

IAF SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Science, Instruments and Technologies (3B)

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FEASIBILITY ASSESSMENT OF OPTICAL COMMUNICATIONS BETWEEN GROUND AND
SATELLITE ON MARS THROUGH THE SIMULATION OF ATMOSPHERIC EFFECTS ON SIGNAL
QUALITY LEADING TO A PROPOSAL FOR A NEW COMMUNICATIONS NETWORK
ARCHITECTURE DURING EXTREME WEATHER

Abstract

Mars is the next milestone in human exploration. However, there are still several challenges that must be assessed to ensure appropriate conditions in a future settlement. Communications services will be essential for this task, providing not only a link between Earth and Mars but also supporting Martian weather forecasting and any potential rescue missions. These applications require a robust, high data rate communications network that allows for rapid response, remote sensing and public engagement.

This research aims to study the feasibility of ground-to-satellite (and vice versa) optical communications during extreme Martian weather conditions, focusing on the link between a ground station on the surface of Mars and a satellite orbiting the planet. Long-lasting and expansive Martian dust storms, particularly common in the southern hemisphere, pose a considerable challenge when considering the feasibility of optical communications with Mars due to their significant impact in terms of signal attenuation and scattering.

The methodology of this study is based on a computer simulation of the system featuring the characterisation of the Martian atmosphere and optical link to measure the attenuation and undesired effects suffered by the data signal when applying different environmental configuration parameters. The flexibility of the approach allows for the prediction of communications link quality in extreme cases such as global dust storms. The simulation is based on atmospheric data from the Mars Reconnaissance Orbiter's Mars Climate Sounder instrument and considers research into data from the recently launched Laser Communication Relay Demonstration which provides insight into optical signal propagation, including atmospheric disturbances.

The extreme conditions during dust storms in the southern polar-hood region lead to the proposal of a new communications network architecture to ensure connectivity during these events. The proposed operation involves the detection of heavy signal attenuation and triggers a two step communications link assisted by a UAV for data relay.

The outcomes of the study may be used by future missions to evaluate the feasibility of optical communications with the planet's surface in different Martian weather conditions.