Free Space Optical Communications

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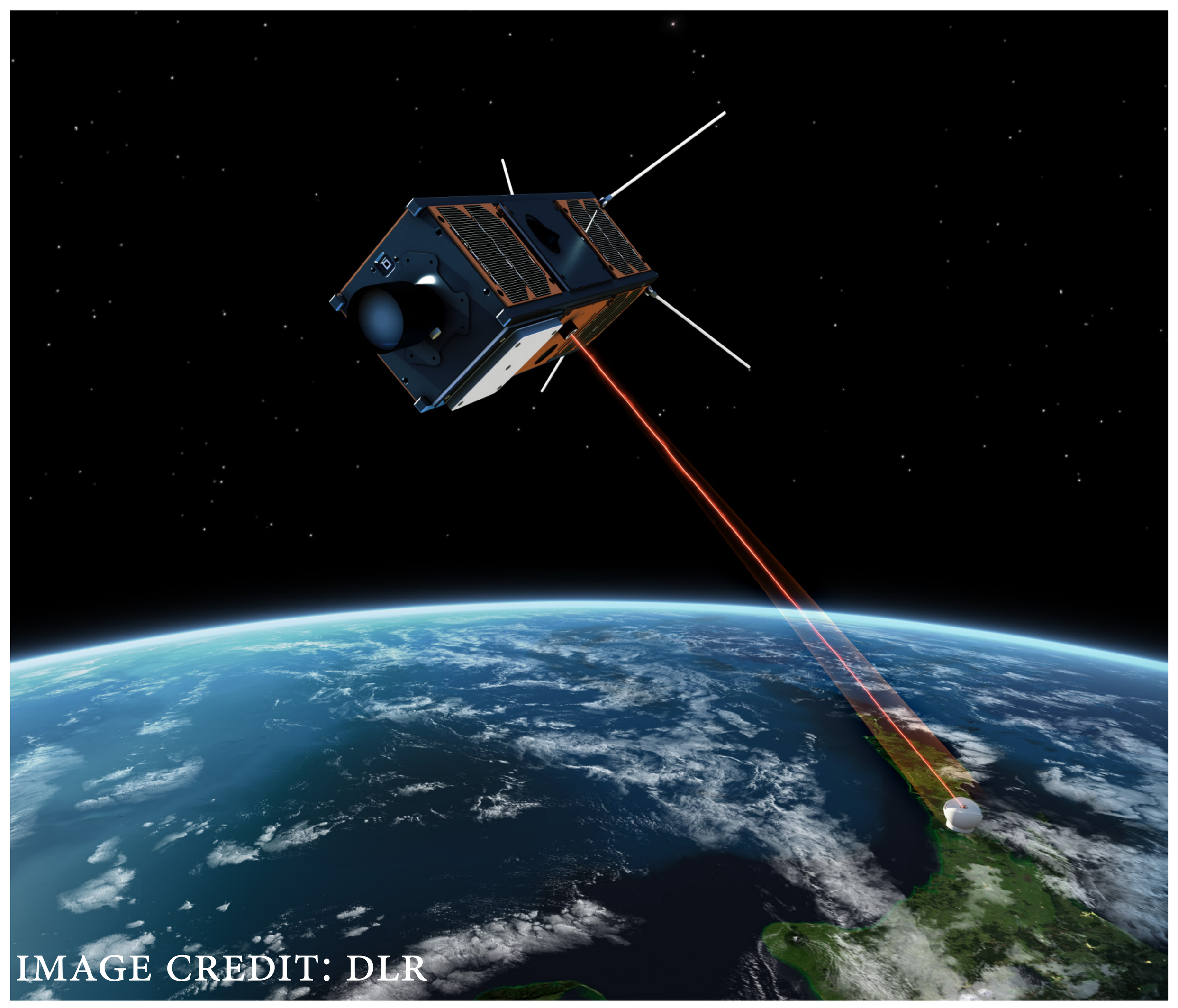
Introduction

Free space optical communication between Earth and space via coherent laser light offers increased bandwidths compared to conventional RF [1]. FSOC is also relatively free from EM interference and offers increased security owing to tight beam widths and the capacity to secure the channel with quantum communication technologies. The power, weight and size of FSOC hardware are also much smaller than their RF counterparts [2]; an important consideration for spacecraft designers.

Challenges

FSOC is possible in the infrared but it is strongly subject to atmospheric conditions. In decreasing order of severity, FSOC is affected by clouds, optical turbulence and atmospheric aerosols [3-5]. The best mitigation against the effect of clouds is to have a network comprised of ground stations, each of which spaced far enough away from each other to avoid being within the same weather pattern. A network with good site diversity can be designed to ensure that at least one ground station in the network can have a cloud-free line of sight to a client spacecraft.

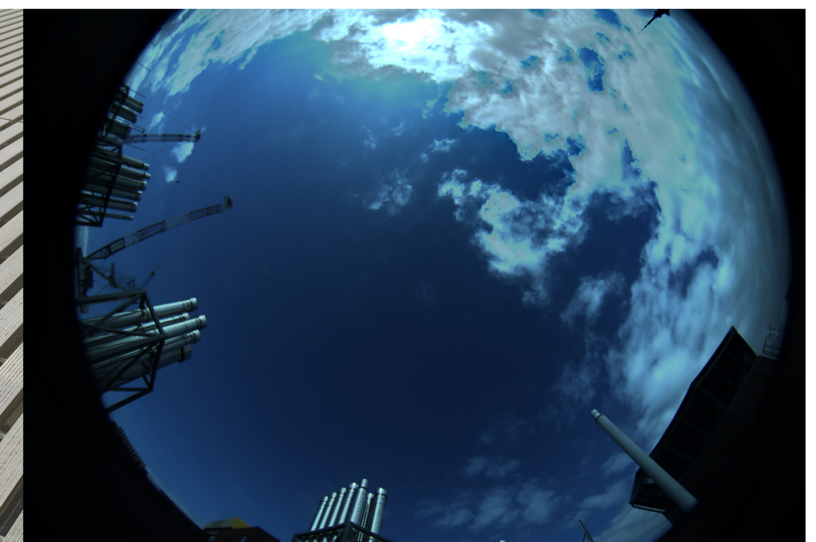


Location, Location, Location

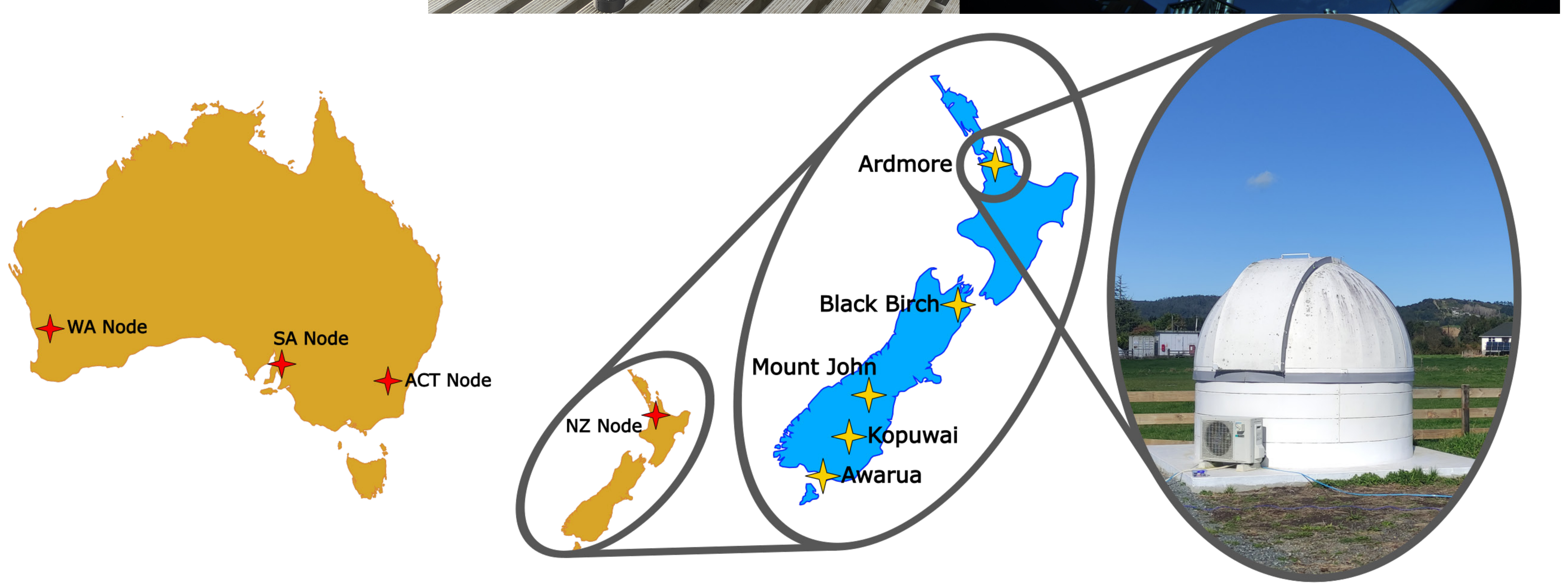
Initial work was done to find a short list of potential sites at which a first New Zealand FSOC optical ground station could be placed, see [6] and references therein. The downselection of a first site was made taking into account a wide variety of considerations, including access to facilities and utilities, ease of physical access, security; as well as cloud coverage statistics.

Results and Current Work

A first set of experiments were conducted using the 61cm Boller & Chivens telescope at the University of Canterbury's Mount John Observatory. It was found that significant amendments would be required to the telescope mount control software to enable tracking of low Earth orbit satellites. The team's activity was pivoted towards developing a basic FSOC ground station using modern components at a site close to Auckland to allow for easy access and experimentation.



A set of three all-sky cameras were commissioned from NIWA to record cloud coverage data. These all-sky cameras are currently being tested and their output validated.



The team is fitting out a dome previously used by the Defence Technology Agency (DTA) with a PlaneWave L-350 mount. The optical assembly will comprise a GSO 12 inch Ritchey Chretien telescope and a Small Optical Ground Stations Focal-Optics Assembly (SOFA) designed and built by DLR team members [7].

Networking

The ultimate goal of this work is to create a NZ FSOC node which could be included in an international FSOC ground station network. We are a part of the Australian Optical Communication Ground Station Network (AOCGSN) Working Group [8]. AOCGSN nodes are being developed by the University of Western Australia, The Australian National University and the Defence Science and Technology Group. A number of FSOC ground stations have been established in Europe, including at the Oberpfaffenhofen campus of the DLR and the Laser-Bodenstation in Trauen (DLR), and the Research Center Space of the University of the Bundeswehr Munich in Neubiberg. The DLR-GSOC also operates a ground station in Almeria, Spain as part of the European Optical Nucleus Network. A FSOC network comprising Australasian and European nodes would provide significant site diversity.

The Next Steps

Our experimental FSOC ground station is being established at the University of Auckland Ardmore Field Station. First light with the terminal is expected by the end of 2023. The three NIWA all-sky cameras will be installed at other likely FSOC sites, and cloud coverage data will be analysed and used to train algorithms to produce short timescale (<60 min) cloud pattern movement forecasts. An integrated seeing monitor (ISM) will be installed at our site at Ardmore.

We aim to seek further funding to support this research, and to establish a first NZ FSOC node in the AOCGSN, comprising a 0.5 -- 1.0m class telescope.

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