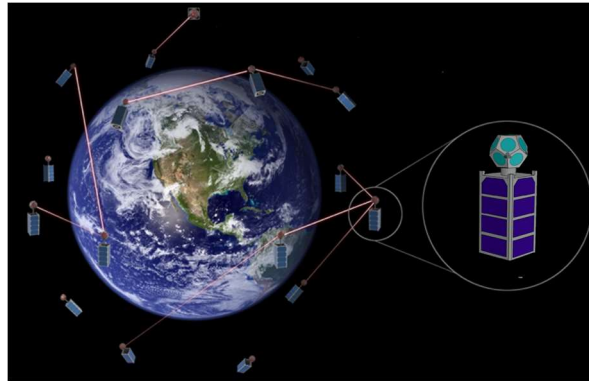


Omnidirectional Inter-Satellite Optical Communicator (ISOC)

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 1Gbit/s data rates for small spacecraft separated by up to 200km. 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, 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 will enable data relaying between multiple satellites *and* relative navigation control.

Inter-spacecraft communication between small spacecraft is conventionally achieved by radio frequency (RF) systems that cannot exceed a few 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 proposed omnidirectional ISOC with 360° FOV optical wireless system will play a significant role in CubeSat missions due to its lightweight design (<2lb), low volume (154cm³), energy efficiency (<3W) and high speed (1Gbps). 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.



Array of small spacecraft networked by proposed omnidirectional ISOC

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 1Gbit/s data rates at a maximum 200km 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

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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 Inter-Satellite Optical Communicator (ISOC)** project is led by the University of California, Irvine in Advanced Photonic Devices and Systems Laboratory (APDSL) in partnership with the NASA Jet Propulsion Laboratory (JPL) in Pasadena, California.

The **Omnidirectional Inter-Satellite Optical Communicator (ISOC)** project is managed by the Small Spacecraft Technology Program (SSTP), which is chartered to develop and mature technologies to enhance and expand the capabilities of small spacecraft with a particular focus on communications,

propulsion, pointing, power, and autonomous operations. The SSTP is one of nine programs within NASA's Space Technology Mission Directorate (STMD).

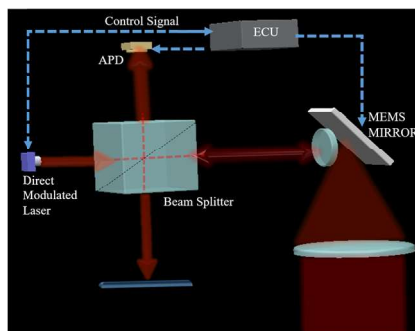
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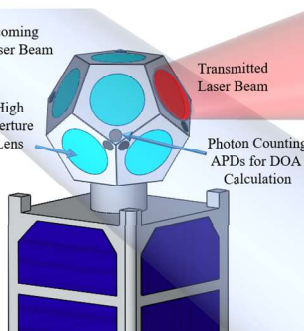
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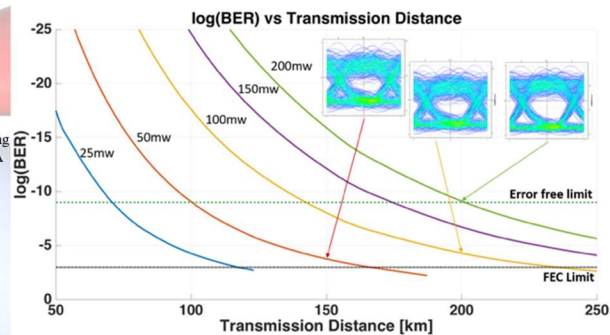
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Schematic of one transceiver module



Dodecahedron geometry of ISOC



Performance analysis of the proposed ISOC

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