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OPTICAL NETWORKS IN LEO BASED ON THE CUBESAT STANDARD

Abstract

The advent of small laser transmitters, in combination with highly-capable CubeSats incorporating precision attitude control, enables the development of optical communications networks in Low Earth Orbit (LEO) based entirely in satellites built to the CubeSat standard. This paper will report on development and on-orbit testing of a laser downlink from a 1.5U CubeSat in the NASA-funded Optical Communication and Sensor Demonstration (OCSD) Mission that launched in November 2017. The laser transmitter developed for this demonstration has a volume of 250 cm^3, a mass of 360 g, and will produce a 3 W optical output with an input power under 15 W. All of these requirements can easily be accommodated in a CubeSat as small as 1.5U. In OCSD, which includes two separate flight units, the two lasers are configured for experimental purposes with beam divergences of 0.15 degrees and 0.05 degrees, supporting downlink rates of up to 200 Mb/s. Continuing improvements in pointing capability will allow the laser beam divergence to be reduced in future iterations, ultimately supporting data rates well into the Gb/s range. The OCSD technology demonstration mission is expected to complete testing by the middle of 2018. Because of long delays in the launch of OCSD, this demonstration mission leads planned implementation of operational laser downlinks in future CubeSat missions by only a few months.

Although the OCSD mission is configured only for downlinks, it has been used as a baseline for designing a 3U CubeSat optical crosslink demonstration mission expected to be capable of Gb/s data rates out to 5000 km range. Basing an optical relay satellite on the CubeSat standard, particularly smaller CubeSats, allows the cost of even very large constellations to be quite modest. This approach would enable a very rapid growth in the number of satellite nodes, as would be required over the long term to develop an in-space internet approaching the magnitude of the terrestrial internet. Beyond the development of the basic laser downlink capability, Aerospace has been investigating several technologies required to support development of large-scale LEO CubeSat relay networks including simple bent-pipe optical relays, agile communication nodes capable of receiving and transmitting multiple beams, and the control algorithms required to manage such complex networks. The results of the combined on-orbit experiments, next-generation relay satellite designs, and analyses of control systems indicate that CubeSat-scale satellites can have a significant role to play in the development of future large-scale in-space internet capabilities.