IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Extra-Terrestrial and Interplanetary Communications, and Regulations (5)

Author: Dr. Thomas Kühne
IQ Technologies for Earth and Space GmbH, Germany

Mr. Bharath Vikram Bhatt
IQ Technologies for Earth and Space GmbH, Germany
Mr. Mathias Reibe
IQ Technologies for Earth and Space GmbH, Germany
Mr. Andreas Maurer
Julius Maximilians Universität Würzburg, Germany
Mr. Clemens Riegler
Julius Maximilians Universität Würzburg, Germany
Mr. Joshua Stadler
Julius Maximilians Universität Würzburg, Germany
Prof. Hakan Kayal
Julius Maximilians Universität Würzburg, Germany

VAMEX3-MARSSYMPHONY COMMUNICATION SYSTEM - A LOW MARS ORBIT CUBESAT TO LANDER LINK

Abstract

Exploration of the surface of extraterrestrial bodies, such as Mars, using robotic missions poses various challenges, with communication being a critical aspect. Communication failures can jeopardize the entire mission, and the limited communication capacity often restricts the scientific output. This is particularly challenging in difficult terrains like the Valles Marineris on Mars, the largest canyon in the solar system. Direct communication between Earth and Mars robots is very limited, and the common solution is a relay satellite orbiting Mars. Current Mars orbiters used for exploration missions, such as the Mars Reconnaissance Orbiter, offer very limited data rates below 2 Mbps towards the Martian surface and are reaching the ends of their lifespan. The members of the VaMEx3-MarsSymphony project within the VaMEx initiative, an interdisciplinary research program funded by the German Aerospace Center (DLR), are investigating a future mission design and technologies to explore the Valles Marineris with a robotic swarm and a CubeSat in a low Mars orbit. An integral component of this investigation is the design of the communication link between the orbiter and the lander, which will serve as the gateway for the robotic swarm. This paper presents the concept and the key specifications of this Ka-band communication link.

The Interagency Operation Advisory Group (IOAG) has recently proposed a future Mars communication structure and recommended frequencies and physical and coding layer specifications. The design of the communication link between the VaMEx3 Mars orbiter and the lander is derived from IOAG recommendations. The link characteristics are analyzed using the simulated orbit and the planned landing site of the lander. The insights gained from this analysis are used to specify the various components of the communication link, including the antennas and the communication transceiver. The full-duplex transceiver is utilized in both the orbiter and the lander to reduce cost and development time. The system design objective is to use commercial-off-the-shelf components and to achieve low SWaP-C (size, weight, power, and cost). This approach is driven by the recognition that both the lander and the satellite are constrained by stringent limitations in terms of available resources, including mass and electrical power.

The paper presents the high-level system design based on a software-defined radio platform, the main facts of the physical and coding layers of the communication design, and RF aspects of the Ka-band transceiver. Additionally, an antenna design is presented that achieves the required parameters along with the simulation results.