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SIMULTANEOUS LASER COMMUNICATIONS AND RANGING TERMINALS ON NANOSATELLITES

Abstract

Laser communications offer numerous advantages over traditional radio frequency (RF) systems for satellite-to-satellite communication links. The high directionality of the laser beam allows for high data rates to be realized with greater efficiency. This in turn enables the laser transceiver terminals to be smaller, lighter, and more power-efficient than comparable RF systems, and makes them highly applicable for micro- and nano-satellite platforms such as CubeSats. While these and other benefits of laser communications, including a less crowded spectrum with fewer licensing constraints, have driven the development of miniaturized laser terminals for space-to-ground and intersatellite links at various companies and research institutes, one key benefit of laser communications has yet to be fully exploited: that ranging and time transfer can be obtained as a byproduct of the communications link, even simultaneously. This observable can then be used for improved orbit determination or navigation of the spacecraft, and the synchronization of the spacecraft clock or scientific instruments. While simultaneous laser communications and ranging have been implemented on NASA's Lunar Laser Communications Demonstration (LLCD) and Laser Communications Relay Demonstration (LCRD), they have yet to be demonstrated on micro- or nanosatellites.

In this work we describe the CubeSat Laser Infrared CrosslinK (CLICK) mission, which will demonstrate laser terminals for the establishment of intersatellite links between two 3U CubeSats in low Earth Orbit (LEO). These satellites, CLICK-B and CLICK-C, will demonstrate full-duplex crosslinks with data rates of at least 20 Mbps using pulse position modulation (PPM), a simultaneous ranging precision capability of better than 50 cm, and a time transfer precision of less than 200 ps single shot. These crosslinks will be established over separation distances ranging from 25 km to 580 km, and both CubeSats will also be capable of space-to-ground downlinks. An initial risk reduction mission, CLICK-A, has been operating on orbit since September 6th, 2022, and has validated key technologies for CLICK-B/C, which is anticipated to launch in early 2024. We describe the design and development of the CLICK-B/C terminals and present the concept for a potential follow-on mission capable of coherent communications links with simultaneous ranging.