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Author: Mrs. Valentina Marchese
Argotec, Italy

Mr. Luca Vigna
Argotec, Italy
Mr. Alessandro Novero
Argotec, Italy
Mrs. Francesca Ingiosi
Argotec, Italy
Mr. Federico Miglioretti
Argotec, Italy
Mr. Simone Simonetti
Argotec, Italy
Ms. Stefania Cornara
Deimos Space S.L., Spain
Mr. Pablo Hermosin
Deimos Space SLU, Spain
Dr. Stefania Tonetti
Deimos Space SLU, Spain
Prof. Luciano Iess
Sapienza University of Rome, Italy
Mr. Paolo Racioppa
Sapienza University of Rome, Italy
Mr. Daniele Durante
Sapienza University of Rome, Italy
Mr. Giovanni Pandolfi
Leaf Space S.p.A., Italy
Mr. Davide Melli
Leaf Space S.p.A., Italy
Mr. Stefan-Vlad Tudor
Leaf Space S.p.A., Italy
Dr. Stephen Lingard
Vorticity Ltd, United Kingdom
Mr. John Underwood
Vorticity Ltd, United Kingdom
Dr. Louis Walpot
ESA - European Space Agency, The Netherlands

SYSTEMS DESIGN OF A DEEP-SPACE MICROSATELLITE PLATFORM FOR MARS COMMUNICATION AND NAVIGATION CONSTELLATION

Abstract

The Mars Communication and Navigation (MCN) mission is a multi-satellite constellation mission comprising several deep-space microsatellites that shall prototype key technologies and provide an Earth-Mars communication and navigation infrastructure to enable a broad range of future exploration missions at Mars without the burden of having an expensive Earth link. The mission shall serve as a pioneer Comms/Nav network at Mars.

The critical challenge lies in communicating with several users and relaying a high volume of data, in the order of few GB per day, and providing accurate positioning in the order of few metres for users simultaneously for 15 years. This work focuses on the systems design of the deep-space microsatellite platforms used for MCN to satisfy the performance objectives. It delineates the mission characteristics pertaining to the transport and deployment of the microsatellites in a Walker-type constellation at Mars. System level requirements are defined and the principal design characteristics of the system, the key design constraints, and rationale behind the design choices are expounded.

To address the challenge of communication, the system utilises a K-Band antenna and an S-Band patch array for Forward/Return link with orbiters, autonomous rovers, landers/ascenders, and human landing missions at Mars. A Ka-Band deployable dish antenna is utilised to relay the user data via a larger Gateway/Relay satellite to the Earth ground stations. A multi-channel deep-space transponder is utilised for near-real time data relay and navigation service. Detailed link budgets are presented that fulfil the Earth link data rate requirement of $\sim$9 Mbps. To provide GNSS-like service at Mars, the system houses an on-board atomic clock for providing high accuracy positioning. The system utilises equipment that are Commercial Off-The-Shelf (COTS), some with modifications, to obtain a cost-effective solution. A novel design concept is used for solar arrays and the electrical power system to satisfy the large power needs. The system also utilises an in-house on-board processing and data handling system as well as in-house power control and distribution unit. The key technologies that require further development are also highlighted. Finally, system budgets are obtained to show design feasibility and the structural composition of the MCN microsatellite platform is detailed. The overall mass of the platform is $\sim$70 kg with a 27+U Cubic form factor.

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