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3D characterization of the deep sub-surface by a bistatic HF GPR operating from the surface

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Despite past and current missions to Mars (including MarsExpress and MRO), little information is available on the structure and composition of the planet's sub-surface, apart from interesting results obtained on its polar caps and on the superficial layer of some specific spots. A ground penetrating radar (GPR) operating from the surface appears to be one of the most promising ways to get information about the planet structure.

The EISS (Electromagnetic Investigation of the Sub Surface) GPR has been designed and developed by LATMOS to perform deep soundings of the Martian sub-surface from the surface. EISS has been designed to take advantage of the potential for bistatic radar investigations of the Martian subsurface between a transmitter positioned on a stationary station (Lander) and a receiver accommodated on a potentially mobile platform (Rover). EISS expected performances should allow the characterization of the 3-D structure and stratigraphy of the subsurface at depths ranging from 100 m to a few kilometers out to a 1-km radius around the Lander.

EISS is an impulse radar operating at HF frequencies ($\sim$ 2-4MHz). It uses an electrical dipole antenna made of two 35 m resistively loaded monopoles, to transmit (and also receive in monostatic mode) the signal. The resistive profile of each monopole is carefully optimized to transmit the pulse without noticeable distortion and avoid ringing [1]. The two monopoles must be deployed on the surface in nearly opposite directions, at an angle which ensures good volume coverage all around the Lander. Electromagnetic simulations have been run to optimize the value of this angle based on its impact on the radiation pattern of the two monopoles [2]. EISS's most innovative capability is its potential for bistatic operation, made possible by the placement of a small magnetic sensor on the rover which can be rotated to measure all 3 components of the reflected signal transmitted by EISS, whatever the direction and orientation of the Rover.

The results presented are based on numerical simulations (FDTD code) which model the bi-static operation of the radar for a series of the sub-surface models going from the simplest ones with one horizontal interface between to homogeneous layers, to more complex ones including non homogeneous layers and inclined interfaces. The simulations produce sets of simulated radargrams which are used to validate the data interpretation algorithms and to assess the potential of the instrument on a variety of environments and radar configuration.
The results of data interpretation in terms of detection, retrieval of the three-dimensional localization of buried structure and characterization of subsurface layers that allows a more accurate sub-surface mapping will be presented.

[1] Biancheri-Astier, M., Ciarletti, V., and Reineix, A. (2010). Optimization of resistive pro le for loaded electrical monopole dedicated to deep Martian subsurface (in press). IEEE Transactions on Antennas and Propagation.
[2] Biancheri-Astier, M., Ciarletti, V., Reineix, A., and Corbel, C. (2010). Modeling the con guration of HF electrical antennas for deep bistatic subsurface sounding. IEEE Transactions on Geoscience and Remote Sensing.