

CSIC Asset Management Project

Executive Summary Document



September 2015

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and Construction

1 Introduction

A large proportion of the research undertaken by the Centre for Smart Infrastructure and Construction (CSIC) is concerned with improving the information available to construction companies – developing technologies capable of measuring in new ways, facilitating deployments in places and manners previously impossible. However, in comparison to the design life of the infrastructure being created, construction projects are short lived. Even the most ambitious projects, such as CrossRail, only take a few years to complete – whereas the design life (or at least, the functional life) is almost indefinite.

As such, there will always be a limit to how useful any information can be to a construction project. Meanwhile, once the asset is constructed, that same information can be used by different stakeholders throughout its entire life for maintenance, or even when it comes to altering or decommissioning the structure.

It is also easy to underestimate the ongoing cost of operating and maintaining infrastructural assets. Networks such as London Underground are so intertwined with and important to cities, they become almost invisible to the public, and are only noticed when they are unavailable through strikes or closure. Construction projects, such as CrossRail or the Thameslink Programme redevelopments, are much more obvious and are frequently in the press – as are their costs. CrossRail, for example, will cost about £15bil, between 2009 and 2019, and the Thameslink Programme about £6bil from 2009 to 2018. Meanwhile, over the same periods, the operation of London Underground will have cost about £20bil, and of Network Rail in the region of £100bil.

CSIC strives to enable better decisions through smarter information - the Asset Management Project contributes to this by addressing the above themes. Building on the work of the PAS1192 and ISO55000 committees, working with leading industry practitioners, and drawing on the Institute for Manufacturing's existing process-optimisation toolkits, CSIC has developed and tested frameworks for managers of civil assets. We look at making optimised whole life decisions, the information required to do so, the approaches to look after that information, and how infrastructural assets can aim to provide for the public into the future, in an uncertain world.

This document summarises the work conducted to date on the suite of CSIC Asset Management Projects. It does not provide in depth descriptions, but will cover the main objectives, case studies, and outcomes. The reader will be directed to other documents relevant to the specific projects, where more information may be found, and of course the team will be happy to discuss further through all the usual channels.

2 Overview of CSIC Asset Management Projects

2.1 Work Package 1 – Value-based Asset Management Decision-making

Asset management is expensive, and the combination of inherently long lifespans of infrastructural assets and the continual reduction in budgets afforded to them require careful consideration to be applied to decision making. This has led in recent years to the development of PAS55, and then to ISO55,000 - standards providing guidance for asset managers wishing to make decisions which provide the most 'whole life value', not only giving the 'biggest bang for the buck', but the bang which is optimised for a range of stakeholders over a long period. **Work Package 1 presents a methodology for decision makers, based on a value-mapping approach to optimise decisions.**

2.2 Work Package 2 – Information requirements for asset management

Decisions must be founded on reliable, relevant, good quality information. By 2016, UK government targets require all new public works to be 'BIM Level 2 Compliant', using the PAS1192-x series. Thus, in the future, there will be a very high minimum level of information quality on civil assets, particularly infrastructural assets. Those structures built in the past, particularly those dating to Victorian times, will of course not be subject to these targets - yet they still need to be maintained to support our transport networks. **Work Package 2 investigates the 'information landscape' available to asset managers at the local authority level and presents practical steps for improvement based on various standards.**

2.3 Work Package 3 – Future proofing of asset information

Perhaps surprisingly, very old assets sometimes have fairly good supporting information, but it is unlikely to be held digitally. Yet, when the information was originally created, it no doubt used the most up to date engineering standards for recording information. Victorian engineers used hand-drafted ink on paper. In many cases these original paper copies are still used, but some have been transferred on to microform systems or digitally scanned. These scanned documents, along with other electronic formats such as Computer Aided Design files, have migrated through a journey of many storage systems – magnetic tapes or disks, optical disks, flash memory, and most recently 'the cloud'. Care must be taken during this migration to ensure quality is not reduced when transferring between media. **Work Package 3 provides guidance for assuring asset information is available into the future.**

2.4 Work Package 4 – Future proofing of infrastructural assets

Environmental factors such as climate change, and human factors such as land use and population growth, conspire to make it difficult to predict the future demands on infrastructure. CSIC conducted two industrial workshops on infrastructure future proofing and its integration with asset management. On the basis of lessons learnt from the workshops as well as from key literature analysis, **Work Package 4 proposes an innovative infrastructure future proofing assessment approach and set of key future proofing criteria to help organisations understand gaps in future proofing considerations across infrastructure assets.**

3 Value-based Asset Management Decision-making

3.1 Background

The ISO 5500X family of standards on Asset Management defines asset management as those activities that enable an organisation to realise value from assets in the achievement of its organisational objectives. Therefore, the emerging guidance is that asset management decisions must be 'value driven' and not 'cost focussed' as they traditionally were. This work package provides guidance on how this may be achieved.

3.2 Overarching Challenges

Currently, asset management decisions are carried out by a network of organisations or different business units within an organisation and therefore the costs and risks are fragmented across the network. Additionally, these decisions are done in silos and they are focussed on short term performance pressures. As a result, current asset management decisions are based on short term perspectives, which lead to inherent problems when considering multiple stakeholders and their long term network-wide objectives. Furthermore, there tends to be pockets of “excellence” and “best practices” in certain asset classes or business units, which are not necessarily shared across the organisation consistently. Lack of a systematic process also inhibits cross-learning between asset classes. Therefore, a structured and repeatable process is needed.

3.3 Approach

The Asset Management Project adopts the generic three-step approach to all aspects of the research

1. Establish the context
2. Understand the value
3. Optimise the value

In this work package, the context was established by literature review and exploring standards such as ISO 55000, ISO 15686-X. Explorative case studies with industry were conducted to understand the challenges, current approaches and the state of the art. This process was then tested and validated with industrial case studies, which was then fed back for process refinement.

The approach developed through this project can be summarised as follows (see Figure 1).

Stage A: Establish the context. Given the nature of infrastructure organisations and their associated variety of assets, it is important to determine the context for the initiative. The asset management decisions widely vary depending on the type of asset, functionality and the wide ranging problems that needs to be addressed. For example, strategic asset management decisions will involve developing whole life valuation for a portfolio of assets to satisfy regulatory compliance. On the other hand, daily operational decisions may involve determining the optimal intervention type for a particular asset. Therefore, it is essential to establish the context and needs.

Stage B: Develop the value map. This stage determines the key value drivers and also establishes the value creation process. Each infrastructure asset and the dependent system generate value by providing the necessary functionality. Consequently, any failure or disruption will have an impact on the value created. This stage helps in understanding the value and the impending risks contributed by the asset towards various stakeholders' requirements. This stage helps in understanding the

value and the impending risks contributed by the asset towards various stakeholders requirements. The output of this stage, which is in the form of a value map can aid asset owners in better understanding of the dependencies that need to be considered for a particular asset when making asset management decisions. Additionally, the value map can also inform organisations to understand the information requirements for asset management decision making. Furthermore, the value map can be used to develop innovative ways for managing assets such as enhancing inspection reports for information gathering purpose, which in turn can be used for learning and modelling of asset deterioration.

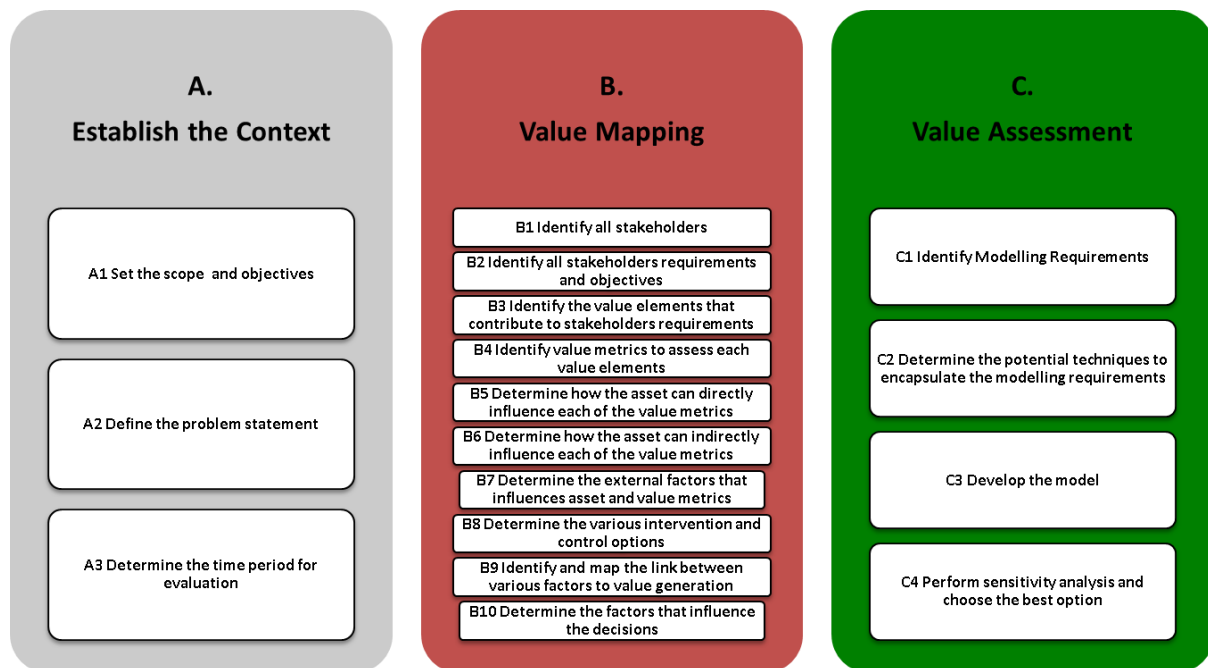


Figure 1 – systematic approach for value based decision making

Stage C: Assess the value. This stage is dedicated to developing an appropriate decision model and calculating the value of the asset and assessing the impact of different decision options on the value generated. This will help the decision maker to choose the best decision that maximises value. The value assessment will depend on the scope and objective of the study. This can include evaluation of options or in determining the optimal intervention type and timing or in prioritising the work schemes based on value. The quantification of value and the impact of decisions on the value will be modelled in this stage. The appropriate elements to model will be obtained from the previous stage.

3.4 Outputs

A value-driven decision process has been developed. The ‘value map’ aims to make an inventory of stakeholders and their requirements (because ‘value’ means different things depending on your perspective), value drivers and how performance towards them is measured. Then, the ways in which these metrics can be influenced, as well as what options are open to asset managers, are all described. The methodology then allows the linkages between these many elements to be mapped together, thus showing the impact decisions on intervention or control options have on stakeholders. This allows a complex system to be modelled in a simple manner to help identify the solutions which will present the best whole life value.

3.5 Case studies

3.5.1 Cambridgeshire County Council – prioritisation of maintenance activities for bridge stock

The council has to maintain around 1500 bridges. Budget constraints (£2.5 million/year) limit the amount of maintenance work that can be performed each year – when allocating OPEX for the bridge works, only a percentage of jobs can be selected. The incumbent method of prioritisation fails to differentiate between low value bridges (for which maintenance can be deprioritised) and high value bridges (where maintenance investment should be a priority).

Key question: How to identify the value of a bridge and how can this be used to prioritise the jobs for different bridges?

First, a value map was created linking asset factors such as structural condition with the impact on stakeholders. A spreadsheet prioritisation tool based on value and criticality could then be developed, which could be populated with information readily available from the existing data set on the bridge stock. This enabled a semi-quantitative risk score to be associated with each bridge, thereby creating a prioritised list of assets requiring maintenance on the basis of value-for-money.

As such, a structured, repeatable method of analysing cost-driven information to rapidly make value-driven asset management decisions has been demonstrated. This provides confidence to justify expenditure and maintenance programming of the structures, and enables targeting limited resources to the maximum benefit of the local communities

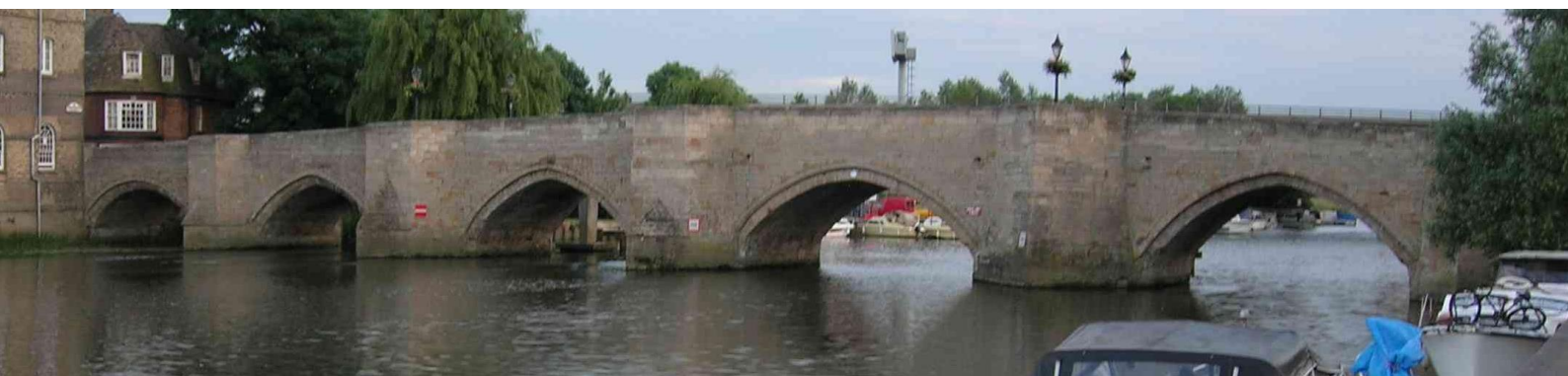
Impact and benefits

CSIC's bridge maintenance prioritisation tool enabled the council to make better-informed decisions:

- helped bridge managers at the council to justify the annual expenditure on bridge maintenance and to clearly prioritise maintenance activities to ensure maximum value for money spent
- engagement with asset managers at the council led to a wider appreciation of the value-based approach to asset management, potentially paving the way for establishing a step-change in the way assets are managed across the council's wider asset portfolio
- could be adapted for use by other councils and bridge owners potentially generating a wide-scale impact

3.5.2 Other case studies

- London Underground – selection of the best value maintenance strategy for tunnel seepage
- Surrey County Council – justifying investment in replacing safety barriers



4 Information Requirements for Infrastructural Asset Management

4.1 Background

While no two Local Authorities are identical, their asset stocks are similar throughout the country. As the UK has a fairly old transport network, with arguably one of the oldest rail networks in the world, many of these assets are very old, in some cases dating back hundreds of years. Clearly, with every passing year, the likelihood of asset owners possessing good quality information decreases, particularly before such time that the information is digitised.

Good examples of these assets are the masonry arches supporting railways. By the nature of rail transport, laying level tracks necessitated the Victorians to construct thousands of bridges. A great many of these are still in use today – even those no longer carrying trains are likely to be used as public rights of way, and need to be maintained to today's standards, requiring the same level of information. As such, local authority asset managers were selected as the topic of interest for this work package, with a specific emphasis on bridges.

4.2 Overarching Challenges

Almost all authorities use a combination of paper, microfilm and database info. Generally, where information exists, it is of high quality, but there are also a number of 'known-unknowns' (they know what parts of their systems are lacking), 'unknown-knowns' (they have archives filled with unindexed info), and 'unknown-unknowns' (they don't even know what assets they own). There are a handful of software systems in use to manage bridge information, but very few of these are designed specifically for use with bridges.

4.3 Approach

For this work package, the same three step approach was adopted as for Work Package 1. Step 1 (establishing the context) and step 2 (understanding the value) were achieved through a series of structured interviews with a wide range of asset owners. Step 3 (optimising the value) pulls together aspects of PAS1192, ISO55,000 and BIM, to identify strategies to improve asset owners information systems. These strategies are presented as accessible frameworks, targetted towards local authority asset managers.

4.4 Case Studies

4.4.1 Local Authorities Bridge Managers

Interviews were conducted with two tier county councils from across England: Buckinghamshire, Cambridgeshire, Cumbria, Devon, East Sussex, Essex, Gloucester, Hampshire, Hertfordshire, Kent, Leicestershire, Lincolnshire, Norfolk, North Yorkshire, Northamptonshire, Nottinghamshire, Oxfordshire, Rutland, Somerset, Suffolk, West Sussex, and Worcestershire

The managers of more than 50,000 bridges and about 300km of retaining walls, with a combined yearly budget of £50mil have been consulted. The study comprised of semi-structured interview questions relating to the information systems used and the quality of information within, and the level of awareness of relevant standards and initiatives. This was made possible with the help of the ADEPT bridge board.

A key finding of the interview process was that, at the local authority level, there appears to be a lack of buy-in to standards that have been fully embraced by asset managers in other fields. Indeed, a large number of interviewees were unaware of PAS55, ISO55,000 or BIM.

There are also many common information challenges that are either currently being faced, or have been recently addressed, by all councils. The most commonly cited information challenges relate to ownership of retaining walls (although the interviews centred around bridges, the same asset managers are responsible for other structures), calculation of replacement costs of bridges (a government requirement), or the legacy issues inherent in dealing with very old assets (older than 50years seems problematic). One or two authorities began a programme of digitisation 25-30 years ago. Only in these offices is all information available in a single repository. Generally, since the point when a digital system was implemented, records are cited as being very good – new records (inspection reports etc) are added to the system as they are created. Where data has been migrated between systems, quality is often reduced.

Information sharing is, on the whole, good between local authorities, who have a strong and active network with the ADEPT board. However, communications are poor between some other stakeholders – notably Network Rail. This is especially true where large strategic works are underway (eg, electrification).

4.4.2 Other Case Studies

In addition to the above local perspective, asset managers involved with information policy have been interviewed from much larger organisations including CrossRail, Highways England and London Underground.

4.5 Outputs

In light of the interview results, a self-assessment tool has been developed to help asset owners and managers identify the areas in their state of practice which would benefit from adopting information management approaches described by ISO55,000 and PAS1192. Aimed specifically at bridge engineers, this tool will provide the user with targeted information from standards, describing specific benefits of adoption. The tool can also be used to prioritise improvements and feed into a business case for investments in information systems.

Another interesting outcome of the interviews surrounded the creation of BIM models for existing structures – there are clearly many more structures that already exist than are being built at any given time, and so structures with BIM models are in the minority. Yet, existing structures could benefit from having their own BIM model. With limited resources, which assets should be investigated first? Complex assets will benefit the most, while simple assets may have only marginal benefits. Clearly there is a point where the benefits of BIM are greater than the costs of implementation. As part of this work package, a proposal will be developed to enable the team to develop a risk-based strategy to identify (existing) assets which would benefit from BIM.



5 Future Proofing Infrastructural Asset Information

5.1 Background

Perhaps surprisingly, even older assets sometimes have fairly good supporting information, but it is unlikely to be held digitally. Yet, when the information was originally created, it no doubt used the most up to date engineering standards for recording information. The Victorians used hand-drafted ink on paper. In many cases these original paper copies are still used, but some have been transferred on to microform systems or digitally scanned. These scanned documents, along with other electronic formats such as Computer Aided Design files, have migrated through a journey of many storage systems - magnetic tapes or disks, optical disks, flash memory, and most recently 'the cloud'. Care must be taken during this migration to ensure quality is not reduced when transferring between media.

5.2 Overarching Challenges

The amount of information created and used in infrastructure and construction sectors is huge and diverse by nature. Organizations need to understand specific requirements for efficient information management throughout infrastructure life cycles and their supply chains. This approach helps organisations understand their information retention requirements, identify and assess risks of information losses in long term and provide guidance on solutions to mitigate the risks of information loss.

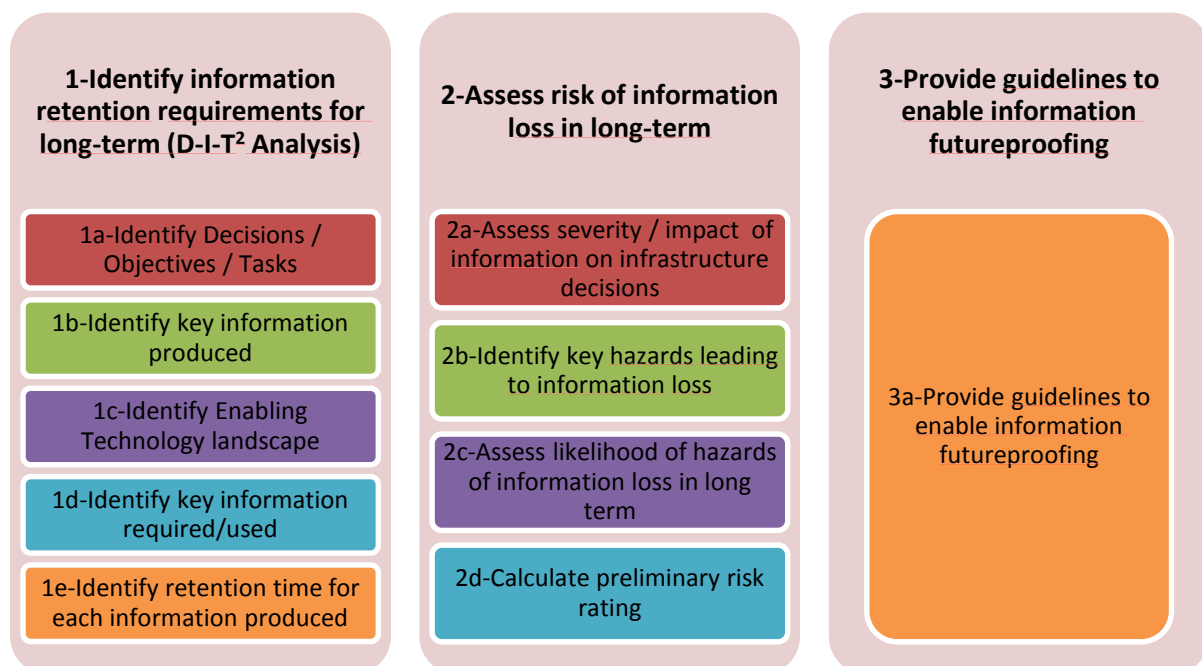


Figure 2: The information future proofing approach

5.3 Approach

The information future proofing approach is aimed at helping in facilitation of information future proofing (assessment), which can be defined as “the process to select or identify technologies and services that would enable long term storage and retrieval of infrastructure information”. This may lead to creating an information future proofing strategy, which can be defined as a group of technical (hardware & software) and organisational (processes, roles, responsibilities, skills)

solutions that needs to be adopted in order to ensure that relevant information is made available at the right quality to asset management decision-makers over the duration of the lifecycle of the asset/system/service. A 3-stage approach has been devised for this research (see Figure 2). Stage 1 aims to identify information retention requirements. Risks of information loss are identified and prioritised during Stage 2. Stage 3 aims to identify information future proofing solutions. In order to make better decisions for future proofing infrastructure, the information should have the following key characteristics in the long term (in order):

1. The information is available, and stored somewhere;
2. The information is accessible;
3. The information is retrievable;
4. Once the information is created, it is reusable more than once; and
5. The information is flexible and can be used beyond its original creation purpose.

5.4 Case Studies

5.4.1 Hertfordshire County Council

Asset managers and engineers at Hertfordshire County Council have been interviewed to establish the context of their information systems – specifically, it is important to understand the decisions, objectives and tasks for which the organisation is responsible, and over what time frame their impact may have. The information repositories were assessed, showing where various types of information are stored, and in what formats they occur. Combining this structured inventory of information entities with the reasons for its existence (eg, to help make decisions) leads to an information map. This illustrates that not all information is of equal importance – some may only be collected/stored for redundant legacy reasons, while some may be legally required, or essential for a particular decision. As such, the tool can be used to identify which entities pose the biggest risk to asset management processes and help shape information collection and storage policies.

5.4.2 Other case studies

- CrossRail (tunnel and pumps)
- University of Cambridge Institute for Manufacturing (department building)

5.5 Outputs

1. A structured method for Decision-Information-Technology-Time Analysis
2. A structured method of risk assessment for information loss in long-term
3. A set of identified hazards for information loss in long-term
4. A structured information futureproofing process and tool)
5. Masood, T and Cuthbert, R and McFarlane, DC and Parlikad, AK, *Information futureproofing for large-scale infrastructure*.
6. Masood, T and Yilmaz, G and McFarlane, *Identifying Hazards to enable Information Futureproofing for Large-scale Infrastructure*.
7. Two more journal papers are currently being written.



6 Future Proofing Infrastructural Assets

6.1 Background

Increasingly, in their respective roles, infrastructure owners, designers, builders, governments and operators are being required to consider possible future challenges as part of the life cycle planning for assets and systems that make up key infrastructure. In this work package, a preliminary study was conducted aimed at exploring the following questions related to infrastructure and infrastructure systems:

- What does 'future proofing' of infrastructural assets mean?
- Why and when to future proof critical infrastructure?
- How can infrastructure assets and systems be prepared for uncertain future events?
- How can future proofing considerations be incorporated into infrastructure asset management practices?

6.2 Overarching Challenges

It is a significant commitment to consider future proofing and take appropriate actions which increase the level of future proofing of key infrastructure. Motivations for considering future proofing of infrastructure in the UK are based on following three key challenges:

- Ageing infrastructure and long operational lifetimes
- Extreme weather events
- Capacity enhancements and changing uses of key infrastructure

These issues capture some of the evolving debates around the need for anticipating and managing future scenarios for critical infrastructure carefully and thoroughly. To overcome these key challenges, it also needs to make economic sense to do so by measuring and quantifying value of potential disruption to a company's operations.

6.3 Approach

CSIC conducted two industrial workshops on infrastructure future proofing and its integration with asset management. On the basis of lessons learnt from the workshops as well as from key literature analysis, an innovative infrastructure future proofing framework, a futureproofing assessment approach and set of key future proofing criteria are proposed. The approach helps organisations understand gaps in future proofing considerations across infrastructure assets.

6.4 Outputs

1. A set of infrastructure future proofing criteria
2. A structured infrastructure future proofing framework and assessment process and tool
3. Masood, T and McFarlane, DC and Parlikad, AKN and Schooling, J (2014) *The Role of Futureproofing in the Management of Infrastructural Assets*.
4. Masood, T and McFarlane, DC and Parlikad, AK and Dora, J and Ellis, A and Schooling, J (2015), Towards the futureproofing of UK infrastructure.
5. Two more journal papers are currently being written.

6.5 Case studies

6.5.1 Liverpool waste water treatment infrastructure

CSIC's futureproofing tool has been successfully piloted on Liverpool Wastewater Treatment Works (LWwTW) with United Utilities and Costain to meet increasing wastewater treatment demand due to long-term population growth while keeping the River Mersey clean. The existing wastewater treatment works at Sandon Dock became operational in 1991 and was upgraded to its current form in 2000. As a result the Mersey now sustains a wide range of fish. However, the works needed replacement. Liverpool Wastewater Treatment Works is a £200 million extension project to keep the Mersey clean for generations to come. Due for completion Spring 2015, the new plant at Wellington Dock will serve around 600,000 residents. The completed plant will be able to cope with 11,000 litres of wastewater a second. CSIC piloted the infrastructure futureproofing tool on LWwTW. We have:

- Identified possible future changes that might affect LWwTW infrastructure
- Defined futureproofing criteria in the LWwTW infrastructure context i.e. resilience, adaptability, replaceability, reusability, system stability and information replaceability
- Assessed various assets of LWwTW infrastructure (e.g. pumps, buildings, piping, screens) against the futureproofing criteria
- Defined futureproofing targets against assets
- Conducted gap analysis of current and targeted futureproofing goals for assets
- Tested usability and usefulness of the infrastructure futureproofing tool

Application of the futureproofing tool has provided direct benefits to LWwTW infrastructure supplying information to support:

- Assessment of the suitability of pump, building, piping and screen assets when considering the design of upgrades and new facilities for long-term use and maintenance
- Selection of a variety of water and wastewater process asset upgrades
- Embedding the infrastructure futureproofing tool/criteria in risk management process/risk register and stakeholder management process/stakeholder map
- Driving innovation and improvement in the industry for future projects
- Informed decision making presenting through-life value benefits
- Improved infrastructure futureproofing strategies to enhance resilience of infrastructure to climate change impacts

6.5.2 Other Case Studies

- London Underground (underground rail infrastructure)
- Crossrail (tunnel and pumps for underground rail infrastructure)
- Pakistan Railways (overground rail infrastructure)
- Network Rail (overground rail infrastructure)
- Heathrow (airport infrastructure)

