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OPTICAL-RF DUAL RELAY COMMUNICATION SYSTEM FOR 1000-AU INTERSTELLAR MISSION

Abstract

The goal of a realistic interstellar mission to the nearest star, recently announced by NASA as a new space exploration objective targeted for circa 2069, presents an exciting prospect for creating a pragmatic but visionary mission design. In light of such a long-term mission goal, potential technological developments that might be mission enablers are a matter of speculation at best, but the basic physical principles underlying telecommunications subsystem conceptual design are well within our grasp. For example, the range required of a communications link to the Alpha Centauri system is prohibitively large due to current and foreseeable engineering limits in pointing capability, receiver sensitivity, and power transmission in both RF and optical domains. However, realistic design specifications can be identified if the mission concept is broadened in two ways: launch a precursor mission to a distance of 1000 AU, and implement the precursor mission not as a single spacecraft but as a fleet of several spacecraft launched in periodic succession. In doing so, the communications subsystem can take the form of a relay chain for which the spacing is determined by the upper limits of downlink transmission capability at the time of launch. By reducing the required link range to within achievable limits, link analysis can be further constrained by examination of tradeoffs in transmitter output power, data rate, bit error rate, antenna sizes, pointing loss, path attenuation, turbulence effects, and link availability at both optical and radio frequencies. The proposed subsystem is dual-channel: an optical link to achieve the minimum required downlink data rates, and an RF link to minimize pointing loss for spacecraft emergency recovery. Through the implementation of a relay-based dual-channel design, the subsystem can yield effective and reliable downlink data transmission over communication distances of unprecedented vastness.