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**Statement of
Mr. John Marshall
Member
National Aeronautics and Space Administration's
Aerospace Safety Advisory Panel**

Before the

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

Chairwoman Giffords and other distinguished members of the Subcommittee, good morning. Thank you for inviting the Aerospace Safety Advisory Panel (ASAP) to testify again before your Subcommittee on the topic of ensuring human space flight safety in future government and potential future non-government space transportation systems.

As you may know, this topic has been an area of interest that the ASAP has focused on over a sustained period. Most recently we have visited the Space Exploration Technologies Corporation (Space X) and Orbital Sciences Corporation, both currently commercial providers to NASA for logistical re-supply to the International Space Station (ISS) – and possible Commercial Orbital Transportation Services (COTS-D) providers in the future, to discuss firsthand their approach towards integrating safety into their vehicles.

Of course interest in using the commercial space industry to fulfill NASA crew-delivery services to Low Earth Orbit (LOE) has spiked because of the recent Augustine report recommendation that appropriate consideration be given to turning this service over to the commercial sector.

Unfortunately, in making this recommendation they also note that while human safety never can be absolutely assured, safety was assumed to be “sine qua non,” or “a given” in their recommendation. The ASAP believes this assumption is premature and over simplifies a

complex and challenging problem, in that there is no “cookie-cutter approach” to safety in space. Nor is it “a given.”

We further believe that since NASA has given serious consideration only recently to what their approach will be in establishing human rating requirements for a vehicle that is occupied by NASA personnel, the commercial sector may be substantially behind in addressing human rating requirements for the future.

NASA’s Procedural Requirements (NPR) 8705.2b identifies the human rating requirements for NASA’s space systems. It contains recently updated requirements and captured lessons learned that are applicable to the development and operation of crewed space systems. NASA emphatically intends this document to be a starting point with detailed requirements to be tailored specifically for each NASA human spaceflight program, including a possible NASA-crewed COTS mission. Additionally, NASA specifically caveats that the results of any tailored effort for a NASA-crewed COTS mission could be different from that developed for a NASA program.

Because it is illogical to rely on commercial providers to develop their own requirements for contractual services on human spaceflight to NASA, the ASAP strongly believes that specific criteria should be developed to establish how safe is “safe enough” for these services, including the need to stipulate directly the acceptable risk levels for various categories of activity. In addition, it is imperative that the COTS enterprises understand in detail how verification of compliance shall be demonstrated. This too is just now beginning development by NASA.

With the above background, I will now briefly address the four specific questions that you posed to the panel:

1. What do you consider to be the most significant safety-related issues that will have to be addressed if NASA were to consider using commercially provided crew transportation and International Space Station (ISS) crew rescue services?

Response: Ensuring the safety of the NASA astronauts that we send into space may be the hardest part of commercializing LEO crew transportation. The significant challenges to be solved include:

- Establishing detailed safety requirements that NASA deems essential to safe flight. These must be in a clear and enforceable form that can be placed on contract(s) and tested for compliance.
- Because of their energy, speed, and complexity, no launch vehicle can be considered truly “safe” in the conventional sense of the word. Therefore, establishing minimum acceptable safety levels to guide system designs and set the baseline for both NASA and their contractors as to what is “safe enough” is critical.
- Even with clear safety requirements and levels, much of the inherent safety of complex systems like spacecraft depends upon the design choices and decisions where risks are weighed against performance, costs, and of course, schedules. An open and effective system has been developed within NASA to accomplish this. A similar process needs to be institutionalized by any commercial provider as well, whereby all potential hazards are properly vetted by both government and contractors. This will not be easy and may require more than the “hands off” approach envisioned by some.
- Establishing disciplined program and process-related checks and balances so that NASA can verify that the contractor has evidence of compliance with the launch vehicle design requirements in the as-built vehicle and successful completion of the activities necessary to demonstrate mission readiness.

2. What safety standard should commercial entities have to meet if they are chosen by NASA to carry U.S. government astronauts to LEO, and what will be required to verify compliance?

Response: As noted previously, NASA’s NPR 8705.2b prescribes human rating requirements for NASA’s space systems. This document, changed in 2008, represents a significant and substantive shift from a prescriptive approach to one that applies good engineering judgment. Prescriptive standards describe how to do things and are applied rigidly. Good judgment offers less specific direction and guidance. The ASAP sees

advantages in both, but with a need for clear written record-of-change and direct connectivity to establish and time-tested engineering standards.

In this regard, it is the ASAP's position that any new standards for commercial entities should begin with NASA's NPR – the “gold standard” if you will - and that the human rating for each system must appropriately be tailored to combine testing, solid engineering, and robust design along with a system safety approach for examining options to prevent and minimize the impact of failures. Doing so will, in the end, provide both high reliability and safety of human life.

With respect to demonstration, verification, and certification, the ASAP agrees that each of these actions must be performed for both government and commercial programs prior to NASA's use. Further, it also is the ASAP position that NASA is best qualified to be the oversight body for each of these actions as today only NASA has the competence in hand to effectively audit the complex technical work required.

3. What would be required to certify the “airworthiness” of any commercially provided crew transportation and ISS rescue service prior to its use by U.S. government astronauts? How long do you anticipate such certification would take?

Response: Similar to other certifications, "airworthiness certification" is a process that is carried out by a regulatory body. Typically that is an agency such as the Federal Aviation Administration or other governmental body that acts in the interest of the party having the most critical concern in the outcome. Certification is an oversight process, which serves to give assurance that necessary practices, policies, and criteria have been satisfied to protect the safety of the crew, passengers, and the public from harm due to a design or operational flaw in the functioning of the vehicle.

Building on this basic principal, for certification of any commercial or government space transportation system, it is clear that human rating standards that have been discussed in prior answers would have to be developed, published, and understood by all participating parties.

Once those standards are known, it then is incumbent on any party presenting a vehicle for utilization covered under the certification process to present compelling evidence that the standards have been met. That evidence can take several forms, most of which are covered by standard industry practice.

Testing typically is used to verify that the design meets the standard. The simplest of these would be the proof testing of pressure vessels that has been common for most of the last century. When testing is not possible because it is either too dangerous or involves conditions that cannot be set up in the laboratory, then analysis or sub-scale experiment is accomplished. Finally, well-validated analysis (finite element structural analysis, computational fluid dynamics, physics based simulations) can form an acceptable mechanism to show compliance.

In the case of crew delivery, cargo delivery, and rescue from the ISS it is well to remember that not only must the certified vehicle be safe in and of itself, but it must be able to approach, dock, and interface with the ISS without presenting a hazard to that vehicle as well. This means that besides the certification standards for the vehicle in question it will also have to meet additional requirements for operation in the vicinity of and docking to/departing from the ISS. These standards have already been developed and thus any new vehicle certification would also have to meet these requirements.

In response to the question of how long such a process would take, our experience indicates that this is most certainly a function of two things. First, there must be clarity and mutual understanding of the requirements and a process for verifying that the requirements have been met. Second, there must be openness and a degree of sharing/cooperation/transparency of the design process to the reviewing authority. Waiting until the design is complete and all parts and pieces are in place, sealed, and potentially inaccessible before inviting review of the design would be a recipe for failure. Conversely, providing periodic design reviews, openness for witnessing testing, clarity of analytical methods as the work progresses can assure a process with minimum to no delay. If the data is delivered as requested, testing is witnessed as it takes place, and the analysis uses known and validated methods, the

finalization of the review remains directly proportional to the complexity and uniqueness of the proposed system. Missing or absent data, analysis that is incorrect or faulty, and tests that have been done but not confirmed can extend the process indefinitely.

4. In its annual report for 2008, the ASAP stated “*the ASAP is concerned about human rating requirements substance, application, and standardization NASA-wide.*” What is the basis of ASAP’s concern?

Response: The basis for our concern is that more than two years into the COTS program, efforts to develop human rating standards for a COTS-D like program have only just begun and no guidance thus far has been promulgated. If COTS entities are ever to provide the level of safety expected for NASA crews, it is imperative that NASA’s criteria for safety design of such systems immediately be agreed upon and provided to current or future COTS providers.

As a minimum, the ASAP believes that NASA should begin a dialogue with the funded COTS partners to address requirements for human rating. Additionally, NASA needs to clarify how much or how little they will be involved in the design, approval and operation of the NASA-crewed vehicles in order to verify that the funded COTS partners are compliant with the human rating requirements. The ASAP recommends the agency be “hands-on.”

NASA has indicated that they are considering a tiered or stair-step approach in addressing the technical review and approval processes to confirm safe flight and operational readiness, starting first with some level of technical insight for the unmanned services for routine supplies, then with greater insight for unmanned services involving high-valued cargo, and finally building up to the technical insight and process to be used for a NASA-crewed COTS mission. In modeling the COTS tiered technical insight processes, NASA will use its experience gained in the ISS program for transfer of routine supplies, and in the launch services program for commercial Expendable Launch Vehicle launches of high valued payloads. The ASAP concurs with this methodology.

Finally, as part of the launch certification requirements, NASA should immediately identify the number of launch successes that COTS partners will need to achieve with the unmanned vehicle in order to demonstrate the required vehicle reliability for a NASA-crewed launch. In developing the criteria for manned launch vehicle certification, NASA may also need to address whether and how the successful flights and results from the COTS ISS cargo re-servicing and NASA launch services programs, can provide evidence for consideration in assessing launch reliability for NASA-crewed vehicle.

Chairwoman Giffords, I would be happy to respond to any questions you or the other members of the Subcommittee may have.