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Author: Prof. Filippo Graziani
G.A.U.S.S. Srl, Italy

Mr. Nicola Sparvieri
GAUSS S.r.l., Italy
Dr. Stefano Carletta
Sapienza University of Rome, Italy

A LOW-COST EARTH-MOON-MARS MISSION USING A MICROSATELLITE PLATFORM

Abstract

The paper presents the preliminary results of a space exploration mission designed by GAUSS Srl, aiming at performing, for the first time ever, the exploration of the Moon and Mars using a microsatellite platform. Microsatellites offer advantages over larger "traditional" spacecraft, such as reduced development time and cost, but they also set several challenges when considering space exploration missions. In fact, their limited volume and mass directly translates into power and thrusting constraints, which do not allow to perform traditional maneuvers required by interplanetary transfers. A solution to this issue is proposed in this paper and consists in taking advantage of the chaotic behavior in the Sun-Earth-Moon system to transfer a microsatellite of the UNISAT class to Mars, with significant savings in the propellant mass. The mission is compatible with launch opportunities to the Moon, in which the spacecraft is deployed along a highly eccentric orbit around the Earth, whose apogee crosses or approaches the orbit of the Moon. From the mentioned deployment conditions, a lunar capture is achieved, taking advantage of gravity-braking effect by the Moon. The spacecraft is injected into a chaotic orbit around the Moon, governed by the combined gravitational effect in the Sun-Earth-Moon system. Adequate conditions can be isolated in this framework, in which the gravity assist by the Moon and, eventually, by the Earth inject the spacecraft along a suitable trajectory to Mars. The arrival conditions can be targeted during the design phase, to achieve a capture at Mars using the same gravity-braking strategy previously performed for the lunar capture. Once orbiting Mars, two 3U CubeSats are deployed by the microsatellite platform. One of them is directed towards the moons of Mars, Phobos and Deimos, the other one is transferred into a polar orbit, to explore the martian polar ice caps. The overall mission architecture and design techniques are discussed and verified by means of numerical analyses. A selection of on-board systems currently on the market and compatible with the resulting mission profile is proposed. The availability of launch opportunities and the need for on-ground services necessary to support the mission is investigated. All these elements are finally examined to outline a risk management plan and to define a suitable budget for the mission, showing that deep space exploration using microsatellites is a real option for current space programs.