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Author: Mrs. Valentina Marchese  
Argotec, Italy, valentina.marchese@argotecgroup.com

Mr. Luca Vigna  
Argotec, Italy, luca.vigna@argotecgroup.com

Mr. Alessandro Novero  
Argotec, Italy, alessandro.novero@argotecgroup.com

Mrs. Francesca Ingiosi  
Argotec, Italy, francesca.ingiosi@argotecgroup.com

Mr. Federico Miglioretti  
Argotec, Italy, federico.miglioretti@argotecgroup.com

Mr. Simone Simonetti  
Argotec, Italy, simone.simonetti@argotecgroup.com

Ms. Stefania Cornara  
Deimos Space S.L., Spain, stefania.cornara@deimos-space.com

Mr. Pablo Hermosin  
Deimos Space SLU, Spain, pablo.hermosin@deimos-space.com

Dr. Stefania Tonetti  
Deimos Space SLU, Spain, stefania.tonetti@deimos-space.com

Prof. Luciano Iess  
Sapienza University of Rome, Italy, iess@hermes.diaa.uniroma1.it

Mr. Paolo Racioppa  
Sapienza University of Rome, Italy, paolo.racioppa@uniroma1.it

Mr. Daniele Durante  
Sapienza University of Rome, Italy, daniele.durante@uniroma1.it

Mr. Giovanni Pandolfi  
Leaf Space s.r.l., Italy, giovanni.pandolfi@leafspace.eu

Mr. Davide Melli  
Leaf Space s.r.l., Italy, davide.melli@leaf.space

Mr. Stefan-Vlad Tudor  
Leaf Space s.r.l., Italy, stefan.tudor@leaf.space

Dr. Stephen Lingard  
Vorticity Ltd, United Kingdom, steve.lingard@vorticity-systems.com

Mr. John Underwood  
Vorticity Ltd, United Kingdom, john.underwood@vorticity-systems.com

Dr. Louis Walpot  
ESA - European Space Agency, The Netherlands, louis.walpot@esa.int

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 microsattellites 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 microsattellite platforms used for MCN to satisfy the performance objectives. It delineates the mission characteristics pertaining to the transport and deployment of the microsattellites 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 microsattellite platform is detailed. The overall mass of the platform is  $\sim 70$  kg with a 27+U Cubic form factor.

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