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Author: Dr. Borja Pozo
IK4-TEKNIKER, Spain, borja.pozo@tekniker.es

STUDY OF AN INTERPLANETARY OPTICAL COMMUNICATIONS SYSTEM VIA LASER BETWEEN EARTH AND MARS

Abstract

Optical communication is considered the future of space communications for long distance and to enable future Mars habitats. The most important consideration for a laser communication is that will increase the current bandwidth in 10 to 100 times compared with current radio frequency systems. In addition, is expected to reduce the size, weight, and power requirements needed to enable communications, contributing to establishing permanent communication between Earth and Mars long-duration mission.

The objective of this work has been to work on the definition and feasibility of an interplanetary optical communications system via laser, in the specific case of Earth-Mars. This activity has gathered the space operation requirements and the development of the conceptual design of the communication solution. Therefore, the bases, principles, and technologies of interest-oriented to the space domain have been defined, emphasising the advantages of optical communication via laser for deep space and for future long-duration Mars missions.

This communication system must ensure and establish communication with the Earth and, in turn, with Mars. For both the positioning system and the communication system, the envisaged solutions require complementary intermediate systems (beacons with repeater function). Thus, three possible mission configurations have been studied, 1- Earth-Mars; 2- Earth-Moon-Mars; and 3- Earth-Moon-Boosters-Mars. Each configuration is possible however the pros and cons have been analysed determining the third one as the ablest to ensure continuous communication. This solution avoids the interferences produced by the sun and the orbital positioning of each planet during the 26 months of launch window or minimum distance between Earth and Mars. However, it is the most complex to implement and the expensive one.

In addition, this work has studied the effect of different parameters that must be considered at least for the communications system definition. The planetary atmosphere effects in laser deflections, losses, and meteorologic influence. Orbital and planetary dynamics for mission configuration selection and enable continuous communication system. In-flight and ground optical and accurate mechatronic systems to enable the laser communication with high accuracy pointing system to enable the reception and sending of the laser beam. Space metrological systems for boosters positioning, as star tracker and inverted multilateration techniques. Thermal effects to be considered in deep space systems. Laser communications protocols, as existing laser communications or quantum technologies. And the required electrical power for spacecraft and planetary/lunar bases and the propulsion systems for spacecraft position correction.