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# Impedance measurements for RIME dipole aboard JUICE

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## Abstract

The goal of the mission JUICE (JUpiter ICy moon Explorer) is the exploration of Jupiter and three of its Galilean moons. In the year 2030 the spacecraft (S/C) will arrive in the Jovian system and investigate the celestial bodies by RIME (Radar for Icy Moons Exploration) and other instruments aboard JUICE. In order to verify the simulation results, a simplified S/C-mock-up is built and measured.

## 1. Introduction

One of ESA's largest future missions is JUICE: JUpiter ICy moon Explorer. The launch is scheduled for 2022 and the arrival for the year 2030. The goal of this mission comprises the exploration of three out of the four Galilean moons, Europa, Callisto and Ganymede, as well as the atmosphere of Jupiter itself. Among several other experiments investigating the Jovian system, RIME will penetrate the celestial bodies with electromagnetic waves to analyse subsurface structures. This subsurface-radar operates at a centre frequency of 9 MHz with a bandwidth of 3 MHz. Due to the relatively low frequency range, RIME is capable to penetrate the surface up to a depth of about 9 km with a maximum vertical resolution of 50 m. The 16.6 m long RIME dipole antenna consists of two 8.3 m long rods, each fed by a 50 Ω coaxial cable. Both coaxial cables are connected to a matching network (MN) in order to achieve the required bandwidth. For the design of the MN, it is necessary to know the impedance within the bandwidth precisely. Due to the dimensions of the S/C, the tip-to-tip length of the solar panels is about 30 m, whereas a measurement with the original S/C model is not feasible. Therefore, the impedance values are determined with a 3D full-wave, frequency domain EM solver. For the verification of the simulation results a S/C-mock-up is built and measured.

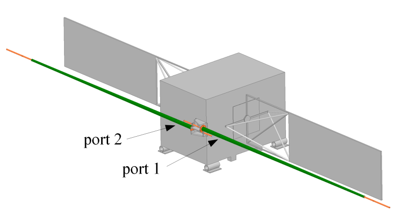
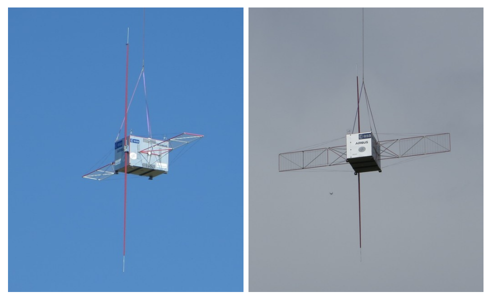



Figure 1: CAD model of the simplified S/C mock-up with horizontally orientated RIME dipole (orange) and GFRP flagpole for stabilization (green).

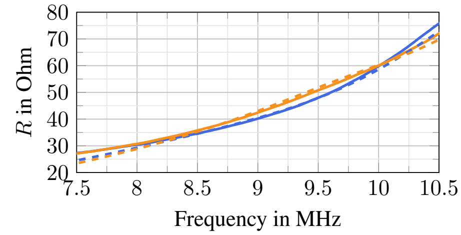


(a) Horizontal solar panel. (b) Vertical solar panel.

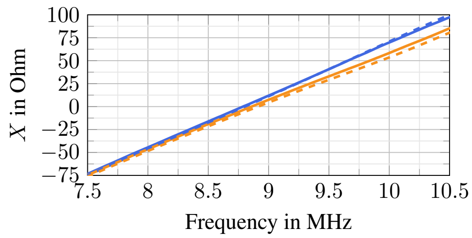
Figure 2: S/C mock-up fixed to helicopter with vertically oriented RIME dipole at an altitude of 320 m.

## 2. Measurements

Due to a centre frequency of 9 MHz, the mock-up cannot be measured in an anechoic chamber. Therefore, the determination of the impedance can only be done in free space. In this case, the mock-up is lifted by a helicopter to a height of 320 m, which corresponds to about ten times the wavelength at the centre frequency. This altitude is chosen in order to minimize the influence of the ground. Moreover, the use of a helicopter requires some simplifications on the S/C mock-up: Due to the wind load, the solar panels have to be shortened from $\approx 30\,\mathrm{m}$ to $\approx 14\,\mathrm{m}$, which complies with the maximum load of 1000 kg for the flight as well. Furthermore, a pivoted antenna is necessary for take-off and land-




(a) Resistance $R$



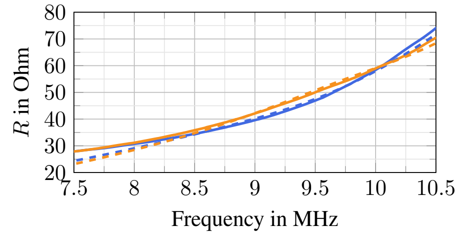

(b) Reactance $X$

Figure 3: Comparison of impedance between measurement and simulation for horizontal solar panel orientation. — port 1: measured, — port 2: measured, - - - port 1: simulated, - - - port 2: simulated

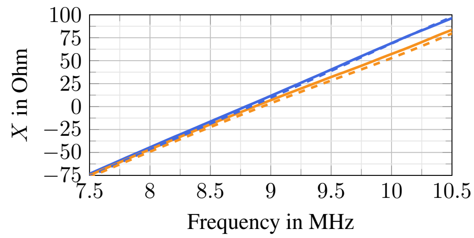
ing. A picture of the CAD model with the horizontally oriented antenna for take-off and landing is shown in Fig. 1.

All components of the S/C mock-up are made of aluminium and the solar panels can be rotated in steps of 45°. In addition to this, the solar panels are isolated with a resistor of 1 kΩ from the S/C body. The antenna consists of hollow aluminium cylinders with a diameter of 40 mm. Due to the gravitation, the dipole needs to be stabilized in order to avoid bending effects. This is realized by centring the antenna inside a flagpole using foam spacers. Glass fibre reinforced plastic (GFRP) with a relative permittivity of $\varepsilon_r = 3.1$ is chosen for the flagpole in order to minimize the impact on the measurements.

The impedance measurements are conducted at an altitude of 320 m aboard the mock-up. As can be seen in Fig. 2, the mock-up is fixed with a 70 m long rope to the helicopter and two different solar panel positions are investigated. During the measurements, a coaxial cable with a length of 5 cm is connected to each feeding point of the antenna. These cables are de-embedded for the following comparison. The results are shown in Fig. 3 and Fig. 4. Both solar panel positions yield to




(a) Resistance $R$




(b) Reactance $X$

Figure 4: Comparison of impedance between measurement and simulation for vertical solar panel orientation — port 1: measured, — port 2: measured, - - - port 1: simulated, - - - port 2: simulated

similar impedance values. The maximum deviation for this analysis always occurs at port 2, which is located in the direction of the ground. For vertically oriented solar panels, the maximum deviation between measurement and simulation is 4.7 Ω in resistance and 4.5 Ω in reactance. However, horizontally oriented solar panels result in a difference of 3.7 Ω in resistance and 5.1 Ω in reactance.

## 3. Summary and Conclusions

For the verification of the simulated impedances of the RIME dipole a S/C mock-up is built and measured. Measurement and simulation results are in good agreement, which justifies the MN design on the basis of simulation results.

## Acknowledgement

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