National Aeronautics and Space Administration

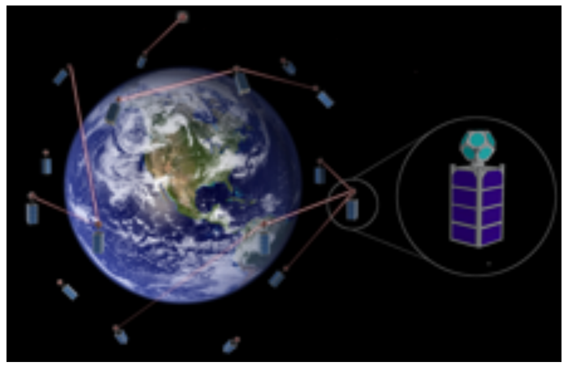
NASA facts

Omnidirectional Inter-Satellite Optical Communicator (ISOC)

ISOC Enables Gigabit Communication Between CubeSats

The objective of the Omnidirectional Inter-Satellite Optical Communicator (ISOC) project is to design a compact, lightweight, and energy efficient communicator module for use between satellites in space. This module will achieve continuous optical communication, with simultaneous data transmission and reception, at up to 1 gigabit per second (Gbit/s) data rates for small spacecraft separated by up to 200 kilometers (km). To achieve this goal, a data communicator with full spherical coverage field of view (FOV) needs to be designed. The proposed ISOC is a dodecahedron geometric array of chip scale, microelectromechanical systems (MEMS) based gimbal-less scanning mirrors that provide adjustable beam pointing and spherical FOV coverage for uninterrupted data transmission between several small spacecraft at arbitrary relative positions. This design eliminates known pointing issues and hence allows accurate direction of arrival calculations. Moreover, the proposed approach will enable data relaying between multiple satellites, and enable relative navigation control.

Inter-spacecraft communication between small spacecraft is conventionally achieved by radio frequency (RF) systems that cannot exceed a a few megabit per second (Mbit/s) data rates. Large spacecraft, such as Artemis and AlphaSat, use laser communication terminals (LCTs) to achieve free space optical communication between spacecraft, and achieve communication from ground stations that are separated by thousands of kilometers by using large area lenses. However, these LCTs are heavy, large and power hungry, and therefore not suitable for CubeSats. The



Array of small spacecraft networked by proposed omnidirectional ISOC

proposed omnidirectional ISOC with 360˚ FOV optical wireless system will play a significant role in CubeSat missions due to its lightweight design (<.9 kg), low volume (154 cm^3), energy efficiency (<3 W) and high speed (1 Gbit/s). As data security is a challenging task in free space communication systems, the proposed communication technique is secured by complex encoding. Therefore, any chance of eavesdropping is negligibly small.

While the small volume of the proposed omnidirectional ISOC limits the size of lens of the receiver that collects light, the ISOC is optimized for higher aperture lenses, which will minimize beam divergence. ISOC can achieve error-free communication at 1 Gbit/s data rates at a maximum 200 km inter spacecraft distance using maximum laser power. The inter spacecraft distance can be extended further by adding electronic Forward Error Correction (FEC) chips into the system. The laser power can also be optimized depending on the inter spacecraft distance to minimize the power consumption of the communicators.

As CubeSats are intended for Low Earth Orbit (LEO) to perform scientific research and explore new space technologies, they have limited time to transmit data to the ground station. By facilitating inter-spacecraft communication and using a relay mode of ISOCs, the communication time can be extended to download more data, while providing connectivity between multiple spacecraft and forming a complex data network.

Beyond spacecraft, this technology has a secondary Earth-based application to ground based temporary distributed network topologies at remote areas. ISOC's lightweight, portable and self-aligned design will enable the quick implementation of such networks when need arises in military operations or in urban areas where no service is provided.

The Omnidirectional ISOC project is led by the University of California, Irvine in the Advanced Photonic Devices and Systems Laboratory (APDSL) in partnership with the NASA Jet Propulsion Laboratory (JPL) in Pasadena, California.

This ISOC project is managed and funded by the Small Spacecraft Technology Program (SSTP) within the Space Technology Mission Directorate. The SSTP expands U.S. capability to execute unique missions through rapid development and in space demonstration of capabilities for small spacecraft applicable to exploration, science, and the commercial space sector. The SSTP will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.

For more information about the SSTP, visit:
www.nasa.gov/directorates/spacetech/small_spacecraft/

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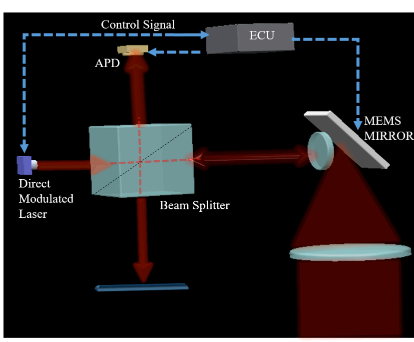
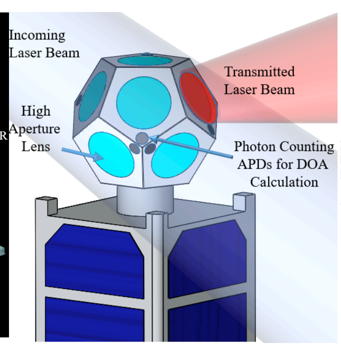
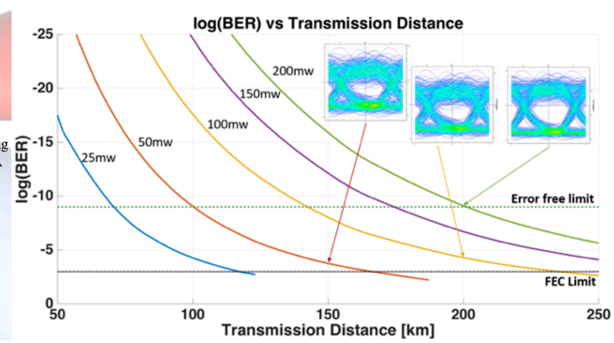


Schematic of one transceiver module



Dodecahedron geometry of ISOC



Performance analysis of the proposed ISOC

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