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THE IMPACTS ON TERRESTRIAL ASTRONOMY FROM VERY LOW EARTH ORBIT TELECOMMUNICATIONS CONSTELLATIONS

Abstract

This paper aims to assess the potential benefits and challenges to multi-wavelength astronomy through the deployment of telecommunications spacecraft into lower operational orbits. Preliminary results show that by operating closer to the user, the profile of a spacecraft can be effectively reduced to minimise impacts in the optical regime. Benefits can also be gained for radio observations by reducing the power of link emissions and focussing service footprints, although there may be additional mitigations required to minimise unintended emissions impacting a terrestrial radio observatory.

In recent years the exponential growth in Low Earth Orbit (LEO) constellations has caused serious concern to the astronomical community. A range of novel services are being enabled by these constellations to great public benefit. Of particular interest is the extension of terrestrial mobile capabilities through the provision of direct-to-device non-terrestrial networks to low power user handsets. Current plans to deliver this service rely on large surface area high power phased arrays as demonstrated on the BlueWalker 3 prototype. This spacecraft deployed a 64 m^2 antenna at an orbit of 510 km and was observed at a peak V-band apparent magnitude of 0.4, making it one of the brightest objects in the night sky and impacting terrestrial observations when transiting the field of view. This is a precursor to a 243-spacecraft constellation to be deployed at $725 - 740$ km that may increase in brightness and will display longer periods of visibility.

A possible mitigation against these astronomical impacts may be obtained by operating constellations in Very Low Earth Orbits (VLEO) below 450km. Developments in erosion resistant and drag reducing materials, along with advances in traditional and atmosphere breathing electric propulsion have begun to open this orbital regime and current applications have generally focused on Earth Observation (EO). However, reductions in power and latency due to shorter transmission distances, access to higher frequencies and data rates from reduced path loss, eased demands on spacecraft components due to the benign radiation environment, and reductions in spacecraft size and launch costs all present opportunities in the delivery of high speed, low latency, ubiquitous global telecommunications and may be particularly beneficial for direct-to-device services. This paper develops analytical models representing these telecommunications spacecraft in the VLEO environment, prioritising for both service delivery and astronomical sustainability, and compares the impact with that demonstrated through observations of current constellations.