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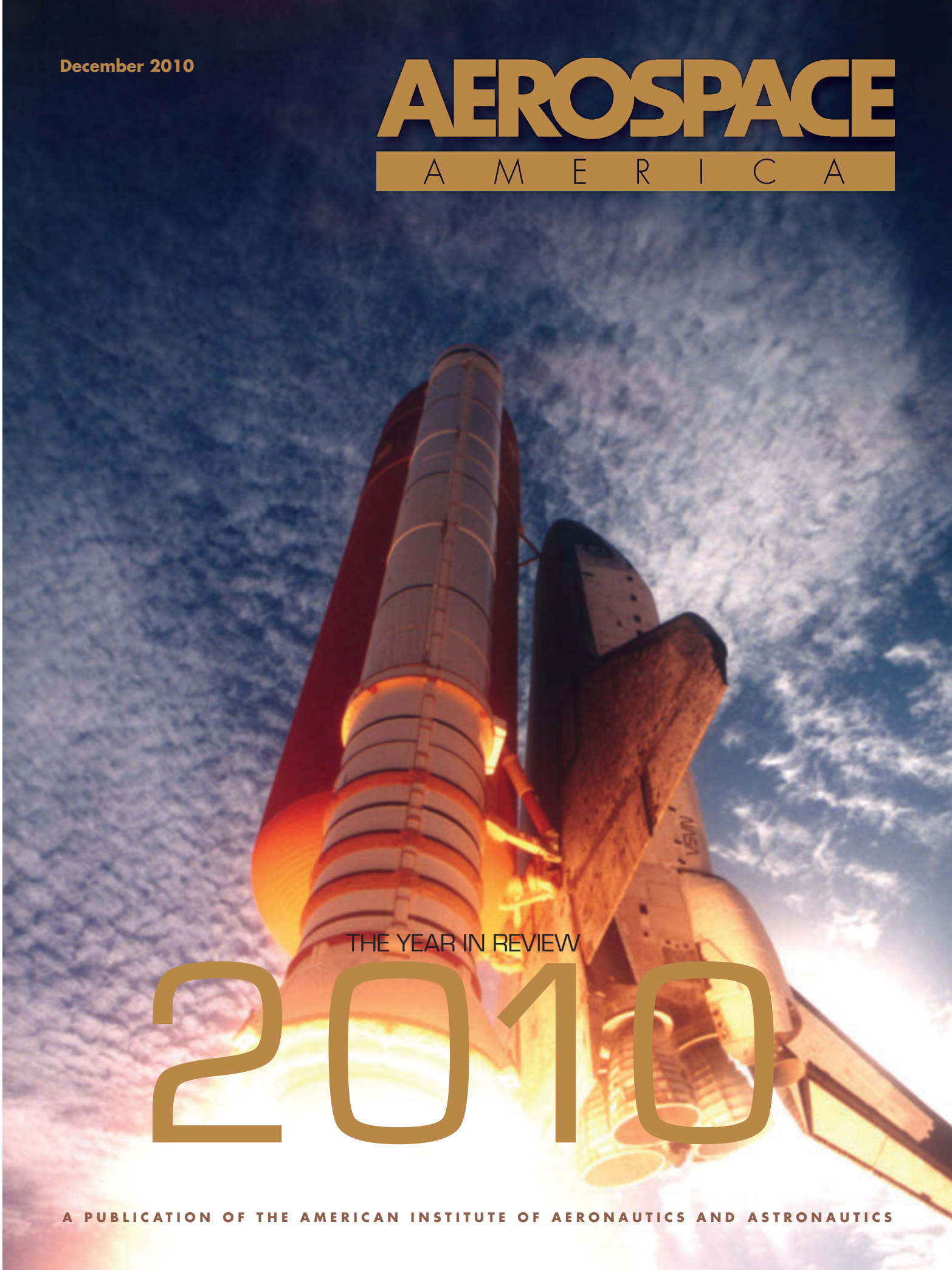
AEROSPACE AMERICA



THE YEAR IN REVIEW

2010

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Space logistics

Space logistics is the theory and practice of driving space system design for operability, and managing the flow of materiel, services, and information needed throughout a space system life cycle. The shuttle's impending retirement will significantly affect space station logistics processes—the original ISS operations and support concept was designed with continued shuttle operations in mind. The imminent cancellation has driven significant ISS sustainment concept changes, which now involve greater reliance on spares prepositioning, on-station ORU (orbital replacement unit) repairs, and the loss of capacity for returning large, high-value parts to Earth for repairs. In sum, the shuttle's retirement will severely challenge our ability to address satellite servicing and significant unplanned ISS system repairs.

Soyuz and Progress flights continue to transfer crews and materiel to the ISS, and Soyuz will become the only vehicle capable of crew and limited cargo return when the shuttle retires. The automated transfer vehicle Johannes Kepler is slated to become the second European spacecraft to reach the ISS, with the launch via an Ariane 5 mission expected early next year. It offers significantly more cargo capacity than Progress, with up to 5.5 metric tons of freight and supplies, 840 kg of water, 100 kg of gases, and 4 metric tons of fuel for ISS orbit correction. ESA is also investigating a reusable reentry vehicle variant that is designed to return crew and materiel to Earth. Other ISS resupply alternatives include the NASA COTS SpaceX Dragon and Orbital Sciences Cygnus vehicles and the JAXA HTV, all of which are planning flights to the ISS in the next few years. Dragon brings the potential for significant downmass capacity.

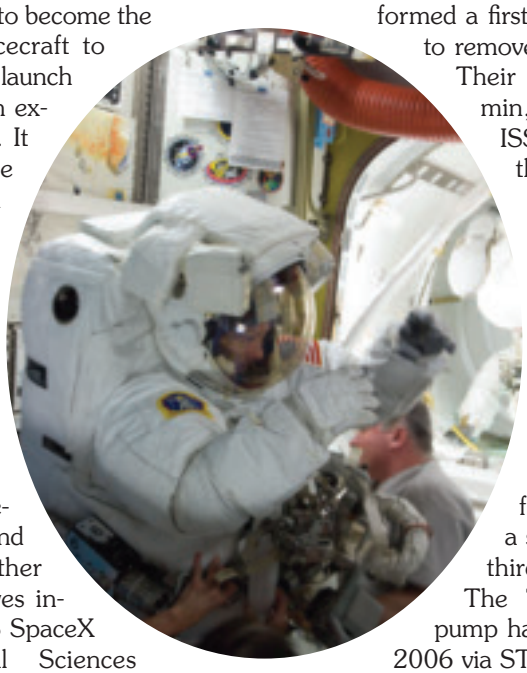
Major tasks remaining for the ISS international partnership include coordinating flight schedules, cargo manifests, docking port availability, and reverse logistics; maintaining a robust set of spares; and the timely delivery of consumables.

The challenge of ISS spares and preposition planning is overcoming the uncertainty in failure rate estimates and minimizing the risk of inaccurate failure predictions. To mitigate this problem, the ISS logistics and maintenance team and ISS reliability and maintainability team use Bayesian inference to update mean time between failure estimates with ORU performance history. As with previous updates, the 2009-2010 operating period generally shows on-orbit hardware performing better than initially predicted. The Bayesian update process will likely continue to be a critical tool for ISS sustainment plans extending to 2020 and beyond.

ISS prepositioning, sustainment, and repair capabilities were showcased in August after an ammonia pump module on the starboard-side truss failed. One of the station's two cooling loops was brought down, necessitating a reduction in power consumption by noncritical systems and payloads. Planning began immediately for removing the broken pump and replacing it with an available spare.

Expedition 24 flight engineers Doug Wheelock and Tracy Caldwell Dyson performed a first spacewalk on August 7 to remove and replace the pump. Their excursion lasted 8 hr 3 min, making it the longest ISS-based spacewalk and the sixth-longest spacewalk in history. Their repair tasks originally included removing the failed pump module and retrieving a spare from an external stowage platform, but an ammonia leak necessitated a second EVA to finish removing the failed pump and prepare a spare for installation in a third and final spacewalk. The 780-lb spare ammonia pump had been delivered in July 2006 via STS-121 and placed on an external stowage platform. The repair and replacement tasks took a total of 22 hr 49 min during the three spacewalks.

The extensive EVA work also highlights the need for implementing EVR (extravehicular robotics) and EVA/EVR cooperative maintenance for other external ORUs (orbital replacement units) using the Canadian Space Agency's special-purpose dexterous manipulator, fondly referred to as Dextre.



Expedition 24 flight engineer Tracy Caldwell Dyson, attired in her extravehicular mobility unit spacesuit in the ISS Quest airlock, completed three spacewalks with flight engineer Doug Wheelock to remove and replace an ammonia pump module that failed July 31.

by **Alan W. Johnson**