Tools for resilient infrastructure
London
5 February 2019
ABOUT THE RESILIENCE SHIFT

The Resilience Shift exists to inspire and empower a global community to make the world safer through resilient infrastructure. More people than ever depend on the critical infrastructure systems that provide essential energy, water, transport and communications services, and underpin food, healthcare and education. When this infrastructure fails the consequences can be catastrophic.

Supported by Lloyd’s Register Foundation and Arup, the Resilience Shift provides knowledge and tools for those responsible for planning, financing, designing, delivering, operating and maintaining critical infrastructure systems. Our aim is to ensure infrastructure systems are able to withstand, adapt to, and recover quickly from anticipated or unexpected shocks and stresses - now and in the future.

DEFINING RESILIENCE

Resilience is the ability to withstand, adapt to changing conditions, and recover positively from shocks and stresses. Resilient infrastructure will therefore be able to continue to provide essential services, due to its ability to withstand, adapt and recover positively from whatever shocks and stresses it may face now and in the future.

CITATION REFERENCE

Contents

Contents ........................................................................................................................................ 2
Introduction.................................................................................................................................... 3
Workshop objectives ..................................................................................................................... 4
Workshop findings ......................................................................................................................... 6
  Session 1: Demand .................................................................................................................. 6
  Session 2: Supply .................................................................................................................... 9
  Session 3: Support .................................................................................................................... 10
Workshop feedback .................................................................................................................... 13
Appendices ................................................................................................................................... 16
  Appendix A. Workshop participants ............................................................................................ 17
  Appendix B. Tool profiles ............................................................................................................ 18
Introduction

The Resilience Shift seeks to catalyze significant change in the way critical infrastructure is planned, designed, operated and maintained by making resilience tangible, practical and relevant. If this change happens, “engineered structures and infrastructure will be not only safer (do not fail) but also better able to assure the continuity of critical functions”.

The focus of the Resilience Shift is to do work, and support others to do work, that will shift the worldwide approach to resilience in practice. This will help practitioners involved in critical infrastructure to make decisions differently, so that it continues to function under both ordinary and extraordinary circumstances.

The Tools and Approaches Project, part of the Resilience Shift workstream ‘Making resilience tangible, practical and relevant,’ aims to identify, assess and promote adoption of the tools and approaches that contribute to enhancing the resilience of critical infrastructure, making them accessible to those who will benefit. The project has delivered a series of three workshops focused on tools and approaches to explore ways and means of implementing critical infrastructure resilience. The workshops brought together users (decision makers, influencers and practitioners) with a role in operation and maintenance of critical infrastructure with developers of tools and approaches to enhance resilience. Each workshop explored tools needed at different stages of the value chain for critical infrastructure.

The following hypotheses of the ‘Tools and Approaches’ project were put to the test at the workshops:

- A platform of some kind would drive adoption of resilience tools by connecting users to the tools they need and developers to potential users.
- A community around resilience tools to provide the necessary support and stimulate dialogue and collaboration.
- A value-based approach can be useful to help stakeholders on the critical infrastructure value chain to focus their resilience implementation thinking and efforts.

This report summarizes the key learnings from the ‘Tools for Resilient Infrastructure - London Workshop’.
Workshop objectives

The London workshop, held in London on 5 February 2019 and convened by the Resilience Shift, focused on organisations representing the Operate and Maintain section of the critical infrastructure value chain. Participants included a wide range of tool developers and potential users of such tools and approaches including government advisors, regulators and, infrastructure operators and owners, see Appendix A for full list of participants.

Facilitated by The Schumacher Institute, and applying an Action Learning methodology to facilitate conversations and implementation of change, the workshop built on the success of the first two workshops in this series, that took place in New Orleans and Washington DC.

At the workshop:

- Users explored a selection of tools and how the tools create or may create value for them in existing or pipeline projects.
- Developers learned what users need from tools and have received feedback on the use and value of their tools.
- Users and developers gained insights on what inputs and outputs are required for tools to be most useful.
- Users and developers provided input to a potential platform of tool resources to share opportunities, challenges, and tool solutions.
- Users and developers discussed the value of a continuing the conversations around tools and creating a community to support these efforts.
Workshop findings

Session 1: Demand

In this session, workshop participants were split in groups to discuss the challenges faced in implementing resilience, and any requirements for tools.

Below we describe the high-level themes of the discussion.

Definition of resilience

To start the session, delegates discussed some of the problems encountered in defining resilience. It was noted that resilience could be defined as a characteristic of a product or a situation, a process, or a target outcome. Clarifying this definition is key so that all practitioners and stakeholders across the world have the same interpretation of resilience. It is also important to have common definitions of resilience within sectors (water, energy, transport) to prioritise investments in resilience efficiently. Delegates also discussed the need to clearly connect the real-world outcomes of resilience (e.g. making people’s lives better) with resilience practice. This takes time to achieve.

“When engaging [with] stakeholders in [the] transport sector, many have their own definition of resilience, which is different, and this is not helpful […]. It’s important to take time to get to the right place to have a common understanding.” Workshop delegate

Aligning theory and practice

The discussion identified a gap between theory and practice in the field of resilience. Some people highlighted especially a perceived gap between the work and publications of academics and the needs of users and practitioners. Often academic papers are not easy for users to understand and can be difficult to translate into a practical language and real-world advice.

In addition to this, some practitioners mentioned that they had encountered difficulties in formulating useable advice. The balance between advice that is too specific or too generic is a fine one. Without paying special attention there can be effects on how widely applicable and useful the advice is.

The point was made that perhaps the difficulties in aligning theory and practice are part of a wider complexity in the field of resilience. Delegates pointed to a web of complex user problems, resilience literature, and tools with very little to help practitioners understand their interdependencies and uncertainties.

Working to deliver resilience on projects

Short-term and siloed thinking were perceived to be barriers to resilience in the experience of workshop attendees. Delegates were acutely aware of the need to address cascading effects deriving from the interdependencies between systems. Connected to this, attendees also debated the need for stakeholder buy-in across the value chain. These stakeholders are often
integral to the success of a project. However, this is at risk when they are not fully ‘bought in’ or aware of the bigger picture in relation to resilience. The example of the need to engage construction firms on long term maintenance requirements and operational needs was given. Understanding and communicating the connections between different individuals and stakeholders along the value chain is integral to ensuring the project delivers resilient outcomes in the long term.

In addition to this, participants were also keen to recognise the importance of ‘soft factors’ such as governance and leadership. This is a key theme in ensuring projects deliver resilience, and generally delegates felt that its importance is often under recognised in comparison to technical work.

“Resilience really is about people, they can relate to individual resilience for them personally, but it takes time for them to relate this to their day to day jobs, and why they should change processes.” Workshop delegate

Demonstrating value
Some of the participants raised issues surrounding the need to demonstrate the economic value and benefits of resilience measures to secure funding. Concerns were raised around the way in which data does not easily quantify the cost benefit of resilience. This is compounded by the lack of clarity around definitions of resilience and the apparent lack of a common understanding. Further to this, participants highlighted the difficulties of communicating, and developing ‘buy-in’ for, the bigger picture of resilience to stakeholders at different stages of the value chain.

Resilience standards
The workshop delegates identified the lack of a definitive source of wisdom to provide to communities for them to factor resilience into their own projects or standards. Connected to this, delegates identified the difficulties and complexity of adapting existing standards to incorporate resilience. These adaptations need to consider interdependencies and various future scenarios to ensure resilience. This is very difficult to build into a standard without a competent expert or practitioner who has experience in resilience. One possibility is to use a framework or structure for addressing resilience within standards. This could be supported by legislation and regulation to ensure the uptake of standards and resilience considerations, helping to address the issue of short- term thinking.

It was noted that another factor contributing to the success of standards is the need for buy-in at higher levels than technical committees. This could include engaging the funders / financiers / insurers to support and push for the implementation of resilience measures more actively. With respect to responses to shock events, delegates pointed out that different cultures react differently to different situations. This is often determined by whether the situation or event is familiar to them or not. (for example, some societies experience earthquakes or flooding far more regularly than others). This poses a challenge to establishing a common understanding of resilience that can be applicable across any society or geographical area.
Solutions
Following this the groups identified and discussed possible solutions to these issues, that could be supported by tools. Evidencing the need for the change and quantifying the effects of resilience are critical to demonstrating the value of resilience and building business cases for resilience investments. Doing this creates a clearer line of sight between tangible benefits and resilience work as well as allowing for a comparative assessment of projects or options. This will allow decision makers to optimise investment in resilience and also support the business case for resilience options. Tools that can create this data will be addressing a significant gap.

In addition to this, assurance standards would be helpful to give users confidence in the proposed outcomes of tools and help to accelerate their adoption. In addition to this, there is also the need to incentivise behaviour that contributes to or supports resilience. This could be done through extensive stakeholder engagement to get buy-in to the resilience bigger picture of the project, or through collective targets that reward all stakeholders for collective success.

In terms of current working arrangements and behaviours, delegates pointed to the need for a multidisciplinary approach to planning and design to address interdependencies and mitigate future cascading effects. The could include involving more environmental experts in the design and build phases of projects, as well as embedding future operational requirements into construction specifications and contracts. Conversely, delegates also highlighted the need for practitioners to take the time to gain a common understanding of stakeholder agendas, working collaboratively and communicating effectively to achieve resilience.

To embed more collaboration and a better line of sight, the importance of managing change effectively was also mentioned.
Session 2: Supply

Five tool developers presented to the audience detailing their tool and ways in which it is being used and accessed. The tools presented were:

1. CAESAR
2. Circle
3. City Resilience Index
4. RASTEP
5. TORC

Appendix 2 includes further details of the tools.

Tool developers then demonstrated their tools in a marketplace model with groups of users and experts who circulated between each ‘stall’, giving them the opportunity to interact with developers about their needs and possible usage of tools.

**Key questions generated by users for tools developers**

- How much input data does the tool require?
- What is the format of the tool? e.g. software, workshop, consultancy, training, webinars, documentation, customisation.
- What is the output of the tool? e.g. ROI of resilience, ‘health’ indicators, benchmarking, resilience “score”, prioritisation matrix.
- What is the focus of the tool? e.g. response, planning, scenario planning (stress, shock or countermeasures), modelling of mitigation.
- Who is the user of the tool? e.g. legal, operations, economics, town planning.
- What sector does the tool focus on? e.g. transport, water, cross-sector.
- Example success stories? Who? What? What was the output?
- What is the level of the analysis? Global, national, regional, city, any.

“[we were able to] engage with the tool developers in a way that’s not the hard sell.” Workshop delegate

“We have narrowed the gap between users and developers – a good result.” Workshop delegate
Session 3: Support

In this section the delegates discussed the requirements and support needed for a tool platform and an associated community.

Key points of discussion

**Users**

Users mentioned that a platform, acting as a ‘one stop shop’ for tools would go very far to making the vast number of tools and information available more easily digestible. It would also help for a comparative assessment of different tools. Users were also keen to point out that there is a gap in the market for a platform that makes the output of tools clear.

A common theme is that often users have difficulty choosing the right tool to use as there are few descriptions of the outputs. Connected to this is the issue of making the platform easy to browse as users don’t always know the tool they need.

Another point of discussion was the difficulty that users have navigating the procurement process, especially in regulated environments. Delegates debated whether this could be something supported by the platform and community. Users also have difficulties customising tools for specific projects or situations. This is also connected to the fact that many users require support to make the case for investment in a tool.

“It can be overwhelming seeing how much is out there, how do we choose?” Workshop delegate

**Developers**

The main points of discussion were around the need for support in the financing and funding of tool development. Developers feel as though there is no established model of funding or financing, making it very difficult to build and refine tools.

This is an area that could be addressed ideally by the platform and community. Developers could connect their tools more closely to their target users and make a better case for investment in their tool with returns being made in the future.

The delegates also raised the issue of the lack of standards to assure tools. Developers perceived this as a blocker in the procurement process with users and finance departments happier to use large software houses even if their tools are not as sophisticated or appropriate. The community and platform should try and find a way of making it easier for small developers to compete in the marketplace.

**Business model for tools**

There was a general consensus that it was very difficult for developers to get the right balance of being open and sharing, and protective about their tool. Being too protective they risk losing customers and being too open they risk losing their intellectual property. Some attendees made
the point that being competitive came from being ahead in development and not necessarily from being protective.

The tools showcased in the workshop had different business models, such as:

- "Freemium": Free but users pay for consultancy support to implement tool and for data to go alongside.
- Licence: very cheap for basic functionality but customised models are charged more.

**Platform**

**Content**
Delegates expressed the need for the platform to replicate an ‘ecosystem of tools’. This would mean that tools would be linked together, creating a map and showing the relationships and gaps between tools. With this the site would become a place where people can identify opportunities for development. Furthermore, when discussing how the tools would be classified, delegates raised the point that this should be user-centric. Categories based around level of skill required and type of output, for example, would do this.

Following this there was also an expression of the need for case studies to be linked to the tools on the platform, allowing for users to make more informed decisions.

Connected to this, there was a discussion of the need to make the platform more than just a website for tools and to make it a broader list of people who are qualified to consult in that area too. Webinars were mentioned as a good medium to get experts involved in the platform and to demonstrate their knowledge to stakeholders. This will help to build the community by building confidence that the knowledge shared, standards and practice are of high quality.

In addition to this, the option of integrating a database of user requirements. This adds extra functionality for tool developers allowing them to easily visualise market gaps and develop new tools to fill them.

**Desirable features**
The delegates identified the key desirable features to be integrated into the creation of the website:

- ‘Reviews’ of the tools
- User and developer profiles
- Comment functionality for advice/feedback.
- Buttons to reveal differing levels of information
- Site usage data collection i.e. which sectors are getting most views etc.

**Tool selection**
Creating a strategic selection of tools to showcase on the platform is a challenge but necessary, according to the group. In order to do this, a platform facilitator is required to make judgements on the makeup and segmentation of the tools showcased. A comparison with the
Apple App Store was raised, pointing out how features such as the ability to choose free or paid apps, filter by category or geography, and view reviews could be transferred to the platform. The facilitator should play the administrative and vetting role played by Apple on the app store. A mention was made for the need to moderate comments on the platform.

**Potential platform models**

The delegates drew up a series of potential models, with different advantages and drawbacks, for the platform.

- **App store**: A tool platform modelled on the App store with user feedback to build confidence in tools. Using data there is also the opportunity to match user profiles based on sector and stage of the value chain with apps that could be of use or interest.
- **League table**: The main benefit of this model is the benchmarking element. It allows for a comparative assessment of tools and could stimulate quicker development of tools through the introduction of soft competition.
- **UCapture**: This model helps to lighten the burden on developers to improve the tools by allowing for a greater amount of co-creation with and feedback from users. This model is the most naturally suited to supporting a community as users are more involved in giving feedback and shaping the future development of tools.
- **Accreditation scheme**: This model would standardise the assessment and certification process for tools. It would also mean that those tools achieving the standard or the certification would stand a better chance of receiving investment or being used.

**Community**

The workshop attendees then discussed the way in which the community would work around the platform. The main intention of the community is to allow users to actively interact with tools, facilitating feedback loops and discussions for developers to improve their products based on user feedback. In addition to this the community could share experiences and best practice allowing for users to make more informed decisions and make the best of the tools they choose to invest in.

Delegates also noticed the value of the community in connecting users who wouldn’t necessarily be connected, supporting a more integrated approach and diversity of perspectives.

One requirement of the community is that it must be formed of actual practitioners and researchers in resilience. A community is very welcome, would need to be electronic, but we must engage the right people, i.e. those who are practicing.

It is important to note that the issue of Intellectual Property will need to be explored depending on the level of engagement between users and developers.

**Gaps**

The group identified that there was a current gap in the market of tools modelling the economic impact of cascading effects. The broader question was raised of whether gaps in existing tools are gaps in supply, or gaps in demand. Often users struggle to know where to find a specific service.
Selected workshop feedback

Overall, the workshop was deemed very useful to participants. Some feedback collated on the day is given below:

“We all agreed that today’s approach, the way the whole workshop was set up, especially the composition of people in this room, trying to match tool developers and users can be described as a huge success”

“Need more days like today. Personal interaction is important.”

“It would be interesting to try out the solution and meet again.”

Feedback was also collated via an evaluation form at the close of the event. Results are shown below.

77% of respondents felt that their knowledge of resilience tools had advanced after the event.
Questions on the utility of the value chain revealed that 69% of respondents found the value chain useful or very useful.

Regarding the hypothesis that a resilience tool platform would be useful in the future, 65% of respondents were strongly positive and 23% positive about this.

71% of participants felt that the event was a positive start for a Community of Practice.
HAS THIS WORKSHOP HELPED TO START A COMMUNITY OF PRACTICE AROUND RESILIENCE TOOLS?

- 71%: Not much progress
- 23%: Some progress
- 6%: Strong community of practice
Appendices
## Appendix A. Workshop Participants

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<td>National Infrastructure Commission</td>
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<td>Doug</td>
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Appendix B. Tool Profiles

CAESAR
TOOL DEVELOPER: FRAUNHOFER EMI
REPRESENTATIVE: DR.-ING. ALEXANDER STOLZ

The Tool CAESAR (Cascading Effect Simulation in urban Areas to assess and increase Resilience) addresses the need to better understand the cascading effects of major disasters in connected and interdependent urban infrastructure systems. CAESAR has the capacity to identify the most vulnerable components within individual infrastructure grids and it allows users to assess potential damages within the grid as well as within coupled grids. In addition, the tool is capable of simulating mitigation strategies and their effectiveness beyond single grid boundaries. Required input parameters can be adjusted to the level of the available information enabling analyses on varying levels of detail. The tool can be applied to vital infrastructure grids such as energy, transport and telecommunication.

CIRCLE
TOOL DEVELOPER: DELTARES
REPRESENTATIVE: SANDRA GAYTAN AGUILAR

Circle is a tool to support the analysis of domino effects of critical infrastructure. It enables users to get insight into which critical infrastructure (CI) is affected in case of failure of other critical infrastructure, whether or not triggered by extreme events such as flooding. Users can describe the dependencies between critical Infrastructure. Circle facilitates the discussion between stakeholders dependent on each other, building trust and stimulating future partnerships. Users are governmental organizations and agencies, network operators, emergency response organizations as well as large industries who are interested in the dependencies between critical infrastructure. Circle’s approach is to: Gather (open) data on CI and vulnerable objects; Gather expert knowledge on direct impacts and dependencies; Combine data with expert knowledge to conduct cascading effect analyses; Complement risk assessments with gained insights on indirect effects; and, Increase cooperation between stakeholders.
City Resilience Index

TOOL DEVELOPER: ARUP
REPRESENTATIVE: SACHIN BHOITE

The City Resilience Index is a comprehensive tool for cities to understand and assess their resilience, enhancing their ability to build sound strategies and plans for a strong future. Through an online platform, it uses a comprehensive, holistic framework that is applicable at the city scale. It combines the physical aspects of cities with intangible aspects associated with human behavior, often relevant in the context of economic, physical and social disruption. It is developed by Arup with support from The Rockefeller Foundation.

EARTH EX [not presented but included for information purposes]

TOOL DEVELOPER: ELECTRIC INFRASTRUCTURE SECURITY COUNCIL

EARTH EX simulates global-scale disruption, with long duration power outages and cascading failures of all other infrastructures. It offers executive and senior level operational decision makers the opportunity to review critical decision-making policies, processes, roles and responsibilities – essential to the success of all other response and recovery operations. The exercise is designed for self-evaluation, with distributed play conducted using electronic tools, and local facilitation for feedback and execution.

GRRASP [not presented but included for information purposes]

TOOL DEVELOPER: EUROPEAN COMMISSION JOINT RESEARCH CENTRE

Geospatial Risk and Resilience Assessment Platform (GRRASP) is a World Wide Web oriented architecture bringing together geospatial technologies and computational tools for the analysis and simulation of critical infrastructure. It allows information sharing and constitutes a basis for future developments in the direction of collaborative analysis and federated simulation. It takes on board security concerns in the information sharing process, thanks to its ability to manage users and roles consistently. Based entirely on open source technologies, the system can also be deployed in separate servers and used by EU Member States as a means to facilitate the analysis of risk and resilience in critical infrastructure. GRRASP can be used for the analysis of complex networked systems taking into consideration cross-sectoral and cross-border interdependencies. It can be used for analyses of critical infrastructure disruptions at local, regional, national, international level. GRRASP follows a tiered approach: Tier 1 modules can be used for the analysis of critical infrastructure at sectoral level; Tier 2 modules for cross-
sectoral analyses (interdependencies); and, Tier 3 modules for high level economic impact of critical infrastructure disruption at state level.

**RASTEP**
**TOOL DEVELOPER: LLOYD’S REGISTER**
**REPRESENTATIVE: ANDERS RIBER MARKLUND PHD**

RApid Source TErm Prediction (RASTEP) is a tool for decision support to emergency response organisations in the event of an accident with potential radioactive releases. It works in the following way: The user answers questions on the ongoing event, and the underlying model uses the given answers together with advanced data modelling to predict the most likely outcome in a database of pre-calculated consequences. We think this tool has potential to be generalized to other situations with uncertain outcome in complex systems, e.g. climate change, volcanic eruptions, epidemics, market development etc. To find out more visit www.lr.org/rastep.

**Training for Operational Resilience Capabilities (TORC)**
**TOOL DEVELOPER: SINTEF**
**REPRESENTATIVE: TOR OLAV GRØTAN PHD**

The Training for Operational Resilience Capabilities (TORC) approach addresses three distinct training arenas; operational training addresses the exploration of the necessary margin of manoeuvre in the “compliance vs resilience” space, managerial training addresses the assessment of a reasonable and accountable space of manoeuvre, while integrated training addresses the active reconciliation of margin and space of manoeuvre. This facilitates a continual process of updating of rules based on the enhanced knowledge about the professional competence and craftsmanship in the organization at hand. The TORC approach is designed to be applicable in different contexts; in a normal operation context where pre-existing rules and procedures form the expectations of compliance, in an emergency context in which emergency plans form the presumptions of compliance, and in a “managing the unexpected” context in which the applicable set of rules and procedures must be collected and formed instantly and situation-dependently.