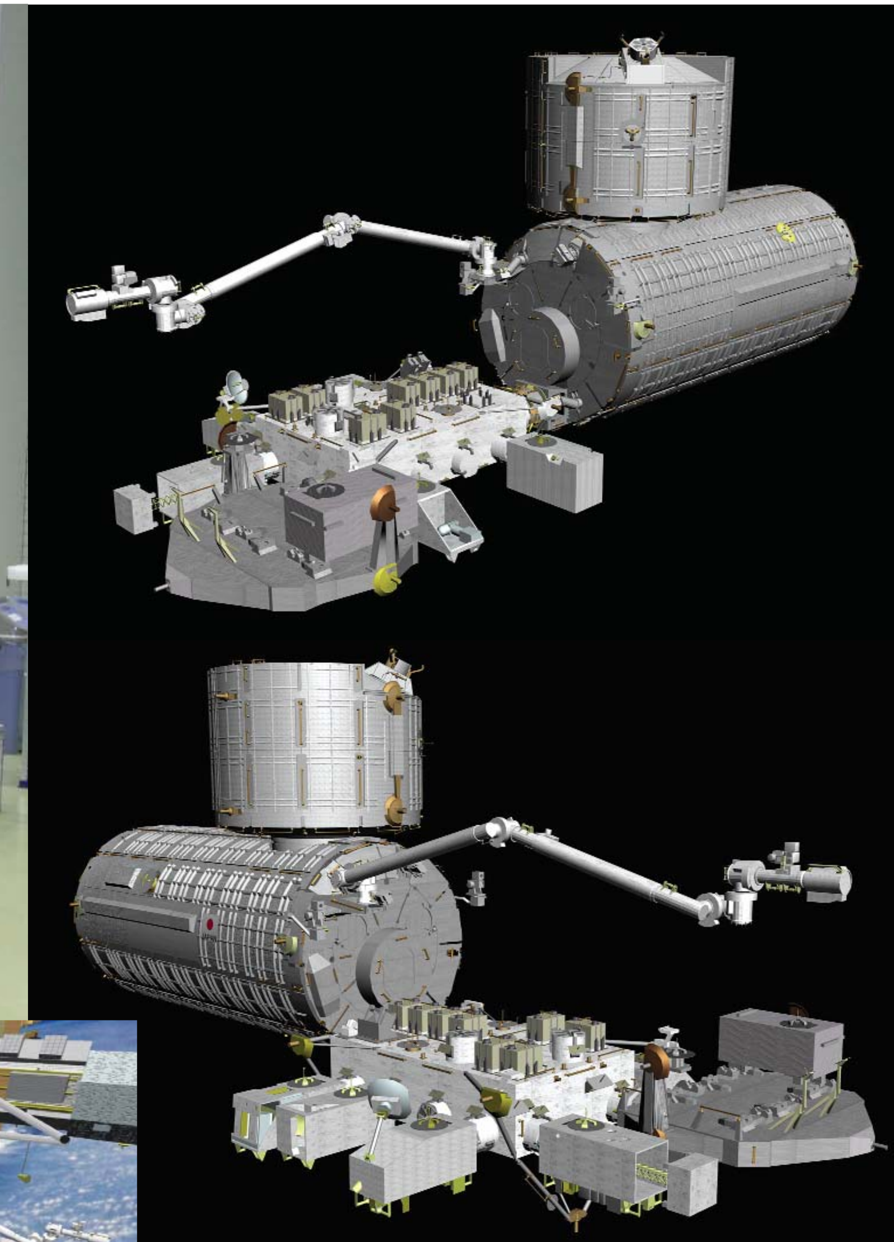

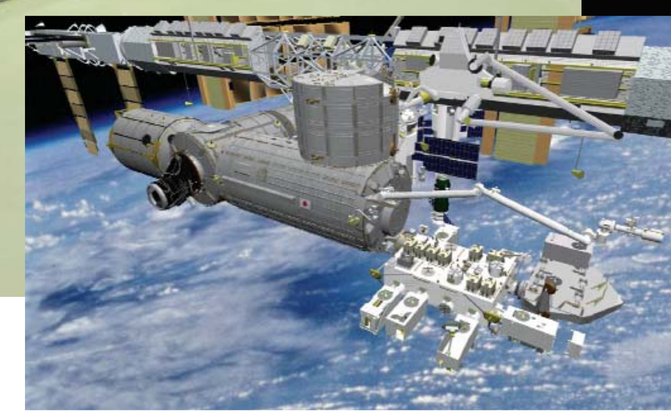

# New Space Station Robot Arm

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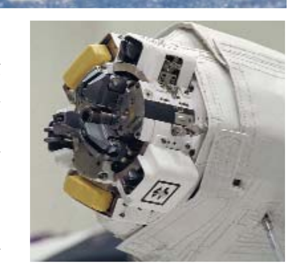
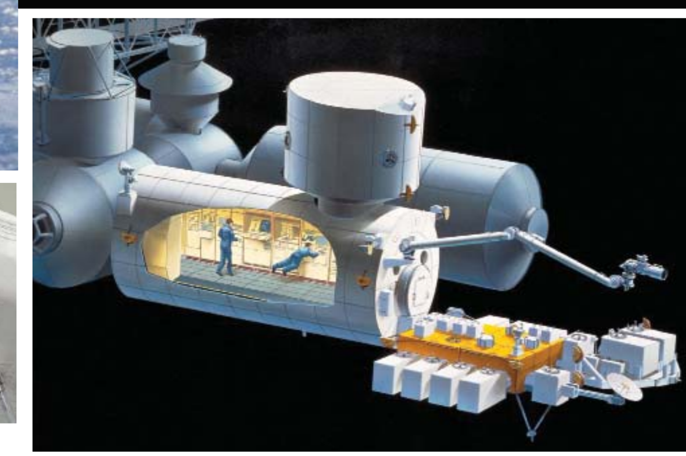
## Made in Japan, Needed in Orbit

The International Space Station's next robot arm is now being deployed with the Japanese science laboratory Kibo, and as may be expected with Japanese technology, it's miniaturized, multipurpose and ingenious. Unlike the Canadian robot arm ("Canadarm 2") and its recently-added "DextrE" hand, which are designed to move things around on the outside of the station, the Japanese arm is designed to transfer things into and out of the station's pressurized section. That kind of "reach" has revolutionary implications for Station science and support operations, especially when it's combined with other critical Japanese space hardware that's about to be deployed.

Called the "Japanese Experiment Module" (JEM) Remote Manipulator System, or JEMRMS, the new arm device so far has no code name. It actually consists of two separate arms: one "main arm" (10 meters long) and one, called the "small fine arm," that can be attached to the end of the main arm for high-dexterity operations (1.7 meters long). That second arm will be delivered early in 2009 along with the full-size "porch" for vacuum science and technology experiments. Better code names are desperately needed, for sure—sometime within the planned 10-year life of the equipment.



The main arm (with a seven-ton maximum cargo) and the small fine arm (300 kilogram maximum cargo) have six joints that allow movements similar to those of a human arm. Inside the JEM, an astronaut will control the arm while watching the images from the camera attached to the arm and other views, including, in critical instances, a view from a camera on the station's big arm. The operator is also aided by force/torque feedbacks from sensors in the arm that are reflected in hand controller responses.



### ARM & AIRLOCK

While the station's existing Canadian arm has been critical to the assembly and maintenance of its structure, the Kibo robot arm system will prove even more important for long-term logistical support. It will allow more flexible external servicing by spacewalking astronauts or teleoperated robots. There are two reasons for this: first, the Kibo arm is paired with a small airlock for passing objects into and out of the station's pressurized chamber. Second, the arm is permanently positioned where it can reach areas where earth-launched supply ships will temporarily be attached, so it can take cargo where it is needed.

PHOTOS COURTESY OF NASA

The cylindrical Japanese airlock is 2 meters long and about 1.4 meters in diameter (too small for an astronaut in a space suit). It has a hatch at either end—"inner" and "outer" hatches—and is attached to the JEM's far end. Items to be passed through the airlock are first fastened to a sliding platform that can be extended into the pressurized module for shirt-sleeve manipulation. The table is then pushed back into the airlock and the inner hatch is sealed. After the outer hatch has been opened, the sliding table is then transferred by the activation of motors that extend it through the outer hatchway. The inner hatch has a small window that allows the inside of the airlock to be viewed.

The largest item that can pass through the hatch measures 576x830x800mm—think of a large picnic cooler. Many items can be bolted to the slide table, which also includes utility outlets for functioning instruments. They can be extended into space for short-term operations or removed from the extended table by the JEM arm.

Cycling the airlock is not a lengthy process, so one can imagine a spacewalking astronaut bungee-tying a broken gizmo to the platform, allowing it to be passed inside for a few hours of inspection and/or repair and then spacewalking back to retrieve the good-as-new unit as it is passed back outside. Alternatively, tools and specialized instruments whose need was recognized only after the astronaut went outside can be passed through the lock with probably no more than an hour's advance notice, if even that long.

### ROBOTICS LOGISTICS

Now, in addition to astronauts, there are lots of items on the space station that are too large for the airlock, and here is where the Japanese robotics-based space logistics strategy (for which the arm is only *one* component) will really pay off.

The space station has hatchways in two sizes. One is a round docking tunnel hatch with highly specialized grappling and attenuation mechanisms on the outer rim and with walls that have been reinforced to take the inertia of slowly colliding visiting vehicles weighing (well, "massing" is the better term) many tons. The other is a square, with rounded corners, berthing port, installed both on the ends of U.S.-built modules and also at four points around their waist—like some cosmic "Construx" kit.

The docking tunnels are based on the Soviet design used on their earlier space stations and have a diameter of 80 centimeters—wide enough to get an astronaut's broad shoulders through but nothing much bigger. But the berthing doors, which are not built strong enough for docking an approaching visitor, are more than 130 centimeters wide and tall and have more than double the diameter and an approximately square shape that accommodates the shapes of large cargo items.

When U.S. modules and the European and Japanese science labs are strung together, they mate at these "Common Berthing Mechanism" units (CBMs). And when the shuttle delivers a big cargo, it is carried inside an Italian-built pressurized module in a payload bay that is not even connected with the shuttle's crew cabin. After the shuttle has locked onto an existing tunnel, the robot arm moves pressurized module against an available CBM.

Later, with that door open, really *big* items can move into the station or back to the logistics module for return to earth. Such items include fridge-size laboratory units, massive atmospheric processing gadgets, and bulk cargo packed in closet-size canisters. Without this large doorway, the space station could never have been as versatile in function, since every large device to be installed in every module would have had to be installed on earth before launch and before the module's ends had been bolted in place.

### ISS ARM & JEMRMS PARTNER

Now, here's where the Japanese plan comes in. The shuttle will stop flying in two years, and thus, so will these large-door logistics modules. The Europeans have built and just flown the first of an automated transfer vehicle (ATV) that carries mass quantities of equipment and supplies. But it has one rarely mentioned drawback: it must dock itself to the Soviet end of the station, so all of the cargo must be small enough to pass along the 80-centimeter-diameter docking tunnel.

The Japanese are building their own automated logistics module, and designers have no intention of limiting it to small pieces. It will be equipped with a CBM-compatible berthing port, which means it will not be able to dock itself at the station, but it will go to the end where the JEM is, park itself a few meters away and wait. The Canadian-built station arm will swing over and grapple it and then position it as gently as is required at a waiting CBM on the station.

Big cargo can then go in, as needed, or out, if it needs to be discarded (when the Japanese craft departs, it will burn up in the atmosphere). But since there also is a need that will not be met after the shuttle has been grounded for big hardware on the outside of the station as well, the Japanese craft will have a non-pressurized section with equipment that is never intended to be transported into the pressurized station.

That section could include a carrier platform holding many objects intended for the exterior. Thanks to robotics, the Japanese arm will move that platform from the visiting supply drone to an attachment point outside the JEM. Once there, the arm, and its small, super-delicate "hand" (if required) will can move the units around, out and in and back out again as needed.

This critical logistics application and "routine" vacuum science and external maintenance support will make the Japanese arm complex a unique and worthy contribution to the future of the International Space Station. Without these new capabilities, it's highly doubtful that the Station would have any future after the shuttle has been grounded, so once again, robotics is right in the middle of the "critical path" of human space flight.

**Links**

**Japanese Experiment Module Remote Manipulator System**, http://kibo.jaxa.jp/en/about/kibo/rms/

**Japan Space Exploration Agency (JAXA),** www.jaxa.jp

**JAXA ISS/Kibo** website, http://iss.jaxa.jp/en/

**JAXA photo archives**, http://jda.jaxa.jp/index_e.html

For more information, please see our source guide on page ___