MITSUBISHI ELECTRIC
Changes for the Better

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

FOR IMMEDIATE RELEASE **No. 3519**

Customer Inquiries

Mitsubishi Electric Research Laboratories, Inc.
Mitsubishi Electric Corporation

www.MitsubishiElectric.com/ssl/contact/company/rd/form.html
www.merl.com

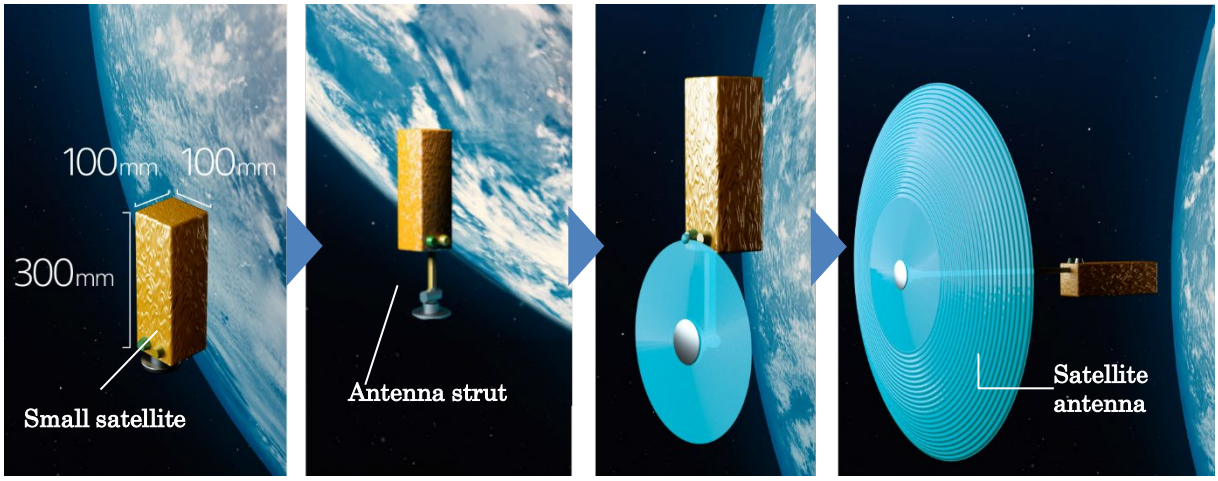
Media Inquiries

Public Relations Division
Mitsubishi Electric Corporation

prd.gnews@nk.MitsubishiElectric.co.jp
www.MitsubishiElectric.com/news/

Mitsubishi Electric Develops Technology for the Freeform Printing of Satellite Antennas in Outer Space

New photosensitive resin harnesses solar radiation for low-power 3D printing in vacuum



On-orbit manufacturing and deployment of a satellite antenna in space (from left)

TOKYO, May 17, 2022 – Mitsubishi Electric Corporation (TOKYO: 6503) announced today that the company has developed an on-orbit additive-manufacturing technology that uses photosensitive resin and solar ultraviolet light for the 3D printing of satellite antennas in the vacuum of outer space.

The novel technology makes use of a newly developed liquid resin that was custom formulated for stability in vacuum. The resin enables structures to be fabricated in space using a low-power process that utilizes the sun's ultraviolet rays for photopolymerization. The technology specifically addresses the challenge of equipping small, inexpensive spacecraft buses with large structures, such as high-gain antenna reflectors, and enables on-orbit fabrication of structures that greatly exceed the dimensions of launch vehicle fairings. Resin-based on-orbit manufacturing is expected to enable spacecraft structures to be made thinner and lighter than conventional designs, which must survive the stresses of launch and orbital insertion, thereby reducing both total satellite weight and launch costs.

Spacecraft antenna designs are challenging due to their conflicting requirements for high gain, wide bandwidth, and low weight. High gain and wide bandwidth necessarily require a large aperture, but economical orbital deployment conventionally dictates that designs be lightweight and small enough to fit or fold inside a launch vehicle or satellite deployment mechanism. Mitsubishi Electric's innovative approach—resin-based on-orbit

manufacturing—efficiently realizes high-gain, wide-bandwidth, large-aperture antennas deployed from a lightweight, vibration-resistant launch package. By developing a 3D printer that extrudes a custom ultraviolet-curable resin formulated for vacuum, resin-based low-power freeform* additive-manufacturing in space has now become possible.

Features

1) 3D printer for the freeform fabrication of antennas in vacuum

- The 3D printer shares the antenna's struts and angle-adjustment motors.
- Antenna size is not limited by the size of the fairing of the launch vehicle or the size of the satellite bus.
- On-orbit manufacturing eliminates the need for an antenna structure that can withstand vibrations and shocks during launch, which is required for conventional antenna reflectors, making it possible to reduce the weight and thickness of antenna reflectors, thereby contributing to the reduction of satellite weight and launch costs.
- Assuming the use of a 3U CubeSat (100 x 100 x 300 mm) specification, an antenna reflector with a diameter of 165 mm, which is larger than the size of the CubeSat bus, was fabricated in air, and a gain of 23.5 dB was confirmed in the Ku band (13.5 GHz).

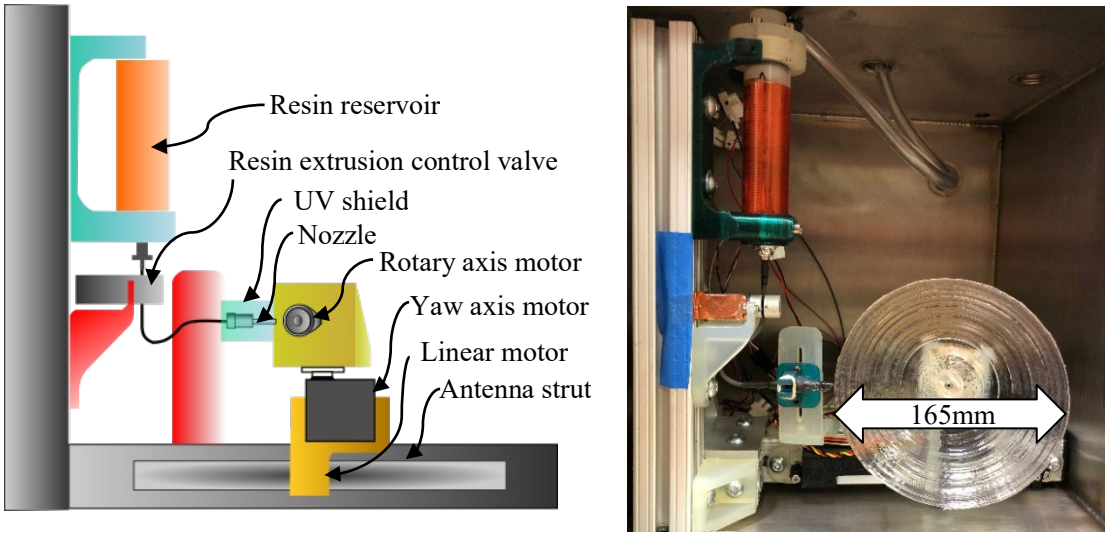


Diagram (left) and photo (right) of the 3D printer

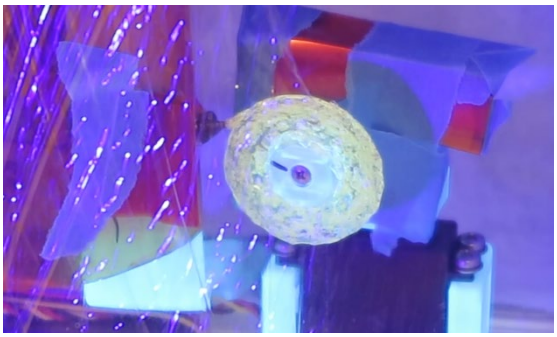
*2) World's first** photosensitive resin with stability suitable for extruding and curing in vacuum*

- Commercial photosensitive resins have low molecular weight, high vapor pressure, and are not suitable for vacuum applications, where they boil and prematurely polymerize. The newly developed ultraviolet-curing resin uses a high-molecular-weight, low-vapor-pressure oligomer base blended with a vacuum-stable plasticizer based on a nonvolatile polyphenyl ether to achieve a viscosity suitable for extrusion in vacuum.
- As most polymerization inhibitors require atmospheric oxygen as a cofactor to prevent premature polymerization and do not function in vacuum, the new resin formulation uses inhibitors that do not depend on the presence of oxygen and have near-zero volatility.

---

* Without requiring auxiliary support structures
** As of May 17, 2022 according to Mitsubishi Electric's research

- When exposed to ultraviolet light, the resin polymerizes by crosslinking into a solid that is heat-resistant to at least 400°C, which is beyond the maximum temperature experienced on orbit.
- The use of sunlight for polymerization and curing eliminates the need for a separate ultraviolet light source, enabling manufacturing with low power consumption.



Mid-printing using an ultraviolet light source in a vacuum below 0.2kPa
(Enlarged area around the nozzle and rotary axis motor)

Future Developments

Mitsubishi Electric's resin-based on-orbit manufacturing enables small satellites to achieve large-satellite capabilities, which reduces launch costs and allows for satellite technology to be used more than ever in applications such as communication and Earth observation. These extended capabilities are expected to enable more timely provision of satellite imagery and observation data that meet the varied needs of individuals and organizations. Going forward, Mitsubishi Electric will continue to develop technologies and solutions that contribute to solving global issues.

Reference

3D Printing Technology for the Freeform Printing of Satellite Antennas in Outer Space

English: https://youtu.be/ebZqaOBZApE

Japanese: https://youtu.be/kebh_KRXMzc

###

About Mitsubishi Electric Corporation

With more than 100 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. Mitsubishi Electric enriches society with technology in the spirit of its "Changes for the Better." The company recorded a revenue of 4,476.7 billion yen (U.S.$ 36.7 billion*) in the fiscal year ended March 31, 2022. For more information, please visit www.MitsubishiElectric.com

*U.S. dollar amounts are translated from yen at the rate of ¥122=U.S.$1, the approximate rate on the Tokyo Foreign Exchange Market on March 31, 2022