Minister for Internal Affairs and Communications Award

総務省

A Practical-Level Optical Data Relay Satellite System Using High-Speed Optical Inter-Satellite Communications

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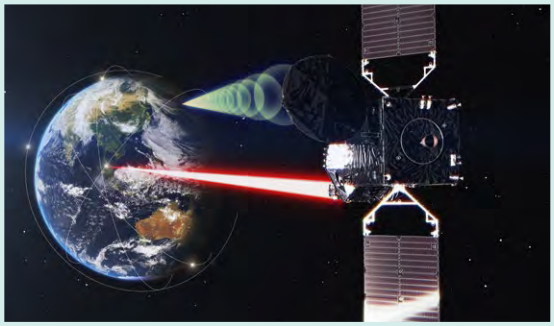
Overview of the case

The recipients of this award developed an optical data relay satellite system and successfully demonstrated data relay, including optical inter-satellite communications between geostationary orbit (GEO) and low Earth orbit (LEO). The system uses a newly developed, world's-fastest optical inter-satellite communications technology that enables high-volume data transmission from Earth observation satellites and highly responsive command operations for disaster observation. Currently, it is making contributions as part of the space communications infrastructure. For example, it is being used to regularly transmit high-resolution SAR observation data from the "DAICHI-4" satellite. Gbps-class optical inter-satellite communications technology—a key technology for which there is fierce competition worldwide—has been achieved for the long-distances between GEO and LEO with a communication quality suitable for practical use.



Optical data relay satellite
(Conceptual illustration of an in-orbit satellite)

Key points regarding receiving the award (Comments from the selection committee)

Successfully developing the world's fastest optical inter-satellite communications technology for the long distances between GEO and LEO satellites with a communication quality suitable for practical use is a highly commendable achievement.

It is highly commendable that the system enables high-volume data transmission from Earth observation satellites and highly responsive command operations for disaster observation, and is currently contributing as a part of the space communications infrastructure by regularly transmitting high-resolution SAR observation data from "DAICHI-4."

Specific results, etc.

1. Contributing to the creation of new fields in space development and utilization

The development of space communications has been a history of gaining new realms within limited frequency ranges. Optical communications can use virtually unlimited bandwidth by using electromagnetic waves with frequencies approximately 10,000 times higher than conventional radio waves. In addition, because the communications interference is significantly lower, communications systems that are resistant to jamming and interception can be achieved. However, achieving them requires a high level of technological prowess. For example, you need to be able to continuously track and point at communications partners with an angular precision of 10 μrad or less while up in orbit, where temperature fluctuations are severe. The award recipients reliably captured the target satellite over distances of more than 42,000 km between GEO and LEO, established a communications system capable of continuous pointing-at and tracking, and achieved stable high-speed optical communications at a speed of 1.8 Gbps. In addition, by introducing this optical inter-satellite communications technology into a data relay satellite system that uses geostationary satellites as communications bases to significantly extend communications times, they turned it into a complete high-speed data relay system. Consequently, the bottleneck in data transmissions from Earth observation satellites in LEO to the ground has been overcome, and an essential technology for space broadband communications has been acquired.

2. Contributing to the expansion of the space development and utilization market

This system was not just a demonstration, but was also achieved to a level that would enable use as a practical infrastructure. Private businesses are entering the optical space communications business, and knowledge and technologies based on this development are expected to be used.

In addition, high-latitude stations overseas near the Arctic and Antarctic have previously been used to receive observation data from Earth observation satellites, but using data relay satellites will mean that receiving stations can be established within Japan. In recent years, the significant increase in the number of Earth observation satellites has caused major issues in terms of congestion and frequency interference at high-latitude stations. Against this background, two key points can be used to appeal to service users: being able to avoid using overseas institutions' receiving stations and, therefore, avoid these issues as well, and being able to ensure a higher level of security.

Furthermore, optical space communications are expected to develop beyond data relay satellite systems to also play roles in fields such as LEO communications satellite constellations and lunar and Mars exploration.

3. Contributing to the advancement of the economy and society

The high-resolution (3 m to 10 m) and wide-swath (100 km to 200 km) SAR observation data from "DAICHI-4" is expected to play important roles not only in understanding the situation after a disaster, but also in the early detection of abnormalities such as volcanic activity and landslides. In addition to being used as a high-volume communications line for transmitting daily observation data from "DAICHI-4," the optical data relay satellite system also enables real-time transmissions of imaging commands and downlinking of observation images. It will therefore be a powerful tool for reducing latency when conducting emergency observation during disasters. In fact, successful demonstrations have been carried out for real-time transmission of observation data for 30 minutes, and for operations that simulate emergency disaster observation. The system, including the ground systems, has achieved an overall operational achievement rate of 97.6% or higher (as of the end of September 2025), which means it has sufficient performance for practical use. Furthermore, optical inter-satellite communications can also be applied to security-related uses and uses where securing frequencies is difficult (such as LEO communications satellite constellations), so they are expected to create new space businesses.

4. Contributing to technologies

Gbps-class high-speed optical inter-satellite communications between GEO and LEO have been achieved—something that only two agencies worldwide (the ESA and NASA) have managed to do. In particular, although Europe has taken the lead, this system offers significant advantages over it. For example, it uses the 1.5 μm wavelength band—a region that poses high technical difficulties, but is used in terrestrial optical fiber communications, and has characteristics such as possessing outstanding development potential and being eye-safe. Optical inter-satellite communications technology is an essential technology for building high-speed communications infrastructure—something that countries all around the world are making it a priority to acquire. Establishing a practical-level optical inter-satellite communications technology between GEO and LEO poses high technical difficulties, and successfully doing so signifies the acquisition of a key technology that will be essential for future space development and utilization. This achievement features the advantages of optical communications—for example, broad bandwidth, compact and lightweight equipment, interference resistance (including resilience), and outstanding compatibility with a future communications technology, namely, quantum communications. It therefore has the potential to open up new application fields.

5. Contributing to the enhancement of citizens' understanding and to human resource development

In terms of the spread of awareness, reports such as the following have been published in the media:

Nikkei Online Edition, January 24, 2025
NEC and JAXA have successfully transmitted images to the ground via satellite relay

Page 14, morning edition, NIKKAN KOGYO SHIMBUN, January 24, 2025
JAXA and NEC have achieved high-volume, real-time transmission via optical inter-satellite communications

Page 3, morning edition, Dempa Publications, January 27, 2025
NEC and JAXA have transmitted high-volume observational data via the world's fastest inter-satellite optical communications

Nikkei Online Edition, 6:54 p.m., January 23, 2025
NEC and JAXA have achieved high-speed optical communications between satellites, and received images on the ground
(Plus 12 other articles)

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