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MODULATING RETRO-REFLECTORS: TECHNOLOGY, LINK BUDGETS AND APPLICATIONS

Abstract

Satellite communications systems today, usually RF, tend to have low data rates and use a lot of on-board power. For CubeSats, communications often dominates the power budget. We investigate the use of modulating retro-reflectors (MRRs), previously demonstrated on the ground, for high data-rate communication downlinks from small satellites. A laser ground station would illuminate a retro-reflector on-board the satellite while an element in the retro-reflector modulates the intensity of the reflected signal, thereby encoding a data stream on the returning beam. A detector on the ground receives the data, keeping the complex systems and the vast majority of power consumption on the ground. Reducing the power consumption while increasing data rates would relax constraints on power budgets for small satellites, leaving more power for the payload and imposing only modest pointing requirements. In the future, this could enable the use of constellations of nano-satellites for a variety of missions, possibly leading to a paradigm shift in small satellite applications. Using analytical tools and physics-based simulations, we investigate modulators and system architectures and develop communication link budgets. A mission analysis identifies the scheme's advantages and disadvantages in comparison to RF communication. We present the results of first experiments including characterizing MRRs, testing detectors, comparing encoding schemes, and quantifying backscatter. We use these results to refine space-to-ground link budgets and to define the requirements for the ground stations.