Astronauts Practice Refueling Spacecraft in Orbit

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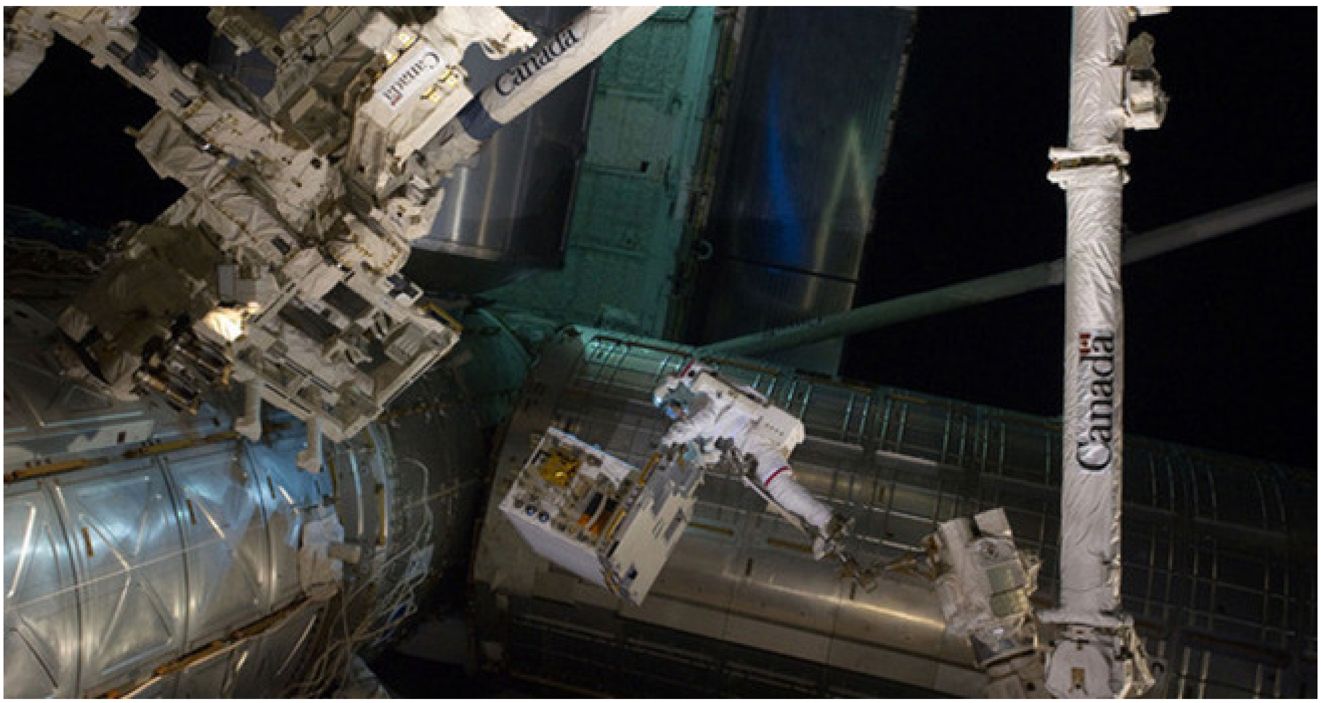

Image: NASA

By Dave Klingler, Ars Technica

On March 9, NASA astronauts aboard the International Space Station quietly began learning the space exploration equivalent of how to remove and replace a gas cap. It's the first in a series of small demonstrations that are intended to have big future consequences, an attempt to learn how to refuel a spacecraft in space instead of on the ground. The experiments have been hotly anticipated in the space community.

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The Robotic Refueling Mission demonstrations were developed by the SSCO team headed up by Frank Cepollina at the NASA Satellite Servicing Capabilities Office (SSCO), formed in 2009 at NASA Goddard Space Flight Center. The team is known for its previous experience planning and executing five highly successful servicing missions for the Hubble Space Telescope.

The past and future of service

In the forty years since the dangerous repairs due to the loss of Skylab's sun shield in 1973, tools, techniques, robotics and spacesuits have improved immeasurably. We've had plenty of chances to practice. In 1984, astronauts in Space Shuttle Challenger retrieved Solar Max, repaired it, and set it free again. Later in 1984, astronauts in Discovery retrieved two more satellites using Manned Maneuvering Units, and returned them to Earth for repair.

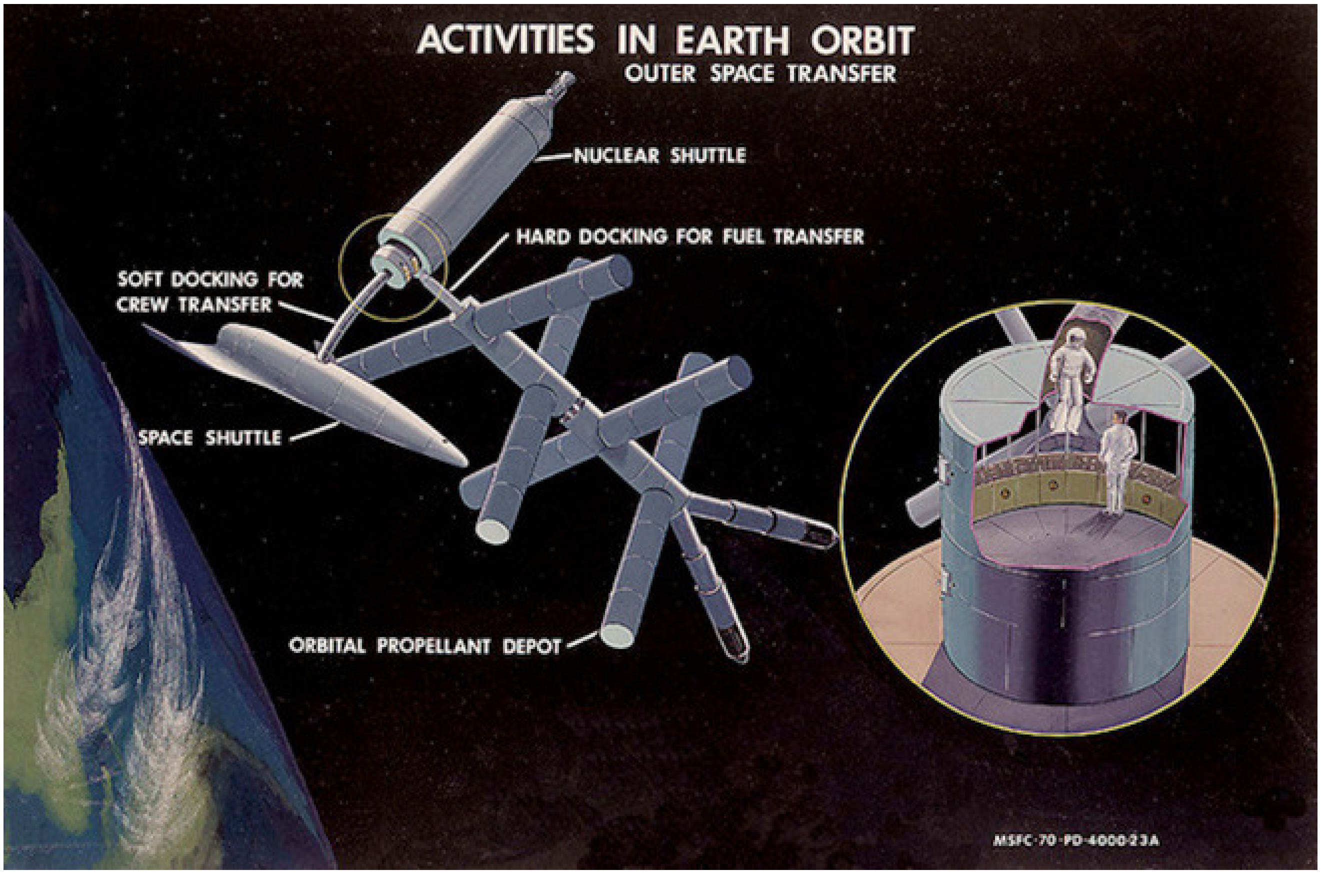
The Hubble repair missions came later, and were so successful that questions arose regarding whether we might try the repair and refueling of satellites that weren't designed to be serviced. What about applying what was learned with Hubble to other missions, including spacecraft in positions much farther from Earth? Just before Hubble's last repair, Congress appropriated $20M in the 2009 budget for Goddard Space Flight Center to go further.

In March 2010, Goddard's SSCO held the International Workshop on On-Orbit Satellite Servicing to begin a discussion on what was needed by industry. The SSCO issued a Satellite Servicing Project Report later in the year, and has since designed the Robotic Refueling Mission and ground test-beds.

The unassuming Robotic Refueling Mission features a large box "about the size of a washing machine," according to the SSCO website, with "protective thermal blankets, caps, valves, simulated fuel, and other servicing-related spacecraft components" designed to teach humans the various aspects of refueling in space. SSCO's current work will be important to satellite operators, but it may be even more important to future historians and the rest of humanity—once we get technology that works, we tend to stick with it.

For satellite repair and refueling, astronauts will pull back the satellites' thermal blankets and dig their way through various obstacles to the fuel valves. Today's satellites aren't designed to be repaired or refueled because it has been thought to be unfeasible. There isn't any question of value, though; billions of dollars have been paid out in insurance claims, and some satellites have died with their transmitters stuck at full power as they floated out of their orbits.

Servicing constellations of similar satellites in similar orbits would be most cost-effective, but once the infrastructure is established, the cost of getting to most satellites should be quite low. Many repairs would be automated or controlled by humans either on Earth or in orbit. The refueling or repair vehicles would match orbits, rendezvous, service, and return for more propellant. It's the "return for more propellant" part that brings us to on-orbit propellant depots.



An early concept drawing for an orbiting propellant depot servicing a nuclear shuttle. Image: NASA

Propellant Depots

Imagine that you're about to begin a trip from New York to Los Angeles and back in a world with only one gas station, in Manhattan. You go shopping for a car that gets 30 miles per gallon with a 200-gallon gas tank. 200 gallons weighs 1200 pounds, so you quickly realize you're going to end up with something bigger. But pickups don't get good mileage, so you need a bigger tank… By the time you're done, you have a 2-ton truck that gets 11 miles per gallon and is mostly fuel tank.

With that picture in your mind, imagine that you now need to travel 100 times as far, and most of the trip is straight uphill. Welcome to the challenges of space travel.

For spacecraft, which use a variety of fuels and oxidizers, the gas station equivalent is a propellant depot. These are an enabling and potentially disruptive technology for spaceflight. Depots have been discussed since the 1960s, but for the first time since then, the discussions are becoming serious.

Propellant tanks can be flown weeks or months ahead of time to wherever they need to be, in some cases by slow, low-cost tugs. If a depot was placed at the Space Station, for instance, space travelers could depart Earth any time the weather was good, then wait at the station for Earth and Mars to swing around to the right positions. The travelers might go to another depot just beyond the Moon, and on to Mars, where more propellant would already be waiting for the return trip.

They could also set off a self-sustaining cycle. Satellite repairs beget propellant depots. Propellant depots beget more satellite repairs plus more long-term hardware in space. More propellant depots beget more space exploration and more infrastructure.

A robot like this one next to Astronaut Cady Coleman might be sufficient to handle refueling duties. Image: NASA

Robonauts And Astronauts

These very early SSCO experiments are intended to provide a direction for future operations. The Robotic Refueling Mission calls for EVRs combined with Dextre, the ISS' dextrous robotic arm. Future efforts may allow the astronauts to stay inside the station and instead use Robonauts mounted on the end of the arm. For now, the majority of the work will concentrate on small tasks involving non-cryogenic fuels common in the satellite industry. After those experiments are concluded in 2013, RRM Phase 2 will go up aboard a Japanese HTV, with replacement boards that demonstrate mating of connectors and a conceptual cryo refuel. Further tasks are still in the planning stages.

According to Dr. Edward Cheung, the team's electrical lead engineer, "At some point, our servicing vehicle will be designed to not only deliver fuel with a hose, but be able to fill up our own tanks with our hose, and thereby extend our own life. So this part of the technology relates directly to being able to get fuel from a passive tanker." Dr. Cheung stressed that right now the work "is conceptual and for study purposes—we do not have approval for an actual mission."

For now, these demonstrations will prepare us for the time when necessity demands that we do more. But many who are watching the technology develop hope that the first depot will launch based on what the RRM and its follow-ons engender. Regardless, there isn't any doubt that something very significant is taking shape in orbit from a task that, on first examination, seems very common.

Source: Ars Technica

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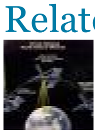
- Skylab-Salyut Space Laboratory (1972)