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Quality assessment in railway ballast by integration of NDT methods and remote sensing techniques: a study case in Salerno, Southern Italy

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Maintenance and rehabilitation policies represent a task of paramount importance for managers and administrators of railway networks to maintain the highest standards of transport safety while limiting as much as possible the costs of maintenance operations.

To this effect, high-productivity survey methods become crucial as they allow for timely recognition of the quality of the asset elements, among which the ballast layers are the most likely to undergo rapid deterioration processes. Particularly, Ground Penetrating Radar (GPR) has received positive feedback from researchers and professionals due to the capability of detecting signs of deterioration within ballasted trackbeds that are not recognizable by a visual inspection at the surface, through high-productivity surveys. On the other hand, satellite-based surveys are nowadays being increasingly applied to the monitoring of transport assets. Techniques such as Multi-temporal Interferometric Synthetic Aperture Radar (MT-InSAR) allows evaluating potential deformations suffered by railway sections and their surroundings by analyzing phase changes between multiple images of the same area acquired at progressive times.

For both of these techniques, despite the wide recognition by the field-related scientific literature, survey protocols and data processing standards for the detection and classification of the quality of ballast layers are still missing. In addition, procedures of integration and data fusion between GPR and InSAR datasets are still very rare.

The present study aims at demonstrating the viability of the integration between these two survey methodologies for a more comprehensive assessment of the condition of ballasted track-beds over a railway stretch. Particularly, a traditional railway section going from Cava de' Tirreni to Salerno, Campania (Italy), was subject to both GPR and MT-InSAR inspections. An ad hoc experimental setup was realized to fix horn antennas with different central frequencies to an actual inspection convoy that surveyed the railway stretch in both the travel directions. Time-frequency methods were applied to the data to detect subsections of the railway affected by the poor quality of ballast (i.e. high rate of fouling). In parallel, a two-years MT-InSAR analysis was conducted to evaluate possible deformations that occurred to the railway line in the period before

the GPR test. In addition, results from both the analyses were compared to the reports from visual inspections as provided by the railway manager.

The results of the surveys confirm the high potential of GPR in detecting the fouling condition of the ballast layers at various stages of severity. The integration of this information to the outcomes of InSAR analysis allows for identifying whether the deterioration of the track-beds is related to poorly bearing subgrades or rather to excessive stresses between the aggregates resulting in their fragmentation.

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