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EPSC Abstracts
Vol. 13, EPSC-DPS2019-1412-2, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

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Abstract

In this paper, we present the results of the tests and characterizations performed on the WISDOM/ExoMars 2020 radar that has been delivered for integration on the Rosalind Franklin mission rover. While the impact of the rover will be determined after a dedicated series of measurements performed at Airbus's premises in Stevenage, reference measurements (in free-space and with specific targets) have been acquired and are currently taken into account in the data processing pipeline.

Calibrated data are obtained that make possible a quantitative analysis of the amplitude of the received signals, especially of the surface echo, which is used to get an estimate of the permittivity value in the subsurface top layer. Results on the achieved vertical resolution will be presented too.

1. Introduction

The ExoMars 2020 rover mission's main objectives [1] are to search for bio-signatures of past Martian life, to characterize the water and geochemical distribution as a function of depth in the shallow subsurface and to investigate the planet's subsurface in order to better understand its evolution and habitability. To reach these objectives, the ExoMars Rover is equipped with a drill that will collect samples at depth down to 2 m, that will be analyzed inside the Rover body. WISDOM (Water Ice Subsurface Deposits Obser-vation on Mars) is a ground penetrating radar that will also be accommodated on the Rover [2],[3]. In accordance with the mission's objectives, the main goal of the instrument is to reveal the geological context and evolution of the landing site. WISDOM observations will be used to select the best places to collect samples in the subsurface. They will also guide the drill in order to avoid hazardous area.

2. Flight model's Characterization

WISDOM is a polarimetric ground penetrating radar that will be accommodated on the Rover payload of the ExoMars 2020 mission [1] WISDOM operates at frequencies ranging from 500 MHz to 3 GHz. It is able to probe down to a depth of few meters with a vertical resolution of few centimeters.

The flight model of the instrument was delivered in January 2019 at Airbus premises in Stevenage for integration in the mission Rover. In order to produce data calibrated both in time and amplitude, it is essential to characterize as much as possible the instrument that will land on Mars. Here we report a suite of measurements in controlled environments that have been performed before the instrument's delivery.

2.1 Effect of the temperature

The electronic unit accommodated inside the rover body has to be able to operate at temperature ranging between -55°C and +55°C. The Thermal Vacuum environmental tests performed on the EU at the PIT (Plateforme d'Integration et Tests of OVSQ, Guyancourt, France) facilities provided the opportunity to quantify the effect of the temperature in low-pressure (~6 mbar) Martian conditions. The measurements show a linear decrease of the transmitted power with the temperature measured on the Radio Frequency board. We determine a power loss of about 0.05 dB per degree Celsius. The corresponding correction will be applied automatically in the WISDOM data processing pipeline in order to remove the effect of the temperature.

2.2 Antenna crosstalk and internal coupling

Measurements performed with both the full instrument i.e. electronic unit and antennas in free space (i.e. without any obstacle closer than 3 m from the antennas) have provided an accurate characterization of the direct coupling between the transmitting and receiving antennas (waveform), as well as of the internal coupling. These parasitic signals will have to be removed from the data collected on Mars.

2.3 Amplitude calibration – link budget

Based on measurements performed with a network analyser, the transfer function necessary to convert WISDOM data into physical units (i.e., the received power in dBm) has been established. We also verify that, in case of a simple target (such as a large metallic plate) the received power is consistent with the characteristics of each element of the radar and settings (antennas' gain and radiation pattern, attenuations in the transmitting chain and in the cables). The achieved link budget enables us to validate the characterization of the instrument and to be confident that quantitative analysis of the data collected on Mars will be possible. In fact, we show in [4] that the calibrated amplitude of the surface echo can be used to estimate the subsurface permittivity value and thus to convert the time of arrival of the detected echoes into distance.

3. Conclusion

The WISDOM radar Flight Model is now well characterized. We are able to use a set of reference measurements to obtain calibrated data and get a satisfactory link budget. Nevertheless, preliminary measurements made on the Charlie rover (used during the ExoFit field trial) that used wheels similar to the ones Rosalind Franklind will have, are shown that the impact of the rover body might not be negligible. Final measurements will be performed on the Rosalind rover in Airbus facilities in Stevenage and will provide the missing information to fully understand and interpret the data WISDOM will acquire on Mars.

Acknowledgements

The WISDOM instrument has been supported by CNES and DLR. This research has been supported by CNES and UVSQ.

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