Development of the International Docking System Standard

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Improving the affordability of future space flight programs is one of the big challenges for NASA as budgets continue to decrease. As exemplified by the current International Space Station (ISS) Program, future large-scale space initiatives will be successful using collaborations with other nations to share the cost burden while achieving the long-term technical goals and benefits. As U.S. Governmental and Agency policies shepherd us toward more global cooperation via such programs, we will find that the development and standardization of space flight elements will enable nations and industries to focus their respective contributions toward a broader collective effort. One such standardization effort initiated, in December 2008, is the International Docking System Standard (IDSS), whose first product—the IDSS Interface Definition Document (IDD)—was initially released in September 2010. This document establishes a recommended standard docking interface to be used for joint collaborative endeavors while enabling potential rescue missions. The interface is based on both validated designs and new technologies.

The IDSS IDD was developed by NASA along with its International Space Station partners, the Canadian Space Agency, European Space Agency, Japanese Space Agency, and the Russian Space Agency. The IDD provides the basic geometry and design parameters that would allow developers to independently design compatible docking systems suitable to their own unique program and mission requirements. The IDSS is intended for crewed or autonomous space vehicle applications ranging from low-Earth orbit to deep-space exploration missions. Among these missions are ISS visitation, lunar exploration, crew rescue, and international cooperative missions.

Detailed physical geometry of the mating interface, along with some performance requirements—i.e., design loads for initial docking capture event and mated loads—have been defined. Adhering strictly to the geometric interface definition ensures physical mating compatibility while accommodating the documented performance requirements supports a broad set of design reference missions and

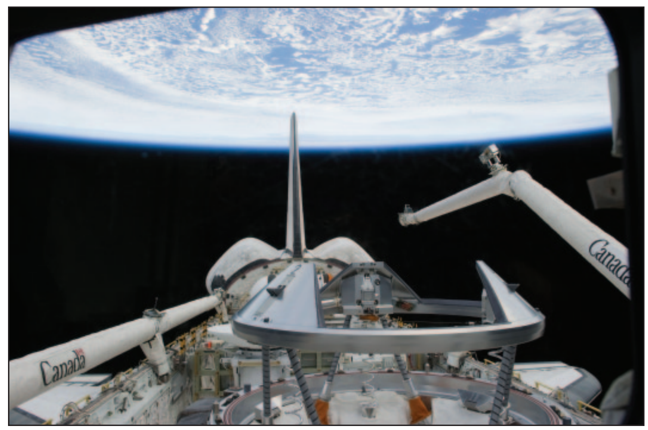

Fig. 1. *Androgynous Peripheral Assembly System.*

conditions, thus increasing the probability of successful docking between different spacecraft. Additionally, using this standard by future developers will provide easier program planning and integration of collaborative efforts of the future.

Achieving total agreement among the International Partners on a docking interface standard proved to be challenging. There is a long history of success with existing docking systems, like the Androgynous Peripheral Assembly System (APAS) built by Rocket Space Corporation-Energia, which has been used on the space shuttle orbiter and the ISS (figure 1). However, new docking system technology development efforts have been under way at NASA for many years and offer important benefits over existing technologies. The Low Impact Docking System (LIDS)/NASA Docking System (NDS) has been under development to specifically address docking challenges associated with a wide array of vehicles, ranging from ultra-light satellites to large space vehicles like the ISS (figure 2). As one can imagine, bringing these two technologies together as a standard created a number of technical challenges and resulted in the need for several key trades regarding standardization of the necessary geometric structures and performance

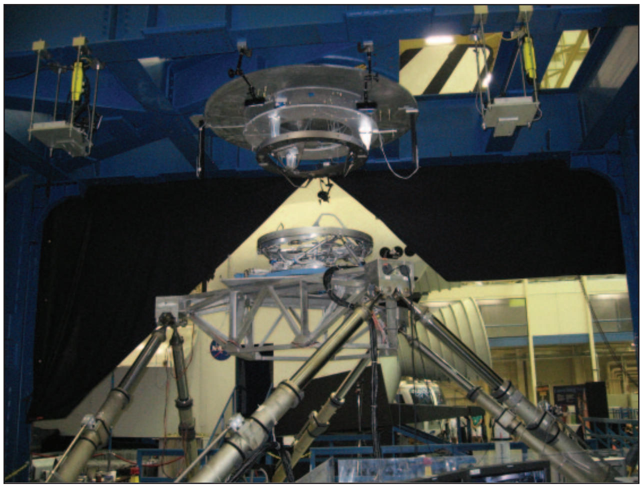

Fig. 2. *NASA Docking System soft capture system degree-of-freedom testing.*

capabilities. It was a goal of the IDSS team to find a way to blend the best of the legacy system (APAS passive mechanical design) with new technology (active force feedback system NDS design) designs to create an international standard.

A docking standard must define the basic geometry of both the capture system and the structural latching/hard docking system. Successes of the operation of the Apollo Soyuz Test Program and APAS docking mechanisms drove early decisions to standardize interface androgyny (meaning the interface configuration is capable of mating to an identical configuration) to enable crew rescue. As such, the characteristics of the APAS mechanism were used as the starting model, but because the new technology designs of NASA required a wider capture system ring than that of APAS, the wide ring soft capture interface became fundamental to the agreement for the docking standard. Another key decision was to maintain the structural latching interface/hard docking ring based on the APAS hard mate geometry. Maintaining the legacy geometry allowed the Russian Space Agency to continue with existing hard dock manufacturing lines and vehicle architectures, but resulted in a slightly reduced capture ring diameter that impacted the transfer tunnel dimensions and the capture performance envelope. These impacts required the team to perform capture system trade studies.

After an in-depth review of the resulting dimensions of the passageway and capture system performance capabilities, the team determined that the resulting specifications satisfied system performance requirements. In addition, implementing a petal design scheme with folding or removable capture system petals will enable a larger transfer passageway, if needed, in contingency scenarios. These decisions resulted in the definition of the basic geometry of the IDSS.

Trade-offs for other interface features of the capture system and the hard dock system were also studied in detail. For soft capture, it was decided to accommodate the features of both mechanical and magnetic capture latch passive systems. This would ensure that docking principles of different countries would be honored, while preserving a future goal toward commonality. The hard dock system features of fine alignment, seal placement and hooks were adopted from the APAS. For other features like separation systems and sensors, designated striker areas were allocated and standardized to allow some flexibility for implementation by developers (striker areas are defined, free areas for active components on one mating half to press against the opposite mating half during docking operations). Resource umbilicals were not standardized as deemed program unique, but future work may be organized to standardize designated areas for umbilical location. It is also a possibility in the future to agree on a specific umbilical standardization if determined beneficial by the IDSS team.

An April 2011 modification of the IDSS resulted in the successful combination of the legacy system hard dock features and dimensions of the APAS with new technology soft capture ring dimensions of the LIDS/NDS low impact system (figure 3). With this standard completed, developers around the world can use it as the basis for their future designs. While the NDS development activities are targeted toward completion and implementation of this standard on the ISS by 2014, other countries and industry are foreseen to take much longer. Having the IDSS available on the ISS is expected to provide the impetus for future ISS visiting vehicles to use the new standard and to establish an excellent test bed from which to gain operational experience.

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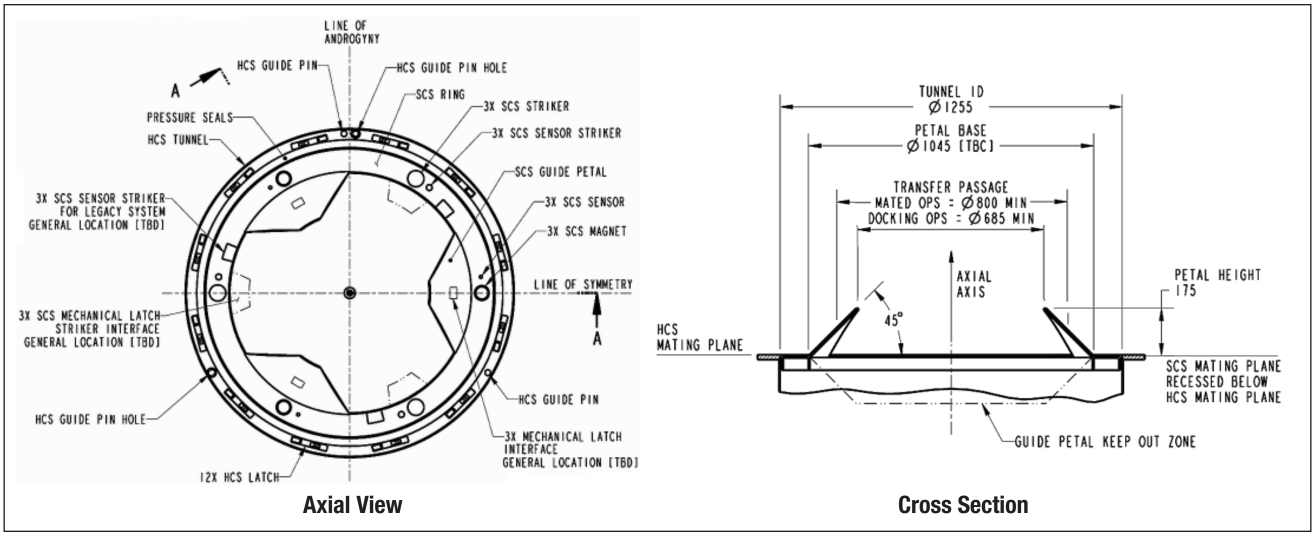

Fig. 3. *International Docking System standard interface.*

The website http://www.internationaldockingstandard.com was established to provide the global community access to the IDD. Plans are under way for further development of the IDSS standard website to include test and verification strategies, docking principles, information on compliant IDSS systems, etc. (figure 4). Collaboration between current IDSS partners will continue, and others are expected to join this technical community. As discussions continue, evolution of the IDSS is anticipated along with additional collaborations within the docking discipline.

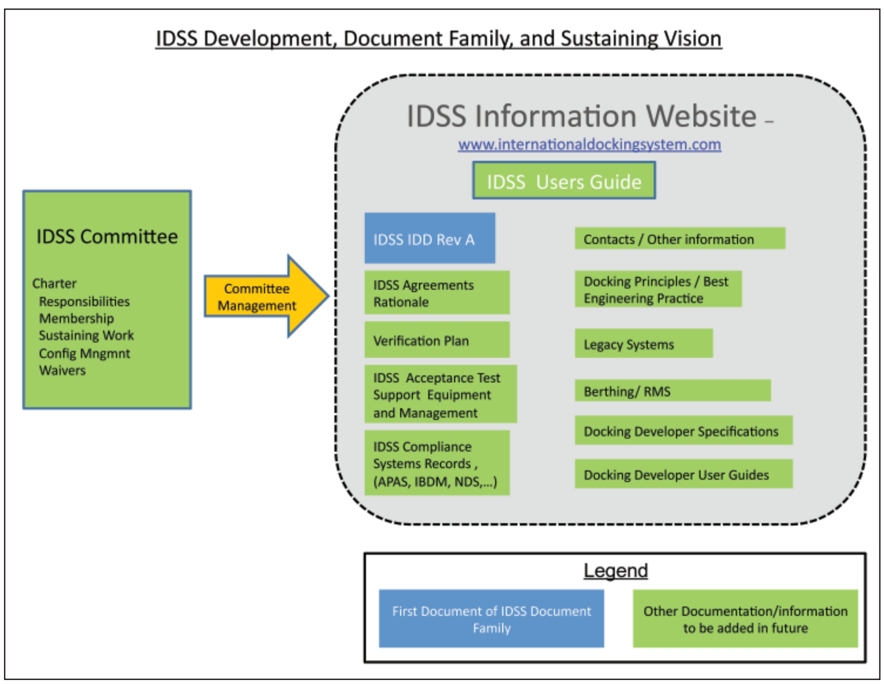

Fig. 4. *International Docking System Standard development, document family, and sustaining vision.*