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Space automation and robotics

On February 24, space shuttle Discovery was launched into orbit for the last time. In addition to the crew of six astronauts, the STS-133 mission included a robotic passenger, NASA's Robonaut 2 (R2). This two-armed humanoid robot is the latest result of a long-term NASA effort to develop robots that have manipulation capabilities similar to those of suited astronauts. In the future, dexterous robots will be able to make use of hand tools without modification and perform extravehicular activity work, enabling a reduction in the amount of consumables used during human missions.

NASA astronaut Cady Coleman poses with Robonaut 2 in the Destiny laboratory of the ISS in March. Courtesy NASA.

by **Terrence Fong** and **David P. Miller**

NASA began formal testing of R2 on the ISS in late summer as part of the human exploration telerobotics (HET) project. The purpose of HET is to assess how advanced remotely operated robots can improve the productivity of human explorers and increase the scientific return of human missions. To do this, HET is conducting tests with a variety of robot systems remotely operated by ISS astronauts and by ground controllers on Earth. These systems include R2, the MIT SPHERES (synchronized position hold engage and reorient experimental satellites) free-flyers, the NASA Ames K10 planetary rovers, and the JPL ATHLETE (all-terrain hex-limbed extraterrestrial explorer) robot.

With the successful completion of the STS-135 on July 21, the shuttle remote manipulator system (SRMS), or Canadarm, was officially retired after having flown on more than 50 missions. The SRMS arms from Discovery and Atlantis will be displayed along with their respective shuttles. The Endeavour arm is being removed and will be on display in Canada.

At this year's International Conference on Robotics and Automation, held in Beijing, Chinese officials announced several lunar rover missions. The first, to fly in 2013, will be an autonomous 120-kg rover to explore Sinus Iridium. The robot is powered by solar panels during the lunar day and kept alive through the lunar night using a U238 RTG (radioisotope thermoelectric generator). Following the rover mission, China expects to conduct a sample return mission in 2017.

In April, ESA tested its ExoMars drill in Mars analog conditions. The drill can penetrate to a depth of 2 m and return core samples by opening and closing the coring port at the drill head. The drill also has a sapphire window on the side of the drill string for the Mars MISSE (multispectral imager for subsurface studies experiment). This imager can take readings from the inside of the bore hole. ESA plans to deploy the drill on Mars as part of a joint 2018 mission with NASA.

At the end of May, NASA announced that it had formally ended the mission of its Mars exploration rover Spirit. The agency made this decision after being unable to reestablish communications with the rover for more than a year. NASA concluded that the rover had likely not survived the recent Martian winter because of inadequate power for its survival heaters. Spirit landed on Mars on January 3, 2004, for a three-month mission, but surpassed all expectations by operating until March 22, 2010.

Elsewhere on Mars, the Opportunity rover (Spirit's twin) continues to establish new records for Mars exploration. In August, Opportunity arrived at Endeavour Crater after traveling for almost three years across a distance of 13 mi. (21 km). Scientists are planning to use Opportunity to sample new types of rocks in Endeavour, particularly clay minerals that may have formed in early, wet conditions on Mars. JPL operates Opportunity remotely, from Pasadena.