

MITSUBISHI ELECTRIC CORPORATION
PUBLIC RELATIONS DIVISION
7-3, Marunouchi 2-chome, Chiyoda-ku, Tokyo, 100-8310 Japan

FOR IMMEDIATE RELEASE

No. 3003

Customer Inquiries

Media Inquiries

Advanced Technology R&D Center
Mitsubishi Electric Corporation
www.MitsubishiElectric.com/ssl/contact/company/rd/form
www.MitsubishiElectric.com/company/rd/

Public Relations Division
Mitsubishi Electric Corporation
prd.gnews@nk.MitsubishiElectric.co.jp
www.MitsubishiElectric.com/news/

Mitsubishi Electric Develops Robot to Manage 492 Segment Mirrors of Thirty Meter Telescope on Mauna Kea

Will ensure accurate, flexible and safe replacement of segment mirrors

TOKYO, February 17, 2016 – [Mitsubishi Electric Corporation](http://www.MitsubishiElectric.com) (TOKYO: 6503) announced today that it has completed a prototype robot for its segment-handling system (SHS) designed to replace the 492 segment mirrors comprising the 30-meter primary mirror of the Thirty Meter Telescope (TMT[®]) that is planned to be built on Mauna Kea in the U.S. state of Hawaii.

TMT, a collaboration among five countries—Japan, the United States, Canada, China and India—will be used to explore the early galaxies and stars of the universe. Its primary mirror is composed of 492 hexagonal segment mirrors, each weighing around 250 kilograms. Mitsubishi Electric has been developing the main structure of TMT, as well as the SHS that will be used to replace the segment mirrors as their aluminum-coated surfaces degrade. The robot, thanks to its automated functions, is expected to help maximize TMT's time available for observations.



Prototype robot of segment-handling system (SHS)

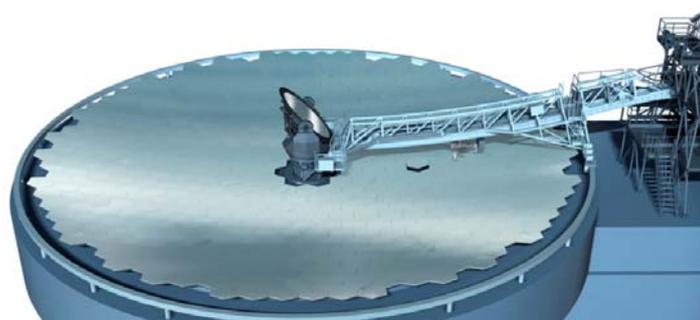
The robot is designed to recognize its position and attitude relative to those of the targeted segment mirror. The problem of sensing the segment mirrors, which have highly reflective surfaces, was resolved by projecting a checkered-flag pattern on them. Three newly developed vision sensors enable the robot to safely approach the mirrors based on accurate recognition of position and attitude.

The robot also incorporates force-control technology to compensate for any error when it approaches a mirror. The technology uses a force sensor to detect loads applied to a mirror with an accuracy within less than one kilogram during the robot's six degrees of freedom (6DoF) movements (forward/backward, up/down and left/right 3DoF, and rotations of each 3DoF). The robot's three independent arms each grasp a mirror with gentle handling, helping to equalize the mirror's 250-kilogram weight and compensate for any deformation caused by the weight. The original design of an installation shaft and force-control algorithm help to reduce the time needed to replace the segment mirrors by 60 percent.

An original parallel-link mechanism consisting of six links enables simultaneous long-stroke motion along the Z axis (up/down) and 6DoF movements. Long-stroke motion ensures adequate space between the primary mirror and the robot to transport the grasped segment mirror safely.

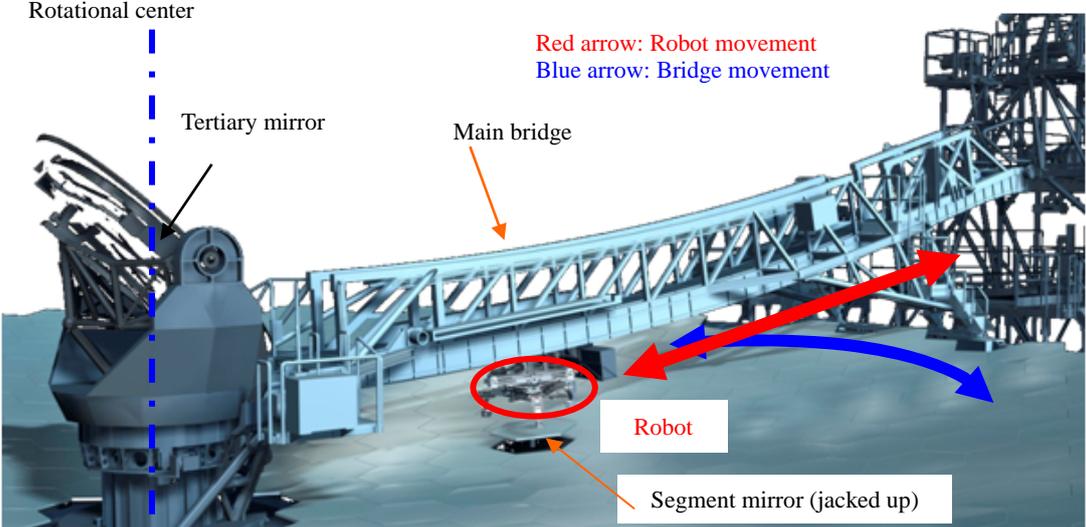


Rendition of TMT®
Courtesy: National Astronomical Observatory of Japan

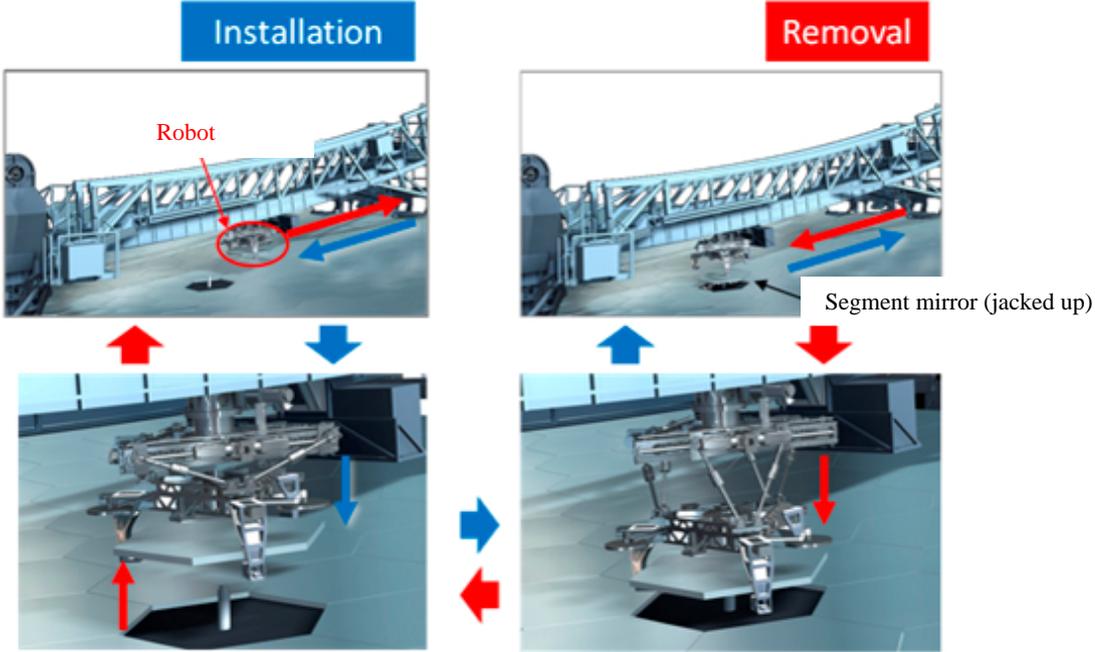


Primary mirror and SHS

The SHS includes a main bridge that projects over the primary mirror when a segment mirror is replaced. The bridge rotates in a circumferential direction and the robot moves forward and backward underneath the bridge.



SHS



SHS operations

Trademarks

The TMT Observatory Corporation has applied for TMT as a trademark in the USA.

Patents

Pending patents for the technology announced in this news release number four in Japan, including one for the structure, one for the vision sensor and two for the force-control technology, and number three in other countries, including one for the structure, one for the vision sensor and one for the force-control technology.

Acknowledgment

This research is being conducted under a contract with the National Astronomical Observatory of Japan.

###

About Mitsubishi Electric Corporation

With over 90 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Embracing the spirit of its corporate statement, Changes for the Better, and its environmental statement, Eco Changes, Mitsubishi Electric endeavors to be a global, leading green company, enriching society with technology. The company recorded consolidated group sales of 4,323.0 billion yen (US\$ 36.0 billion*) in the fiscal year ended March 31, 2015. For more information visit:

<http://www.MitsubishiElectric.com>

*At an exchange rate of 120 yen to the US dollar, the rate given by the Tokyo Foreign Exchange Market on March 31, 2015