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DESIGN OPTIMIZATION AND STATISTICAL PERFORMANCE EVALUATION OF OPTICAL COMMUNICATIONS RELAY ARCHITECTURES

Abstract

As science-driven space exploration missions become increasingly complex, the requirements for data returned from these missions is approaching the limits of existing radiofrequency (RF) communications infrastructure. Adding optical communications capabilities to the network provides a way to increase the achievable data rate by moving to a higher frequency band without incurring increases in mass and power, however, optical communications make use of fundamentally different architectures and also come with many challenges and technical uncertainties in their design and operation including atmospheric attenuation, susceptibility to cloud coverage, strict pointing requirements at long distances, and noise introduced into the system due to background light sources. Space relays, placed strategically in locations such as Lagrange points, may help to mitigate and overcome some of these challenges.

This paper presents a study of the optimal location and design of space relays for deep space optical communications. A statistical approach is used to model data rate capacity and availability as the primary figures of merit used to evaluate the performance of an optical link that uses relays. Predicted performance using the relay architectures is evaluated for a variety of deep space mission scenarios, including missions to Venus, Mars, and the outer planets, and is compared with the existing capabilities of RF communications using NASA's Deep Space Network.