MM uses satellite radar interferometry

An accurate and affordable method of monitoring ground surface movements over Milan's public sewerage network

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The public sewerage network of Milan, Italy, runs for approximately 1500 km. It includes 150 km covered by the main collector system that transports water to the Milan San Rocco and Nosedo purifiers, and partly to the Peschiera Borromeo purifier.

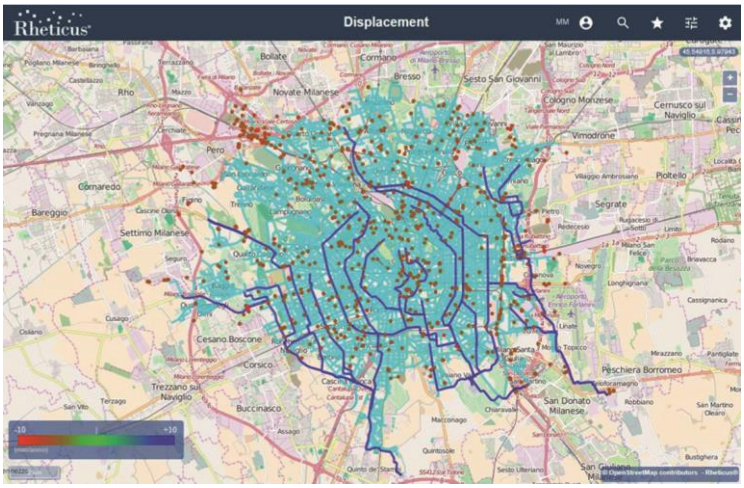
MM SpA (former Metropolitana Milanese SpA), the managing company of Integrated Water and Wastewater Services of the City of Milan, had been searching for a method to better understand the scenario of ground surface movements caused by the structural defect of its collector that could affect the area above the primary network and adjacent areas. The purpose was to prevent damage to surface structures (roads, buildings, services) by detecting the movements underway whose effects are not yet visible.

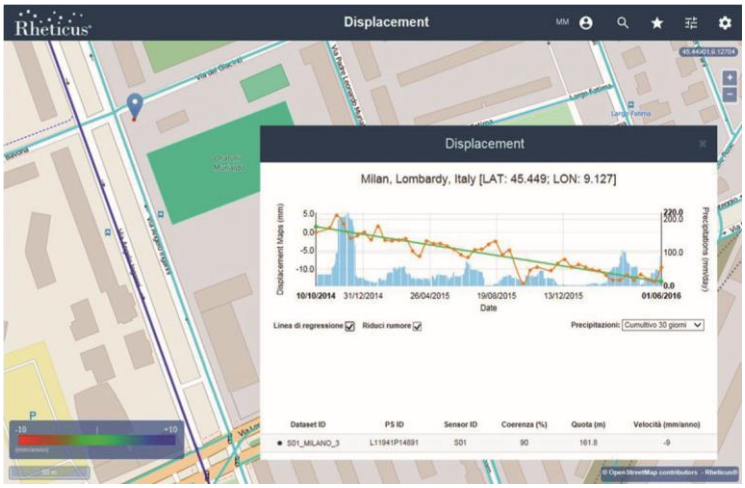
The choice of the method

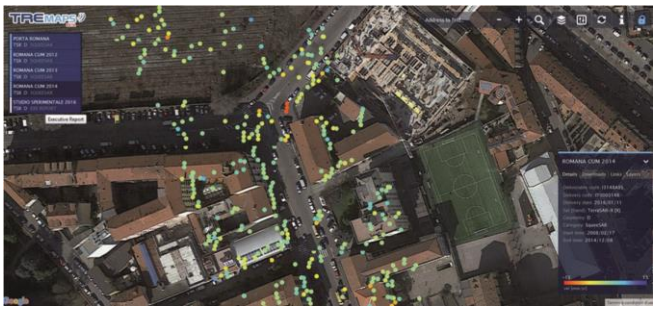
The desired survey method had to meet the need for a dense network of reference points within a linear development of the ducts and numerous intersections between main and secondary collector systems.

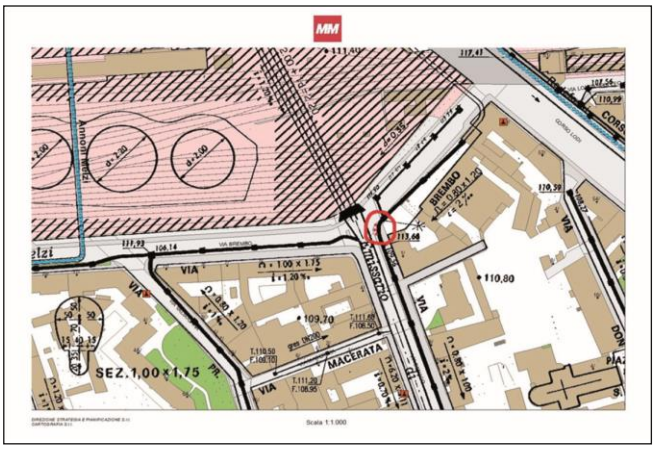
For an assessment of the subsidence trend, a time series of past movements was required to build a future trend scenario.

In view of the millimeter-long displacement of structures and resulting hyperbolic extent of damage, a method for guaranteeing a greater precision in detecting vertical movements compared to other technological surveys, such as GPS, was sought to obtain the best results. MM SpA also aimed for a cost-effective solution that did not require the installation of instruments or









their maintenance and suitable for low budget and time-restricted surveys.

Satellite Radar Interferometry - SAR

The advanced satellite-based techniques for detecting the Earth's surface displacements are known as SAR interferometry (InSAR). The radar systems, in particular, SAR (Synthetic Aperture Radar) radars are capable of measuring the distance between the sensor and the target on the ground, recording the time elapsed between the electromagnetic wave emission and reception of the backscattered signal from the target itself. Thanks to their periodic acquisition, SAR data provide repeated measurements of the sensor-target distance along the satellite's direction of sight. A comparison of the distances measured in different time points allows calculating potential displacements of the targets on the ground. The conventional technique employed to study SAR data is differential interferometry (DInSAR), which is based on a comparison of two distinct images acquired on the same area of interest. Over the years, the development of advanced remote sensing techniques based on multi-image analysis has enabled to bypass the typical limitations of interferometry in order to obtain accurate and quantitative measurements. Today, satellite surveys allow: measuring millimetric surface deformations; studying the evolution of displacements in time and processing periodic trends, based on a series of acquired data, to identify non-linear movements; determining the horizontal and vertical displacement speed of points; performing multi-scale analyses; and integrating other data sources.

Application in the Milan sewerage network

The collector in Via Brembo

Thanks to a collaboration with TRE ALTAMIRA, and through an analysis of the data received from the TerraSAR-X satellite, a movement speed of 13.79 mm/year (2014) was detected in three points. Upon inspection of the duct, it was found that the target's movement on the ground was due to a partial replacement of the sewerage system with a duct substantially smaller in diameter.

Road conditions in sustained traffic

The substructures of roads with heavy traffic are the most stressed and may give rise to subvertical soil movements, which have a high probability of determining collector failure and exacerbating the subsidence. Thanks to the Rheticus® platform owned by Planetek Italia that processes the interferometric data of Sentinel satellites, we have identified approximately 50 points with sensitive sub-vertical movements on 24 roads with heavy traffic, which will be investigated in a detailed field survey.

Conclusions

Satellite radar interferometry resulted in being the most accurate and affordable survey method to prevent and detect potential sewerage failures, even in relation to the high traffic volume of metropolitan cities like Milan.