

**Statement of
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National Aeronautics and Space Administration
before the
Subcommittee on Space, Aeronautics, and Related Sciences
Committee on Commerce, Science and Transportation
United States Senate**

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the various aspects of the Space Program after the Shuttle is retired, including the status of space transportation in support of the International Space Station (ISS). I would like to give you an update on our plans to ensure that space transportation capabilities remain available through the completion of ISS assembly and during the ISS post-assembly period after the Space Shuttle fleet has been retired in 2010. These capabilities are essential to successfully complete, operate and maintain the ISS, ensure productive utilization of this valuable national asset, and meet U.S. obligations to our international partners, including Canada, Europe, Japan, and Russia.

For the remainder of this decade, the Space Shuttle fleet will remain a highly capable and reliable system for assembling and servicing the ISS. The Shuttle, in concert with the consistent performance of our Russian partner's Soyuz and Progress vehicles, and the emerging cargo transfer vehicles from our European and Japanese partners, will ensure that the ISS will have adequate support for the remaining assembly period. The use of the Shuttle to deliver ISS components, essential spares and external stowage platforms is critical during this period.

Looking to the post-assembly period, NASA's next human spaceflight vehicle, the Orion Crew Exploration Vehicle, is on track to achieve Initial Operational Capability (IOC) in early 2015. The Constellation Program, of which Orion and its Ares I Crew Launch Vehicle are key components, has already made significant strides in the development and testing of system components.

The next decade, 2011 to 2020, will be an exciting period in the space transportation industry. There are many initiatives underway in both the public and private sectors to field new vehicles to serve the next generation of space exploration and development. It is important that NASA closely monitor the progress of individual development projects and actively manage risk so as not to jeopardize the viability of the ISS due to an inability to service it on a timely basis. Flexibility will be important to our success.

The capability to transfer crew to and from the ISS, and to ensure a safe and expedient return in the event of an emergency, is relatively limited in the near term. On the other hand, capabilities

to transport cargo and crew should become more diverse in the next decade, and thus will involve detailed trades among cost, schedule, performance, and risk. NASA's policy is to employ U.S. commercial services for both cargo and crew exchange at the earliest available opportunity, while minimizing the technical risks of interrupting the U.S. crew presence on orbit, or having to leave the ISS in a state of disrepair because failed components cannot be replaced.

The Space Shuttle Legacy

The ISS was designed to employ the Space Shuttle fleet for assembly and ongoing servicing. With a capacity for launch and return of up to 16 metrics tons (Mt) of non-pressurized cargo and four Mt of pressurized cargo, the Space Shuttle's supply and return capability far exceeds that of all other domestic and foreign vehicles. In addition, the Space Shuttle provides ISS crew exchange, while also transporting the construction crew needed to conduct complex assembly operations in space. The Shuttle's robotic arm is essential to these tasks, as are the Shuttle-based capabilities for conducting extravehicular activities. When necessary, the Space Shuttle can be employed for ISS attitude control and re-boost. For these reasons, the ISS was designed to be assembled and maintained based on the Space Shuttle's capabilities. The transition from Shuttle-based space transportation to a mixed fleet of U.S. commercial spacecraft and international partner assets is challenging due to this design heritage, but NASA is committed to developing options to satisfy the requirements of the ISS after the retirement of the Shuttle.

Retirement of the Space Shuttle is on schedule for 2010 and critical to future Exploration plans. As we approach this date, we are hopeful that we can complete the ten remaining Space Station assembly flights, the servicing mission to the Hubble Space Telescope, and the two contingency Shuttle missions to the ISS within this timeframe. If it becomes clear that we will not complete the flight manifest by 2010, NASA will evaluate options and make adjustments consistent with not flying any flights beyond 2010. Continuing to fly the Shuttle beyond 2010 does not enhance U.S. human spaceflight capability, but rather delays the time until a new capability exists and increases the total life cycle cost to bring the new capability on line.

In the second half of 2006, NASA successfully completed three Space Shuttle missions which continued ISS assembly with the addition of the P3, P4, and P5 truss segments. In June 2007, ISS-13A (STS-117) added the S3 and S4 truss segments, boosting available power on the ISS to 63 kilowatts. All of these new systems continue to operate as designed, with the exception of the starboard solar array rotary joint. We need to determine the source of the contamination within this joint, but all of the rotational elements are replaceable and there is a high probability of repair. Analysis completed to date shows this problem will not impact the next assembly flight ISS-1E (STS-122).

The most recent mission, STS-120, landed safely at Kennedy Space Center on November 7, 2007, after having delivered the Node (Harmony) safely to the ISS. The Harmony will now be moved to its permanent location at the end of the U.S. laboratory. This activity will involve three spacewalks and two major robotic maneuvers. Harmony will be ready for ingress and final activation around November 24. Pending successful activation and relocation of Harmony, the Shuttle and ISS teams are set to complete four flights this year. This is remarkable considering

that 2007 started with an external tank sustaining 2,000 hail damage hits and a three-month delay to flights.

The next ISS assembly flight 1E (STS-122) is scheduled to launch the European *Columbus* laboratory in early December 2007. With this flight, we will turn our attention to integrating the long-awaited elements of our international partners. It will be followed next year by deployment of the Japanese *Kibo* laboratory complex, and the Canadian *Dextre*, a special purpose dexterous manipulator for the ISS external robotics system. With the addition of these features, the ISS will emerge as a prominent example of the benefits of cooperation in science and technology for peaceful purposes. The ISS will house three premier research laboratories, one from the U.S., one from Europe, and one from Japan.

Future missions will enable us to increase the ISS permanent crew size from three to six and deliver critical system spares to the Station. A crew of more than three is needed if Space Station partners are to conduct a robust research program on board the ISS. Pre-positioning spares gives us the ability to ensure a prudent margin on systems performance, while allowing the U.S. commercial transportation capability to mature. This strategy was also one of the principal recommendations found in the February 2007 *Final Report of the ISS Independent Safety Task Force*.

The Space Shuttle will retire at the end of Fiscal Year 2010. After 2010, there is no mission requirement for the unique capabilities of the Space Shuttle. Flying the Space Shuttle past 2010 would carry significant risks, particularly to our efforts to build and purchase new transportation systems that are less complex, less expensive to operate, and better suited to serving both ISS utilization and exploration missions to the Moon, Mars, and beyond. Already, Shuttle facilities are being closed or transferred to exploration, Shuttle contracts are being phased out, and Shuttle engineers are transitioning to exploration activities. If we were to take the costly step of reversing those changes to keep the Space Shuttle flying past 2010, at a cost of \$2.5 billion to \$4.0 billion per year, using the same facilities that Constellation needs to develop, test, and begin operating Ares I and Orion, we would only exacerbate the gap in U.S human spaceflight and put at risk our Nation's preeminence in space exploration. NASA is committed to a transition and retirement process that is efficient, innovative, and that minimizes the gap in U.S. human spaceflight to the greatest extent possible. In support of this effort, we have modified the Space Program Operations Contract (SPOC) to create a strong bridge between Shuttle and Constellation operations.

Transition

NASA recognizes that the foundation of its success in conducting human spaceflight activities is the professional strength and dedication of its workforce. While the development of the Orion spacecraft and the Ares family of launchers will involve the integration of new technologies and procedures, many of the basic skills needed to create these are already resident at NASA's human spaceflight Centers. In an effort to maximize the benefit of the Agency's corporate knowledge and minimize potential disruption to the workforce from the transition from the Space Shuttle to Orion, NASA has placed emphasis on refocusing its human spaceflight

workforce on activities supporting the Exploration program as Shuttle activities ramp down. We have also put in place a system which allows employees to have two charge codes, one for Constellation work and one for Shuttle and Station work. This gives the employees a chance to begin transition as they fly out Shuttle. Examples of NASA's efforts to retain Shuttle workforce for Constellation projects include:

- The Space Shuttle Program manages "Retention of Critical Skills" through the last Mission in 2010 as a "top program risk." The second Space Shuttle civil service employee survey closed July 13, 2007. As was the case with the 2006 employee survey, many employees wish to continue working on Space Shuttle until the end of the program, but they want to have more information about their specific job assignments after Shuttle has been retired. Results of the survey will assist NASA in crafting employee assignment and motivational strategies to best use our dedicated civil service workforce through the last Shuttle mission.
- NASA's Human Capital leads held a joint Government/Contractor Human Capital Forum in August 2007 to share best practices in communications. NASA is working with the Space Shuttle prime contractors on ways to optimize skilled employee retention. Since both government and contractor employees cite meaningful future Exploration work as a primary motivator to continue working on Shuttle, NASA can affect employee retention by competing and awarding the remaining Constellation contracts as that work is defined by the Government.

In addition to preserving the expertise of its workforce, NASA is also committed to leveraging key facilities for the Orion and Ares projects, rather than letting them fall into disuse after the retirement of the Shuttle. To that end, we are examining our inventory of manufacturing, integration, assembly, and check-out facilities to determine whether they can be used to support the needs of the Exploration program; such facilities represent a significant investment by the taxpayer, and we will work to ensure that, where cost-effective, they are put to use effectively in the years ahead. Transition also provides with an opportunity to change and improve the way that we are operating. Some facilities no longer needed and with maintenance costs will be closed. Examples of NASA's efforts to turn over or retire Shuttle-related facilities include:

- The Space Shuttle Program has turned over the West Mobile Launch Platform Park Site at Kennedy Space Center to the Constellation Program. Echoing its use during Apollo and early Shuttle development, the Park Site will be used as a staging area for early construction and modifications at KSC as Constellation launch facilities are built up. At Stennis Space Center, the "A-1" Engine Test Stand turned over by the Space Shuttle Program in November of 2006 was outfitted with the first Power Pack Assembly for the Ares I Upper Stage J-2X liquid rocket engine and is soon to begin engine testing.
- NASA continues to retire Space Shuttle capabilities once they are no longer needed for the successful fly-out of the remaining Space Shuttle missions through 2010. NASA has begun removal of the Forward Reaction Control System (FRCS) rocket testing system at the White Sands Test Facility in New Mexico. At the Palmdale, California Boeing site, temporary building and tooling for the Space Shuttle have begun to be removed as part of

a pilot project to assess the time and cost required to dispose of assets that are no longer required. Similarly, at the Michoud Assembly Facility in New Orleans, old Space Shuttle Orbiter tooling and spares no longer needed to meet the manifest are being excessed to clear out space needed for the Constellation Program's Ares I Upper Stage production.

Orion Crew Exploration Vehicle and Ares I Crew Launch Vehicle

NASA's Constellation program, which includes the Orion Crew Exploration Vehicle and the Ares I Crew Launch Vehicle projects, has made great strides this past year. The program has tested hardware, logged wind tunnel hours, conducted rocket firings, and hired contractors for almost all program elements. Constellation has an integrated schedule and is meeting its early milestones. The Ares I has passed its system design review and is on track for preliminary design review, with test flights slated for 2009. All major elements of Orion and Ares I will be under contract by the end of 2007, bringing the program closer to the IOC of Orion in March 2015 and full operating capability about one year later.

The Orion will translate the hopes and aspirations of explorers the world over into an operational system for the next generation in human space exploration. It is the first element in an evolving architecture that will one day carry people back to the Moon, on to Mars and beyond. The Orion will also have the capability to exchange crews on the ISS and serve as an emergency crew return vehicle. In this role, which it will serve if U.S. commercial services are unavailable, it will have a capacity for up to six crew members and a stay time on orbit of up to 210 days. Its associated command module will have a limited capacity for some pressurized dry cargo transfer.

International Space Station: Post-Assembly Transportation Requirements

Once ISS assembly is completed and the Space Shuttle fleet is retired in 2010, transportation requirements decline from the approximately 50 – 60 Mt per year associated with assembly to approximately 10 – 20 Mt per year needed to sustain the system and utilize the internal laboratories and external platforms. NASA is continuously evaluating these space transportation requirements to ensure that maximum operating efficiencies are gained and minimum maintenance and utilization needs are met. Cargo re-supply requirements fall into two broad categories: (1) items necessary to meet internal demands, such as consumable liquids and gases (e.g., water, oxygen, and nitrogen), internal system spares, crew provisions, and internal scientific payloads; and, (2) items such as external system spares, ammonia tanks, and external scientific payloads.

NASA's analysis of post-assembly logistics demand and supply considers first the transportation assets available through the baseline ISS program. Initial analysis indicates that there remains a significant shortfall between the logistics demand to sustain and utilize the ISS and the logistics supply available through international agreements, contracts, and services owed. This shortfall corresponds to approximately 10 Mt per year after Space Shuttle retirement, or over 50 Mt through 2015. When one takes into consideration the packaging structure and carriers necessary

to transport a net usable cargo of 50 Mt, the gross requirement approaches 80 Mt through 2015. Some options for addressing this challenge are detailed below.

In addition to cargo services, six crew members will permanently occupy the ISS in six-month rotations. Three of these crew members will be provided by Russia; the remaining three crew members will be from the U.S. and Canada, Europe, or Japan. The U.S. is obligated to provide bi-annual crew exchange, as well as emergency crew return capability and habitation accommodations, for these three crew members. Once the Space Shuttle is retired, the Russian Soyuz will be the only vehicle available for crew exchange and rescue services until a U.S. commercial crew service, or Orion, is available. NASA has contracted with Roscosmos to provide Soyuz and limited cargo services through the end of FY 2011, as permitted under the Iran and Syria Nonproliferation Act (P.L. 106-178, as amended by P.L. 109-112). NASA is monitoring the progress of potential domestic commercial providers to develop cargo and crew transportation services to the International Space Station (ISS), and the Orion project is on track to reach its Initial Operational Capability in March 2015. The Administration is considering options to maintain a U.S. crew presence aboard the ISS. Purchasing cargo and crew transportation services domestically is NASA's preferred method to meet the needs of the ISS. Another option may be to seek relief from the provisions the Iran and Syria Nonproliferation Act for additional Soyuz services to keep a U.S. crew presence on the ISS until either domestic commercial crew transportation services, or Orion, become available. We will keep the Congress fully informed of our plans.

U.S. Commercial Orbital Transportation Services (COTS)

U.S. space policy directs pursuit of commercial opportunities for providing transportation and other services to low Earth orbit and beyond. Successful COTS partners may open new space markets and provide reliable, cost effective cargo and crew transportation services, ushering in a new era for commercial space. NASA is investing \$500 million to stimulate the commercial space industry and to facilitate U.S. industry demonstration of commercial space transportation capabilities under Phase 1 of the COTS project. NASA plans to utilize the commercial space industry to re-supply the ISS after retirement of the Space Shuttle in 2010.

The COTS launch providers are not developing systems to be operated by the government or its contractors, but are demonstrating a capability that NASA and others can later purchase as a commercial service. Since these companies are developing vehicles that they intend to use commercially for other customers in addition to NASA, they are assuming a significant portion of the financial and programmatic risk.

As part of Phase 1 of the COTS project, the Agency signed two funded Space Act Agreements (SAAs) with emerging commercial launch providers or “partners” to facilitate the development and demonstration of the vehicles, systems, and operations needed to resupply, return cargo from, and transport crew to and from a human space facility, with the ISS providing the representative requirements for such a facility. Performance milestones culminate in a flight demonstration in which the partner’s vehicle will launch, rendezvous and dock with ISS, and return safely to the Earth’s surface. The partners are only paid a pre-negotiated, fixed amount if

they successfully complete a milestone. If they do not complete the milestone to NASA's satisfaction, they are not paid. These milestones are both technical (e.g., a successful design review or hardware test) and financial (e.g., raising a certain amount of private funding). NASA has also entered into multiple unfunded SAAs with various emerging commercial launch providers to provide support in the development of a low Earth orbit transportation capability.

NASA assists the COTS partners' efforts by providing a network of Agency technical experts across all discipline areas -- known as the COTS Advisory Team. Extensive NASA technical and facility resources are also available to the commercial partners through reimbursable SAAs.

On October 18, 2007, NASA terminated one of the two funded SAAs because the commercial partner had failed to perform under the terms of the agreement. NASA remains committed to the COTS project and to stimulating a robust commercial space industry, as demonstrated by the release of a competitive announcement on October 22, 2007, seeking a new round of Phase 1 proposals. Industry proposals for this new competition are due to the Agency on November 21, 2007.

NASA's Space Operations Mission Directorate, in cooperation with NASA's Exploration Systems Mission Directorate, will oversee procurement of commercial cargo services to and from the ISS. The President's 2008 Budget included \$1.9 billion over five years in the Space Operations Mission Directorate for crew and cargo services, the majority of which will be available for commercial services. We continue to analyze the exact amount of funding required in this area. A government procurement of commercial cargo services is planned. NASA released a Commercial Space Transportation Services Request for Information (RFI) on July 7, 2007. Issuance of a Request for Proposals (RFP) is currently expected in FY 2008.

Japanese H-II Transfer Vehicle (HTV)

Japan's HTV is an expendable, automated cargo transfer vehicle designed to launch on the H-IIB expendable rocket and rendezvous with the ISS. It will include both pressurized and non-pressurized carriers, thus allowing delivery of rack-mounted equipment, water and gases, and non-pressurized system spares. The HTV has completed its critical design review and is scheduled for demonstration in the mid-2009 period. The cargo capacity will be approximately 5.5 Mt and the lead-time to production is estimated to be three to four years. Japanese plans currently call for a production capacity of one HTV per year. This rate corresponds to Japan's commitment to fly one HTV per year over the period 2009 – 2015.

A portion of the HTV cargo capacity is owed to the ISS program based on Japan's share of common system operations costs and prior barter arrangements. This cargo capacity is important since it has already been factored into the ISS baseline program for cargo supply. Approaches to acquiring further HTV cargo delivery services, particularly in the area of non-pressurized system spares, are under evaluation in the event that COTS cargo services are delayed. If system sparing becomes critical to maintain the station and U.S. commercial cargo services are delayed, it would be prudent to have the flexibility to execute a sound contingency plan.

European Automated Transfer Vehicle (ATV)

Europe's ATV is an expendable, automated cargo transfer vehicle designed to launch on the Ariane V expendable rocket and rendezvous with the ISS. It will have capability to deliver dry cargo at the sub-rack level, and external tanks for water, gases, and propellant. The cargo capacity will be approximately six Mt and the lead-time to production is estimated to be about three years. The first ATV, *Jules Verne*, is currently in final integration at the Guiana Space Center, Kourou, French Guiana (South America) and is scheduled for launch to the ISS in the first quarter of calendar year 2008. European plans call for production of five ATVs, corresponding to their commitment to fly five vehicles to the ISS over the period 2008 - 2013.

A portion of the ATV cargo capacity is owed to the ISS program based on Europe's share of common system operations costs. This cargo capacity is also important and has been factored into the ISS baseline program for cargo supply. In addition, the ATV is capable of performing ISS re-boost and attitude control, and propellant can be transferred to the ISS tanks for use after the ATV has departed.

Russian Progress and Soyuz Vehicles

The expendable Russian Soyuz rocket has over 1,700 successful launches in the past 40 years. In the ISS Program to date, it has been used to launch 15 Soyuz crew transfer vehicles, each having a capacity for three crew, and 26 expendable, automated Progress cargo transfer vehicles. Both vehicles rendezvous with the ISS. In the future, the Russian segment is planned to expand to accommodate two Soyuz and two Progress (or a Progress and an ATV) vehicles to support six crew. The Progress has the capability to deliver dry cargo and tanks for water, gases and propellant. Its cargo capacity is approximately 2.5 Mt. The lead-time to produce a unit is estimated to be a little over two years for both Soyuz and Progress. Russian plans currently call for the production of two to four Soyuz crew vehicles per year and three to five Progress cargo vehicles per year for missions to the ISS through at least 2015.

The ISS program has purchased approximately six Mt of cargo capacity from Russia for use during the FY 2009-11 period in order to help bridge any time between the Shuttle retirement and U.S. commercial cargo transfer availability. These services are considered important and have been factored into the ISS baseline program for cargo supply. In addition, Soyuz services have been purchased through the end of FY 2011 to provide crew rotation and rescue before U.S. commercial crew transfer, or Orion, services become available. These services have also been factored into the baseline program for crew exchange.

Conclusion

NASA is making excellent progress toward completion of the ISS assembly phase. In the coming year, popular awareness will expand dramatically around the world as the laboratories of Europe, Japan, and later, Russia, begin operations alongside the U.S. laboratory. The

performance of on-orbit systems, transportation systems, and the flight and ground crews has been outstanding. The teams have successfully dealt with many challenges and will no doubt continue to face challenges; operating continually in space is an extremely difficult endeavor, but despite the difficulties, the ISS has now been continuously crewed for more than seven years. This remarkable level of achievement is possible only because individually, and collectively, we have learned how to actively manage risk with maturity and prudence.

The future of space transportation is uncertain in detail, but clear in direction. The next decade will offer more opportunities, and choices, than did the last decade. We must continue to examine these choices if we are to be prepared for the next phase in the ISS program. While we focus our sights on enabling discovery and a new economy in space, we must also develop our transportation plans to withstand the risk of short-term setbacks that are inevitable in the development of new technologies for new frontiers. We have done the planning, understand the options, and are prepared. We appreciate your continued support to maintain the flexibility needed in order to be successful.

Thank you for the opportunity to appear before you today. I would be pleased to respond to any questions that you may have.