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The first step in the planning for a renewal of a railway network consists in gathering information, as effectively as possible, about the state of the railway tracks. Nowadays, this activity is mostly carried out by digging trenches at regular intervals along the whole network, to evaluate both geometrical and geotechnical properties of the railway track bed. This involves issues, mainly concerning the invasiveness of the operations, the impacts on the rail traffic, the high costs, and the low levels of significance concerning such discrete data set. Ground-penetrating radar (GPR) can represent a useful technique for overstepping these issues, as it can be directly mounted onto a train crossing the railway, and collect continuous information along the network. This study is aimed at defining an empirical model for the prediction of fouling in railway ballast, by using GPR. With this purpose, a thorough laboratory campaign was implemented within the facilities of Roma Tre University. In more details, a 1.47 m long $\times$ 1.47 m wide $\times$ 0.48 m height plexiglass framework, accounting for the domain of investigation, was laid over a perfect electric conductor, and filled up with several configuration of railway ballast and fouling material (clayey sand), thereby representing different levels of fouling. Then, the set of fouling configurations was surveyed with several GPR systems. In particular, a ground-coupled multi-channel radar (600 MHz and 1600 MHz center frequency antennas) and three air-launched radar systems (1000 MHz and 2000 MHz center frequency antennas) were employed for surveying the materials. By observing the results both in terms of time and frequency domains, interesting insights are highlighted and an empirical model, relating in particular the shape of the frequency spectrum of the signal and the percentage of fouling characterizing the surveyed material, is finally proposed.

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