Forum highlights technology tested on Space Station for deep space exploration

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Three satellites fly in formation as part of the Synchronized Position Hold, Engage, Reorient, Experimental Satellites investigation on the International Space Station. Credit: NASA

Investigations on the International Space Station are not only helping astronauts live and work in space, but also are perfecting valuable tools and technologies that may help us at home and as humans travel to new destinations in our solar system.

To highlight these technologies, a panel of experts gathered Oct. 27 for the Destination Station: International Space Station Technology Forum at the U.S. Space & Rocket Center's Davidson Center for Space Exploration in Huntsville, Alabama. The forum, the second in a new series of public discussions dedicated to research on board the station, emphasized current and future technology research that will prepare astronauts for long-duration missions farther into the solar system than ever before and provide lasting benefits on Earth.

The space station is an orbiting laboratory where we are looking for answers to fundamental questions about life, the world in which we live and the universe around us. The space station also serves as the world's leading test bed for cutting-edge technology in microgravity. Although much of this technology has applications for use on Earth, this forum specifically focused on the technology we will need to enable human and robotic exploration of destinations beyond low-Earth orbit, including asteroids and Mars.

"On the station, experimenters can see exactly how advanced technologies behave over long durations in a microgravity environment or when exposed to the space environment," said Jeffrey Sheehy, senior technical officer of NASA's Space Technology Mission Directorate in Washington. "And conveniently, it's only about 200 miles above us and reachable by a fairly quick rocket trip, so it's a safe and readily accessible laboratory for testing the innovations that will enable humans to travel farther into space than ever before."

Life support systems are critical to maintain the health of space crews. Systems for long space journeys will need to be durable and lightweight and recycle materials. Engineers developing advanced life support are learning from experience with the Environmental Control and Life Support System (ECLSS) on the space station. It efficiently recycles a majority of the water from waste, hygiene and other activities and

produces water that the crew drinks. It also recovers half of the oxygen from the crew's exhaled carbon dioxide. The station experience is teaching engineers to create an even more advanced life support system so astronauts do not have to carry any makeup water or oxygen with them.

Making exercise a requirement in microgravity not only supplies investigators with the sweat they need to perfect the water recovery system, but it also has the ancillary benefit of keeping space travelers healthy by using muscles—including the lungs and heart—to keep them strong and functional. Engineers at NASA's Marshall Space Flight Center in Huntsville learned how to reclaim water from human sweat and urine for reuse by astronauts in space.

NASA astronaut Don Petit installs the Water Recovery System into the Destiny Lab on the International Space Station in November 2008. Credit: NASA

So, what happens if a part of the life support system or other equipment breaks or needs to be replaced on the station? Right now, NASA has to ship a new part to space. This would be impractical if astronauts are millions of miles from Earth. Another technology, 3-D printing, could make it easy for crews to create a new part with some raw materials and the push of a button.

The 3-D Printing in Zero-G Technology Demonstration—delivered to the station on the fourth SpaceX cargo resupply services mission - plans to demonstrate that a 3-D printer can make parts in space. This 3-D printer heats plastic to build parts layer on top of layer. Testing a 3-D printer with relatively low-temperature plastic on the space station is the first step toward establishing an on-demand machine shop in space, a critical enabling component for deep-space crewed missions and in-space manufacturing.

Technologies, such as 3-D printing, make space travelers less dependent on resupply from Earth, but they will still want to stay in contact with home. The farther away from Earth astronauts travel, the more difficult communication becomes. This is because of delays in transmissions. The Space Communications and Navigations Testbed (SCAN Testbed) contains state-of-the-art radios for communications with Earth, and are built to allow changes and updates after they launch. This provides unprecedented flexibility during development and while in space. The radios conform to common, non-proprietary standards so agency flight controllers can change the software and how the equipment is used in space. Recent tests on the space station used the radios for high rate communications, new networking concepts, cognitive and autonomous operations, and for navigation with global positioning satellites.

Changing a radio's software after launch would give mission operators on the ground the ability to enhance communication systems for increased data flow and possibly resolve problems with the

communications systems. The flexible radio system—designed at NASA's Glenn Research Center in Cleveland and currently undergoing rigorous testing in orbit—would allow spacecraft crews and ground teams to recover from unpredicted errors or changes in the system. Using the same hardware platform for various missions and only changing the software to meet specific mission needs also would reduce cost and risk.

Communication systems, manufacturing equipment, and life support systems are all important to long-term space travel. To travel farther away from home, humans also will need robotic systems to assist them with a variety of tasks. Autonomous programmed navigation systems are addressed in a series of investigations on the space station called the Synchronized Position, Hold, Engage, Reorient, Experimental Satellites. These SPHERES - developed by the Massachusetts Institute of Technology in Cambridge—are a group of bowling-ball-sized, free-flying satellites designed to demonstrate and test, in a complex environment, enhanced technologies and techniques related to visual inspection and navigation. Each satellite is self-contained with power, propulsion, computers and navigation equipment. Perfecting this technology could be important for satellite servicing, vehicle assembly and spacecraft navigation.

These satellites are testing autonomous maneuvers, including successful collision avoidance, recovery of lost satellites, scatter maneuvers, trajectory tracking and realignment, coupling together multiple satellites, path-planning algorithms, remote operation of robots and manual abort and navigation. The initial investigation concluded with a successful docking to fixed and tumbling targets, the latter a space first. Researchers concluded that remotely operated robotic spacecraft can conduct repairs, maintenance, inspections and monitoring and de-orbit malfunctioning or defunct spacecraft. The SPHERES currently operate as an in-orbit facility for education and other research opportunities into

areas such as fluid behavior and flight formation.

These are only a few examples of the technology capabilities NASA is perfecting on the space station today. These advances help perfect the tools humans will need to reach destinations beyond Earth in the not-too-distant future.

"Living on the station has taught me how much we need to learn before we can travel to Mars," said astronaut and Expedition 41 flight engineer Reid Wiseman, who lives and works on board the space station. "Not only does the human body operate differently, so does most everything else including the technologies to help humans survive. The station is the only place in space where we can test technologies in the environment where these critical systems will operate."

Space station investigations with robotics and life support systems not only benefit future explorers but also have already led to technologies that are benefiting life on Earth. For example, technologies based on the station's life support equipment are currently used to provide clean water during disaster relief. More findings like these will advance technology development on Earth and help promote the safety and success of NASA's deep space exploration missions.

Provided by NASA