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Advancing robotics

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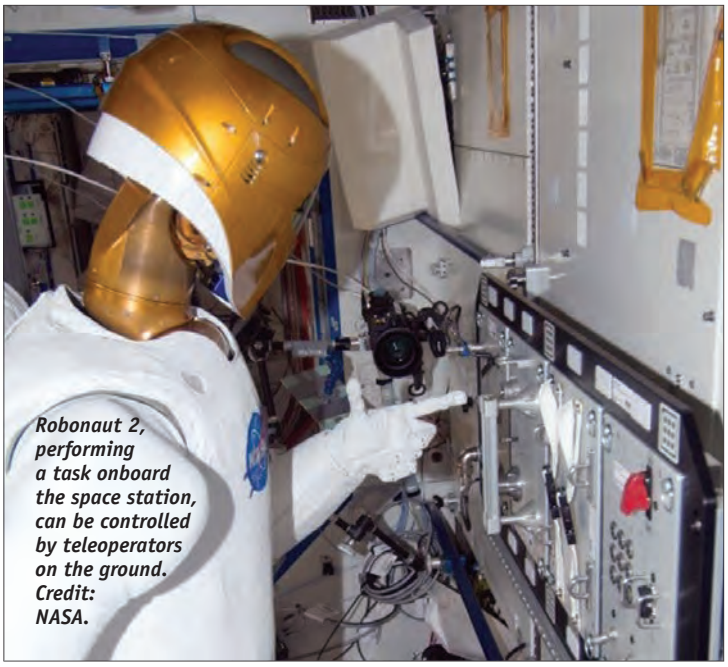
*The **Space Automation and Robotics Technical Committee** works to advance the development of these technologies and their application to space programs.*

Teleoperation—meaning remote control of a robot by a human—saw significant progress in 2013.

The **NASA Robotic Refueling Mission**, or RRM, which is attached externally to the Dextre robotic arm on the International Space Station, conducted orbital refueling technology demonstrations. With **Dextre** teleoperated from the ground, the RRM accomplished fluid transfer tasks, cut thermal blankets, and removed fasteners and caps. A new hardware box was delivered to the station in August so that RRM can begin a new phase of even more complex servicing tasks.



Robonaut 2, performing a task onboard the space station, can be controlled by teleoperators on the ground. Credit: NASA.

Inside the ISS, **Robonaut 2** is mastering the art of working alongside humans in orbit. Earth-based control teams can now teleoperate this humanoid robot to wipe handrails, make airflow monitoring checks, and perform other cleaning duties, freeing ISS crewmembers to focus on the onboard science experiments. Robonaut 2 is also providing technology spinoffs that are now available for licensing across a variety of industries. Also onboard the ISS is **Kirobo**, a small Japanese humanoid talking robot. JAXA, the Japan Aerospace Exploration Agency, launched Kirobo to study human-robot interactions during long-duration space missions.

Someday astronauts will need to teleoperate robots on the surface of a planetary body from the safety of their orbiting spacecraft or habitat. To demonstrate this ability, NASA sent hardware to the ISS so that astronauts onboard could operate a robot located on Earth. In separate activities during June and July, three astronauts on the station each **drove a robot** on the ground and manipulated it to perform several tasks. These were the first demonstrations of a robot on Earth being controlled from space.

In the area of planetary surface robotics, the Mars Exploration Rover **Opportunity** celebrated the 10-year anniversary of its Mars landing on August 6. Opportunity also broke the record for the longest distance traveled by a NASA rover, surpassing the Apollo 17 lunar rover's mark. The Mars Science Laboratory's Curiosity rover spent its first year successfully driving and drilling on the Martian surface. Curiosity also began using autonomous navigation in August to avoid hazards while driving.

Japan's Kirobo, now onboard the ISS, is a small talking humanoid robot. Credit: Kibo Robot Project.

There are also many space robotics initiatives currently in development. This year DARPA's satellite servicing program, **Phoenix**, completed Phase 1. NASA's **Asteroid Redirect Mission** is in its early planning stages and will need a variety of space automation and robotics capabilities to be successful. Also in development are several international planetary rovers destined for the Moon, Mars, and asteroids.