

# Infrastructure resilience in an interdependent world



*Summary of collaborative workshop held on 2 July 2015, which examined infrastructure resilience and interdependencies with innovative UK research programmes*

The UK's infrastructure sector performs a vital role in supporting the economy and society, and in protecting the environment. The importance of infrastructure in a national strategic sense and in enabling society and commerce on a daily basis is well recognised. However, its vulnerability has also been highlighted on many occasions in recent years. The solution to many of the challenges currently faced will depend on the development and application of new evidence and knowledge from research.

In response to these challenges the following three major stakeholder-led projects are undertaking innovative research to deliver evidence-based recommendations, tools and models to help shape the way the UK's future infrastructure is planned and implemented:

- Infrastructure Business Models, Valuation and Innovation for Local Delivery (iBUILD)
- International Centre for Infrastructure Futures (ICIF)
- Infrastructure Transitions Research Consortium (ITRC).

Infrastructure is a complex, interdependent system with a range of stakeholders including investors, operators and users. By working directly with stakeholders, these projects aim to provide outputs of relevance to practitioners at the local, regional and national scale. Between them, they represent £12m of investment by the Engineering and Physical Sciences Research Council (EPSRC) and the Economic and Social Research Council (ESRC) over seven years.

## Workshop aims and objectives

The importance of maintaining high standards of infrastructure

A number of workshops held during the course of the day explored issues of infrastructure resilience and interdependencies, and the implications of the latest evidence-based research findings. Participants were invited to take part in all workshop topics to share perspectives and better understand critical areas for practitioners where further research is needed.

Each workshop was jointly planned, developed and facilitated by iBUILD, ICIF and ITRC and considered cross-cutting themes from the three research programmes. These included current challenges faced by practitioners around infrastructure interdependencies (technical, processes and business models), and how these are being addressed by the current research landscape:

- Capturing the value of resilience – the business case for investment.
- Making use of data to identify and manage critical interdependencies.
- The issue of scale: interface between local, national and international scales.
- Value of considering a service-oriented approach to help with planning, identifying interdependencies and quantifying the risks of infrastructure failure.

The conclusions of these collaborative workshops are examined in three related briefings.

performance is well recognised for the functioning of society and commerce, quality of life, and in supporting sustainable national economic growth. However, its vulnerability has also been highlighted on many occasions in recent years due to impacts of environmental changes and hazards, increased user demands, and the historicity of assets. As infrastructure systems have been continually expanded, improved, and modified over the years, complex interdependencies have developed at both national and local levels. Infrastructure stakeholders (eg investors, commissioners, operators and regulators) face cross-cutting challenges relating to the provision of current and future infrastructure. Infrastructure planning, design and operation is increasingly being considered as a complex interdependent system, and can no longer be viewed as a series of discrete assets or sectors.

On 2 July 2015 a collaborative workshop *Infrastructure resilience in an interdependent world* was held bringing together industry practitioners and researchers from these three major research programmes (iBUILD, ICIF and ITRC),

to explore issues of infrastructure resilience and interdependencies, and the implications of the latest evidence-based research findings. It was facilitated by the Adaptation and Resilience in the Context of Change Network (ARCC network) and CIRIA. Delegates had the opportunity to hear about current ongoing work in these programmes, and to take part in workshops looking at key topics relating to infrastructure resilience, further engage with research and ensure future research responds to industry's challenges.

Summaries and conclusions of the day are discussed in this briefing, and in more detail in the related briefing notes, which are listed at the end of this note.

## Resilient and inclusive infrastructure

Since 2010 the National Infrastructure Plan and the National Infrastructure Pipeline have provided a more integrated approach to the assessment, planning and investment of infrastructure. However, in recent years, interdependent and deteriorating infrastructure assets that have a reduced capacity to adapt to increased use, growing population

**Table 1 UK regulators network summary of resilience roles (from UKRN, 2015)**

Resilience role	CAA	FCA	Ofcom	Ofgem	Ofwat	ORR
Resilience duties	Yes	Yes	Yes	Yes	Yes	Yes
Including cross-sector resilience?	Not explicitly, but implicit in general resilience	Not explicitly, but implicit in general resilience	Not explicitly, but implicit in general resilience	Not explicitly, but implicit in general resilience	Not explicitly, but implicit in general resilience	Not explicitly, but implicit in general resilience
Issued general rules/guidance on measures/outcomes	Yes	Yes – general rules and guidance	Yes – guidance	Yes – eg via price control incentives	Yes – via price review	Yes – via price review
Involved in setting or agreeing specific measures or outcomes	Yes	Yes – review current practice and request changes	No – although may require changes as part of enforcement	Yes – eg via price control incentives	Yes – via price review. Moving to outcome based	Yes – via price control

or extreme weather events have highlighted their weaknesses.

Addressing delegates of the workshop, Keith Clarke, Vice President of the Institute of Civil Engineers (ICE), challenged the civil engineering community to consider the current standards, approaches and attitudes to the performance, resilience, capacity and condition of the UK’s infrastructure networks, in the UK and globally. Reconsidering current accepted approaches to infrastructure design and maintenance are required, as over designing and over compensating to increase the range of normal and reduce stress is common, and usual accepted solutions are often carbon intensive and expensive to maintain on long-term global levels.

Referencing the ICE *State of the Nation* report (ICE, 2014), he highlighted the challenges and projected impacts affecting future infrastructure from changing environmental conditions, increased populations and capacity requirements, to current societal expectations of available infrastructure.

The ICE (2014) report focuses on the performance, resilience, capacity and condition of the UK’s infrastructure networks. It also analyses the economic, social and environmental benefits of infrastructure. The key message from this is that the infrastructure sector is becoming increasingly complex and interdependent with many aging assets, presenting new challenges that cannot be solved

with old solutions, but depend on the development and application of new evidence and knowledge from research and innovation.

There are many barriers for infrastructure sectors in adopting or applying new research and innovation. As a monopoly industry, it requires a different environment for innovation compared with faster moving industries that are influenced by competition. Its traditionally risk-averse culture can be attributed to public scrutiny, a ‘compliance’ and mind-set related to tight regulation, and complex supply chains involving many roles, types of contract, and commercial interfaces.

However, there are also increasing opportunities for the UK civil engineering community to demonstrate their expertise through a continued commitment to research, innovation and development of best practice, as the UK moves towards a lower carbon, more intelligent provision of infrastructure and services. Investing in research can be used to address targets across other areas such as environment, carbon reduction, health and safety, or user experiences, as well as improving efficiencies and lowering costs in design, construction, and maintenance.

### Regulators landscape

Providing an overview of the regulatory aspect of resilience, John Holmes, the Office of Rail and Road (ORR), and representing the UK Regulators Network (UKRN), outlined the framework within which economic

regulation is applied and how this concerns service quality and value. Regulation is a process that balances the needs of competing stakeholders concerned with service quality and consumer interest, and a range of duties such as safety, economic regulation, and competition. These are particularly important for monopoly networks where market competition may not exist, infrastructure being a prime example.

Economic regulation sits within a statutory framework, which is set by parliament and increasingly European Commission regulations. Within this there are legal frameworks such as licence conditions and obligations, and regulatory tools including price controls, supervision, reporting, and enforcement within legal processes.

There are a number of regulators involved with the infrastructure sector with differing levels of responsibility during significant interruptions and different roles and obligations specifically towards resilience.

An increasing number of regulators are now asking for resilience reviews to be undertaken as a measure to ensure ongoing service and sector capability. This increasing focus will begin to affect business operations and subsequently lead to the need for new and innovative solutions to ensuring infrastructure resilience.

One example is the Water Act 2014, a new statutory duty for water and wastewater networks. This Act requires long-term resilience to environmental pressures, population growth, and changes in behaviour by promoting appropriate planning and investment,

and measures to manage water resources in sustainable ways, increase efficiency and reduce demand.

However, it is recognised that cross-sector resilience remains to be addressed by regulators as the remits are limited and cross-sector issues tend to be more difficult to enforce or address through regulation. Interdependencies will be one of the biggest challenges for infrastructure in future years.

## Long-term infrastructure investment priorities

Richard Ploszek, Infrastructure UK (IUK), provided an overview of the remit of IUK within HM Treasury and how they consider long-term infrastructure spend priorities for new build and refurbish/retrofit of existing infrastructure. IUK is responsible for co-ordinating and simplifying the planning and prioritisation of investment in UK infrastructure and improving it by achieving greater value for money on projects and transitions. It considers resilience as a strategic priority for investment decisions as the ability of assets, networks and systems to anticipate, absorb, adapt to and/or rapidly recover from a disruptive event. Considering the vast network of infrastructure at national and local level that exists across the UK, the varying levels of upkeep, historic assets, over-capacity assets and areas where interdependencies have built up, a national view of this increasingly complex 'system of systems' is required.

Improving the understanding of these interdependencies brings new opportunities for better resilience enabling and properly valuing 'passive provision' to allow future proofing of resilience in new assets. In addition, good design of new infrastructure assets can improve system resilience, which are also key priorities for IUK. Considering pre- and post-event issues, research and studies into sharing infrastructure corridors to reduce land takes and engineering costs, geospatial analysis of network densities, identifying synergies and strategic planning are providing new solutions to increasing resilience without prohibitive costs.



Figure 1 Cabinet Office framework of components of infrastructure resilience (from Cabinet Office and IUK, 2010)

IUK future priorities for increasing national resilience will include:

- 1 Valuing infrastructure spend provides better guidance on passive provision and resilience measures, but need better understanding of network and non-marginal values they bring.
- 2 Work on 'smart infrastructure' implementation for Ebbsfleet – taking a cross-sectoral, comprehensive view of utilities provision in a large (15 000 dwelling + 1M sqft commercial) brownfield development.
- 3 Working closely with UKRN on their cross-sectoral resilience study.

## Participating research consortia

### *The Adaptation and Resilience in the Context of Change network (ARCC network)*

Bringing together research, policy and practice communities, the network supports collaboration to create robust built environment and infrastructure sectors. The ARCC network promotes co-operative working between practitioners and academics, and facilitates the sharing of information and knowledge more widely to deliver benefits to society, the economy and the environment.

For more information go to: [www.arcc-network.org.uk](http://www.arcc-network.org.uk)

### *Infrastructure Business Models, Valuation and Innovation for Local Delivery (iBUILD)*

Developing new business models to improve the delivery of infrastructure systems and the services they support at the neighbourhood, town and city scale. These models will better exploit the technical and market opportunities that emerge from the increased interdependence of infrastructure systems.

For more information go to: <http://research.ncl.ac.uk/ibuild/>

### *International Centre for Infrastructure Futures (ICIF)*

Creating new ways of bringing together stakeholders involved in renewing the UK's infrastructure to exploit structured, multidisciplinary systemic thinking about infrastructure interdependencies when developing new business models. This research will be embedded in the international context.

For more information go to: [www.icif.ac.uk](http://www.icif.ac.uk)

### *Infrastructure Transitions Research Consortium (ITRC)*

Delivering a new generation of simulation models and tools to inform the analysis, planning, design and operation of national infrastructure systems at a national scale. This includes new methods for analysing performance, risks and

interdependencies to provide a basis for cross-sectoral and long-term decision making and investment.

For more information go to:

ITRC: [www.itrc.org.uk](http://www.itrc.org.uk)

NISMOD: [www.itrc.org.uk/nismod/nismod-models](http://www.itrc.org.uk/nismod/nismod-models)

#### Briefing notes series 'UK research of infrastructure resilience'

This briefing is one of a series that presents summaries and conclusions of the workshop 'Infrastructure resilience in an interdependent world' held on 2 July 2015 with ARCC, iBUILD, ICIF and ITRC. The full series includes:

- Infrastructure resilience in an interdependent world (CIRIA ref: 08-01-16)
- Use of Data and critical interdependencies (CIRIA ref: 08-02-16)
- The issue of scale (CIRIA ref: 08-03-16)
- Capturing the value of resilience (CIRIA ref: 08-04-16)

## References

CABINET OFFICE (2010a) *Section A: Introduction, definitions and principles of infrastructure resilience*, Cabinet Office, London, UK. Go to: <http://tinyurl.com/ob428jy>

CABINET OFFICE (2010b) *Strategic framework and policy statement on improving the resilience of critical infrastructure to disruption from natural hazards*, Cabinet Office, London, UK. Go to: <http://tinyurl.com/pzsut2y>

ICE (2014) *State of the Nation: Infrastructure 2014*, Institute of Civil Engineers, London, UK. Go to: <http://tinyurl.com/otfprur>

HM TREASURY and IUK (2010) *National Infrastructure Plan 2010*, HM Treasury and Infrastructure UK, London, UK (ISBN: 978-1-84532-785-9). Go to: <http://tinyurl.com/ncnhrzp>

UKRN (2015) *Cross-sector resilience – Phase 1 report*, UK Regulators Network, UK. Go to: <http://tinyurl.com/j2wfhc4>

### Statutes

Water Act 2014 (c.21)

### Websites

ARCC: [www.arcc-network.org.uk](http://www.arcc-network.org.uk)

ESRC: [www.esrc.ac.uk](http://www.esrc.ac.uk)

EPSRC: <https://www.epsrc.ac.uk>

ICE *State of the Nation*: <http://tinyurl.com/ojfg8jw>

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