be handled as proprietary, it can still be accessed, but it is important as you point out that NASA and the government have access to understand and to be able to certify the transport of U.S. astronauts.

Ms. EDWARDS. And do we have the ability to know in this interim period whether we have that same level of access to information and ability to evaluate it independently from the Russians?

Admiral DYER. From the Russians, I think that is a question you really ought to pose to Mr. Gerstenmaier. He is closest to it, but as I mentioned in my remarks, the excellent job that Bill has done personally in building a relationship of understanding and sharing with the Russians. From my perspective the answer is yes.

Ms. EDWARDS. Well, could we, Mr. Palazzo, if we could just get a really quick shout out from Mr. Gerstenmaier about whether that is really true.

Chairman PALAZZO. Without objection.

Ms. EDWARDS. Thank you.

Mr. GERSTENMAIER. We have adequate insight into what the Russians are doing. The other advantage we have with the Russian system is we have a tremendous heritage. The Soyuz booster that has been flying is basically the same booster that has been flying for 50 years with modifications, whereas a new emerging design, there are a lot of new things that come with that. A new emerging design requires extra insight, additional data to go see what happened. So in this case we weren't as worried about the basic design problem as we might have in a new emerging system. We needed to look at that to make sure we didn't miss something, but we were now focused more on the processing and manufacturing aspect and not on the basic design itself.

So it is a function of the maturity level of the design, the amount of insight required into the activity.

Ms. EDWARDS. All right, and thank you very much, Mr. Chairman.

Chairman PALAZZO. I now recognize Mr. Smith from Texas.

Mr. SMITH. Thank you, Mr. Chairman. Most of my questions have already been answered, but I do have a couple more that I would like to address to General Stafford and to Admiral Dyer.

And the first is this. Some have suggested that we might consider returning the Space Shuttle to active duty status. What do you think of that idea?

Lieutenant General STAFFORD. Well, Mr. Smith, it has been proposed but, again, Mr. Gerstenmaier would probably be better to answer that, but the long poles and the tent is that external tank and that would probably take about two years to start up, but Mr. Gerstenmaier would be the one to answer that.

Mr. SMITH. Okay.

Mr. GERSTENMAIER. Sir, the Aerospace Safety Advisory Panel has looked at that question in some detail, and our observations really are first that this would have been a great research question three or perhaps four years ago, but it is not a good question or a practical question at this time.

Mr. SMITH. It is too late now. Let me assume that all of you would agree with that.

Next question is this. There has obviously been somewhat of a brain drain from NASA. Do you think that has any long-term safety consequences to the programs themselves?

General Stafford?

Lieutenant General STAFFORD. Well, I have been involved with NASA, in some capacity, for over 40 years. There has to be an influence there; you have safety because people, young people coming out of college want to be involved and stay there for a career or the same way with industry, but then when they see complete disruptions and all this, say some of your best and your brightest tend to leave.

And so you have, to me, an indirect effect right there.

Mr. SMITH. Okay. Admiral Dyer.

Admiral DYER. It is a concern and a worry, and if one thinks for a minute about root cause, not the superficial topics of the moment but root cause——

Mr. SMITH. Uh-huh.

Admiral DYER [continuing]. We would offer, sir, that perhaps it is consistency of purpose. If you look back over the history of the space program for the last several years and the last several Administrations, you will see new courses plotted at different times, and perhaps staying the course is one of the answers to your question, sir.

Mr. SMITH. It seems to me you might lose not only experience, you might lose continuity as well, and whether this is a parallel to the energy industry, I am not sure, but I do know that when the energy industry in effect is out of business for any period of time, it takes a couple of years to get back to where they were, and I was thinking that that might affect the space industry as well.

Lieutenant General STAFFORD. Mr. Smith, one of the findings from the Columbia Accident Board that Admiral Gehman headed——

Mr. SMITH. Uh-huh.

Lieutenant General STAFFORD [continuing]. Said one of the underlying causes was that the United States did not have a long-term continuous plan, and that is very definitely a concern.

Mr. SMITH. Okay. Thank you. Thank you, Mr. Chairman.

Chairman PALAZZO. At this time, we will go into a second round of questions, and I will begin.

Mr. Gerstenmaier, under current law NASA has an exception from certain provisions of the Iran, North Korea, Syria Nonproliferation Act, commonly referred to as INKSNA, allowing NASA to purchase seats on the Soyuz for U.S. and our international partner astronauts and acquire other ISS-related services. This exception expires in 2016. What would be the impact of the ISS Program if the INKSNA exception is not extended, and when must a new exception be granted if additional Soyuz flights are necessary beyond 2016?

Mr. GERSTENMAIER. We think an exception to the Iran, North Korea, Syria Nonproliferation Act is needed, and it is needed even if we don't need to purchase Soyuz seats. For basic operations of the ISS we purchase certain services, minor, but from the Russians, and we need an exception for that to continue operations of ISS.

So we are working the appropriate exception through the Administration. We need that in place some time probably in late 2012, early 2013, and that would be either for services, for transportation, or just generic services to ISS.

Chairman PALAZZO. Mr. Gerstenmaier, your statement says that NASA anticipates one or more operational commercial crew systems being available by the middle of this decade, which sounds like 2015 to me. This statement differs substantially from a briefing NASA officials just gave Subcommittee staff last week.

Subcommittee staff were told to expect a notional date of 2017, for the potential start of commercial crew flights. NASA officials indicate that even holding that date would be dependent upon Congress giving NASA the total amount requested, $850 million per year, for the next few years.

How do you explain the discrepancy between the optimistic time table contained in your testimony and the much less optimistic time table brief to staff?

Mr. GERSTENMAIER. I would say the key consideration is the funding level assumed in that analysis.

Chairman PALAZZO. At this time I yield back my time.

Ranking Member Costello.

Mr. COSTELLO. Thank you, Mr. Chairman.

Mr. Gerstenmaier, as you know, in the 2010 NASA Authorization Act it directs NASA to provide a government backup service to the ISS, and I wonder if you might tell us what NASA is doing to comply with that authorization.

Mr. GERSTENMAIER. What we are doing is our basic plan to use commercial crew transportation as the way to get to low-earth orbit, and the reason for that is the system can be optimized for the low-earth orbit environment. In other words, the capsule can be simpler to operate, the rocket doesn't need to be as sophisticated or heavy as the government SLS solution we are starting to work on or the Orion multi-purpose crew vehicle.

Both the SLS and the Orion multi-purpose crew vehicle could be used to go to low-earth orbit. It would be an extremely inefficient use of both of those systems. The capsule is designed to return from entry velocity distances as far away as the Moon, asteroids, Mars, et cetera, so the heat shield system is much larger than would be required, more expensive to maintain than could be used, that would be needed for low-earth orbit.

It also has a life-support system that is much more robust than is needed in low-earth orbit. Also it is a much larger capsule and weighs more because you need to have the crew volume to do those distances I just described.

But that is our back-up system beyond the commercial crew transportation system. It is a government solution that could be used to go to low-earth orbit. We are not doing anything to preclude the SLS or the MPCV being used for low-earth orbit transportation to ISS, but we are also not actively pursuing changes to the design to make them better for that efficiency. We are designing them for beyond low-earth orbit, but they can then satisfy the requirements of low-earth orbit in a less-than-efficient manner.

Mr. COSTELLO. Thank you. Thank you, Mr. Chairman.

Chairman PALAZZO. The chair now recognizes Mr. Rohrabacher from California.

Mr. ROHRABACHER. Thank you very much. You know, when we look back at the Space Station and American Space Program these past three decades, we can see what came out of the Space Station. This was a great investment. I think we are talking, what, about $100 billion investment or at least, maybe more, maybe a lot more. I am not sure.

By the way, what is that? What is the end result? How much have we put into Space Station?

Mr. GERSTENMAIER. I believe the number we quote is on the order of, I think, $60 billion.

Mr. ROHRABACHER. Okay. I got a feeling that is low. My gut instinct tells me that $60 billion, it was more than $60 billion in this project. But one of the things that we actually learned from this is how to construct things in space, which I think that is a skill that can serve great purposes for mankind, for humankind.

And one of the reasons why some of us are skeptical about putting so much money into a vehicle that will be used 10 years from now for putting things into exploration of the outer areas of space is that it will drain money away from potential projects that we see are important in low-earth orbit. I just mentioned debris clearing and perhaps some sort of any near-earth object type of deflection concepts that I think would be important for humankind.

Do you see any other projects that would involve space construction and for which we would use the lessons from the Space Station? That is number one. Do you see any more of those happening, and number two, are we going to have the capability to construct things in space without the Space Shuttle and the arm that we used so importantly in constructing something big in space?

I put that out to the panel.

Mr. GERSTENMAIER. Again, I think we have seen the benefit as you described of the ability to construct things in space. I can see some other applications, maybe even some satellite things, some telescopes, some large mirrors, some other things that may have application in construction in space.

We are also learning to use robots to do activities. We recently did an activity onboard Space Station. We changed out a remote power controller using a robot commanded from the ground. That was the first time that we had done that. Typically that had only been done via space walks with crew members. So there is some ability to grow in that area. So I think there are some real applications of you doing construction.

We have also looked at the Orion capsule. The Orion capsule has some space in the back where we could actually put an arm on the Orion capsule, and we could do some limited assembly and limited construction with the Orion capsule.

We are also looking at another vehicle which may be more of a multi-armed vehicle that would actually sit kind of on the front end of the Orion capsule. It would be more of a, kind of a construction vehicle. To say another term it might have an air lock in front to allow crew members to go EVA.

So there are some modular pieces that we are looking to add onto the Orion capsule that gives us the ability to do construction in low-earth orbit and that same technology, same interfaces would be needed to go visit an asteroid, you would want to use those same robotic manipulators. You may use some of the same grappling mechanisms with an asteroid that you could use for a low-earth orbit construction.

So I don't think we are going to give up on low-earth orbit construction. We still have the capability to do that with the Orion capsule the way it is envisioned.

Lieutenant General STAFFORD. Mr. Rohrabacher, the Soviet Union, later Russia, they started back in 1986, building the Mir Space Station, putting together just robotically large structures up to 45,000 pounds, and they did that continually as they built up the Mir. So that technique has been demonstrated, and if you have the ability of the rocket to put that weight up there, it can be done, sir, robotically, very easily.

Admiral DYER. Interesting linkage perhaps between Mr. Smith's question and yours and that is—I should acknowledge up front that I come from the ground robotics business, not the space business, but we are having tremendous success in recruiting young men and women out of college and getting people started in that scientific and engineering undertakings in college, out of high school, thanks to the FIRST work in high schools.

I certainly agree with you that low-earth orbit is important and will be for many, many years, but perhaps one of the most important parts of space launch system is its reach beyond and represents an opportunity to really reignite the excitement of American youngsters with regard to space.

Mr. ROHRABACHER. Thank you very much.

Chairman PALAZZO. The chair now recognizes Ms. Edwards from Maryland.

Ms. EDWARDS. Thank you, Mr. Chairman. I just want to follow up, if I could, Mr. Gerstenmaier, on the questions raised by Ranking Member Costello, and it has to do with—I understand the ability to develop a backup capacity. What I am trying to figure out is just how timely that would be, and so I wonder if you could help me out there. And then I had some other questions regarding safety and our ability to begin to get the Soyuz back on track.

Mr. GERSTENMAIER. Again, our focus is to try to stay with the commercial crew transportation as our primary means of getting crew to ISS, and we had planned to focus on that with the budget activities and making progress as we move forward.

If we see some dramatic change in either the cargo world, the commercial cargo world or the commercial crew world, we could refocus our efforts back to the government solution to try to advance that and pull that forward at the time we see that. But right now at this point we have kept our focus on the commercial side for both commercial crew and commercial cargo transportation as our focus of providing an alternate way to get crew to Station other than the Soyuz.

Ms. EDWARDS. So does that mean that, you know, for now for this interim period that you—when would you fully anticipate that we would have our own capacity even if it is the commercial capacity?

Mr. GERSTENMAIER. We think, again, the commercial capacity would be in the 2015, 2016 timeframe, again depending upon the actual budget scenario we get. As we discussed with the SLS MPCV, the first un-crewed test flight is in 2017. With our current budget scenarios the first crewed flight would be in 2021, for the government SLS/MPCV solution, and that is also a function potentially of budget. That can be advanced a little bit if we get additional budget in that area.

Ms. EDWARDS. But we actually really don't have any way of knowing whether we are really talking about, you know, sort of '20, '21, or perhaps even beyond that because we know all of these things are all very fluid, which raises my next question, which would have to do with getting back on track with Soyuz.

Have you—has NASA been able to determine when it is going to be safe to resume crewed flights if a commercial vehicle ever has a Soyuz-like accident?

Mr. GERSTENMAIER. Again, it is hard to speculate what the problem was that occurred. You know, I think we need to go step back for a minute and look at the cargo world first. The Progress vehicle had, as we described, I think it was heard earlier, we had 1,800 firings of this engine, particular engine that fired. So it has——

Ms. EDWARDS. Uh-huh.

Mr. GERSTENMAIER [continuing]. A tremendous history behind it, but yet it still failed. We need to watch as the commercial cargo providers are coming online, there is a fairly high likelihood they could have some problem and potentially lose a cargo vehicle at the beginning of their programs. We need to be prepared to accept that, understand that, fix the problem, and get ready to move on. If we stop everything and we go back and do a detailed, deep investigation, we go back and question our acquisition philosophies and put a protracted or extremely long investigation on that, that could be very problematic to getting commercial cargo available.

So we need to start actively having discussion about what would be needed in the instances that you described, but it is very difficult to speculate because it depends upon what the failure was, was it a simple fix, something that was easily missed or something that needs much more involvement and more investigation.

Ms. EDWARDS. I mean, the trouble is that we actually have that kind of extensive data as you described before with respect to the Soyuz, but if we got started with a commercial flight, we actually wouldn't have our own vehicles here. We wouldn't actually have any kind of a data set, and so how would you then determine, you know, first, when you would be able to—or when would that data be available? It is kind of hard for me to know without then predicting a 50-year history like the one that we have with Soyuz.

Mr. GERSTENMAIER. Again, part of our strategy is we have redundancy to somewhat redundancy in cargo transportation. So we not only have the commercial providers, we have the automated transfer vehicle provided by the Europeans which can deliver cargo to the ISS, we have the Japanese HTV vehicle which can provide cargo, and then we have two commercial cargo providers.

So we have a fair amount of way to get cargo to Space Station so we have some time to go work these problems, and we would have to pull the data and understand the problems as we move forward.

But, again, I don't think it is an insurmountable problem. We just need to be ready to go do that, and we are prepared generically ready to go do that.

Ms. EDWARDS. Thank you. Mr. Chairman.

Chairman PALAZZO. I want to thank the witnesses for their valuable testimony and the Members for their questions.

The Members of the Subcommittee may have additional questions for the witnesses, and we will ask you to respond to those in writing. The record will remain open for two weeks for additional comments from Members.

The witnesses are excused, and this hearing is adjourned.

[Whereupon, at 3:28 p.m., the Subcommittee was adjourned.]

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. William H. Gerstenmaier, Associate Administrator, Human Exploration and Operations Mission Directorate, National Aeronautics and Space Administration

Questions submitted by Chairman Steven M. Palazzo

Q1. Please provide the cost and schedule estimates for the commercial crew initiative and the detailed analytic basis of those estimates.

A1. NASA has worked for several years to refine an estimate of the required government investment to successfully develop a commercial crew capability. In 2009, the Final Report of the Review of U.S. Human Spaceflight Plans Committee provided an estimate of $5B over five years. In the planning for the President's 2011 budget request, the Administration refined this estimate and requested a lower-risk funding level of $5.8B for commercial crew development over five years. Since that time, NASA has continued to receive detailed information from potential commercial partners and independent analysis, providing a general range of $2.5–$3.5B per system. NASA strongly supports carrying at least two systems as far along through the development process as possible. This approach will take advantage of continued competition for an estimated investment of $5–$6B.

A detailed description of the analysis behind the outline of the NASA estimate follows:

The analysis used to develop that estimate and that has been refined with time was from the Final Report of the Review of U.S. Human Spaceflight Plans Committee, "Seeking a Human Spaceflight Program Worthy of a Great Nation": *http://www.nasa.gov/pdf/396093main_HSF_Cmte_FinalReport.pdf.*

That analysis was used as the primary basis for the FY 2011 President's Budget Request for commercial crew development. During the FY 2011 budget development process, it was decided to add some risk margin to the "Final Report of the Review of U.S. Human Spaceflight Plans Committee" estimate of $5B, given the uncertainties associated with major development programs and the importance of acquiring this capability. Thus, a $5.8B budget was included for commercial crew development over five years, with the following phasing:

($ in millions)	2011	2012	2013	2014	2015	Total
FY 2011 BUDGET	500	1,400	1,400	1,300	1,200	5,800

Subsequent to the FY 2011 President's Budget Request, several events occurred, which further informed NASA's budget estimates. First, in May 2010, NASA requested additional information from industry in the form of a Request for Information (RFI) in which NASA requested, among other things, the following:

"What is the approximate dollar magnitude of the minimum NASA investment necessary to ensure the success of your company's Commercial Crew Transportation (CCT) development and demonstration effort? What is the approximate government fiscal year phasing of this investment from award to completion of a crewed orbital flight demonstration? What percentage of the total development cost would the NASA contribution represent?"

The information NASA received in response to these questions was limited and somewhat incomplete, but estimates for full (government and private investment) commercial crew system development costs appeared to range from approximately $1B to $8B per system, with an average around $2.5B to $3B. Two average-cost systems would therefore require $5 to $6B in total investment through certification. Also, NASA received informal cost and technical data during our interactions with the original Commercial Crew Development (CCDev) partners (Boeing, Sierra Nevada, United Launch Alliance, Blue Origin, and Paragon) and the CCDev Round 2 partners (Boeing, Sierra Nevada, SpaceX, and Blue Origin) and others interested in developing commercial crew transportation systems.

In addition, NASA received other data from industry in more formal settings, including: Industry Days, Program Forums, and One-on-One Meetings with potential commercial crew transportation system providers. All these data appeared to substantiate estimates for full commercial crew development costs in the range of $2B to $4B per system, although some were as low as $1B. Ranges of proportional industry investment also were wide, with most centering between 10 percent and 20 percent, while some were above 50 percent.

During the FY 2012 budget development process, NASA strove to strike the right balance between Human Exploration Capabilities and the development of commercial crew transportation systems. Based on the many needs in FY 2012 and NASA's moderately better understanding of the crew transportation system development costs, the Agency submitted a request for $850M for FY 2012 for the Commercial Crew Program. For planning purposes, this amount was assumed to remain flat for FY 2013–FY 2016 at $850M.

This amount ($850M) was above the amount authorized in the 2010 NASA Authorization Act for FY 2012 ($500M). The higher amount for the Commercial Crew Program was estimated to be the minimum amount necessary in FY 2012 to achieve safe, reliable, cost-effective U.S. crew transportation capability by 2015/2016. The 2010 NASA Authorization Act established commercial crew as the primary means for U.S. access to the ISS, and NASA wanted to take all steps necessary to provide assured access to the ISS for NASA and NASA-sponsored personnel.

Since the release of the FY 2012 President's Budget Request, NASA has continued to refine its budget estimates to inform the FY 2013 Budget. An additional input came from a recently completed external assessment of the cost, schedule, and technical estimates that NASA has been using for the Commercial Crew Program. This external assessment was performed by Booz Allen Hamilton, which confirmed that NASA's estimates were reasonable (because the report contains Privileged/Proprietary Commercial or Financial Information, NASA has submitted this document to the committee under separate cover).

While the $406 million for the Commercial Crew Program funded in the Consolidated and Further Continuing Appropriations Act of 2012 (Pub.L. 112–55) will enable the Agency to move the Program forward, NASA has had to reassess its acquisition strategy for this Program.

On December 15, 2011, NASA announced a modified competitive procurement strategy to keep the Commercial Crew Program on track; instead of awarding contracts for the next phase of the Program, the Agency plans to continue to use multiple, competitively awarded funded Space Act Agreements (SAAs). Using competitive SAAs instead of contracts allows NASA to fund multiple partners during this phase of the Program. This new acquisition strategy will allow the Agency to preserve competition and maintain momentum to provide a U.S.-based commercial crew launch capability at the earliest possible time.

This new strategy has resulted in an estimated availability date for U.S. commercial crew services likely by 2017.

1. COTS A is defined as External Cargo Delivery and Disposal, COTS B is defined as Internal Cargo Delivery and Disposal, COTS C is defined as Internal Cargo Delivery and Return.

2. Note: Capsules will be used for both Crew and Cargo missions. However, the configuration for Crew Capsules will be different than those used for Cargo.

Q2. Given the delays in NASA's commercial cargo program, and the lack of the European ATV after 2014, what backup plan is in place to meet the ISS logistics requirements after 2014?

A2. NASA mitigates the logistics resupply risk by using existing capabilities to preposition critical cargo and by supporting the development of independent commercial resupply capabilities. To protect the International Space Station Program from commercial cargo program delays, NASA used established cargo capabilities to preposition cargo prior to Shuttle retirement. This strategy has enabled NASA to absorb the commercial cargo program delays with minimal impact through 2012. Although not expected, if the commercial cargo programs are delayed into late 2013, the scheduled HTVs and ATVs can likely support ISS operations but this would result in significant deferment of utilization. If the commercial cargo program is delayed beyond 2014, it would require additional actions, such as reducing the crew size. The impact of terminating European ATV flights after 2014 is reduced by coinciding with the solar cycle minimum. During the solar cycle minimum, the ISS propellant needs are greatly reduced. Current propellant deliveries on ATV1 through ATV5 satisfy the NASA propellant contribution requirements through 2020. Roscosmos Progress vehicles will satisfy the remaining propellant requirements per existing ISS agreements. It is fully expected that both commercial cargo delivery providers will be operational post 2014. Additional commercial services procurement in the 2016–2020 time frame will meet the cargo delivery needs. NASA has mitigated the logistics resupply risk by procuring cargo services from multiple, redundant providers and pre-positioning cargo.

Q3. What options are available from our international partners to supply the necessary up-mass capability from 2014 to 2020?

A3. In the unlikely event the commercial cargo delivery providers are unavailable in 2014 through 2020, three ISS partners have capability to provide up-mass services in 2014–2020. JAXA and ESA can supply one HTV and one ATV, respectively, per year within their current manufacturing capability if provided the proper notice and resources. Similarly, the Russian Federal Space Agency (Roscosmos) could supply additional Progress capability for NASA and U.S. Operating Segment (USOS) use within their manufacturing capability, also with proper notice and resources. These cargo delivery capabilities can support the safe operation of the ISS but with impact to the utilization of ISS.

Q4. Please provide for the record (1) the effects of the reduced crew size on scientific utilization for research, (2) which area of research is most affected and to what degree, and (3) how has the reduced crew size impacted the overall station operation.

A4. Crew size affects research progress in two primary ways. The first is the amount of crew time available to conduct experiments. In short-term periods of reduced crew size, some work could be replanned to allow high-priority experiments to stay on course, but over the longer term, the impact of reduced crew size will be greater. A smaller crew will also reduce the number of human subjects for biomedical research on the effects of spaceflight and potential countermeasures. An important aspect of the human response to spaceflight, and to countermeasures, is the statistical variability shown in experiments. In order to determine the statistical variability of results in biomedical research, there must be data from a number of subjects. If the number of crew is reduced, the number of potential subjects for biomedical research will be reduced, and the time required to gather the necessary data is drawn out as researchers wait for new crew to participate. The area of research most affected by crew size is biomedical research on the consequences of long-duration spaceflight, and the development of countermeasures for medical issues like loss of bone and muscle, cardiovascular deconditioning, and visual impairment. Since this research depends on both crew time availability and on the total number of participating subjects, the progress of human biomedical research is more or less directly proportional to the number of participating subjects, or the participating crew on orbit.

ISS has continued to operate safely and execute its research plan during periods with three crewmembers instead of six, an operating mode in which we are well experienced. The primary difference is in crew time available for research, time-critical maintenance and systems enhancements. There has been no effect on the crew's readiness to respond to emergencies during periods of reduced crew size. Each Soyuz three-crew complement is thoroughly trained to respond to both system emergencies, such as fire or loss of pressure, as well as any medical emergencies. During the two months from September 15–November 16, 2011, with two United States Operating Segment (USOS) crewmembers to perform our work, lower priority maintenance tasks were deferred in order to maximize research. These tasks were accomplished when the ISS returned to its full complement of 6 crewmembers in December of 2011. Examples of these deferred tasks are pre-routing of cables for future avionics upgrades, troubleshooting and repair of non-essential hardware, and arranging more efficient stowage in the Permanent Maintenance Module (PMM).

Additionally, because crewmembers are not cross-trained to perform extravehicular activity (EVA) in the other segment's spacesuits, NASA did not have a fully trained ISS EVA team on-board. Russian Segment EVA capability was restored following the arrival of the next Soyuz crew in late November; however, USOS EVA capability was unavailable until additional USOS crewmembers arrived in December. Current ISS performance as well as built-in ISS system redundancy significantly minimized the risk of requiring an EVA; however, the time frame of risk exposure was increased due to the extended duration of the three-crew period.

Q5. Please quantify for the record the type and amount of research that has been lost as a result of reduced crew time on orbit.

A5. The loss of the Progress 44P has resulted in delays to the launch or return of four Soyuz flights. This extended the periods of three-crew operations on the ISS, and a subsequent reduction in crew utilization hours from a planned 515 hours to a current estimate of approximately 333 hours, based on actual hours recorded and estimates of utilization through docking of Soyuz 29S in late December. By this estimate, the impact to research on ISS from the failed Progress launch is about a 35 percent loss of science from the baseline plan over the ~6-month increment.

Q6. NASA has done a thorough job pre-positioning supplies and spares on ISS, but assuming no major anomalies, how long could ISS safely operate without crew? Which on-board systems carry the greatest risk or cause the most concern?

A6. The ISS is designed to be safely operated for extended periods in both crewed and de-crewed modes. For the de-crewed mode, ISS systems are reconfigured to allow continued safe operation under only ground-based command and control. In this decrewed configuration, all critical systems will be left in a fully redundant configuration. However, after the crew leaves, it will not be possible to repair failures that occur.

The ISS requires re-boosting approximately every three months, which requires use of Russian thrusters and consumption of propellant. As of the time of the Progress anomaly, there were approximately 6,000 kg of propellant on board the ISS, which would have allowed the ISS to maintain orbit for approximately two to three years without resupply.

The greatest risk is failure to maintain attitude in the de-crewed mode. The ISS motion control system (MCS) is composed of Russian and U.S. segments that maintain attitude control. When the Russian segment is in control, it uses attitude thrusters, which burn propellant. When the U.S. segment is in control, Control Moment Gyros (CMGs) are used. The two systems continuously exchange data for redundancy and comparison tests. They are complementary except for propulsion, which is provided by the Russians. The Navigation portion of the U.S. Guidance, Navigation and Control system primarily relies on Global Positioning System (GPS) data to determine ISS position, velocity and attitude. Russia's GPS counterpart, the Global Navigational Satellite System (GLONASS), provides data to the Russian segment's Motion Control System (MCS). Attitude data is also drawn from two sets of three U.S. ring laser gyros called "rate gyro assemblies." These use variations in laser light beam lengths to sense attitude change and the rate at which it is occurring. The data they produce is used to supplement GPS data. In addition, Russia's system determines the ISS's attitude by tracking the stars and the Sun, and by gauging the horizon. In addition to failures in the MCS, failures in the systems that support the MCS such as the command and data handling system, or the thermal control system can also lead to loss of attitude control. It takes not only multiple failures, but specific multiple failures that take out all capability of a critical system, to cause Loss of Vehicle for a decrewed ISS.

Q7. The Russians have been valuable partners on the ISS, but without the shuttle, NASA is now exclusively buying crew transportation services from Russia. This changes the Russian's role to something more akin to that of "supplier" with NASA as a "customer" for crew transportation. In this new role as a "customer" of Russia are the previous ways of doing business adequate or do you think NASA's insight and oversight of the Russian operations should be strengthened?

A7. NASA has been purchasing transportation and rescue services from Russia for many years as a customer, and the Russians have proven to be consistently reliable partners. For example, in the aftermath of the Columbia accident, the Russians provided the Soyuz spacecraft necessary to keep the ISS operational. In terms of NASA's insight into technical systems and issues, the Russians have kept NASA officials very well informed regarding anomalies experienced (e.g., Soyuz ballistic reentries, the Progress 44P anomaly). The Russian Federal Space Agency (Roscosmos) is responsible for resolving technical issues related to anomalies and coordinating with all of the International Partners, including NASA. This coordination is formally manifested in meetings of the Space Station Control Board, as well as the partners' participation in the standard Stage Operations Readiness Reviews and Flight Readiness Reviews. NASA is satisfied with this level of insight.

Questions submitted by Acting Ranking Member Jerry Costello

Q1. What was the extent of NASA's insight into the quality control of Shuttle components? How does this compare to the insight NASA maintains for the quality control of NASA Launch Services launchers used for NASA science missions? How does this compare with the level of insight NASA expects to achieve in assessing the quality control of components used by commercial cargo and crew providers?

A1. For the Space Shuttle Program, the role of the Office of Safety and Mission Assurance (OSMA) was consistent with the roles performed on all human and robotic space flight missions as defined in NASA Policy Directive (NPD) 1000.0A, the NASA Governance and Strategic Management Handbook and NASA Procedural Requirements (NPR) 7120.5, NASA Program and Project Management. This role included the structured application, implementation, and oversight of Agency-wide safety, reliability, maintainability, and quality assurance (SRM&QA) policies, procedures, and requirements. OSMA had the lead in ensuring incorporation of appropriate NASA human space flight safety and mission assurance (SMA) strategies, policies, and standards from early program activity through program completion in July 2011. For the duration of the Space Shuttle program, NASA had assigned a Program Chief SMA Officer (CSO) who had Safety and Mission Assurance Technical Authority responsibility for Space Shuttle. This CSO reported independently through the Center SMA Director, the Center Director, and then to the NASA Headquarters Chief, Safety and Mission Assurance (OSMA). In addition, the staff of the Headquarters Chief, Safety and Mission Assurance provided independent assessments/viewpoints at Agency level management forums over the duration of the program.

For the NASA Launch Services Program (LSP), the quality control of the NASA Launch Services (NLS) launchers is governed by NASA Policy Directive (NPD) 1000.0A, the NASA Governance and Strategic Management Handbook and NASA Procedural Requirements (NPR) 7120.5, NASA Program and Project Management. This role includes the structured application, implementation, and oversight of safety, reliability, maintainability, and quality assurance (SRM&QA) policies, procedures, and requirements as they apply to commercially developed systems procured thru the NLS contract.

OSMA has worked with the LSP SMA to ensure incorporation of appropriate safety and mission assurance (SMA) strategies, policies, and standards in program activities and subsequent efforts verify compliance with these requirements. As NASA has done in other Programs, a Safety and Mission Assurance Technical Authority has been delegated responsibility for the NASA Launch Services procured by the LSP. The SMA Technical Authority reports independently through the Center SMA Director, the Center Director, and the Chief, Safety and Mission Assurance (OSMA). In addition the staff of the Chief, Safety and Mission Assurance interface with the Launch Services Office within the Human Exploration and Operations Directorate at Headquarters, as well as directly with the LSP safety and mission assurance personnel and Technical Authority providing independent assessments/viewpoints at Agency level management forums.

The NLS contract contains a clause for insight and approval that enables the processes NASA utilizes for launch service certification of flight readiness (COFR). This clause enables LSP to meet the requirements in NPD 8610.23, Launch Vehicle Technical Oversight Policy. In performing Technical Oversight of the launchers used for Science missions, "NASA uses a combination of specified approvals and targeted insight in order to establish, apply, and modify mission technical requirements, identify technical issues and resolve disputes, and assess the competency and adequacy of the technical work performed by the commercial launch service providers." These processes are executed throughout the launch service life cycle (launch vehicle manufacturing/production through launch).

For the NLS contract, it is important to note that ownership of the technical standards, engineering design, analysis and manufacturing/quality processes resides with each launch service provider, not NASA. In addition, similar to how the SMA Technical Authority operates, the LSP Engineering Technical Authority and associated engineering functions operate with, but independently from, the LSP management. As a result, the LSP Engineering and SMA Technical Authorities are both an integral part of the overall LSP Mission Assurance approach, of which quality control of the NLS launchers an element.

The data resultant from the NPD 8610.23 Technical Oversight, including the resident office quality assurance activities, forms the foundational basis for NASA's overall launch vehicle mission assurance assessment. From these assessment activities, NASA gains a detailed understanding of the quality of the commercial launch service provider's flight systems and the overall launch service acceptability including identification of any associated risks resulting in NASA's launch service mission/flight readiness certification (COFR).

The quality control system for NASA's Commercial Crew Program (CCP) is still under development and will be finalized in the coming years.

At present, it is expected that insight into commercial crew provider processes, including quality control, will be governed by NASA Policy Directive (NPD) 1000.0A, the NASA Governance and Strategic Management Handbook and NASA Procedural Requirements (NPR) 7120.5, NASA Program and Project Management. As with other programs, a Chief Safety and Mission Assurance Officer (CSO) has been assigned to carry out the roles of the SMA Technical Authority for CCP. The CSO reports independently through the Center SMA Director, the Center Director, and the Chief, Safety and Mission Assurance (OSMA).

It is also expected that NASA will include the appropriate set of safety, reliability, maintainability, and quality assurance policies, procedures, and requirements in commercial crew agreements worked between NASA and commercial service providers. One example is that NASA's commercial partners are expected to be responsible for developing and implementing a quality management system that is compliant with AS9100. Other policies, processes and workmanship standards will be utilized as applicable.

NASA expects to perform assessments to determine if the commercial partner's quality control processes provide adequate documentation and sufficient process control to ensure crew safety and mission success. NASA will evaluate specific hardware and software data and non-conformances as they relate to NASA's key interface requirements. In addition, NASA has insight into the commercial companies' compliance to industry standards such as AS9100 and has the ability to review and assess performance to those standards.

Overall, NASA will verify that key performance parameters are trended, evaluated, and understood and each commercial partner will obtain NASA Certification prior to flying NASA or NASA-sponsored crewmembers.

Additional quality control processes and procedures are currently under evaluation by the Commercial Crew Program and the approach to quality control will be finalized over the coming years.

Q2. You indicate in your statement "We need to anticipate inevitable start-up challenges associated with a technologically ambitious endeavor." Does the possibility of "inevitable start-up challenges" also apply to commercial crew?

A2. Yes. While the U.S. has transported crew to and from low-Earth orbit for decades, each crew vehicle is unique and its integration with the launch vehicle also needs to be considered from a systems engineering perspective. The challenge of flying humans into space will always require careful application of engineering principles and quality control procedures. NASA does anticipate challenges for this program, some significant and some associated with the early phases of development, test, and operations. NASA plans to address and/or mitigate these challenges as we execute the program.

Q2a. Given that, what is the basis of the estimate of "middle of this decade" for when commercial crew services would be operational?

A2a. NASA has been told consistently by a broad range of potential providers that private sector partners expect to be able to achieve a capability of providing commercial spaceflight services to the ISS within three–five years from initial development start. NASA's FY 2013 budget request for the Commercial Crew Program would provide sufficient funds to continue development of commercial crew transportation systems, which would enable services to ISS likely by 2017, but earlier availability of services will not be precluded.

Q3. In the case of the recent Soyuz mishap, I understand that the Russians plan to fly two unmanned flights before astronauts are allowed back on the Soyuz rocket. If a commercial launch vehicle experiences a serious anomaly, what will NASA require of the companies before they are allowed to resume flights carrying NASA astronauts?

A3. It will depend on the anomaly and when it occurs. It will also depend on whether the flight was licensed by the FAA and/or the provisions of the contract under which NASA is flying astronauts on commercial crew transportation systems. In general, NASA requires an identification of the root cause of any anomaly and an approved corrective action plan with verification that the plan has been followed. If there is a loss of life, Title 51 of the US Code provides guidance as to what NASA would do for a mission provided under contract to NASA:

51 USC Ch. 707—HUMAN SPACE FLIGHT INDEPENDENT INVESTIGATION COMMISSION

§ 70702(a): Establishment.—The President shall establish an independent, nonpartisan Commission within the executive branch to investigate any incident that results in the loss of ——

- (1) a space shuttle;
- (2) the International Space Station or its operational viability;

- (3) any other United States space vehicle carrying humans that is owned by the Federal Government or that is being used pursuant to a contract with the Federal Government; or
- (4) a crew member or passenger of any space vehicle described in this subsection.

Q3a. Who will bear these costs? What assurance can you offer the members that this will not be additional "hidden costs" to the taxpayer?

A3a. As in the previous questions, it will depend on the anomaly and when it occurs. It will also depend on whether the flight was licensed by the FAA and/or the provisions of the contract under which NASA is flying astronauts on commercial crew transportation systems.

Q4. In your prepared statement you say, "the Station will also serve to promote the growth of a LEO space economy by operating as a customer and a destination for U.S. companies capable of transporting crew and cargo into orbit." What analysis has been done on the potential research utilization of the ISS as a driver of demand for commercial crew and cargo services to low-Earth orbit?

A4. Pursuant to Section 403 of the NASA Authorization Act of 2010 (Pub.L. 111–267), on April 27, 2011, NASA submitted a report to Congress on "Commercial Market Assessment of Crew and Cargo Systems." Section 5.2 on Applied Research and Technology Development is directly responsive to the question, and is excerpted from the report below:

Historical Experience (Lower End of Range)

To date, virtually all of the funding for experiment development, transportation, accommodation and resources has been provided by government sponsors with few notable exceptions of commercial investment. Commercial investments have been limited to covering the costs of their investigators and incidental expenses. The share of experiments with a commercial interest, as a percent of total experiments performed, has been approximately nine percent.

In some cases, an experiment conducted on board the ISS by a private, non-U.S. Government entity had its investigator costs paid for by that private entity, but costs of transport and use of the station were covered by NASA. Thus, none of the research included in the "U.S.-commercial" category was completely funded by private entities, and it is unclear if any of this research would have been conducted had the government financial contribution not existed. Accordingly, the low end of the range for this market is zero pounds of cargo, even though private entities have contributed financially, in some cases quite substantially, to this research.

Market Potential (Upper End of Range)

As mentioned, approximately nine percent of ISS utilization interest has originated from commercial sources. This figure provides an estimate of the level of commercial market interest in Applied Research and Technology Development activities, when the research costs are largely covered by NASA. Accordingly, it can be used to provide the ISS-related portion of the upper end of the range. Applying nine percent to the total projected National Lab utilization gives an estimate for commercial ISS cargo of approximately 3,900 pounds [through 2020].

Q5. You say in your prepared statement that "[the ISS] is the only space-based multinational research and technology test-bed available to identify and quantify risks to human health and performance, identify, and validate potential risk mitigation techniques, and develop countermeasures for future human exploration."

- Is NASA on track to retire and mitigate against critical human risks to long-term exploration in order to support a human mission to an asteroid in the 2025 time frame?

A5. The NASA Human Research Program has identified the human health and performance risks for long-duration space missions and is working toward addressing each of those risk areas (*http://humanresearchroadmap.nasa.gov/*). These efforts are aiming to address and provide solid research to quantify and provide mitigation for most human health and performance risks to support an asteroid mission in the 2025 time frame. The most challenging and uncertain risk areas at the present time are the health effects associated with visual impairment/increased intracranial pressure and space radiation. Both these areas have the potential of limiting mission duration. The Advanced Exploration Systems, Space Technology, and Human Research Programs are working to characterize space radiation environments, and to develop radiation shielding. Other areas, while still challenging, such as providing necessary muscle and bone countermeasures, approaches to dealing with crew isolation and confinement, asteroid chemical/dust human exposure limits, and requirements for habitable volume, are within the current research capability and should have acceptable mitigation strategies before any mission to a near-Earth asteroid.

Q5a. If the ISS were to go into a de-crewed status for an extended period (six months or more), how would NASA plan to acquire the human health research needed to address long-term exploration risks?

A5a. The ISS provides unique long-term access to the space environment and is essential for reducing crew health and performance risks associated with exploration missions. As such, ISS utilization is in the critical path for reducing these risks and extended de-crewing would impact NASA's ability to complete the research necessary to understand the severity of certain risks, to gather evidence to quantify the risks, and to complete the development of key countermeasures.

ISS de-crewing would have a significant impact on current ISS human research experiments in musculoskeletal countermeasures, cardiac function, aerobic capacity, sensorimotor changes, and crew performance. If the de-crewing were for less than six months, the long-term impact may be limited, as we would continue to use appropriate ground analogs, like bed rest studies, to refine future ISS research experiments. However, one area that would be disproportionately impacted is new ISS research on space induced visual impairment/increased intracranial pressure. A de-crew would delay our ability to understand this significant health issue, since there is currently no means of making progress without the ISS data collection and research performed on the ISS. Although it is difficult to predict how long it will take to understand and solve this problem, the agency has a preliminary plan to provide an understanding and potential countermeasure before the end of ISS.

Responses by Lieutenant General Thomas P. Stafford, USAF (Ret.), Chairman, International Space Station Advisory Committee

Questions submitted by Chairman Steven M. Palazzo

Q1. NASA is entering into an increasing number of Space Act Agreements and other non-contract relationships involving hundreds of millions of dollars of taxpayer money. Based on your experiences with this investigation or others, please describe the level of insight your organization has with NASA itself, with NASA's commercial crew partners using Space Act Agreements, and with NASA's international partners such as Roscosmos.

A1. We have very little or no insight to the commercial partners for commercial cargo. At this time, no insight to commercial crew except that briefed by the ISS Program Office. We have somewhat good insight into Roscosmos.

Questions submitted by Ranking Member Jerry Costello

Q1. If a mishap, failure, or anomaly were to occur on a commercial vehicle used for transporting NASA crew or cargo, what information and documentation would NASA need to obtain from commercial companies in order to evaluate the safety of return-to-flight plans, ensure confidence that the root cause of any mishap had been identified and resolved, and make a decision to resume flight operations?

A1. The same as if it was a NASA vehicle.

Q1a. Do you know if such data is being kept by the companies and if they plan to make it available to NASA?

A1a. We have not been briefed on any data or process.

Q1b. What other types of information are needed to ensure the safety of astronauts flying on commercial vehicles, since extensive accumulated flight data, as was used in the case of the Soyuz, will not be available?

A1b. Need complete insight to data and processes used by commercial partners.

Q2. What steps has the Russian space agency taken to address the root cause of the recent Soyuz/Progress incident?

A2. They have explained the steps they are taking. Most data received through ISS Program Office.

Q3. In considering the future of the ISS servicing and resupply, to what extent do you think NASA and the international partners have identified and addressed all safety issues? Are there any gaps and if so, what are they?

A3. There is a series of safety requirements issued by NASA.

Q4. NASA has a multi-decadal history of working with the Russians on cooperative human spaceflight activities. What aspects of the Russian-NASA process for dealing with Soyuz mishaps, incidents, and anomalies are critical for NASA's partnerships with future non-government ISS crew and cargo transportation providers?

A4. The information channels are open and at this time all aspects are satisfactory.

Q5. The Appendix to your Prepared Statement is a summary of findings of an ISS Advisory Committee and ASAP review of the status of commercial logistics vehicles now under development. Those findings highlight concerns with respect to the developments for commercial cargo resupply services to the ISS. What plans do the two external bodies have for further investigation of the issues identified in the findings and what, if anything, needs to be addressed now in response to these issues?

A5.
A7. The ISS Advisory Committee (ISS AC) and the ASAP have continued to pursue the Comercial Cargo Vehicle concerns identified at their 9 August 2011 Joint Meeting at the Johnson Space Center, Houston, TX.

The ASAP conducted Panel follow-up visits at the SpaceX and Orbital Sciences facilities and the following is quoted from their report: " . . . found positive signs of progress. SpaceX is communicating more openly with greater transparency. Its production facility has greatly matured; its energy and innovation are exciting and infectious. The visit to Orbital was very interesting. Orbital is a company that is both experienced and innovative. It has deep knowledge from having launched over 1,000 satellites and vehicles for both commercial entities and the government."

At the Johnson Space Center, the ISS AC continued to closely monitor the SpaceX-D flight preparation, and in particular its various Safety and Flight Readiness Reviews. ISS AC team members also observed on a daily basis the launch, rendezvous, capture and berthing maneuvers and operations. There were no observed deviations or exceptions to the established flight rules, required demonstration maneuvers, or requirements.

As both the ISS AC and the ASAP have identified, of major concern is the budget. Schedule and resources inevitably precipitate safety. Both the ISS AC and the ASAP are well aware of the tenor of the times, and understand the shortfalls and deficits that our government faces; however, if America wants a solid space program, it must be a priority and must be paid for, and the funding committed must be effectively and efficiently managed. However, as I testified from NASA data, both companies were overly optimistic in both funding and schedule projections. Both entities are several years late from their original contracted flight dates and to date have exceeded their original contractor estimates by approximately a factor of three.

Q6. In light of the recent Soyuz incident, how does the 2010 NASA Authorization Act provide direction for NASA and a government backup to service the ISS? What priority within NASA's human spaceflight activities would you ascribe to this backup effort?

A6. The 2010 NASA Authorization Act does give direction for NASA to provide for the MPCV (Orion) and SLS to provide backup services in case the commercial cargo or commercial crew fails to meet their required schedules.

Responses by Vice Admiral Joseph W. Dyer, USN (Ret.), Chairman, Aerospace Safety Advisory

Questions submitted by Chairman Steven M. Palazzo

Q1. Specific to the recent Soyuz incidents, what is ASAP's opinion of the information that has been provided by Russia? Has the engineering analysis, safety and mission assurance information, and support from the Russian entities been sufficient to determine whether to resume crewed Soyuz flights? What other information or criteria must NASA have to gain enough confidence to resume flight?

A1. The ASAP has found the information flowing to NASA from the Russians to be creditable and the transparency to be in harmony with the serious risk of decrewing the International Space Station (ISS). While our insight into the safety and mission assurance work the Russians have performed is not first hand, we have closely monitored the information NASA has received and the process used to acquire that information. The members of the Russian State Committee (what the ASAP would call a Mishap Investigation Board) were very senior and had high technical credentials and experience.

Russian actions reflected good practice, prudent judgment, and a risk-averse approach which mirrored typical U.S. practice. There was a detailed and significant effort to determine the root cause and recommendations for future mitigation. A parallel effort by NASA propulsion experts supported the work done and came to the same conclusion using U.S. tools, techniques, and equivalent approaches. Nothing can be perfectly certain, but we can say the work has been detailed, competent, complete, and carried out with expertise in the areas highly relevant to the failure.

We note the constraints in dealing with a sovereign nation in a technology area typically subject to export control; however, we have been told that the Russians have been extremely open and straightforward in providing information. We do not know of any other data that is either needed or available to make the return-to-flight decision. We have noted the importance and success of the "relationship building" accomplished by NASA and the Russians. We especially highlight the outstanding work done by NASA's Mr. William Gerstenmaier. We believe NASA has gained the insight and confidence necessary to resume the U.S. astronaut flights aboard Soyuz.

Q2. From a safety and mission assurance perspective, what do you consider to be the "lesson learned" from the Progress accident? What did this accident and response from the Russians and U.S. space agencies tell you about the safety culture of the ISS program?

A2. The information gleaned from the investigation into the Progress launch mishap indicated that a failure in quality during production was responsible for the mishap, rather than an inherent design deficiency. This mishap illustrates that even when utilizing a mature launch platform that has had over 700 successful launches, there are still risks, such as quality breaches, that must be acknowledged and planned for. Spaceflight is several orders of magnitude riskier than commercial aviation and the Progress mishap is factual evidence.

NASA had recognized and planned for a possible interruption of scheduled Soyuz availability. From a safety perspective, there was no immediate impact on the crew due to the Progress failure; however, the Soyuz vehicles already docked at the ISS had a "shelf life," and NASA recognized that crew would have to return on these vehicles before they exceeded their "use-by" date, regardless of whether or not new Soyuz arrived at the ISS. NASA behaved appropriately in bringing home three crewmembers and leaving only three on orbit when one Soyuz at ISS reached its shelf-life limit. This action was entirely consistent with an appropriate concern for crew safety. At the same time, the Russians were conducting a mishap investigation to determine if it would be possible to deliver another Soyuz to the ISS to prevent the need to bring the remaining three crewmembers home before the Soyuz on orbit reached its shelf-life limit. The information concerning the Progress mishap demonstrated to the ASAP that the Russians did a thorough and creditable investigation, and that their conclusions seemed reasonable.

From a safety perspective, all ISS crew must have the capability to de-orbit. This means that for a full, six-member crew, two Soyuz vehicles must be present. In the current situation where only one Soyuz is at ISS, there is a substantial reduction in the useful work accomplished, thus negatively impacting the ability to accomplish the ISS mission as planned. Should the remaining Soyuz have to be brought home, it would mean that the ISS would be left with no crew on board and with a virtual cessation of all ISS productivity. While disappointing, this is a risk that has always been acknowledged and accepted by the U.S. and its partners when the Shuttle program ended and the Soyuz became the sole means of access to the ISS. (Though, it should be noted the Shuttle could not support long-duration "lifeboat" support.) Despite the profound impact on accomplishing mission objectives, the ISS can be maintained in a safe condition remotely for an extended period of time.

The current situation demonstrates that while mission capability has been significantly diminished, the safety of the crew has been preserved. Further, NASA had anticipated the potential for the eventualities that we are now experiencing, and the current crew safety level and mission capability is what was expected. NASA's and Russia's actions appear to be consistent with an appropriate concern for safety and a good safety culture.

The ASAP notes that the third-stage failure of the Russian Progress Rocket highlights a number of known but underappreciated constraints to ongoing ISS operations. They include:

- The 200-day "use-by" requirement of the docked Soyuz. The delay in the planned Soyuz flights means that the capsule docked at the ISS is at risk of "aging out" before a replacement capsule can be transported there. If the Russians cannot safely launch a Soyuz mission prior to the expiration of the currently ISS docked capsule, there is risk the ISS will have to be de-crewed.
- No pre-planned, ready-to-execute process for de-orbiting the ISS.
- Implicit risk in not having a "second source" for crew transportation to and from the ISS.

Another lesson learned from the Progress mishap is that no matter how long, admirable, and/or extensive the history of any device built by man, it is still vulnerable to the most simple of failure causes—a momentary carelessness or misstep by the people preparing the machine for use. We note that this is equally applicable to any group working with hardware that must be failure free. While the term "zero defects" may have gotten a poor reputation due to overuse, we are, in fact, dealing with hardware that truly must meet those criteria. Hence, constant vigilance, continuous efforts and oversight, and absolute adherence to best practices must be maintained.

The best indication of a strong safety culture is not the incident itself, but the response to that incident. In all cases, the response was immediate, complete, and focused on maintaining the safety of the ISS crew. It was clearly demonstrated in every action and proposed action that the crew safety considerations were first priority.

Q3. NASA is entering into an increasing number of Space Act Agreements and other non-contract relationships involving hundreds of millions of dollars of taxpayer money. Based on your experiences with this investigation or others, please describe the level of insight the ASAP has with NASA itself, with NASA's commercial crew partners using Space Act Agreements, and with NASA's international partners such as Roscosmos, ESA, or JAXA.

A3. In accordance with ASAP's charter and mandate, our focus and strength is assessing NASA's safety-related processes, policies, and procedures and comparing them to those used by world-class organizations, both government and non-government. This includes identifying any areas where improvements are possible that could maximize the safety of the inherently risky space exploration undertaking. In accomplishing this task, the Panel receives deep and detailed insight into NASA's programs, processes, and people.

ASAP has complete access to all NASA Centers and project/program managers. We also enjoy excellent support from NASA Headquarters leadership all the way up to the Administrator. We hold quarterly meetings at different Centers during which we meet with various program representatives, safety staff, and engineering staff to discuss issues. We provide written recommendations to the Administrator and receive formal responses from the relevant NASA personnel. More importantly, we have an excellent but more informal relationship with key members of the NASA staff and leadership through which we can exchange information, views, opinions, and seek information. We recently have expanded our relationship with the NASA Advisory Council (NAC) and have jointly chaired sessions on Commercial Crew with the ISS Advisory Committee. Our relationship with NASA provides a high degree of fidelity to our assessments. Historically, it has also afforded us significant insight into the operations of NASA's prime contractors since past contract vehicles provided for a high degree of government control and oversight.

The Panel's ability to understand and assess the processes of other organizations and partners that NASA relies on for critical support is typically limited to an assessment of NASA's procedures and processes for dealing with these providers. Specifically, our insight into commercial crew partners under Space Act Agreements can vary depending upon the degree of those partners' openness and transparency. ASAP enjoys a good relationship with the current commercial crew partners. We have recently been briefed by the two principal partners, Orbital Sciences Corporation and SpaceX, and subsequently followed up with a site visit to each. In all these cases, a frank and open discussion concerning the safety aspects of their programs was discussed.

Our insight into the processes used by our international partners is generally limited to an assessment of the procedures NASA uses to interface with these partners and is based upon information provided by NASA personnel. In all cases we have found this satisfactory.

The Panel continues to emphasize the need for the development of clear, concise, and firm safety requirements to guide all providers on what design, process, and certification standards NASA expects. Clear communication of NASA's safety needs is a key to efficiently and safely interfacing with the variety of partners that are in NASA's future.

Questions submitted by Acting Ranking Member Jerry Costello

Q1. In considering the future of the ISS servicing and resupply, to what extent do you believe NASA and the international partners have identified and addressed all safety issues? Are there any gaps and if so, what are they?

A1. NASA and the international partners have done a very thorough job of identifying and addressing safety issues with respect to ISS servicing and resupply; howeve,r provisioning the ISS is not without risk. Some possibilities, such as huge meteorite damage, simultaneous failure of many life support systems, and unanticipated sickness among the crew are recognized, and their solution is not obvious nor could it be fully provided for within the limitations of today's technology. That said, NASA has done an excellent job of providing for crew safety and support. The cargo resupply situation is actually quite robust. Progress, despite a recent failure, has a very long and reliable service history. The European Space Agency and the Japanese cargo visiting vehicles have demonstrated their ability to take cargo to the ISS. U.S. commercial providers, SpaceX and Orbital Sciences, are on the verge of demonstrating equivalent capability. The supply support situation on board the ISS is such that currently, the crew can be sustained for a considerable period without further cargo flights, hence protecting them from potential program slips or delays.

In terms of its ability to dock with the ISS, any cargo visiting vehicle qualification is governed by a set of requirements and a successful demonstration process. These requirements have been known to all potential providers for some time, and all have agreed to meet those requirements. These requirements are primarily to protect the ISS from an inadvertent collision or damage from an approaching vehicle. We have reviewed these requirements and the process for demonstrating that a new cargo visiting vehicle meets those requirements and find both robust and complete.

There are gaps in the "corners" of the risk matrix that remain. Two examples are apparent: (1) an unscheduled and unplanned-for ISS de-orbit; and (2) Micrometeorite and Orbital Debris (MMOD). Prior planning had assumed the Constellation Program's Crew Exploration Vehicle (CEV) would perform the ISS de-orbit burn. Since the CEV is not available, alternate methods must be found to provide an end-of-life (EOL) de-orbit burn. Several methods have been discussed, but none have been agreed upon. MMOD damage remains the largest threat to the ISS. While provisions for and safeguards against MMOD are in place, the odds remain that over the ISS's 10-year life span, this damage will occur. Contingency planning for a rapid ISS depopulation needs to continue and become more robust. Given its size and mass, an uncontrolled ISS re-entry would be a noteworthy event that must be appropriately planned for.

Q2. NASA has a multi-decadal history of working with the Russians on cooperative human spaceflight activities. What aspects of the Russian-NASA process for dealing with Soyuz mishaps, incidents, and anomalies are critical to be infused into NASA's partnerships with future non-government ISS crew and cargo transportation providers?

A2. As correctly noted, Russia and the United States have worked cooperatively for a sustained period of time on spaceflight activities despite sometimes different and competing objectives. This cooperative, but sometimes fragile, relationship has been necessary for multiple reasons, including mitigating the high cost of space operations and overcoming substantial technical challenges. Nevertheless, despite significant barriers such as "sovereign national issues," technology transfer challenges, and working around classified programs for both parties, a successful collaboration has been possible through transparent communication, constructive feedback, and trust. The recent Progress mishap investigation is an excellent example of how both the Russian Federal Space Agency (Roscosmos) and NASA cooperatively have supported one another.

As NASA transitions to a new partnership with commercial crew and cargo providers, it is reasonable to expect that different, but equally challenging problems will need to be overcome. Issues caused by using Space Act Agreements versus traditional contracting methods (or vice versa), proprietary concerns, or addressing issues caused by the competitiveness of the environment, certainly will challenge both organizations' management.

Transparent communication, constructive feedback, professional trust, and flexibility will be necessary. There must be a clear focus on doing everything possible within the confines of performing the mission to assure the safety of the crew. The commercial partners must clearly demonstrate that focus, and NASA must insist upon it. It must be obvious to both parties that this objective is not open to compromise. Development of a long-standing, mutually trusting relationship is essential to any program's or partnership's safe and efficient organization. Not every issue can raise itself to the highest management decision level or, worse, contract disputes clauses. In that case, it is inevitable that costs will rise and schedules will be missed. The parties, while recognizing that their motivations can differ in part, must be willing to trust that their partner will not knowingly do something to damage the partnership or reduce the project's success. When issues arise, they need to be openly and thoroughly discussed. This situation took time with the Russians, beginning with the difficulties caused in part by "Cold War" thinking on both sides; however, as clearly demonstrated by the recent Progress incident, this is a thing of the past. Withholding information, hiding concerns, and keeping secrets all are clearly signs of trouble in a relationship designed for human transport to space. This must be worked on by both sides until an open and transparent relationship is established.

Q3. The ASAP's 2010 Annual Report stated "Safety can suffer in high-risk, complex programs—or programs with new or unproven technology—when operating in a fixed-price environment.The ASAP is not yet comfortable with the harmony between technical readiness and the anticipated fixed-price contracting approach for NASA's Commercial Space Transportation Program. A lack of compatibility between these elements can often increase risk as funding runs short and time runs out." What needs to happen to ease ASAP's concerns and to what extent is NASA taking such actions?

A3. Several things can ease the ASAP's concerns regarding the programmatic and safety risk associated with developing a commercial space transportation system for NASA astronauts via a fixed price type contract:

- An independent and creditable cost estimate;
- A realistic schedule (assuming full funding provided);
- Sufficient resources to fund the undertaking with historically realistic management reserve;
- Design competition between at least two providers and not relying on a single source (assuming full funding provided); and
- Completion of NASA's safety design and certification requirements and process.

Firm-fixed-price (FFP) contracting makes the tacit and stated assumption that the government knows precisely what it is buying, has a firm cost estimate, and knows both the financial and technical risk. On the provider's part, it assumes that he knows the requirements, has a firm grasp of the technology, and can control the costs. Few of these conditions appear to be present in the current Commercial Space Transportation Program environment. Hence, technical, financial and schedule risks are inevitable and must be dealt with.

Technical risk represents perhaps the most controllable risk. NASA has undertaken to provide a set of requirements to all bidders. This lists the objectives which NASA must achieve as well as (if available) a known approach for achieving them. In addition, all of NASA's engineering standards are provided, e.g., safety factors on pressure vessels. Further, NASA has provided that should a provider feel that he has an alternate method of achieving the same ends, he can propose that and, if found to be sufficient by NASA, it will be approved ahead of proceeding with final design. While technological risk can never be fully eliminated, this approach is well proven for mitigating such risk to the extent possible

Schedule risk is a more difficult risk to mitigate because, like cost, it tends to be a "victim" of whatever else goes wrong. However, the best approach to handling this risk is to develop an agreed-to IMP/IMS (integrated management plan/integrated management schedule) which calls out specific, measureable events that are easily discernable by all parties so that progress is clearly measureable and evident. Technology maturity is one of the largest causes of schedule extensions. Mandating that TRL levels be in the 6–7 range for all needed systems wherever possible is a key to mitigating that risk. More to the point, concentrating management and engineering attention to those areas where such technological maturity cannot be found is a key way to prevent technology "surprises." When these occur, especially late in the development schedule, their impact is enormous. This is an area where "taking a chance" that something will work is clearly an enemy of safety.

Financial risk is, without a doubt, the most contentious risk category, from both the funder's perspective and the performer's perspective. The tendency to "promise beyond ability" and to "expect beyond capability" is strong in our program culture. This is why the ASAP singled out this risk for special mention. Once set in a FFP contract, the pressure to hold cost down at the expense of much else is very high. This is the environment where we have seen safety, reliability, and maintainability sacrificed again and again in programs of all types.

It is the highest priority and absolutely essential that a competent, complete, and accurate cost estimate for this program be established. Non-affiliated or non-advocate resources should be employed to assure that no unsubstantiated optimism or pessimism is included in the estimate. This baseline then must be used for establishing the most likely total program cost. Then, the resources to accomplish this program must be provided. No matter how "bitter the pill" when the estimate is available, the resources must be found or the program should not be attempted. That is not to say these all have to come from NASA. Given the commercial nature of this effort, it is reasonable that some investment should come from the private sector; however, it must be remembered that the source of funds does NOT affect the requirement for funds. The total cost will remain the same. An accurate cost estimate and funds to cover that estimate will go a long way to resolving the ASAP's concerns in this area. NASA's effort to provide an adequate program cost estimate needs to be considerably increased. It is inadequate at this time.

Q4. Have ASAP members discussed what type of information the panel will need to assess the safety of future commercial crew transportation systems? What are the general categories of information and do they differ when the systems are being demonstrated and when they become operational?

A4. The Panel has discussed the types of information, along with suggested timing, that are needed to seek additional insight into the Commercial Crew effort. In addition to information gained via questions and answers at briefings, the panel has discussed potential future scenarios in order to anticipate needs. Since there is some overlap between Commercial Cargo and Commercial Crew, the Panel has been active in visiting both Commercial Cargo vendors, and will continue its visits to Commercial Crew vendors in the upcoming calendar year.

General categories of information include status briefs on workforce, standards, risk management, hazards analyses, testing protocols, schedule commitments and the condition of the physical assets. The type of information does not differ materially from the information needed to assess the safety of any human spaceflight program, including the type of information that was provided during Shuttle. NASA has set out technical requirements and they are based on the experience of the only U.S. entity that has safely put humans into space—a fact that should be remembered. The next step is to develop the validation/verification matrix which outlines how each provider will assure that the requirements have been met. Then, oversight into the manufacture/assembly/preparation of the vehicle has to be provided to assure that it has been built/assembled/operated in accordance with the agreed-to requirements. Subsequently, any and all re-use materials or components have to be refurbished back to their original specifications. This process is very similar to the process utilized today by the DoD and FAA in the design, production, maintenance, and operation of air vehicles of all sorts. This is the very process that we all put our faith, indeed our lives, into every time we buy an airline ticket. Assurance information is thus needed to make certain that the provider: (a) designs to meet the requirement; (b) validates the design in accordance with the validation matrix; (c) builds it like they designed it; (d) operates it within the agreed operating envelope such that all limits are within the capabilities of the design; and (e) maintains it such that all components are repaired or replaced such that no design degradation takes place. When operations commence, NASA and the Panel will be able to review actual results and performance outcomes.

Lastly, the Panel has highlighted the potential for cultural differences between NASA and its Commercial Crew developers. For success, it will be incumbent on all parties to be mindful about open and clear communications.

APPENDIX 2: ADDITIONAL MATERIAL FOR THE RECORD

SUMMARY OF FINDINGS OF THE ISS ADVISORY COMMITTEE AND THE AEROSPACE SAFETY ADVISORY PANEL

APPENDIX A

SUMMARY OF FINDINGS

ISS AC—ASPA REVIEW OF SPACEX "DRAGON" AND ORBITAL "CYGNUS" LOGISTIC VEHICLES

9 AUGUST 2011, NASA—JSC

On August 9, 2011, at the request of the Associate Administrator for Space Flight Operations Mission Directorate, members from the NASA ISS AC and the ASAP met jointly in a fact-finding session at the NASA Johnson Space Center (JSC), Houston, Texas, to review the status of the two Commercial Resupply Services (CRS) contractors for the ISS—Orbital Sciences Corporation (Orbital) and Space Exploration Technologies Corporation (SpaceX). The focus of the working groups from the ISS AC and the ASAP (herinafter referred to as the "Review Team") was to review the status of the SpaceX "Dragon" and the Orbital "Cygnus" logistics vehicles. The Team's review was limited to only one day, and therefore should not be considered thorough or complete.

Both SpaceX and Orbital launch schedules (respectively November 2011 and February 2012) are very success oriented, but as a result of prepositioned spares and consumables, NASA is in a position to absorb up to a year's delay in either or both logistics delivery schedule(s). The Review Team strongly supports the ISS Program Office (ISSPO) plans to keep contingency options in place in the event of extended CRS delays. With current manifest planning, six-crew operations aboard the ISS cannot be logistically sustained beyond January 2013 without CRS.

A number of items attracted concern and comments from the Review Team.

SpaceX Agressive Mission Planning

Combining the SpaceX C2/C3 mission with two Orbcom launches appears to be very aggressive mission planning. At the time of this review, the ISSPO had not approved this mission, and was carefully considering all aspects. In SpaceX's presentation, one of the comments that SpaceX repeatedly made was the need to "keep it simple" for mission success; however, by introducing the additional payload launch, complexity would be added. At the time of this review, NASA had not had time to review this proposal. If the decision is to allow this additional launch requirement, it seems to the Review Team that it is added complexity and has the potential to compromise focus on the demonstration.

The SpaceX development and test schedule seems highly compressed. To go from System Readiness Review (SRR) to first flight in three months—with most of the systems engineering reviews taking place in one month—is not consistent with good practice and experience. As a general observation, both groups did address their respective safety efforts. While the time allotted in the discussions was not sufficient for the group to unequivocally endorse the safety efforts, the Review Team did not find any indications of significant systemic failings of their safety efforts.

Safety and Mission Success

During discussions with ISSPO representatives, the comment that "NASA was responsible for Safety, and Mission Success was the responsibility of the Contractors" raised concern with some of the Review Team members. Realizing different guidelines and responsibilities exist for the COTS Space Act Agreement, the Review Team has concern about the perceived responsibility in the event of a catastrophic failure. The ISSPO acknowledges this concern and is exercising insight and oversight to the extent possible under the Space Act Agreement and the Contract to make sure that it is well defined and covered. Regarding the question of allocation of responsibility for mission success for the early flights, it is very likely that NASA cannot escape being seen (at least partially) as responsible for mission success. This is a concern, and while it cannot likely be easily settled, it seemed somewhat casual in the current discussion. Written ground rules and assumptions need to be well documented. NASA needs to ensure there is a clear, well laid-out understanding of the responsibilities.

Different Approaches

There is a major difference in the design and verification approaches being taken by SpaceX and Orbital. SpaceX builds their computers up in house using commercial-grade parts, while Orbital purchases a computer using milspec, radiation-hardened parts. SpaceX has a one-size large thruster that is used for all operations (fine maneuvering is accomplished by millisecond pulsing of this large thruster), while Orbital has a more traditional approach with a large thruster for spacecraft transfer and small (7 lb.) thrusters for fine maneuvering. SpaceX builds the majority of their componentns in house, while Orbital procures a large number of their components from second sources. Both approaches, while different, can be made to work with a performance-based contract.

Flight Rules

There was concern voiced that there was no formal document signed by all parties that defines who has go-no go authority during all phases of flight. While the Review Team was sure that those discussions have taken place, this should be formally documented, with clarity of language that all parties have agreed to and signed. There was Review Team consensus on this issue.

Software

During the Orbital presentation, one issue that was brought up was the frequency response of one of the contractors. While the explanation was good, the 2 Hz cycle being used leaves open the question about latency in the Operational Flight Program (OFP) resulting in a "PIO" situation. The SpaceX Software presentation was unsettling to the Review Team. There was no Capability Maturity Model Integration (CMM) accredited capability or process, and the software chief said he didn't worry about errors because "there were no mistakes in the software." In the Review Team's experience, this is unlikely. Another comment was "we don't set requirements, we just do coding." The very essential part of software development is understanding that of requirements so as to identify missed requirements, unexplained actions, and possible unsafe conditions.

Crew Hazards

NASA systems personnel working with the two companies reassured the board that proper flight rules and hazard mitigation would be in place to include crew precautions for use of eye protection and proper use of telephoto lenses to prevent exposure to LASER and other radiation hazards. Off-gassing requirements are similar to those of other vehicles such as the Multi-Purpose Logistics Module (MPLM), the Automated Transfer Vehicle (ATV), and the H–II Transfer Vehicle (HTV).

MMOD Shielding

The MMOD requirements and environmental models for commercial resupply vehicles were developed several years ago to provide consistent MMOD protection for all ISS resupply vehicles (ATV, HTV, SpaceX Dragon, and Orbital Cygnus). Damage to the Thermal Protection System (TPS) of SpaceX Dragon that causes loss of vehicle during entry or damage causing vehicle functional failure of either the SpaceX Dragon or Orbital Cygnus vehicle is not included.

Engine Failure and Anomalies

Although not the focus of this review, propulsion is critical to meeting the launch schedules. In the case of Orbital, there was a detailed discussion on the failure and the corrective actions. In case of SpaceX's early engine shutdown, the Team didn't see that kind of detailed discussion. Only in response to a direct question (and after the SpaceX presentation was completed) was there acknowledgement that "We had an engine shut down early on the previous launch, but that's OK." There was no explanation or root cause analysis or corrective action on this particular anomaly. This statement is troubling, i.e., not recognizing that premature engine shutdown is a significant event. Orbital uses a rocket engine that is from the old Russian N1 rocket. It has experienced a recent firing failure at Stennis due to build-up of stress fractures, and it has not had normal nondestructive inspection (NDI) or testing (it is now undergoing inspection and testing).

Culture Observations

Experience has shown that an organization's culture can and does affect the decision-making processes and the level of risk the firm is ready to assume. A number of positives were noted during the briefings. Identified differences in cultures can be a benefit, if the differences are recognized and used in a positive manner. SpaceX and NASA are aware that their cultures are vastly different. Orbital and NASA are aware that their cultures are somewhat different from each other.

There appears to be good communication between all three organizations on technical detail. NASA has been studying, measuring, and working on opening up its culture and has made progress. SpaceX has an entrepreneurial mindset which is emphasized and encouraged throughout the entire design team. While this is a proven success process in many business fields, given the complexities of building and operating spacecraft, there is a concern that too much streamlining of accepted "best practices" without an associated experience base could lead to unexpected challenges to mission success. SpaceX has addressed this issue by ensuring that some key personnel with NASA backgrounds are in place and charged with monitoring this tendency. There are several items of concern with respect to safety culture. Both commercial cargo providers could pay more attention to the cultural differences in a more formal manner. NASA Commercial Cargo personnel who interface with the contractors/partners have an excellent opportunity to be alert to cultural issues that could harm the outcomes that all parties seek, and it is not clear that they are effectively trained to recognize their role and to execute against it. Unfortunately, the language contained in the Space Act Agreements is so obscure as to what is and is not allowed, it has blurred NASA's current oversight role. It will be beneficial to the program for executives of all three organizations to continue to recognize their roles in establishing a good "tone at the top."

General Observations

The importance of NASA as the keeper of the broad body of knowledge on space flight, and the importance of their role in shepherding commercial space forward cannot be overemphasized. This is working well, but the Review Team strongly encouraged aggressive transparency between the companies and NASA Headquarters and NASA centers with regard to the issues and the challenges, calling upon that body of knowledge to move forward. Also, there is the importance of transparency internal to NASA.

With regard to Orbital and SpaceX, Orbital generates the confidence of a company that has "been there, done that." They understand best practices. The also have the humility born of experience; they understand how hard this is. SpaceX is entrepreneurial; their thinking is a fresh approach. They challenge conventional wisdom and have the potential to deliver at lower cost with innovations; they are aggressive by nature. However, their comments with regard to software were very disturbing and presented a lack of insight and sophistication on what can go wrong in this business. Schedule compression is also a concern.

○