

# Satellite technology to detect millimetric surface deformation in Tunnel construction



## ❖ Satellite technology to detect millimetric ground motion

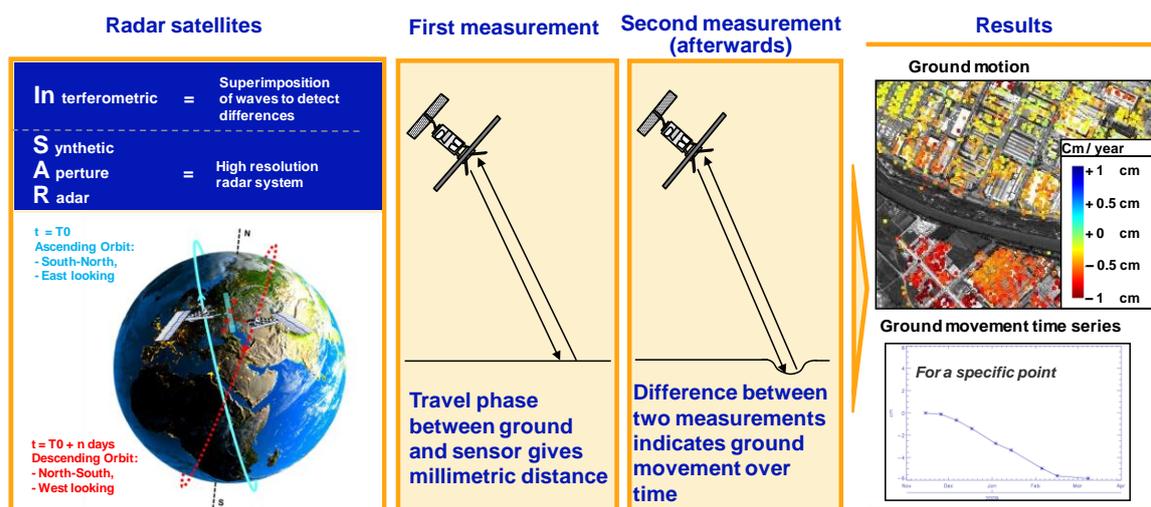
InSAR SPN technique is able to detect ground movements on the Earth's surface with millimetric precision by detecting permanent reflectors on the surface and measuring their movements with successive satellite passes over the same area

ALTAMIRA INFORMATION has developed and implemented InSAR SPN technology using radar satellite images to detect and measure surface ground movements with millimetric precision allowing monitoring deformations caused by excavations during underground infrastructures construction and prior to them.

The range of movement that can be measured using this technique depends on the satellite and the number of images used for the period of the study.

This remote sensing technology is particularly effective in studying cities, as buildings and infrastructures serve as almost perfect reflectors to the radar signal.

## What does "InSAR technology" mean?



**Ground movement is measured with radar satellites, comparing the satellite distance at different moments of time.**

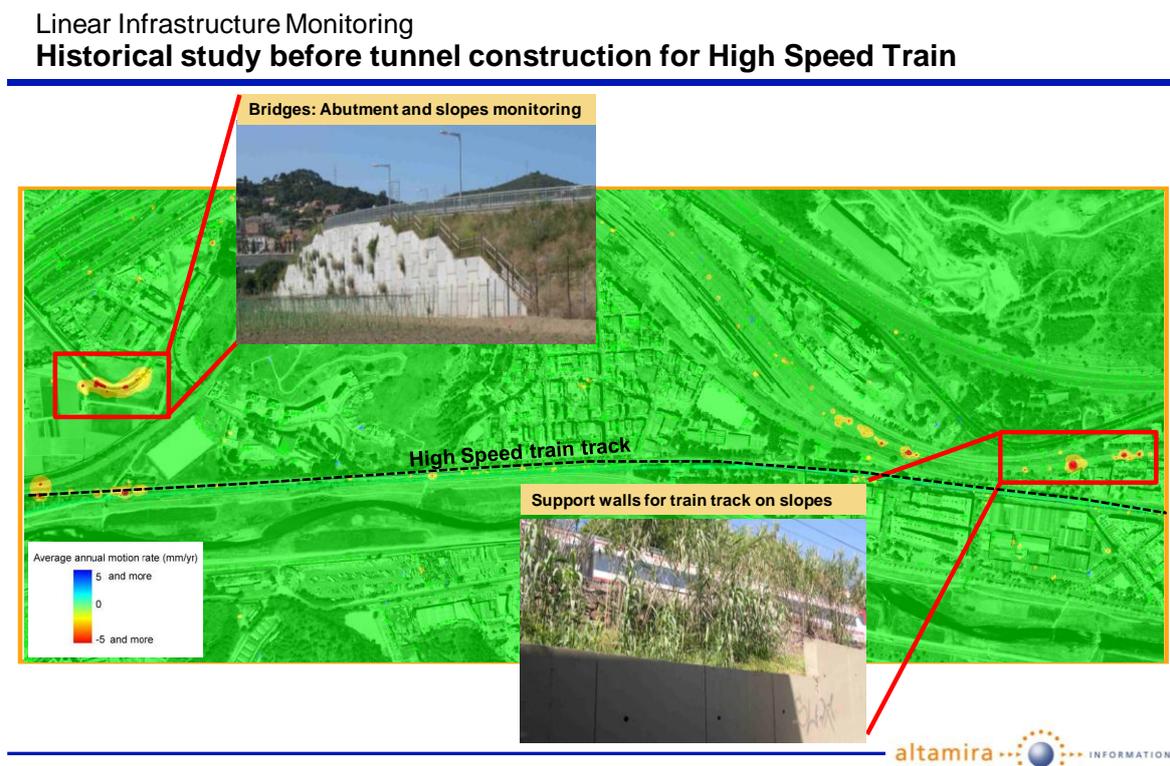
Figure 1. Principles of InSAR technology

### ❖ *Historical studies to reveal the uncertain before construction*

Extensive radar images archives including data from 1992-onwards are available. These archives make possible to perform historical studies of ground deformation for long periods of time and covering very large areas thanks to the dimensions of the radar images.

Taking into account that the smallest radar image is 40x40km wide, if the reflectivity of the area is high for the radar signal, as is the case in urban areas, InSAR technology can provide ground deformation data for wide areas with very high precision (+/- 3 mm per measurement) and very large density of measurements points (from 1.000 up to 25.000 points/km<sup>2</sup>) -

These historical studies will reveal the areas already affected by movements before tunnelling works start.



**Figure 2. Principles of InSAR technology**

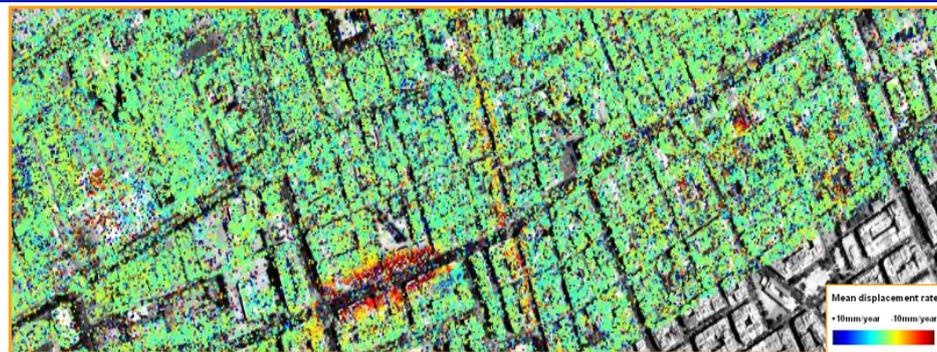
### ❖ *Monitoring while tunnelling: the advantage of surveying a wider area with millimetric precision*

This technology can also provide deformation measurement updates of the reflection points on the ground as the satellites can be programmed for future acquisitions.

ALTAMIRA INFORMATION has implemented this technology in several projects to monitor the surface of cities such as Madrid, Barcelona (Figure 3), Bilbao, London, Santiago de Chile and Warsaw, amongst others, where Metro lines have been constructed. InSAR SPN results show several areas of subsidence coinciding in time and space with the construction timing and areas tunnelled for the metro.

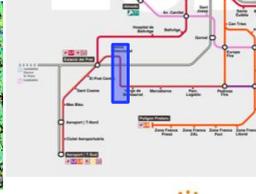
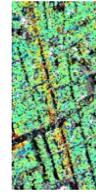
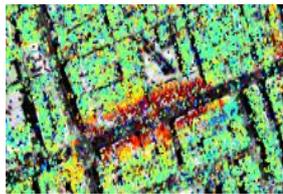
In some occasions the results show movements on buildings and structures starting during tunnel construction and movement acceleration in areas previously affected by movements when the construction starts.

Subsidence areas detected in Barcelona (2007-2009)  
**Barcelona Metro Line 9 and underground car park**



**Underground car park construction**

**Metro construction**



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**Figure 3 Surface movements due to the construction of a car park and Metro Line 9 (Barcelona)**

In conclusion, it is important to highlight the promising future of InSAR technology with the launch of new radar satellites improving every time spatial and temporal resolution. This means an enormous improvement in the detection, measuring capabilities and evolution analysis of ground movement with radar satellites.

***To learn more about it please visit us at Booth X6  
and come to our technical session on 23rd May  
World Tunnelling Congress 2012***

***Technical Session 23th May 15:30 -17:00***

***“Urban Tunneling and the Advantages of Using InSAR SPN Satellite Technology  
to Detect and Monitor Surface Deformation” M. De Faragó and G. Cooksley***

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