Analysis on the GPR Detection of Dielectric Scatterers in Shallow Subsurface

Guido Valerio* (1), Alessandro Galli (2), Davide Comite (2), and Elena Pettinelli(3)

(1) IETR, Université de Rennes, Rennes, France,
guido.valerio@univ-rennes1.fr

(2) DIET, "Sapienza" University of Rome, Rome, Italy,
{galli, comite}@diet.uniroma1.it

(3) Mathematics and Physics Dept., "Roma Tre" University, Rome, Italy,
pettinelli@fis.uniroma3.it

The capability to properly detect and locate shallow buried targets with Ground Penetrating Radar (GPR) systems is a topic of great scientific interest in remote sensing, involving a wide variety of geophysical, civil, and space applications. In general, the detection of the scatterers depends on the target/background electromagnetic contrast, being also influenced by possible attenuation effects in the media, by the signal waveforms chosen, and by the antenna features.

The specific problem investigated here is the critical detection of targets whose dimensions are comparable to the typical signal wavelengths and are buried very close to the interface where various ground-coupled bistatic antenna systems can operate. Our analysis is focused on the location of dielectric scatterers buried in a host medium for challenging sensing resolution conditions as found in various GPR applications (G. Valerio *et al.*, *Planetary Space Sci.,* 2012). The approach has been developed through a customized numerical setup, with suitable ad-hoc simulations of two commercial bistatic GPR systems, accounting for different signal features (in terms of waveforms and spectra) and antenna parameters (spacing between Tx and Rx elements).

The simulations have been implemented for some cases of potential interest in various applications, concerning rocky inclusions in a sandy ground. Specifically, the host environment corresponds here to a mixture of silica glass beads, while the scatterers are chosen as basalt blocks. The appropriate electromagnetic response of the media has been derived with independent Time Domain Reflectometry (TDR) measurements on real samples. In particular, these conditions tend to recreate the shallow subsurface of the equatorial Martian region, a topic of great interest in connection with the future planetary explorative missions (E. Pettinelli *et al.*, *IEEE Trans. Geosci. Remote Sens.*, 2007).

Simulated results on the scattering have been derived in the form of radargrams and of single time-domain traces, in an analogous way of the typical output of GPR instruments. The relevant results are discussed within a theoretical frame that considers the different wave propagation contributions to the scattering problem. Extensive comparisons of suitable experimental data from a laboratory setup are also offered for further validation and discussion. The analysis has revealed that the typical GPRs can validly detect and locate scatterers even though their depth and dimensions are comparable to the operating wavelengths and to the antenna distances.