Leica Geosystems TruStory
Building a Precise Monitoring Network

The structures that accompany our everyday seem static and unalterable to our eyes. Weather conditions, aging, human activity, geological changes and other factors alter these structures and pose a challenge for engineers that strive to maintain the health of the constructions that our economies and daily lives depend on.

Structural behaviours are not always predicable by design and simulations. An unexpected bridge failure cannot just prevent you from arriving to work or getting back home. A lack of proper monitoring and maintenance can also result in the total isolation of cities and even in the loss of lives. Engineers, therefore, need to detect in an accurately and timely manner any structural movements under all natural physical conditions.

To gain knowledge of the integrity and changes of any structure, engineers today have Structural Health Monitoring (SHM) tools to obtain a clear picture of the current state, degradation and evolution of any structure to make fast informed decisions.

Led by UbiPOS UK as the prime contractor, consortium members including academics from the University of Nottingham's Geospatial Institute and industrial partners from Leica Geosystems, GVL, Amey, Transport Scotland and China Railway, are developing GeoSHM (GNSS and observation for Structural Health Monitoring), a system to provide users with an integrated solution to monitor and assess in real time the operational conditions of different types of assets. Aware of the challenges to maintain the structural safety and operation of long span bridges, the European Space Agency (ESA), has supported the grant through the Integrated Application Promotion (IAP) Programme.

The complete picture

It is of critical importance to have the ability to monitor remotely and in real time any asset. GeoSHM uses real-time data gathered with Leica Geosystems GNSS receivers and software to analyse the operational conditions of bridges with the GeoSHM Deformation Analyst that is developed by the consortium.

Leica Geosystems GNSS monitoring systems provide the complete picture by producing 3D real-time displacements and tilt of the bridge. GeoSHM converts data into useful information to end users and delivers it through a web-based interface that provides precise deformation information that allows bridgemasters to understand the loading and response effect of the bridge under normal loading conditions.

Bridgemasters can measure the performance of structural design models against the current conditions to identify unusual deformations under extreme weather conditions and detect movement at millimetre level. When deformations surpass designated parameters, the GeoSHM Deformation Analyst issues an early and emergency warning. In this way, GeoSHM provides a service that offers 24/7 monitoring, and facilitates a targeted maintenance by identifying structural failures promptly and assessing the bridge after an event.

"We selected Leica Geosystems products for their high positioning precision and reliability. The GRIO, the GM30 receivers and the Leica GNSS Spider software are stable, easy to use, and provided excellent results," said Dr. Xiaolin Meng, GeoSHM project leader from Nottingham Geospatial Institute. "Integrating Leica Geosystems GNSS technology allowed us to simplify our process, save time, and remotely control and monitor the status of the project."

The test platform

The Forth Road Bridge, a long span suspension bridge in east central Scotland, was the test bed for GeoSHM. The bridge was inaugurated in 1964, the longest steel suspension bridge in Europe at that time. When the bridge was designed in the 1950s, engineers could not predict the increasing traffic this crucial corridor between south-east and north-east Scotland would need to support. Initially designed to sustain a traffic of 30,000 vehicles per day, the bridge can normally be exposed to support twice the traffic it was originally designed for.

The Forth Road Bridge, like many other span suspension bridges, must defy the most challenging conditions, such as unexpected deformation, unusual traffic loading, temperature changes, high winds and extreme tides. Bridgemasters and infrastructure managers, therefore, have an urgency to understand the behaviour to develop a maintenance programme that allows access to a rapid, targeted, and automated assessment of the bridge's health to assure cost efficient maintenance and management.

A sensor network you can trust

Currently the GeoSHM service collects the Forth Road Bridge data from four permanent Leica Geosystems GNSS receivers and two anemometres to measure the speed of the wind, but the programme will be further expanded by the consortium. The Leica GNSS Spider software provides the professional solution for controlling and operating the installed GNSS reference stations and networks. The GNSS receivers collect and stream out data through Leica Spide via internet processing in real time, providing the positioning to analyse the bridge health status with the GeoSHM Deformation Analyst.

One Leica GRIO reference station was set on top of the bridge and three Leica GM30 monitoring receivers where set throughout the bridge to acquire the data from the GNSS satellites and sent via optic fibre network to a local hub. GNSS data is sent for processing through secure internet connection to the Central Processing Centre at the University of Nottingham where it is integrated with the data collected from the bridge sensors to generate changes in deformation and displacement information with millimetre accuracy and high resolution. At the Control Centre, the further processed GNSS data as deformation information is combined with InSAR, a radar technique used in remote sensing, to measure long-term structural trends and local environmental effects.

A proven solution

Using Leica Geosystems monitoring technologies, together with other sensors, the GeoSHM project aims to establish a state-of-the-art system that can address the challenges in structural deformation monitoring of long bridges, and other critical infrastructure, with a model that combines reference monitoring systems with the engagement of multiple stakeholders. As a next stage of development, GeoSHM will be expanded on a selection of bridges in China.

Using Leica Geosystems GNSS solutions that are empowered with the GeoSHM Deformation Analyst engine, GeoSHM has demonstrated that having a deep understanding and monitoring of this critical transport infrastructure can extend and safeguard the lifetime of aging bridges. Leica GNSS Monitoring Solutions provide vital information to reduce the maintenance costs with a targeted approach of inspections and timely identification of potential structural damage.

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- when it has to be **right**