The Jacques-Cartier Bridge in Montreal, Canada. Photo reproduced under the Creative Commons Attribution Share Alike 2.5 Generic Licence

Bridging the gap

Cristian Rossi looks at the challenge of bridge maintenance, the benefits of SAR satellite imagery in spotting structural problems, and the development of new decision support software that brings the two together

Cristian Rossi
is Principal Earth Observation Specialist with the Satellite Applications Catapult at Harwell, Didcot, Oxfordshire (www.sa.catapult.org.uk)

Bridges are infrastructures we traverse in everyday life. They help us cross boundaries, connect people and transport goods and, as with every critical infrastructure, they need careful and regular maintenance. Many are in urgent need of refurbishment and face challenges of limited capital investment and inflexible inspection and maintenance regimes. Another important challenge is climate change and which affects the structural health of bridges.

Although rare events, bridges may collapse with tragic consequences as happened in Genoa in August 2018 when 43 people died. To guard against such events, bridges are generally inspected every two years to identify structural problems and plan for their remediation. However, difficulties may arise in inspecting hard-to-reach locations or in identifying invisible signs of deterioration. Moreover, the inspection frequency may be insufficient to tackle escalating problems.

Help from on high

Can satellites help in this context? Several hundreds of satellites are monitoring our planet every day, with some of them able to measure the subtle displacements of infrastructures. These satellites carry radar sensors and are called 'Synthetic Aperture Radar' or SAR. These sensors have highly desirable qualities in providing weather-independent imagery with a resolution up to 25cm.

The measuring of displacement requires several images taken at different times, as well as advanced processing techniques that can detect millimetre-level movement in ground structures. Ground motion maps have been validated for several scenarios over the past 20 years and the Earth Observation industry providing this service is growing. But how can this support bridge maintenance?

Recent studies published in the scientific literature have demonstrated how anomalous bridge motions may have a strong correlation with their subsequent collapse. Selvakumaran *et al*. reported in the *International Journal for Applied Earth Observation and Geoinformation* about a collapse case for a masonry bridge in Tadcaster, UK, in December 2015, and found anomalous measurements at the collapse location with an increasing displacement value.

Milillo *et al*. reporting in the journal *Remote Sensing* about the Morandi bridge collapse in Genoa also found that satellite measurements indicated an increased acceleration in anomalous behaviour in the collapse area.

First-of-its-kind tool

It is in this context that Britain's Satellite Applications Catapult has partnered with the National Research Council of Canada to build a decision-support tool for end-users and asset owners in charge of bridge maintenance and inspections.

This tool, called BRIGITAL, will be able to integrate data from different sources (e.g. satellites, sensors, numerical models and visual inspection reports), to deliver performance indicators on structural stability and safety, and assist asset owners in their decision making.

Several consultations are being conducted to understand end-user needs and implement them in BRIGITAL. This project - the first of its kind - is currently in its initial phase ... one focused on the visualisation of data and the provision of related information. Early warning systems providing advance indications of failure are of vital importance, and the current satellite technology can be exploited to address corrective actions in a timely matter.

The BRIGITAL tool being tested on the Jacques-Cartier Bridge that crosses the Saint Lawrence River in Montreal, Canada. (see image top of page). Screen shot courtesy Satellite Applications Catapult

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