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Introduction

Chairwoman Giffords and distinguished members of the Space and Aeronautics Subcommittee, thank you for the opportunity to testify. I am pleased to be here.

The Commercial Spaceflight Federation is an association of 20 leading businesses and organizations working to make commercial human spaceflight a reality. Our members include developers and operators of orbital spacecraft, suborbital spacecraft, and the spaceports from which they fly. Our membership also includes product and service providers for human spaceflight training, medical, and life support needs. Our mission is to promote the development of commercial human spaceflight, pursue ever higher levels of safety, and share best practices and expertise throughout the industry. One goal of all of our member organizations is to greatly increase the number of people that fly into space, generating new economic activity here on Earth.

Significant investment has already been committed to the development of commercial human spaceflight. According to a recent survey done by The Tauri Group, $1.46 billion in investment has been committed to commercial human spaceflight activities to date. Coupled with the more than $500 million in development funding provided by NASA under the Commercial Orbital Transportation Services, or COTS, program, more than $2 billion has been pledged for the development of commercial spaceflight capabilities. I want to take this opportunity to thank the Congress and NASA for your support of the COTS program.

In my testimony today, I will address the safety and oversight questions relating to commercially procured crew services. In order to understand these issues, it is important to first discuss the context of commercial spaceflight. My testimony covers the following key topics:

Summary of Key Points

1. Commercial crew transportation to Low Earth Orbit (LEO) is a goal endorsed by the Vision for Space Exploration (2004), the Aldridge Commission (2004), the 2005 NASA Authorization Act, the 2008 NASA Authorization Act, and the Augustine Committee.

- Commercial crew is complementary, not competitive, with NASA activities, as commercial crew transportation to LEO will allow NASA to focus its unique resources on the more difficult task of beyond LEO exploration.
- After shuttle retirement, the United States will send billions of dollars overseas to purchase seats on Russian vehicles during the gap in U.S. government launch capability. Only commercial crew allows us to reduce the gap, prevent future Russian price increases, and preserve redundant access to the Space Station.

2. Safety is paramount for the commercial spaceflight providers. Indeed, commercial vehicles such as Atlas V and Delta IV, developed with substantial private funding and engineering expertise, are already trusted to launch key government national security assets upon which the lives of our troops overseas depend.
3. Since computer calculations of vehicle safety cannot account for most of the root causes of accidents historically, such as human error or design flaws, and since even reliable vehicles have historically suffered a period of "infant mortality," the commercial spaceflight industry believes that safety must include the following:
    - Demonstrated reliability from orbital flight tests of the full system
    - Not placing crews on initial flights, since early flights are historically most risky
    - A highly reliable crew escape system
    - Standards-driven design and operations
4. Industry believes that the safety of commercial spaceflight must be greater than that of any vehicle currently in operation today. In addition to the FAA's existing regulatory authority, as codified in U.S. law, industry will satisfy customer-specific requirements levied by NASA in partnership with industry. This process has already begun with the cooperation of the stakeholders involved.
5. NASA and FAA will be there every step of the way, and will have oversight during design, testing, manufacturing, and operations. As codified in existing U.S. law, a licensing, rather than certification, regime is appropriate for these vehicles.

Government *Beyond* LEO, Commercial *to* LEO

Support and encouragement for the commercial development of space, including commercial space transportation services, has been a cornerstone of civil space policy for decades. It has been endorsed by numerous Presidential Administrations and Congresses, and by both parties. A quarter-century ago, the law that created NASA, known as the Space Act, was amended to specify that NASA is to "seek and encourage, to the maximum extent possible, the fullest commercial use of space" and "to encourage and provide for Federal Government use of commercially provided space services and hardware." Additionally, the Commercial Space Act of 1998 directed all agencies including NASA to "acquire space transportation services from

United States commercial providers whenever such services are required in the course of its activities."

In 2004, following the Space Shuttle *Columbia* accident, the Vision for Space Exploration (U.S. Space Exploration Policy, National Security Policy Directive-31), announced by President George W. Bush on January 14, 2004, directed NASA to:

- *"Develop a new crew exploration vehicle* [now called Orion] *to provide crew transportation for missions beyond low Earth orbit."*
- *"Acquire"* – and it's important to note here the intentional use of the word "acquire," not "develop" – *"cargo transportation as soon as practical and affordable to support missions to and from the International Space Station."*
- And again *"Acquire crew transportation to and from the International Space Station, as required, after the Space Shuttle is retired from service."*
- To put further emphasis on this point, the policy directed NASA to *"Pursue commercial opportunities for providing transportation and other services supporting the International Space Station...."*

This was reinforced by the Aldridge Commission on implementation of the Vision which recommended in June 2004 that*"NASA recognize and implement a far larger presence of private industry in space operations… most immediately in accessing low-Earth orbit."*

This fall, the Review of U.S. Human Space Flight Plans Committee endorsed the development of commercial crew capabilities as the primary means to transport astronauts to and from the International Space Station. Astronaut Sally Ride, a member of the Committee, stated, "We would like to be able to get NASA out of the business of getting people to low Earth orbit."

Given the above history, the Augustine Committee's endorsement of the development of commercial crew capabilities should come as no surprise. Commercial crew and cargo to the Station has always been part of the Vision for Space Exploration, which had at its most fundamental core the philosophy that government should explore beyond low Earth orbit and the commercial sector should provide transportation to low Earth orbit. As such, commercial is complementary to government activities, not competitive.

Congress has noted the importance of commercial spaceflight as well, as the 2005 and 2008 NASA Authorization bills endorsed commercial cargo and crew. The 2005 NASA Authorization Act directed NASA to *"work closely with the private sector, including by...contracting with the private sector for crew and cargo services, including to the International Space Station, to the extent practicable."* The 2008 NASA Authorization Act directed NASA to initiate a commercial crew program and to fund *"two or more commercial entities…for a crewed vehicle demonstration program."*

To its credit, NASA has already been acquiring cargo delivery to the Station. First, NASA invested $500 million in the development of two commercial systems, with additional investment contributed by the companies themselves, through the Commercial Orbital Transportation Services (COTS) program. After several years of development, NASA demonstrated its confidence in the commercial cargo sector by declining to purchase additional Russian cargo flights after 2011 and instead awarding over $3 billion in domestic Commercial Resupply Services (CRS) contracts for Space Station cargo. In just four years, commercial cargo has transitioned from a small initiative to a program that is crucial to the continued existence of the Space Station. The bottom line is that commercial space services are on the critical path for cargo to the Station and NASA has a vested interest in its success.

With commercial cargo now on the critical path for the Space Station, it is time to consider the value of commercial crew services for Space Station as well.

Commercial Crew is Essential to Mitigate the Gap

Despite having an option for crew transportation in the COTS program – the so-called Capability D option – NASA has not yet invested in the development of full commercial crew capabilities, opting to prove out cargo services first with the possibility of crew later. The case for beginning a commercial crew program has grown stronger in the years since the COTS cargo program began:

- Flights of the Atlas, Delta, Falcon, and other vehicles have helped mature the capabilities that will be needed during a future commercial crew program;
- Commercial companies have invested their own internal R&D and study money to explore commercial crew;
- NASA's $50m CCDev program is revealing the strength of interest in commercial crew by both large and medium-sized companies in the aerospace industry;
- And the Augustine Committee notes that "the use of commercial vehicles to transport crews to low-Earth orbit is much more of an option today than it might have been in 2005."

Today, three years after the award of the COTS Space Act Agreements (SAAs), we no longer have the luxury of time. The Space Shuttle will be retired next year, or shortly thereafter, while the first flight of Ares I and Orion has slipped to at least 2017, according to the Augustine Committee. In fact, the Committee added that if the Space Station is extended to 2020 as seems likely, the first human launch of Ares I would slip further, even if NASA receives the extra money the Committee recommended. As a result, we will be dependent on the Russians for crew transportation to the International Space Station for at least five years, if not longer.

Given that Ares I/Orion is not likely to be ready until at least 2017 and that system is optimized for the unique requirements of exploration beyond Low Earth Orbit, we believe a vibrant U.S. commercial crew program is essential for avoiding a sole-source reliance on the Russian Soyuz vehicles in the interim. In fact, we have already purchased rides on Russian Soyuz spacecraft at the price of $51 million per seat, having taken extraordinary measures and changing U.S. nonproliferation laws to allow these payments. Buying crew services from U.S. industry should not be viewed as nearly so extraordinary.

Moreover, Russia's prices are rising and are certain to increase once we become totally reliant on them. A robust U.S. commercial crew program, however, will apply competitive pressure on Russia to keep costs down. Also, NASA's ability to purchase Soyuz vehicles from Russia expires in 2016. Ares/Orion is not likely to be ready by then. It is impossible to know with certainty whether another extension of INKSNA (Iran, North Korea, and Syria Nonproliferation Act) will be granted by Congress at that time. Pursuing a commercial option to meet near-term needs for Station could help alleviate the risks inherent in Russian reliance. By not pursuing commercial, it is almost certain Congress will have to re-address the INKSNA issue.

Complementary, Not Competitive

Commercial crew is complementary, not competitive with NASA's exploration program. NASA should once again be focused on exploration beyond low Earth orbit, and turn over to the private sector the repetitive tasks of resupplying the Station – and that includes transporting people there too. Not just a few people, but a multitude of researchers, engineers, and technical specialists. We need more activity in low Earth orbit, not less.

Exploration beyond low Earth orbit will not be sustainable – if it happens at all – without a vibrant commercial sector providing transportation services to and from low Earth orbit. The Center for Strategic and International Studies recently released a report on the U.S. space program which stated: *"Without commercial engagement, exploration will… continually expand the scale of government obligations, rather than keeping civil space programs focused on the frontiers of exploration."* None of us believes that the government can continuously expand the obligations and expectations of our civil space program without reaching a breaking point, regardless of where one thinks that breaking point is. The additional resources and capabilities of the private sector are essential.

Commercial to LEO is Less Difficult than Exploration Beyond LEO

The Augustine Committee, like the Aldridge Commission before it, found that the commercial sector is ready and capable to handle the task of transportation to Low Earth Orbit. Low Earth

Orbit is less difficult, and therefore more achievable by the private sector, compared to the more capable tasks that NASA's current exploration vehicles are optimized for.

Thus, it is not an apples-to-apples comparison to compare a commercial crew capability to the Orion crew exploration vehicle. Rather, it is apples and oranges, because transporting crew to and from the International Space Station requires a far less complex spacecraft than exploring beyond low Earth orbit. It is akin to developing a Gemini spacecraft for low Earth orbit, rather than an Apollo spacecraft for reaching the Moon. The Orion spacecraft, for example, must reenter the atmosphere at one-and-a-half times orbital velocity, encountering heat loads nearly double those when returning from low Earth orbit, and Orion must do so with far more precision. Orion must also operate autonomously in lunar orbit untended while astronauts explore the surface, acting more like a space station than a crew taxi, and requiring more complex onboard vehicle systems.

As a result, the Orion spacecraft is a 25 metric ton (mT) vehicle, whereas spacecraft designed solely for low Earth orbit transportation are expected to be in the 8-12 mT range, or less than half the size for the same number of crew. Quite simply, you don't take an 18-wheeler to the corner grocery store. Nor do you drive a Formula One racecar. The Orion crew exploration vehicle is, in fact, far more capability than is needed to go to and from the Space Station.

Because it serves a simpler mission, *any vehicle* that is designed simply to service the Space Station – and not go beyond – should be faster and more cost effective to develop without sacrificing safety, *regardless of whether it is a government or commercial capability*. The Gemini spacecraft, for example, was developed in just under 2 ½ years, and had a perfect crew safety track record.

Regardless of the extent to which "the gap" can be reduced, a spacecraft designed solely for low Earth orbit transportation will be more cost effective to operate and require smaller launch vehicles. The result will be more frequent missions to the Station, increased research and other utilization of the Station, and more resources available for exploration beyond low Earth orbit.

Implementing a Commercial Crew Program

In light of all the considerations above, the Augustine Committee outlined a $2.5-3.0 billion fixed-price Commercial Crew program, in which NASA would invest in multiple private companies, each of which would also be required to invest their own funds, thereby putting their own "skin in the game." The committee also suggested that NASA fund human rating of a proven U.S. launch vehicle to mitigate the dependence on the development of new launch systems in addition to the spacecraft themselves.

A Commercial Crew program of $2.5-3.0 billion over 5 years should be sufficient funding. For example, one major aerospace company conducted a study that concluded they could develop a commercial capsule to transport crew to low Earth orbit and human rate an existing U.S. launch vehicle for around $1 billion. As another example, SpaceX has an unfunded option in its COTS Agreement for $308 million to upgrade its Dragon spacecraft to carry crew to and from the Station. Demonstrating the diversity of interest and capability, the Augustine Committee received price estimates from, according to the report, "five different companies interested in the provision of commercial crew transportation services to low-Earth orbit. These included large and small companies, some of which have previously developed crew systems for NASA."

Additional evidence that a Commercial Crew program is viable at $2.5-3.0 billion is again provided by the Gemini program. Despite only having access to 1960s technology, and with only a few years of total experience with spaceflight, NASA and industry human-rated the Titan II launch vehicle (which required 39 months), and designed and tested a crew capsule, for about $2.5 billion in today's dollars. The Gemini program completed all missions safely.

Since NASA's budget for the next five years is almost $95 billion, a $2.5 billion Commercial Crew program represents less than 3% of total NASA expenditures. Clearly, it is not an either/or proposition between commercial crew and NASA exploration. Commercial vehicles will not have the capability to go beyond low Earth orbit, while NASA *must* develop the capability to conduct exploration beyond low Earth orbit.

To promote competition and innovation, NASA's investment in a Commercial Crew program should be structured using milestone-based, fixed-price agreements as it is in the COTS program, unlike traditional cost-plus contracts. The COTS Cargo program has shown the wisdom in this approach. NASA initially selected two winners, SpaceX and Rocketplane-Kistler, rather than putting all of its eggs into one basket. When Rocketplane-Kistler failed to raise the capital to meet its milestones under its Space Act Agreement with NASA, NASA terminated its funding, held a new competition, and had 85 percent of the funding left over to give to the new winner, Orbital Sciences. This "portfolio approach" diversified the risk to NASA, greatly enhancing the likelihood that NASA will get the expected level of capability that it needs.

Safety of Commercial Human Spaceflight

Let me now address the safety of commercial human spaceflight systems. Safety is paramount. Private companies understand that they will not be in business if the systems they develop are not safe. In fact, private industry recognizes that it must increase safety from that demonstrated in the past in order to fulfill its vision of greatly increasing human activity in space. I believe industry has a healthy respect for the limits of their knowledge when it comes to safety. They do

not presume to know it all and they maintain a strict discipline of safety. At the same time, they bring fresh eyes and insights from other cultures and I believe this will ultimately enhance safety.

Human spaceflight is an inherently risky endeavor. This has been true for government human spaceflight and will also be true for commercial. Working in partnership with NASA, U.S. industry firmly believes it can develop the capability to transport crew to low Earth orbit safely. Last month, 13 former NASA astronauts[1] endorsed commercial human spaceflight in a statement in the *Wall Street Journal*. This group of astronauts are highly experienced with spaceflight -- collectively, they have flown a total 42 space missions and logged a total of 2 years and 48 days in space flying six different spacecraft including Gemini, Apollo, Space Shuttle, Soyuz, Mir, and the International Space Station. They stated:

> *"As astronauts, we know that safety is important. We are fully confident that the commercial spaceflight sector can provide a level of safety equal to that offered by the venerable Russian Soyuz system, which has flown safely for the last 38 years, and exceeding that of the Space Shuttle. Commercial transportation systems using boosters such as the Atlas V, Taurus II, or Falcon 9 will have the advantage of multiple unmanned flights to build a track record of safe operations prior to carrying humans. These vehicles are already set to fly over 40 flights to orbit in the next four years."*

Working together, NASA and the commercial industry *can* develop the capabilities to safely conduct human spaceflight. NASA and industry must begin the dialogue *now* on the requirements, standards, and processes necessary to make this successful for all involved. Agreement on the requirements is essential to the success of any partnership between NASA and the commercial sector.

There are several important factors to keep in mind when discussing the safety of commercial crew vehicles:

Commercial Spaceflight Has a Demonstrated Track Record

First, when we discuss commercial spaceflight, some tend to think of an activity in the future. In fact, commercial spaceflight occurs right now and has for years. Currently, the Atlas V and Delta IV launch vehicles – both commercially developed with substantial private funding – are used to launch multi-billion dollar national security payloads upon which the lives of our troops overseas depend. These vehicles are also entrusted by NASA to handle some of the most safety-critical applications in the civil space sector. For example, the Atlas V is Category 3 certified by

[1] The astronaut signatories were Buzz Aldrin, Ken Bowersox, Jake Garn, Robert Gibson, Hank Hartsfield, John Herrington, Byron Lichtenberg, John Lounge, Rick Searfoss, Norman Thagard, Kathryn Thornton, Jim Voss and Charles Walker.

NASA for launch of NASA's most critical payloads, and is also certified for launch of nuclear payloads, such as NASA's *New Horizons* spacecraft to Pluto, launched with radioactive plutonium onboard.

Not only is the commercial spaceflight sector real, but it has an extensive history of successful flights to orbit: the Atlas and Delta families of rockets, many of which were developed with substantial private investment and serve multiple customers, have a combined record of 114 consecutive successful flights since 2000. The Atlas V, for instance, has had 19 consecutive successful flights since its inception.

We must now turn our efforts to extending this demonstrated track record and depth of operational experience to human spaceflight. Fortunately, commercial human spaceflight to LEO will not require the development of new launch vehicles. Instead, it can be accomplished using existing launch vehicles and those currently under commercial development, such as the Atlas V, Falcon 9, and Taurus II launch vehicles. This will allow us to leverage our existing track record.

I will now examine some of the key requirements for ensuring the safety of commercial spaceflight, and explain how the commercial spaceflight sector can meet these high standards.

Key Requirements for Commercial Spaceflight Safety

Since computer calculations of vehicle safety cannot account for most of the root causes of accidents historically, such as human error or design flaws, and since even reliable vehicles have historically suffered a period of "infant mortality," the commercial spaceflight industry believes that safety must include the following:

- Demonstrated reliability from orbital flight tests of the full system
- Not placing crews on initial flights, since early flights are historically most risky
- A highly reliable crew escape system
- Standards-driven design and operations

I will now consider each of these topics in turn.

I. Demonstrated Reliability from Orbital Flight Tests: By the time any astronaut climbs onboard a commercial vehicle, including the Atlas V, Falcon 9, and Taurus 2, each will have had multiple demonstrated successful flights to orbit. For example, SpaceX's Falcon 9 would likely have more than 15 missions prior to its first crewed launch, due to customers such as the COTS Cargo program and satellite launches. As the *Wall Street Journal* astronauts pointed out, the Atlas, Falcon, Delta, and Taurus systems combined have over 40 more missions on the manifest

before 2014, in addition to numerous flights of commercial systems that have taken place before this year.

Human-rating of existing launch systems will cost money, and care must be taken, but as a recent study by The Aerospace Corporation concluded, there are no show-stoppers to human rating the existing proven fleet of launch vehicles. Norm Augustine pointed out that we did it safely for Mercury and Gemini, when our expertise in human spaceflight was much lower than it is today, and we can do it now.

Demonstrated reliability is so important because computer models and Probabilistic Risk Assessments (PRAs) are not sufficient to capture the majority of failure modes that affect real, flying vehicles—especially vehicles that are flying their first few missions. The Augustine Committee, which included two experienced astronauts, pointed out the following on PRAs:

> "*Studies of risk associated with different launch vehicles (both human-rated and non-human-rated) reveal that many accidents are a result of poor processes, process lapses, human error, or design flaws. Very few result from so-called random component failures. The often-used Probabilistic Risk Assessment (PRA) is a measure of a launch vehicle's susceptibility to these component or system failures. It provides a useful way to compare the relative risks of mature launch vehicles (in which the design is well understood and processes are in place); it is not as useful a guide as to whether a new launch vehicle will fail during operations, especially during its early flights.*"

Probabilistic Risk Assessments and computer models are useful tools, but they have limitations. While the commercial spaceflight industry will make use of every tool that is available to improve safety, computer models are just one tool among many. Demonstrated reliability and a robust flight test program are crucial. Reasonable minds can differ on *how many* successful launches is sufficient before putting people on top, but there is no debate that *more is better*.

At this point, let me briefly address two myths surrounding the safety of commercially procured crew transportation systems. First, some have claimed that commercial crew systems will only be able to produce cost savings for NASA by cutting corners and being less safe. In fact, commercial crew systems are cheaper for a different reason – because they have a less ambitious mission than systems designed for exploration. Since commercial LEO systems are simply tackling a less difficult challenge, commercial crew will be able to achieve cost savings for Space Station missions without cutting any safety corners. By focusing on a less ambitious mission that requires less capable vehicle performance, the commercial spaceflight industry is following a statement of the *Columbia* Accident Investigation Board that "the design of the system should give overriding priority to crew safety, rather than trade safety against other performance criteria."

Second, some have claimed that NASA's Exploration Systems Architecture Study (ESAS) shows that the current exploration vehicles are safer than commercial crew vehicles. In actuality, commercial crew vehicles were never even analyzed in the ESAS report – the ESAS report only looked at vehicles large enough to carry Orion, such as Ares I and variants of the triple-core Delta IV Heavy, and did not examine the smaller, simple, single-core vehicles, such as Atlas V Medium and Falcon 9 Medium that are sufficiently sized for commercial crew missions. Moreover, even if ESAS had compared exploration vehicles to commercial crew-sized vehicles, the comparisons would be "apples vs. oranges," because of the dramatically different tasks of these two types of vehicles.

II. Not Risking Crew During Initial Flight Tests: Historical records show that even reliable vehicles, such as the Soyuz, initially go through a period of lower reliability ("infant mortality") as design flaws are caught and corrected. The use of proven launch vehicles enhances safety by using a mature system with a demonstrated track record that has gone through the infant mortality stage experienced by most new launch systems.

By leveraging the cargo and satellite flights, such as the COTS Cargo flights, that precede the first crewed flights, the commercial sector can help ensure that the infant mortality phase does not risk human lives. Commercial providers are free to pursue multiple customers, such as NASA science missions, national security missions, or commercial satellite missions, to help extend and strengthen the crucial test flight phase before humans are launched. Again, reasonable minds can differ on how many test flights are needed in light of infant mortality, but all can agree that it is good that the commercial sector can leverage non-crewed flights, such as cargo and satellite launches, to help alleviate crew risks associated with flying during the infant mortality phase.

III. A Robust Crew Escape System: In addition to demonstrated reliability of the launch vehicle, ascent safety will be based on an *emergency detection system* to detect any anomalies during launch and a *crew escape system* to separate the spacecraft from the launch vehicle in the event of an anomaly.

The commercial spaceflight industry understands that safety requires not just a reliable launch vehicle, but an integrated system with robust crew escape capabilities. As the Augustine Committee notes, "It is unquestionable that crews need access to low-Earth orbit at significantly lower risk than the Shuttle provides. The best architecture to assure such safe access would be the combination of a high reliability rocket and… a launch escape system." The commercial spaceflight industry is committed to meeting this combination.

IV. Effective Government Oversight: Human spaceflight is now almost 50 years old with the first flights of Alan Shepard and John Glenn occurring before I was born. It is time to transition access to low Earth orbit to the private sector so NASA can once again lead exploration beyond. Nevertheless, NASA and the FAA will be involved in every step of a Commercial Crew Program. In fact, every human spacecraft to date has been developed in partnership between NASA and U.S. industry, and this will also be true for a Commercial Crew Program. I will now address this crucial topic in more detail.

First, any NASA Commercial Crew Program must be conducted under the current regulatory regime established by law, namely, licensing by the Federal Aviation Administration (FAA) Office of Commercial Space Transportation. FAA licensing of commercial spaceflight activities is established by law, requires a high degree of system safety, and provides a stable and predictable regulatory environment necessary for the success of commercial human spaceflight businesses. As codified in existing U.S. law, a licensing regime, rather than a certification regime, is appropriate for these vehicles.

While the FAA would retain overall licensing approval authority, NASA would maintain strong oversight as the mission customer. As with today's commercial expendable launches, the customer has go/no-go authority over the readiness of the mission and, therefore, NASA would maintain its role as safety approval authority for its crew onboard any commercial vehicle. NASA-unique requirements would be imposed as customer requirements, rather than as the overall regulator of the commercial spaceflight activity. (This is discussed in more detail in the next section.)

While it is appropriate for NASA to establish customer-specific requirements, an entirely new licensing or regulatory regime, separate from the current FAA regime, should not be established for NASA or any other entity that would require compliance with different rules and regulations for commercial human spaceflight services provided for U.S. Government and commercial customers. The creation of a NASA-specific regulatory regime would impose parallel regulatory and operating environments for commercial operations for private customers and "commercial" operations for NASA. A two-track regulatory environment could hurt industry's ability to obtain non-NASA customers, impacting business viability by lowering the total number of flights. Such a situation would be the opposite of the more robust flight history and greater operational experience that is crucial to enhance safety.

NASA Will Be There Every Step of the Way

In any Commercial Crew program, NASA will play a pivotal role in the design, development, and operation of the commercial vehicles. NASA will be there every step of the way. In particular:

- NASA, in consultation with industry, will establish baseline human spaceflight safety requirements. That dialogue must begin now.
- NASA will also establish its mission-unique requirements, such as crew capacity; ability to dock with the International Space Station, including meeting visiting vehicle requirements; and functionality as a crew rescue vehicle, among others.
- And NASA will have final approval authority over the launch of NASA astronauts on commercial vehicles, which would be granted *only after being satisfied* that the vehicle is safe for launch, just as it does for today's Space Shuttle missions.

Whether or not these safety requirements are the same as those found in NASA's current human-rating requirements document (NPR 8705.2B) is currently under consideration. NASA is reviewing its human-rating requirements as they would be applied to commercial human spaceflight capabilities. This is the right thing for NASA to do and I applaud them for doing so.

In fact, there is already a precedent for reviewing human-rating requirements. During the Constellation Program, NASA revised its human-rating requirements document in May 2008, going from the original version A to the current version B. Based on the judgment of NASA engineers, version B revised some requirements related to structural safety margins and dual-fault tolerance. In fact, no existing U.S. spacecraft – or Russian, for that matter – has ever met all of NASA's human-rating requirements, but rather have obtained waivers to certain requirements. These examples demonstrate the importance of early dialogue between NASA and the commercial spaceflight sector on the nature of human-rating requirements for commercial systems, with demonstrated reliability, robust test flights, and a reliable crew escape system being key.

While NASA is conducting its review, U.S. industry is also conducting a similar review. We have established a Commercial Orbital Human Spaceflight Safety Working Group. While the Commercial Spaceflight Federation has taken the lead in organizing the effort, the working group includes representatives from a broader spectrum of companies, including several of the major aerospace primes and more traditional government space contractors. The goal of the effort is to develop industry consensus on principles for safety of commercial orbital human spaceflight. So far, we have met among industry and have begun to engage NASA and the FAA. There is much more work to be done. However, consensus has been reached among a number of companies on principles with other companies currently reviewing the document. Regardless, it has already been useful in illuminating the issues and differing perspectives of those involved and is an important step in the right direction.

Finally, I note that industry and NASA standards will include more than just the launch vehicle. For example, once in orbit, spacecraft must rendezvous with the Space Station, dock or berth with it, and then undock and de-orbit, reentering the atmosphere and landing safely back on

Earth. The technologies to rendezvous and dock with the Station have been demonstrated by the United States, Russia, Europe and Japan. Working in partnership with NASA, Europe and Japan demonstrated these capabilities this year, and NASA is working with SpaceX and Orbital Sciences here at home to demonstrate the same capabilities under the COTS Cargo program. Examples such as these illustrate the importance of cooperation between the private sector and NASA to ensure safe operations.

Conclusion: A Partnership Between NASA and U.S. Industry

The discussion of standards brings me to one of the most important prerequisites for success of any Commercial Crew Program – *how* NASA engages with the private sector is ultimately as important, if not more important, than the amount of funding provided. NASA's COTS Cargo program is an excellent example. While some were initially resistant to commercial resupply of the Station, once it became a necessity NASA engaged the private sector in true partnership in order to ensure that the capability is available as soon as possible.

I have every confidence that we are at such a turning point with Commercial Crew as well. It is now a necessity, and I believe that NASA and industry will *both step up* to make it happen.

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

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