Coherent Optical Doppler Orbitography

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Motivation

Current microwave-frequency techniques for orbital determination (e.g. PRARE) are able to measure relative velocities with a precision of around 1 mm/s [1]. Greater precision is desired for improved calculations of orbital parameters and thereby a better understanding on the International Terrestrial Reference Frame [2]. Doppler orbitography at optical wavelengths has the potential to drastically improve the precision of these parameters.

Experimental Setup

We experimentally demonstrated a free-space Doppler measurement using a 193 THz (1550nm) continuous-wave laser over horizontal links up to 2.2 km in length. Horizontal links between 2 km and 5 km have previously been estimated to have similar total integrated turbulence as ground-to-space links [3-4]. Our system uses a coherent optical carrier round-trip phase measurement to determine the Doppler shift between the optical transceiver and reflector target that result from their relative motions as well as turbulence of the intervening atmosphere. It can then feedback to the outgoing to optical carrier to stabilise the phase fluctuations of from atmosphere [5].

Demonstrated Performance

For the 2.2 km link, the measured uncertainly in the relative velocity is 2 μm/s at 100 s of integration. Our system can also suppress short-term fluctuations to improve the measured uncertainly to 1 nm/s at 100 s. We expect similar performance for space links.

Future Ground-to-Space Link

The system is power limited due to beam divergence to 40 km; we are working towards a 350 km+ link by increasing power from 30 mW to 1 W and reducing beam divergence by using a larger transceiver. A ground-to-space demonstration is planned for late 2019. A chip rate can also be modulated onto the carrier for absolute distance.

For More Information

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Acknowledgements

Prior work: David Gozzard, Michael Messineo, Joshua Horton, Ben Stone.
Images: Background, Patrick Francis; Bottom inset, Google Earth.
Funding: ARC LIEF LE160100045, ARC CoE CE170100009.

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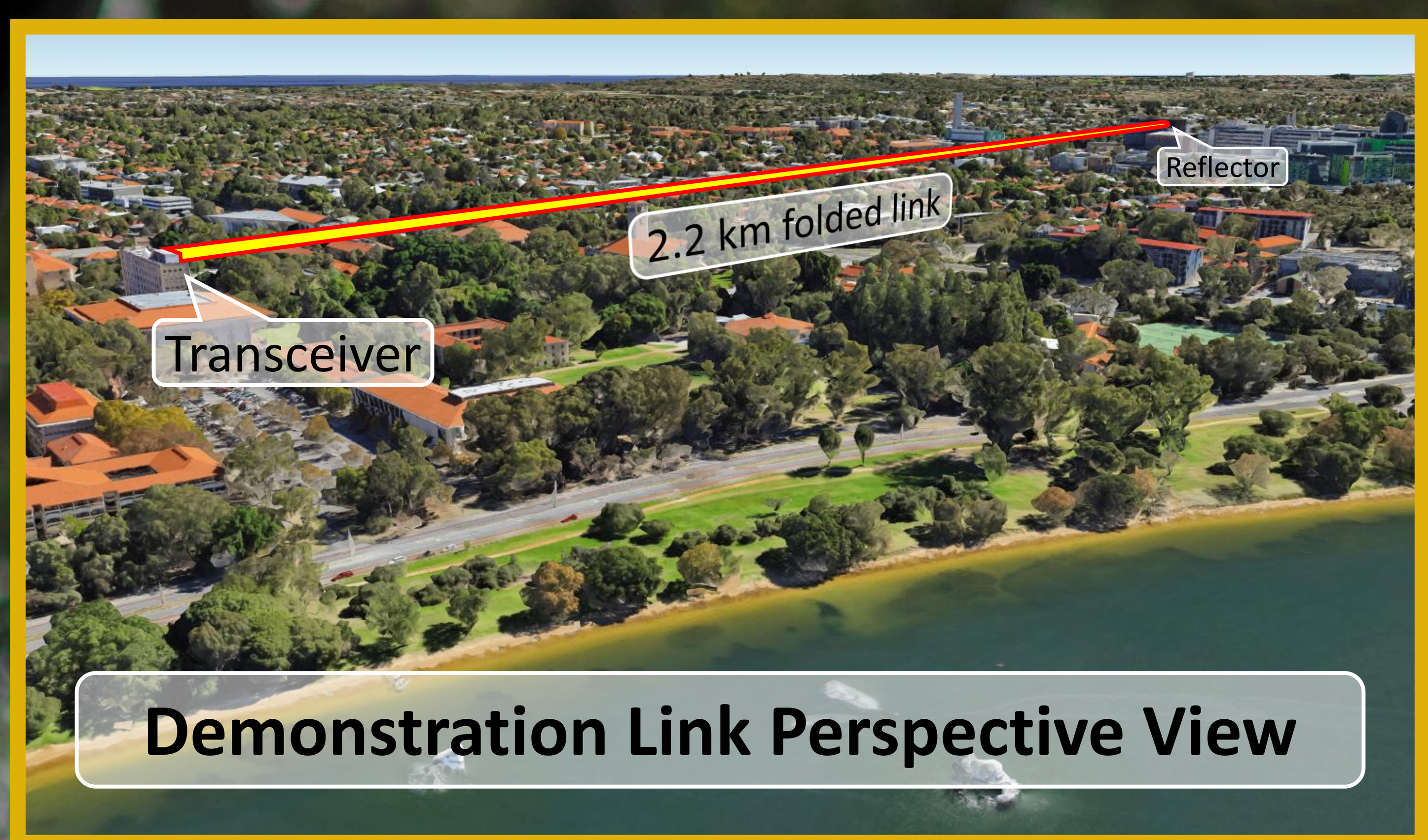

Demonstration Link Perspective View