Micro-ARES: the electric field sensor for ExoMars 2016
Atmospheric interaction simulations

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Introduction

The first mission of the ExoMars programme, scheduled to arrive at Mars in October 2016, consists of a Trace Gas Orbiter (TGO) plus an Entry, Descent and Landing demonstrator module (EDM), known as Schiaparelli. The electric field sensor Micro-ARES is part of the EDM surface payload, and it is dedicated to the very first measurement and characterization of Martian atmospheric electricity [1]. It uses the principle of a relaxation probe [2][3][4] which measures the potential difference between the spherical electrode (located at the top of a 27-cm high antenna) that adjusts itself to the local atmospheric potential, and the lander structure, connected to the ground.

Figure 1: *Micro-ARES electrode*

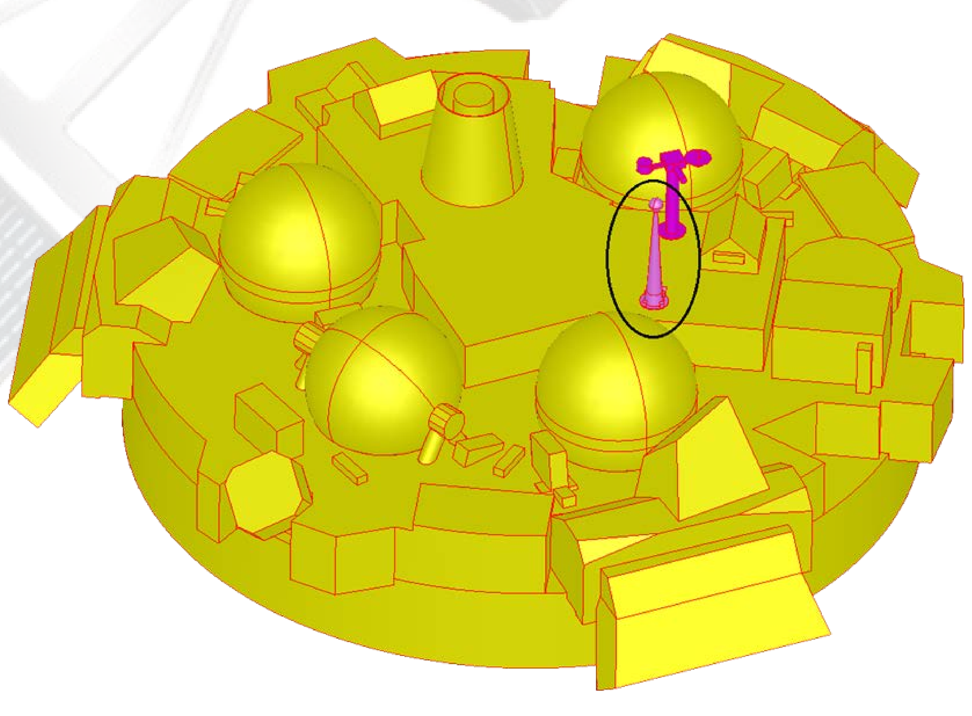

Figure 2: *Location of Micro-ARES on EDM*

Computational Methods

Ionization and tribo-electrification processes on the surface of Mars generate a vertical electric field which varies with height and wind shear velocity. This Efield profile, which is introduced in the *Electric Currents* interface via an external current density $J = \sigma E$, is the input of the simulations. Since the antenna is located roughly in the middle of the aluminum-covered lander structure, the proper data processing and interpretation depends strongly on reliable modeling of the field lines' deformation around the lander and instrument antenna. To first order, the model is expected to simulate the field lines' deformation to allow accurate potential measurement at the electrode's height in an unperturbed environment.

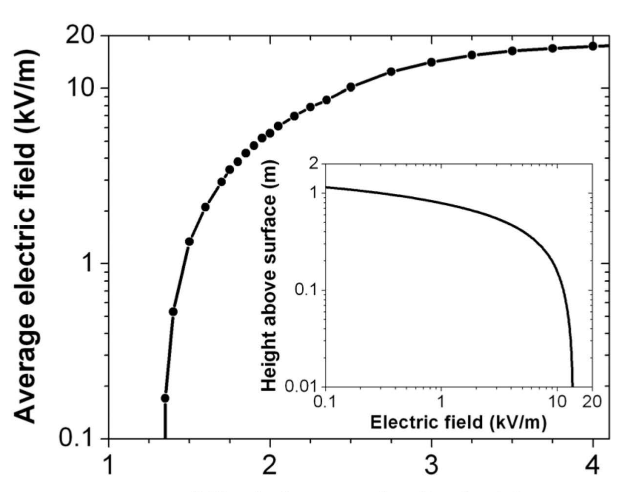

Figure 3: *Efield profile [5]*

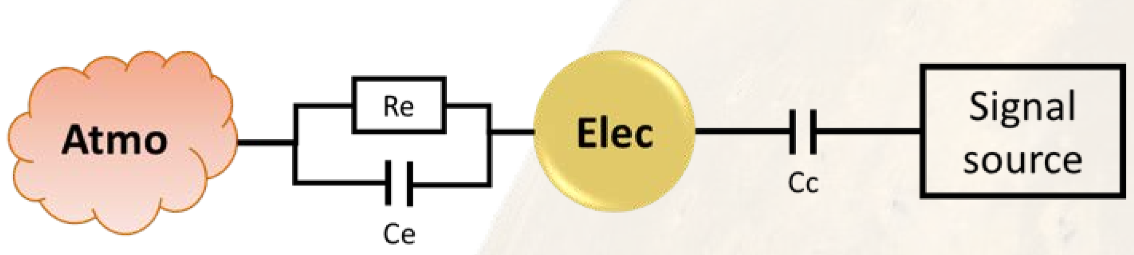

Figure 4: *Atmospheric coupling*

The atmospheric coupling of the electrode, which can be modeled with a resistor and a capacitor in parallel, must be taken into account and is linked to the atmospheric conductivity $R_e C_e = \frac{\epsilon_0}{\sigma}$. The atmospheric electric conductivity measurement is performed by introducing a sudden increase in the potential of the electrode, after which the electrode recovers the initial value. The recovery time is scaled by the relaxation time of the medium and is a function of its conductivity $\tau = (C_c + C_e)R_e$. On the other hand, a frequency domain analysis is performed by injecting a sinusoidal signal through a capacitor and studying the electrode potential:

$$U_{out} = U_{in}\frac{1}{(C_c + C_e)\varepsilon_0\omega - jC_e\sigma}$$

Results

Several atmospheric conductivities were used in the time-dependent and the frequency studies. The solution obtained from the simulations varies as expected with conductivity (the frequency response is independent while the relaxation time varies inversely). The values of interest derived from the simulations lie close to the theoretical ones, and are $C_e = 1.2\,pF$ and $R_e = 7 \cdot 10^{11}\,\Omega$. On the other hand, the deformation of the equipotential surfaces around the lander has been obtained.

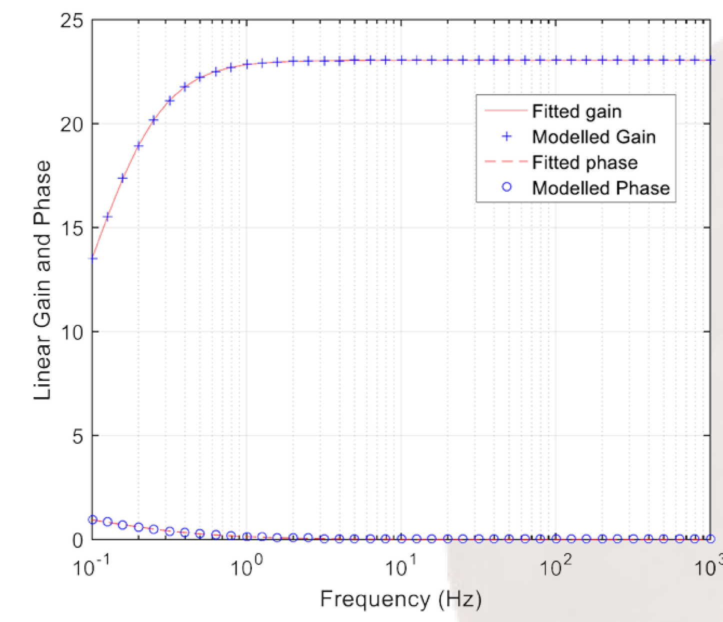

Figure 5: *Frequency study*

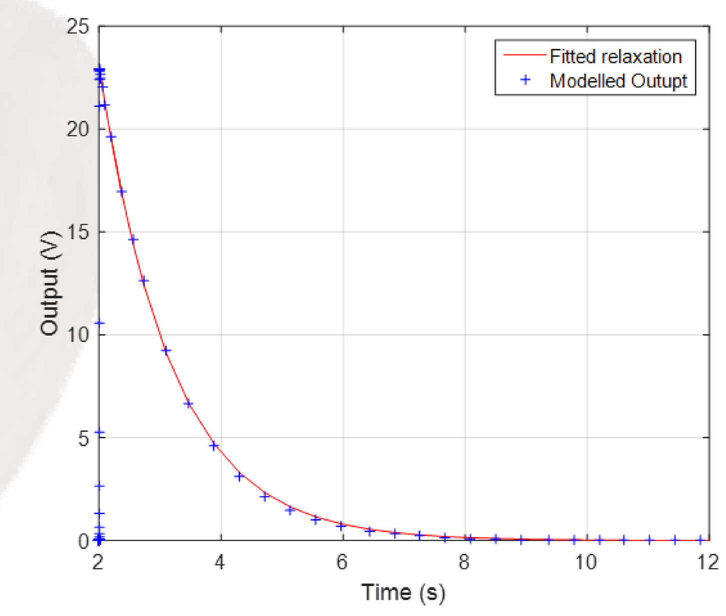

Figure 6: *Time study*

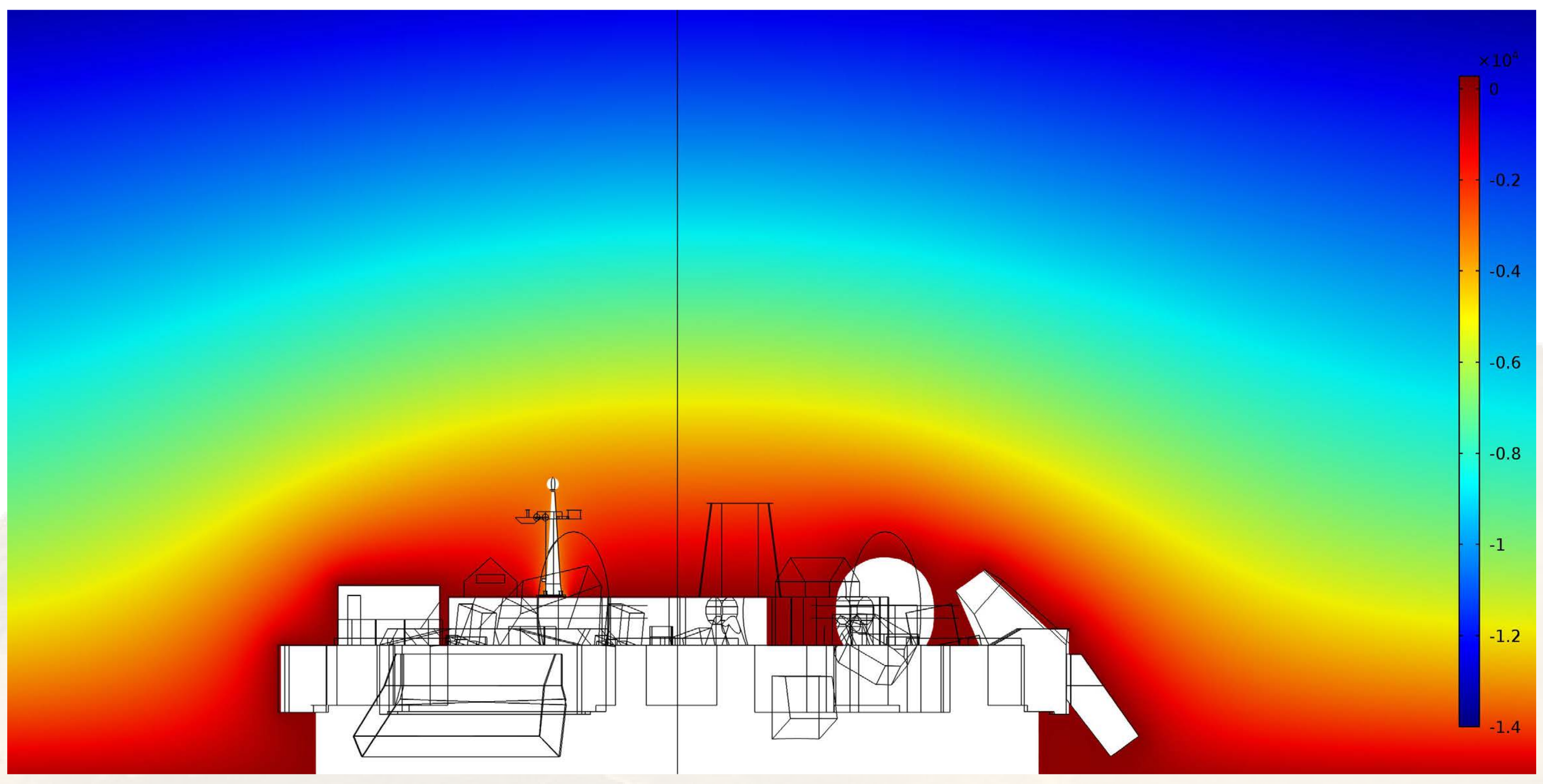

Figure 7: *Electric potential perturbation*

Conclusion and future development

The results obtained from the simulations have been used to quantify the atmosphere-electrode coupling and the electric field distortion due to the lander. Future studies to be carried out include: time-varying electric field profiles, lander position and orientation over surface, plasma and particle tracing for charged dust effects simulation, lander-ground coupling with both the soil and atmosphere, and inclusion of instrument program mimic in order to properly reproduce the instrument behaviour over time.

References

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