UNIVERSITY OF CAMBRIDGE

**Transforming construction: impact case study**

**Benefits to industry:** innovation, whole-life performance monitoring, design optimisation. Collaboration delivers value to all stakeholders, including researchers, asset owners and asset managers.


# Bridging the gap: why collaboration between industry and academia produces innovation that delivers value to all stakeholders

## The challenge to industry

In this digitally-abundant age the case for Smart Infrastructure – the result of combining physical infrastructure with digital infrastructure to provide improved information to enable better decision making, faster and cheaper – is both strong and pressing. Inadequate infrastructure is currently estimated to cost the UK £2 million a day (UKCRIC) and Smart Infrastructure is a global opportunity worth up to £4.8trn (Smart Infrastructure: Getting more from strategic assets.

The ICE State of the Nation 2017 report calls on industry and government to use the modern Industrial Strategy to drive the uptake of digital technology and data in infrastructure design and delivery. By building upon pioneering work in digital engineering, government and industry could improve the performance of UK infrastructure and support economic growth.

Innovation will be key to enabling the UK construction industry to improve performance, compete in international markets and become a world leader in Smart Infrastructure. Major infrastructure projects, including Crossrail and HS2, are adopting innovation as a driving force, but wider industry take-up is required for change to be truly transformative.

It is vital for industry to invest in new technology – the economy of this country depends on having modern, fit-for-purpose infrastructure – and collaboration between industry and academia is key to this investment.

## The proposed solution

Collaboration between industry and academia can drive innovation. The Laing O'Rourke Centre (LOR Centre) for Construction Engineering and Technology works with The Centre for Smart Infrastructure and Construction (CSIC), at the University of Cambridge, providing Co-Investigators to lead appropriate projects. CSIC is a hub for the infrastructure and construction industry. CSIC brings together leading academics and industrialists (Industry Partners), developing

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a faster route for innovation adoption, providing an ecosystem for building confidence in new innovations and enabling their timely implementation and exploitation. This model of collaboration implements innovation and brings shared benefits to all stakeholders, including researchers, asset owners and managers and the end users.

## The project

The Staffordshire Alliance, which includes Laing O'Rourke, Atkins, Network Rail and VolkerRail, is an award-winning example of the value of collaboration. By working together, this multidisciplinary team successfully delivered the Stafford Area Improvements Programme (SAIP), a £250 million rail upgrade and development project on the West Coast Main Line, under budget and more than one year ahead of schedule.

## The innovation

CSIC and the Laing O'Rourke Centre engaged with the Staffordshire Alliance at the early stages of this project to deploy novel fibre optic sensor (FOS) networks for use in short and long-term performance monitoring, delivering the most comprehensively instrumented new rail bridges in the UK. This achievement was largely possible due to Laing O'Rourke's drive to include innovation as an integral part of this project from the beginning.

More than 500 discrete FOS and in excess of 600 metres of distributed FOS cable were installed on two of the 11 new bridges being constructed as part of the scheme. The pervasive network of fibre optic strain cables, akin to a nervous system in a living organism, can sense strain changes in a structure caused by external forces. The bridges, completed in April 2016, are more than just passive masses of concrete and steel – they act as 'self-sensing' structures capable of informing asset managers and engineers of their changing condition.

## Added value

Data generated by sensor technologies enables the continued monitoring of an asset throughout its construction and productive lifecycle.

The monitoring system has the potential to be controlled remotely, allowing data to be collected, analysed and assessed in real time from an asset manager's office. Based on the analysed data, the system can provide evidence for removing the uncertainties when determining additional structural capacity in the future. Using real performance data gathered over time to inform maintenance schemes will represent a step-change in how these types of assets will be managed in the future.

## Benefits to industry

Instead of operating as separate entities, industry and academia can become strong allies in driving innovation, reaping its associated benefits, while contributing to transforming the way infrastructure is designed, built and managed.

The benefits of this productive alliance between academia and industry are numerous and all stakeholders benefit.

The data gathered from each bridge offers the asset constructor, Laing O'Rourke, and the bridge owner Network Rail, a 'bridge structural health passport', enabling them to access information on the performance of their assets throughout the construction process, providing the quantifiable means on which to confirm the quality of workmanship.

For designers Atkins, the 'self-sensing' bridges can provide critical information about the actual stresses and strains that the bridges experience under real loading conditions – information that most engineering designers simply do not have access to. Understanding of the performance of infrastructure through structural health monitoring, both during its construction and throughout its design life, enables fresh thinking in future railway bridge design to minimise use of materials, energy and labour while still ensuring resilience.

The project has led to the development of procedures to integrate sensing technologies during on-site and off-site construction in concrete bridge beams, on steel beams, in prestressed concrete railway sleepers, and within concrete bridge decks.

In terms of the wider impact, the installed fibre optic sensor networks will continue to provide a real world laboratory for studying the behaviour of railway bridges for many years to come.

The Laing O'Rourke Centre for Construction Engineering and Technology, in the University of Cambridge Department of Engineering, was launched in 2011 with industry partner Laing O'Rourke to fulfil a shared vision of transforming the construction industry through innovation, education and technology.

### Case study

This case study is by Dr Liam Butler, Research Associate at the Centre for Smart Infrastructure and Construction, Department of Engineering, University of Cambridge (2017). For more information see:


- **Butler LJ** (2016). Smart alliances make for smarter infrastructure. Infrastructure Intelligence magazine. Association for Consulting and Engineering, 21 November/ December, pg. 30.
- **Butler LJ** and de Battista N (2017). Railway bridge condition monitoring through integrated fibre optic sensing. Rail Technology Magazine, Cognitive Publishing Ltd.


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