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DEMONSTRATION OF GNSS-REFLECTOMETRY TECHNOLOGY FOR A SECONDARY PAYLOAD ON SMALL SATELLITES

Abstract

GNSS Reflectometry (GNSS-R) has been proven to be a highly effective means of implementing bistatic radar remote sensing technology on small satellites. No transmitter is required as signals from GPS and other GNSS satellites are used as radar sources, and forward scattered reflections contain the geophysical imprint of the surface, from ocean, ice or land. As a modified GNSS receiver, very little power is required, and size is dominated by the antenna.

The TDS-1 and CYGNSS missions primarily targeted wind speed over the ocean but demonstrated the potential for cryospheric and hydrological applications. The shortlisted ESA HydroGNSS Scout mission concept has been developed to specifically explore hydrological essential climate variables, specifically soil moisture, inundation, freeze / thaw state and biomass, and uses a 13 dBi gain 4-element dual feed nadir antenna to test out new GNSS techniques such as polarimetry and dual frequency. For ocean winds and soil moisture measurements, however, it is possible to collect useful measurements from a smaller single element antenna. On a 50+ kg-class microsatellite telecoms or Earth observation constellation, GNSS-Reflectometry could be accommodated as a secondary payload, giving a denser cover of measurements, and addressing the World Meteorological Organisation call for GNSS Reflectometry in its 2040 WIGOS vision document at a low cost.

An 18 kg technology microsatellite, DoT-1, built by SSTL, has been able to demonstrate GNSS-R as an opportunistic payload. DoT-1 was designed and built within 18 months, and launched in Summer 2019. Its purpose was to prove the "CoreDHS", a new integrated avionics suite to be used on all future SSTL satellite missions. A small 8 dBi Left-Hand Circularly Polarised nadir GNSS antenna was included to support GNSS-Reflectometry. By exploiting the front-ends of the existing GNSS receiver (SGR-Ligo), and the Zynq processing unit, GNSS-Reflectometry capability was brought onto the satellite, with the support of an ESA study.

Preliminary analysis of the Delay Doppler Maps from DoT-1 show a reduced peak signal to noise compared to TDS-1, as expected, but the wider antenna beam-width means that more simultaneous reflections with usable reflected power are accessible, and a lower sensitivity to the attitude uncertainty due to the shallower antenna gain gradients.

In principle, assuming a small nadir antenna could be accommodated and the minimal extra data and power requirements met, future small satellite missions can carry GNSS reflectometry capability as a low cost secondary payload, and offer a contribution towards much needed higher spatial-temporal resolution observations of the Earth's weather and climate.