Coherent Free-Space Optical Communications

Project Case Study

Project Partners

University of Western Australia, Defence Science and Technology Group, University of South Australia (UniSA), Thales Australia, Goonhilly Earth Station

Project Overview

This project aims to demonstrate a system that will enable optical fibre-like data transfer rates for atmospheric free-space communication links.

Free-space optical communication links have several advantages over traditional radio-frequency links for ground-to-ground, space-to-ground, and inter-satellite communication, including the potential for much greater data rates. However, due to atmospheric turbulence, space-to-ground optical communications missions have so far only demonstrated data rates that are on par with the current best radio-frequency links.

The project will develop an advanced optical communications system that has been shown to support data transfer over atmospheric free-space communication links at rates several orders of magnitude greater than is possible with radio-frequency links. This will be achieved using a unique combination of adaptive optics and coherent phase-stabilisation technologies. This will allow the deployment of coherent optical communications system that is able to support modern, higher order combined phase and amplitude modulation schemes such as quadrature amplitude modulation (QAM) with high spectral efficiency.

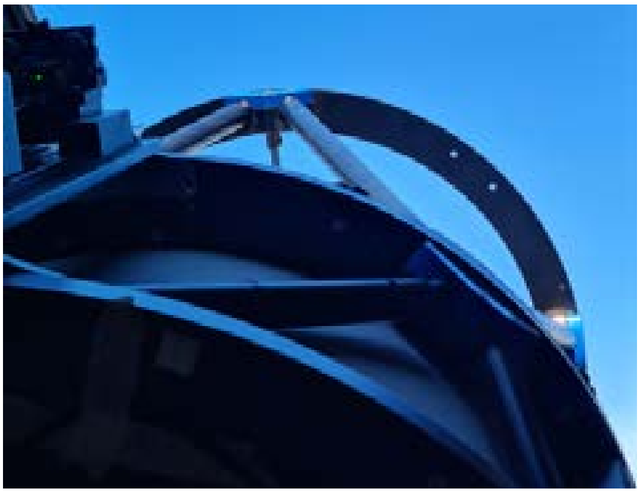
The project's main aims are to investigate and quantify the effects of the atmosphere on Earth-Satellite-Earth laser communication links. In particular, to develop methods to stabilise the carrier phase and phase noise to permit the use of coherent high-order amplitude/phase modulation to facilitate the reception of extremely high data rates. The project will focus on deploying this system over vertical free-space communications links through Earth's turbulent atmosphere, starting with low-altitude targets, progressing to light aircraft and stratospheric vehicles. Preliminary work has already demonstrated successful communication over 2.4 km and 10 km horizontal free-space links.

In addition, the project team aims to extend the project to test ground station acquisition and tracking concepts using a space-based optical terminal deployed by the industry partners.

Utilisation

Coherent free-space optical communication links can provide the high data transfer rates required for relaying information captured by modern hyperspectral imaging instruments and other data intensive activities. High data rates are critical for spacecraft with short-duration orbital transits over critical ground stations. In addition, high data rates also remove latency bottlenecks for time-critical information. This is important for disaster management (tracking of wildfires, storms, sea ice, and flooding), and for national defence and security. Optical transceivers can be much more compact in size compared to RF link antennas. This results in a drastic reduction in the required weight and power consumption, critical factors for the spacecraft, and for any potential mobile optical ground stations.

Optical communication links also enhance communication security and resilience, as their highly directional nature make them much more robust against detection, eavesdropping, jamming and spoofing. In addition, phase-stable coherent optical detection is required for advanced data encryption techniques such as quantum key distribution. Optical communication links also avoid the issue of spectrum management, as they are highly directional.



Collaboration

Goonhilly intends to make use of the project intellectual property (IP) as part of its ongoing development of niche ground station products in the RF and free-space optical domains. Such products will be sold or licensed on a global basis.

Thales Alenia Space (TAS) is a global supplier of satellite payloads, across many applications from Earth Observation to civilian and military communication systems. TAS has an existing product range and future roadmap in the optical communications sector.

In parallel, the project team will also investigate opportunities to further qualify the system through testing with optical payloads on-orbit and at the Western Australian Optical Ground Station. The optical payloads could include the industry partners Optel-μ terminal, and Defence's Buccaneer satellite. The outcome of these investigations could also form the basis of an extension of the work in collaboration with the SmartSat CHORUS project team for a 'full' systems demonstration and deployment.

The project aims to develop the next generation of ultra-high-speed space-to-ground optical communications technology and demonstrate this using laser links between an advanced Australian optical ground station and airborne vehicles.

Dr Sascha Schediwy, Project Lead, University of Western Australia

Goonhilly Earth Station is a world-class facility at the forefront of both satellite and deep space communications. Goonhilly's future ground terminals in the UK and overseas will incorporate free-space coherent optical communications capabilities and this aligns perfectly with the strategic objectives of Thales.

Dr Bob Gough, Head of Business Development, Australia & APAC, Goonhilly Earth Station

Thales Australia is a local business with a global reach and significant credentials in the space sector. This project is an important step towards the ultimate objective of achieving high data rate satellite-to-ground optical communications and is a great example of how large organisations like Thales can work in partnership with the Australian research community to develop the next generation of space technologies, while also generating opportunities for local manufactures to feed into our global product supply chain.

Michael Clark, Director Technical Strategy, Thales Australia