Making the Business Case for Resilience

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1: Introduction and background

Arising from a discussion between John Beckford (Beckford Consulting) and Richard Ploszek (Infrastructure and Projects Authority (IPA)) a group of interested parties met at University College London (UCL) on 27th February 2023 to consider:

"How to make the business case for the value of resilience"

The original discussion was prompted by a paper (ref 1) prepared by John Beckford and Richard Berry for the National Preparedness Commission reflecting on the role of data in national preparedness.

Those attending were a cross section of interested parties from Industry, Academia, Consulting and Civil Service:

Katie Barnes, Executive Director, National Preparedness Commission
Prof. John Beckford, Beckford Consulting, Convener
Paul Beckford, Doctoral Student, UCL, Institute of Transport Studies
Gerry Casey, ARUP
Andy Champness, Independent Consultant
Prof. Jordan Giddings, NED and Independent Consultant
Prof. Stephanie Glendinning, Newcastle University
Prof. Brian Haddock, Network Rail
Chris Heald, Independent Consultant
Dr. John Hillier, Loughborough University
Dr. Fleur Loveridge, Leeds University
Richard Ploszek, Infrastructure Projects Authority
Dr. Carla Washbourne, Associate Professor, UCL, Department of Science, Technology, Engineering and Public Policy

The following text summarises three framing presentations and key points of the whole group discussion.

2: Key points

- There is an acknowledged ‘price’ of resilience;
    - Cost exists through maintenance activity that keep assets available, value arises in their utilisation;
    - But can we usefully value the resilience of infrastructure?
- A thorough evaluation of the efficacy of appraisal tools might be beneficial to fully capture the realities that;
    - Infrastructure either works as a system, or not; it is either resilient as a system, or it is not.
- Effective and timely maintenance extends asset life;
- A number of challenges prevent the value of resilience being recognised;
- Investment decision making is often political rather than engineering or societal impact driven;
    - Data availability and quality are often poor;
    - The argument for ‘spend now and save later’ meets resistance when benefits are spatially, temporally or functionally distant;
- Investing in resilience is unlikely ever to offer a short-term gain.
- Future questions arise
    - What should be the role of organisational, engineering and political leadership in the management of infrastructure assets?
    - Is resilience an inverse measure of the social and economic cost of disruption?

3: Framing

3.1 What do we mean by resilience?

Given that there are multiple definitions of infrastructure ‘resilience’ (ref 2) in use by varying bodies we have chosen this one from the UK government with refinement and extension to principles from that of the Institution of Civil Engineers (ICE). These provide an effective summary of the view of resilience from the perspective of those working in decision-making and the built environment:

> “Resilience in infrastructure may be interpreted simply as the robustness of a structure, to withstand hazards.”
>
> "the ICE’s resilient infrastructure community is focused on ensuring engineering interventions not only tackle immediate needs, but also reduce further climate change and mitigate its effects.” (ref 3)

The ICE has adopted a set of Principles for Resilient Infrastructure developed from a UNDRR (United Nations Office for Disaster Risk Reduction) report by Varga, Dolan, et al (ref 4 and 5):

- Resilient infrastructure:
  - must be able to adaptively transform
  - must be environmentally integrated
  - must be protected by design
  - must be conducive to social engagement
  - must be a shared responsibility
  - requires continuous learning

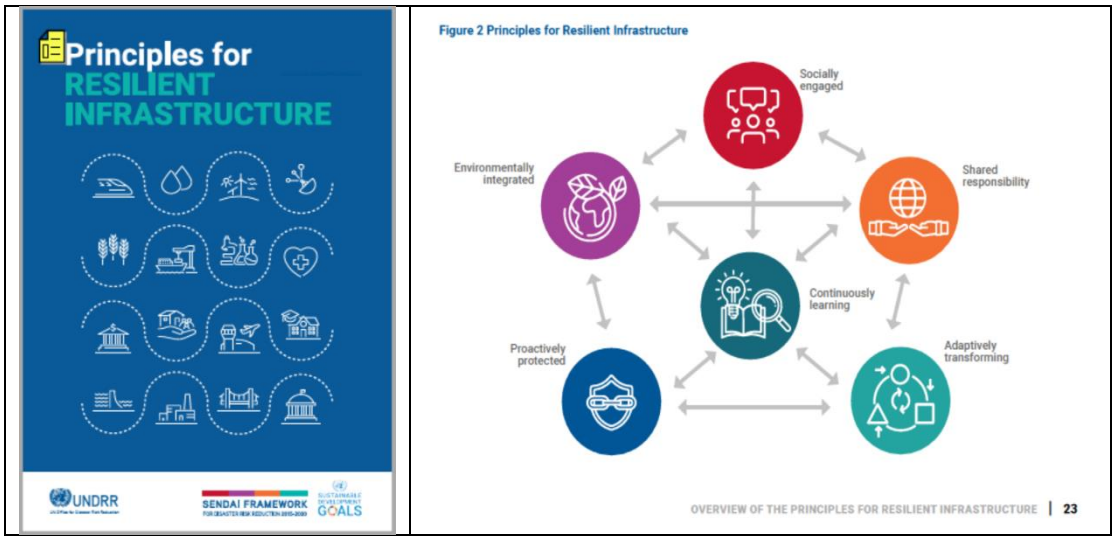

Figure 1: Principles for Resilient Infrastructure (ref 3)

Both of these approaches imply, through the language they adopt, that resilience is dynamic and responsive (the principles of being able to 'adaptively transform' and 'continuous learning') and has utility, therefore implicit or explicit value e.g., the 'ability to withstand hazards'. It should not then be unreasonable to consider that it would be possible to develop a business case for maximising that value, which can be further linked to a recursive understanding in which societal or national resilience emerges from individual, local and regional structures.

4: Setting the scene

4.1 Understanding the challenge

Opening the discussion, Richard Ploszek suggested that there is (UK Government) Treasury resistance to explicitly including the idea of resilience in business cases defined by the "Green Book" and that it is seen to be difficult to value [the resilience of infrastructure] as there is no formally recognised methodology for its valuation. He suggested that there is a tendency for "post appraisal value engineering" which drives resilience out of projects, this can be coupled to the

pace of project approval processes which are inadequate when measured against the rate of change of technology in certain fields. While resilience and life extension to assets is considered a good thing, the government, in effect, places a barrier to demonstrating value for money, particularly for low frequency, high impact risks.

It is understood that as connectivity between nodes increases (Figure 2) there can be greater resilience (although equal increases in risk of cascade failure) but that the value of such connectivity is not fully understood or appreciated.

Although typically governed, regulated and managed separately, infrastructure systems are in practise deeply interdependent (refs 6, 7, 8, 9). Each shares at least one continuous and absolute interdependence with at least one other (ref 6) (Figure 2). Therefore, in practise, none can operate without a predictable flow of infrastructure products and services from at least one other. Moreover, no individual infrastructure product or service is produced by a single sector operating in isolation. Therefore, disruption to one sector is highly likely to result in disruption to all sectors (ref 10).

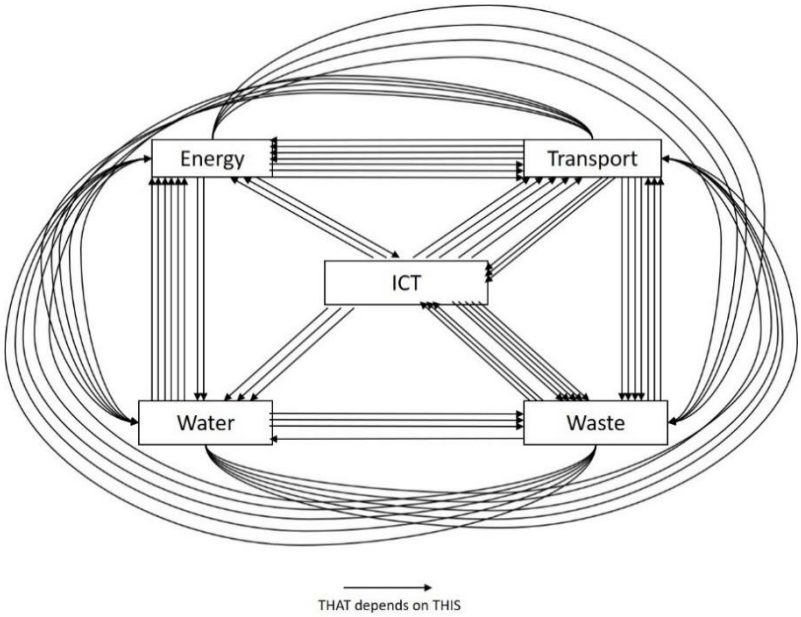

Figure 2: Systemic Interactions of National Infrastructure
(From Beckford, Intelligent Nation, Routledge, 2021, ref 2)

There is a continuing challenge with comprehending the “value of not failing”, i.e., ‘what is continuity of service and supply worth?’ This is an area with good comprehension in other areas in the private sector where, particularly in retail, the value generation of assets (e.g., revenue generation per freezer in a supermarket) is commonly understood and priced in to maintenance regimes.

A further continuing challenge is in pursuing the broader definitions of resilience adopted in other areas such as cyber, fire and defence where the **value of prevention** is more adequately pursued, as it is in the insurance sector, with formal calculation of lost value as a business risk. Beckford (2021, ref 2) has again noted that it is not uncommon for some such risks to be insured against. Insurance transfers the commercial consequences rather than mitigates the risk, it does not increase the resilience of the system.

3.2 Understanding life-cycle

Prof. Stephanie Glendinning followed on explaining how assets are managed through a life cycle of design, build, operate (and deteriorate) and that there is, or should be, a performance threshold that drives intervention to correct or sustain that performance. It was explained that such intervention commonly follows a catastrophic failure although the timing of such failures could be deferred by effective maintenance. This then raises a set of questions that researchers and practitioner(s) need to consider:

- How can we intervene earlier to extend life and prevent failure?
- What is the cost-effective intervention point?
- What are the cost AND technical AND social and environmental consequences?

Asset maintenance requires a series of questions to be addressed around the timing of intervention, the extent of deterioration tolerable (or necessary?) before intervention is appropriate. Particular consideration must be given to understanding the extent to which weather drives such deterioration and the challenge of separating weather related from wear related issues, especially as we experience the effects of changing climate. There is always a cost of sustaining asset performance and underinvesting in that respect leads to poorer performance over time. There is a price to resilience and an opportunity cost to insufficient resilience.

This presentation led to an immediate discussion about the definition and responsibility for performance, who defines it, or perhaps more correctly, who owns the definition of performance? There was some consideration that performance is not an objective property of the asset under consideration but rather a function of the observer or user and that the perception of value might stem from the same source. That led us to reflect on who that observer might be, and that there may be multiple observers with multiple perspectives on both purpose and value. The choice of observer and their definition of the artefact and the product of its existence is crucial. Two good examples are aircraft and railways. Each has an observable, verifiable, existence as an artefact but their ‘purposes’, the completion of a journey, can be found not in what they are but in what they do (or is done with them). Once constructed, their costs exist in the maintenance activity required to keep them in working order, their value in journeys completed.

Further debate ensued around the age of assets and the total cost of replacement and whether different rules might be appropriate for older artefacts. This suggested we need to consider whether resilience is, or should be, at the core of

asset management or is an optional extra. While suggesting that 'the sooner we intervene the better for the asset' it was recognised that we must price in volatility in relation to certain aspects and that the value of an intervention will depend heavily on timing.

Tying in to the earlier points about the purpose of the artefact, it is recognised that avoiding disruption has both social and economic value so, in understanding the business case, we need to factor in that value as well as the impact on geographically or topologically adjacent assets. The cited example was land use alongside a railway and how change in that use can, often adversely, affect the railway itself and its performance. One characteristic of that, and often cited in the early days of the HS2 project was around the value of travellers time, i.e. shorter journey times increase value – but the service provider does not directly benefit or receive value from that, the beneficiary is the traveller; this is the inverse of the cost experienced by travellers when journeys are delayed or cancelled, the service provider does not, for the most part, compensate for lost value, only failed tickets.

Drawing these threads together we were led to ask:

- Does value rest in the assets in a network or the service provided, or both?
- Should we not be concerned with the resilience of the system (and the network) rather than just robust, reliable assets?
- How do we consider the reputational risk arising from loss of service?
- What is the impact of political position on investment in maintenance?

This leads us to consider whether we should be seeking to reform one of the key tools for infrastructure planning and decision-making: the financial appraisal process. This would first mean consistent application of the tools we already have with the inclusion of the value of maintenance (extended life, greater value generation) and also the cost of inaction (the impact of failure). A thorough evaluation of the efficacy of these tools and necessary future amendments would be useful.

3.3 Understanding value not just cost

Paul Beckford introduced his research which is developing an understanding of the value of investment in transport infrastructure maintenance and renewals. His research has shown that the conventional methodologies consider primarily economic cost of maintenance of an asset rather than the value enabled by its existence and he suggested we need a different, richer model rooted in a deeper understanding. Arguing that effective and timely maintenance extends asset life, it was observed that such decision making is often dominated by political priorities rather than objective engineering or wider societal impact considerations.

Key learnings arising from the research so far highlighted:

- Government (and owners and operators) pursue new artefacts at the expense of the existing;
- Data availability and quality are often poor, this appears to be both chronic and endemic;
- Deferral of maintenance increases costs;
- There is a focus on cost over value;
- Projects are sometimes driven by, or seen to serve, public perception rather than public need;
- Existing tools for appraisal are rarely fully or adequately applied even in application to new projects;
- The Green Book now allows for the inclusion of residual asset value but it does not include guidance on design life beyond the appraisal period. This is particularly important in relation to long life investments.

The research suggests that a reconceiving of the value of maintenance and renewals is required with greater attention paid to both the wider value of the existence of artefacts and the cost of failure which will be realised across society. The aim would be a methodology considering total value rather than simply total cost. This consideration led to a suggested conclusion that larger societal benefits would emerge from increasing service and asset availability but this would require the embedment of asset management principles into the appraisal process itself which would in turn require that asset performance levels would be a key part of that appraisal. Collectively these would support reconsideration of the way that assets are used, maintained and valued, and the same might be said of capabilities, the skills and knowledge to support the use of the assets

Reflecting on these points it was noted that Fire and Rescue Services are organised and funded on a preventative basis encouraging them to engage more in preventative activity with a significant reduction in some activities. Notably, at least for some areas, Fire and Rescue are more engaged in dealing with road traffic events than with domestic fires. Conceptually, prevention is recognised to be better than correction, suggesting a ‘invest now and save later’ philosophy would pay dividends in performance but such an argument meets resistance when benefits are spatially, temporally or functionally distant, i.e. in circumstances where the (financial) beneficiary is not the funder of the activity.

4: DISCUSSION

4.1 A funnel of considerations

To enable a more holistic appreciation of the value of infrastructure at project scale, it seems that there is a need to, if not rewrite then at least reinterpret existing guidance such as the ‘Green Book’, to make it more than the ‘box-ticking’ exercise it is seen as by some; and to move debates and decisions away from bureaucratic processes, often dictated by the time lines of elections, purdah and the life cycles of governments.

There are, of course, significant infrastructural challenges which need to be addressed regardless of political preferences and timelines, whether that be relatively local issues such as rural bus services or the supra-national need to move to a net-zero economy with greater attention paid to social equity.

The realisation throughout this discussion was that we operate in a world where the increasingly common tools that we use to support decision-making, such as modelling are often slow and poor. Decisions sometimes precede the modelling so we end up with what might be thought of as “policy-based evidence making” especially as the models themselves are not properly validated and, it can be argued that the established practices of government have codified a belief system, any challenge to which is considered heresy.

The challenge of effective data acquisition and model making cannot be underestimated. As was shown during the early days of the COVID-19 pandemic, modellers can produce any result that is desired and when even the established models are not fully or properly applied there is a reliability issue of great significance. The emerging suggestion was of the need to create more open models with the challenge then arising of provision of data, ownership of the models (and the data) and, of course, the funding of the process of modelling. It was thought that coupled to vivid analogies and connecting to work done by others, for example in medical cases and by the National Infrastructure Commission, stronger cases might be made. This, brings us full circle back to the initial article on anticipatory reasoning (ref 1) which stimulated this work.

An interesting thread emerged around ageing assets, recognising that the majority of infrastructure in the UK is well-established. For example the London Underground is over 150 years old, many elements of the railways are up to about 180 years old, Bazalgette’s sewer system is over 170 and so on, even what we think of as modern artefacts are ageing – the ‘Prince of Wales Bridge’ is now 27 years old, the Severn Bridge 57 years and all of these artefacts are both dealing with demand beyond the expectations of their designers and pre-digital, i.e. the means by which data about their well-being, performance, condition and so on can be evaluated relies still on traditional and conventional methods. This limits what we can know about them and their failure risk. So, we then ask what is (or should be) the role of organisational, engineering and political leadership in their management to ensure appropriate resilience?

4.2 Systemic understanding

As the conversation evolved it became clearer that to be more reflective of the reality of the world we need to talk about and address resilience at a systemic rather than a functional level. That ties the debate around resilience more clearly to the notions of purpose and performance, asking in the broadest terms what infrastructure is ‘for’ and how well does it fulfil that purpose, rather than to the functional aspect of an artefact in its own right or the capabilities required to operate and maintain it.

This produces a challenge of considering for reasons of practicality in design, planning, construction, maintenance and governance, where and how do we draw system boundaries – are they around functions, with all the inherent limitations that they imply, or around societal purposes and groupings? If we ask questions not about the cost of a bridge or road but about the value of physical connection and social connectivity, we start to develop a very different understanding.

That understanding is perhaps rooted in the idea that all infrastructure is (or should be) enabling; it does not exist in and for itself but for the contribution it makes to wider society.

That led us to ask how can we best understand the systemic consequence(s) of asset performance and thereby appreciate the value of the network? Some work on ideas of economic and environmental sustainability might be drawn on here, starting with Lovelock (ref 11, 12), Lomborg (ref 13) and Raworth (ref 14). In recognising the societally enabling effect of infrastructure we can then consider how there is an interactivity, a co-dependence, between people and systems which creates feedback loops (Beckford, ref 2, 15) which can be amplifying or attenuating of the systemic value. For example, if there are not enough people using public transport to sustain them through the fare box, the response can be to reduce services (with the aim of reducing cost) which generates a loop of attenuation:

> the less people use the system the less service the system provides
> and
> the less service the system provides the less people use the system.

We risk creating a self-reinforcing doom loop in which the structure of the system ensues that our prophecies are self-fulfilling. Beer (ref 16) described the Beeching work as ‘a machine for eating the railway’. It seems not much has changed.

4.3 Infrastructure: value as a public good?

If we wish to create and sustain value enabling infrastructure, we need to consider afresh some challenging questions:

> Should some infrastructure services be run explicitly as a public good with no expectation of cost recovery? And if so, how do we govern and manage them effectively?
> How should and can we usefully value the resilience of infrastructure systems?
> Is resilience simply an inverse measure of the social and economic cost of disruption, and restoration?
> How do we create the conditions under which the definition of ‘value’ becomes useful?

It may be our attempts to simplify, functionalise and fractionalise that are key elements of the problem. We create for ourselves artificial boundaries and limits, not just to the asset artefacts and networks but also, and perhaps more importantly, to our thinking and, in doing so misdiagnose the failure points, sources of risks, and likelihood of cascade failure. For example, under adverse weather conditions, it is not sufficient to ensure that railway assets are fit for use, it is also essential to also consider the likelihood of the adverse weather conditions disrupting essential flows from other interdependent systems, such as ensuring that roads are free to enable the drivers to get to the depots and the passengers to the stations; and that sufficient electricity is available to power the operation of railway assets!

Infrastructure either works as a system, or not; it is either resilient as a system, or it is not. If we cannot get that point understood and accepted then our inevitable destiny is a severely weakened, and intrinsically vulnerable, economy dependent upon fragmented, low resilience infrastructure systems. In short, we are in trouble!

4.4 Sources and nature of resistance

The idea of embedding the value of resilience in future business cases and adopting a systemic perspective is bound to be challenged when it has to be addressed within a reductionist, consciously functionalist framework. Within such a bureaucratic system, short term accountability for resources used outweighs long term accountability for objectives achieved. The players or contenders participating (or not perhaps) in the development of the case are themselves bringing a range of knowledge and understanding but also the expression of differing social and political philosophies. They are arguing them into an established policy context (another barrier to overcome perhaps) and are time bound by the arbitrary nature of both budgetary cycles and regulatory periods and, of course, by the political cycle of elections whether local or national. The short-term, siloed, nature of all of these things militates against the argument for resilience which is long-term, perhaps multi-generational, systemic and requires a business and value model that reflects that. Investing in resilience is unlikely ever to offer a short-term gain.

A second source of resistance is that we do not sufficiently (or perhaps at all) value continuity and reliability of service, we do not value the realisation that 'all of a sudden nothing happened'! When we do reflect on the complexity of contemporary life we should be celebrating more than anything else its overall reliability. We should be investing in maintaining that reliability, whether it is the 99.999999% uptime we demand of our computers and the networks and power systems on which they rely or that of the railway, underground train, bus and tram systems (and their various permanent ways) that make our journeys for work and pleasure so reliable overall, that reliability that resides in the interactions of the elements of the system not the individual asset or service.

It would be easy to conform to the social, political, and economic orthodoxy; and accept that the case has not been made for resilience and the world has not (yet) ended, to assert that ‘we don’t do it like that’ but it still works. Except that it doesn’t – and certainly not as efficiently and reliably as it should.

There is reluctance to pursue innovation particularly if there is perceived risk of failure – technical or economic. It is difficult to persuade ourselves and others of the benefits AND that they outweigh the risks and satisfactorily answer the question ‘what happens if it all goes wrong?’ A more interesting, but equally hard question to address is ‘what happens if it all goes right?’ (or at least enough of it to call it a win!).

There is much higher blame attached to failure by governmental institutions after innovation or unorthodox action than is experienced by entrepreneurs. By contrast, you don’t get blamed if you follow the norm, even if the outcomes are demonstrably unsatisfactory. What we need to underpin our innovation, to overcome the resistance to the inclusion of

resilience as a key aspect of infrastructure investment is a deeper appreciation and application of competent science, a recognition of the agency of the individuals involved and acceptance of the sense of professional responsibility and exercise of judgement AND acceptance that, once in a while, our judgements can turn out to be incorrect.

5: Conclusion

In the sense of a 'concluding conclusion' there is not one, yet. Like many research questions we end up suggesting that further research is necessary!

There are though some immediate steps we could consider. Working, as a starting point, within the established processes of greatest proximity to our question, we acknowledge that Green Book guidance does not preclude the inclusion of resilience so it should be possible to seed elements of resilience through each of the five main themes and integrate the requirements within the assessment criteria already established.

Building resilience by stealth perhaps, but a key contribution would be to fully realise or appreciate the 'value' argument, in particular the economic and social value of the established infrastructure base. This might be achieved by considering the 'replacement cost' of existing assets against which the 'cost of resilience' is likely to appear modest – especially when economic value generated through the use of assets is considered.

In summary, it was suggested that to more meaningfully integrate resilience into business cases (of the kind articulated in the Green Book?) we would need to:

- Gain substantially greater consideration of purpose and vision; and embrace the notion of infrastructure as a system of systems;
- Consider outcomes not outputs;
- Embed resilience in each of the five major threads of the business case such that it cannot be eradicated;
- Develop and model richer, more complex systemic scenarios which directly support evidence-informed decision-making;
- Incorporate non-economic factors in the Strategic Case;
- Change the context into which the business case is being landed.... moving from 'business case' to 'value case'
- Engage in wider, more effective stakeholder management;
- Challenge policy at least as much as comply with it;
- Consider how the Green Book could force consideration of interdependence;
- Recognise that we are making decisions for an unknown, possibly unknowable, future and that such decisions and investments must be appropriate for a wide range of future scenarios.

We intend now to pursue the following steps:

Obtain reflections from original contributors and readers;

Review one or more submitted business cases (volunteered by the group) from a resilience perspective;

To consider from that how to seed resilience throughout the cases;

To conduct a further event based on our learnings.

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