Asset Management

ICE Thought Leadership

Institution of Civil Engineers

Realising a World Class Infrastructure

ICE's Guiding Principles of Asset Management

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01. Foreword

Infrastructure forms an essential part of our daily lives and is vital for creating economic prosperity and maintaining society's health and well being. Civil engineers across the globe play a pivotal role in developing, operating, and maintaining the economic infrastructure networks we use on a daily basis.

In an ever changing world affected by environmental changes including climate change and socio-demographic and financial constraints, our essential infrastructure is constantly being put to the test. In order to increase awareness of the value of our infrastructure networks on our standard of living and the role civil engineers have in maintaining those networks we must take a holistic view of our networks from inception to decommissioning.

Asset Management creates this holistic focus, viewing our economic infrastructure over its entire lifecycle, and provides the basis for a coordinated and coherent approach. It ensures our essential infrastructure receives appropriate investment and attention, has the appropriate resilience to meet new challenges and can sustain our economic prosperity.

The document outlines:

- the issues and challenges faced by economic infrastructure and how these can be overcome

- and the principles key decision makers should use to effectively create, develop, operate and decommission their assets.

I would like to thank the working group from the joint Institution of Civil Engineers / Chartered Institute of Civil Engineering Surveyors Management Expert Panel for creating this guide and setting out the foundation for the important issues affecting economic infrastructure in the 21st Century.

Professor Barry Clarke
President, Institution of Civil Engineers

02. Characteristics of civil engineering infrastructure assets

Civil infrastructure assets are predominantly one-off or prototype projects. They must be adaptable to changes in capacity and usage and they must be considered as holistic, multi-disciplinary systems.

(i) Unique infrastructure
Civil Engineering Infrastructure Assets (assets) typically have a number of features that set them apart from those in other industries. Firstly, the majority are effectively "prototypes" when constructed in that they are one-offs, even if some of their components are mass-produced (e.g. precast concrete elements in modular construction).

(ii) Asset longevity
Secondly, the majority of assets are designed for a relatively long life. Indeed, few are decommissioned at the end of a pre-determined lifetime. They may be replaced for reasons of safety (e.g. nuclear power plants), fashion (e.g. some commercial buildings), capacity (e.g. bridges) or function (e.g. realignment of roads), but typically not on a widespread basis. Many assets are simply retained in service, which may result in reduced understanding of the associated risks and costs of ownership.

(iii) Multi-disciplinary collaboration
Assets are not only the result of multi-disciplinary collaboration (assets include electro-mechanical, and information technology sub-assets) but are themselves typically part of larger systems/programmes. A bridge, for example, is of little practical use without the rest of the transport network of which it forms an integral part. Most equipment sub-assets will have several replacement cycles within the lifecycle of the overall civil asset.

Multi-disciplinary expertise is therefore required for the effective management of such assets, as well as cross-cutting expertise in generic skills and processes such as "systems thinking", finance and procurement, operational risk techniques, material lifecycles, IT systems, organisational performance development and change management.

(iv) Changes in purpose
During the asset's life, it may even be reassigned to a purpose very different from that for which it was originally designed. A well-known example is the former Battersea Power Station, which has seen plans to turn it variously into a rock festival venue, football stadium or most recently houses and offices.

03. Key challenges

(i) Whole-life asset management
The characteristics of civil engineering infrastructure assets bring their own particular challenges, including:

- managing a portfolio of largely existing assets that cannot economically be replaced, but must be maintained and in many cases see their economic lives extended

- from an engineer's perspective, understanding the implications of practical asset life extension within today's design codes, which encourage minimum spare capacity

Traditionally assets have not been treated holistically or considered throughout their entire lifetime. Instead, asset strategies have developed on an ad hoc basis, often on the basis of the funding available at any given point in time.

(ii) Competing priorities
In the public sector, infrastructure assets compete for funding at a national and local level with other priorities, such as social provisions. In a capital-constrained environment, there can be a bias towards selecting solutions with the lowest initial cost rather than considering the whole-life total expenditure which includes capital, operational and decommissioning costs.

(iii) Inspection and maintenance
Asset inspection regimes are traditionally based on visual inspection at standard intervals. This can often be sufficient but there are inherent risks in:

- the inability to detect deterioration that is not yet visible, or obscured

- failure to address some deterioration from being more economically repaired through regular maintenance, before it becomes visible, especially if the costs of down-time and other consequential impacts are taken into account

- that certain deterioration could lead to catastrophic rather than progressive failures.

(iv) The future
Long-term issues facing our assets are:

- adapting our assets to climate change (extremes of temperature, rising sea levels, more frequent flood events, etc)

- social change, e.g. changes in demography and the way we interact with our infrastructure

- economic challenges as it becomes increasingly difficult to fund maintenance in a period of stunted economic growth

- shortages of critical skills e.g. in older technologies, to effectively maintain older assets

- political aspects of infrastructure provision, e.g. failure to recognise and effectively respond to increasing demand for rail and airport capacity

- new uses of technology, both as a burden to our assets but also as an opportunity to improve their stewardship

- lack of knowledge of our assets through ineffective data capture and knowledge management.

(v) Development of young asset management professionals
It is important to ensure that young engineers are given the skills and tools to undertake effective asset management in order to keep our infrastructure running in the future.

The ICE recognises that core skills for effective asset management include:

- **conservation/heritage awareness**
- **data management**
- **finance**
- **lifecycle engineering**
- **performance management**
- **procurement**
- **sustainability**

The ICE will work with industry and academia to ensure future civil engineers have the training and experience essential to address these issues.

04. Addressing the challenges

"The UK's approach to infrastructure investment has in general been timid, uncoordinated, incremental and wasteful in its procurement and insufficiently targeted to supporting balanced and sustainable growth in the economy." [1]

(i) UK Government enabling
As a major asset owner, Government (including local authorities) and the regulated sectors understand the challenges of managing major assets over the long term well. It is also widely known that infrastructure investment enhances the lives of present and future generations as well as having major economic benefit. To this end in 2010, the UK Government created a 'National Infrastructure Plan' (NIP) to set out "a broad vision of the infrastructure investment required to underpin the UK's growth"[1] a large part of which included the need to maintain and make better use of the infrastructure we currently have. This plan has since been updated with the latest version produced in 2012. The NIP has three elements: [2]

- effective planning for the medium term across all sectors.
- mobilising finance and funding for infrastructure investment.
- the Government taking an active role in ensuring the infrastructure in the plan is delivered.

Through the implementation of the NIP the UK Government can provide effective direction and enable future growth of the UK's essential infrastructure.

Other UK Government initiatives include:

Infrastructure cost review report (2010): identified the opportunity to improve delivery and make efficiency savings of at least 15%: Government and industry groups are working towards enabling and implementing these savings.

Infrastructure procurement routemap: published in January 2013, brought together public and private sector clients with academics to develop asset delivery models: a key component of the Routemap is a capability assessment of the sponsor and the appropriate approach to asset management.[3]

Supply chain engagement:
Government is working to reduce inefficiency and improve strategic collaboration between clients and the supply chain: good examples of this are the Nuclear Supply Chain Action Plan[4] and Nuclear Industrial Strategy[5]. A Construction Sector Industrial Strategy is also being prepared for release later this year.

Public Sector Social Value Act
This is a new government provision, which has the potential to drive wider recognition of the real value to society of economic infrastructure.

ICE has supported the work in these three areas particularly, through facilitating the discussions between industry and government.

ICE is continuing to host the Cost Review's Client Working Group, which is working on projects to develop efficient delivery of the UK's essential infrastructure.

[1] National Infrastructure Plan 2010, www.hm-treasury.gov.uk/iuk_cost_review_main_report.htm
[2] National Infrastructure Plan 2012, www.hm-treasury.gov.uk/d/national_infrastructure_plan_051212.pdf
[3] Procurement Routemap, www.hm-treasury.gov.uk/iuk_procurement_routemap.htm
[4] The Nuclear Supply Chain Action Plan www.gov.uk/government/uploads/system/uploads/attachment_data/file/65658/7176-nuclear-supply-chain-action-plan.pdf
[5] Nuclear Industrial Strategy: The UK's Nuclear Future www.gov.uk/government/publications/nuclear-industrial-strategy-the-uks-nuclear-future

05. Who needs to act?

It is important that asset management is embraced at all levels from commissioning bodies, to delivery/service providers to professional bodies. The embracing of asset management principles and philosophy will serve as a good basis for delivering a consistent, robust approach.

(i) Commissioning bodies

With Government, Local Authority and public/quasi-public sector bodies* being the typical clients that commission, procure, deliver, operate and maintain major assets, asset management solutions are especially important during a period of reduced spending where value for money is extremely important. Plans such as the National Improvement and Efficiency Strategy (NIES) set out an ambition for Local Authority-led improvements. These should be made in collaboration with local service providers using available resources to support improvement and efficiency within a local area.

Two examples of major clients who have learnt to develop procurement methods that focus on asset management are:

Highways Agency: which has created a portfolio approach to enable it to effectively manage infrastructure while ensuring value for money in terms of whole life cost, safety and durability: where appropriate a risk-based approach is used to evaluate capability and improve performance, balancing reactive demands against proactive development.

Network Rail: effective asset management supports the delivery of a promise to "deliver the timetable, so that trains run safely, punctually and reliably now, and in increasing numbers in the future".

The client should have an organisation that is imbued with an asset management culture and has processes for ensuring that asset management extends into operation, maintenance, renewal and disposal. It should have adequate information and data on operations available to influence future decision-making and apply risk-based techniques for prioritisation and decision-support. It should also be able to share the asset data with important stakeholders.

In addition, the client can ensure that there are robust processes that they and their delivery partners can ensure will provide the right level of performance, which in turn can be achieved by formalised asset management policy/strategy procedures (PAS 55 / ISO 55000) and risk management process (ISO 31000).

(ii) Delivery/service providers

It is important for delivery/service providers to have the right expertise, knowledge and approach to delivering a consistent asset management service. They should consist of asset managers with suitable technical backgrounds and personnel in all business sectors. A useful approach is to co-locate the financial, legal and engineering groups with asset management groups. Staff from these groups can then form the basis for project-specific teams based on the size/complexity of a project.

(iii) Professional bodies

Professional bodies should endeavour to work together to develop a dedicated knowledge and understanding of asset management for the benefit of society.

These professional organisations should gather, collate and present best practice and contemporary research, as well as providing tools to assist organisations to act on this knowledge.

The ICE will spearhead this engagement and endeavour to bring professional bodies together to recognise the issues necessary for understanding infrastructure asset management. We will aim to ensure that Civil Engineers have the best tools and guidance available to undertake these essential tasks.

Additionally ICE Publishing is currently in the process of launching the 'International Journal of Asset Management'. This aims to be an interdisciplinary and international journal publishing articles on all the major aspects of asset management, providing an invaluable source to those working in or learning about asset-intensive industries.

* Examples of public/quasi-public sector clients are: Network Rail, the Highways Agency, Water companies and other regulated bodies.

06. Guiding principles

(i) Best practice principles & asset management standards
Core elements of asset management best practice are defined in PAS 55 and its replacement IS0 55000, using a framework of competencies. This framework aims to create an optimum balance between the performance, risk and cost of assets over their entire lifecycle. Key aspects of best practice include:

- Clear line-of-sight from organisational strategy to activity "on the ground"
- whole-organisation alignment with asset management
- active and visible sponsorship from senior executives
- defining the levels of performance provided by the assets to customers
- recognising the lifecycle and associated risks of the assets
- turning data into useful information
- understanding the true costs of ownership
- understanding the implications of deferred interventions
- evidence-based decision making

These benefits also provide the data and understanding necessary to avoid physical and financial surprises.

(ii) Embracing with asset creation focus
Asset creation or procurement is defined by the Government Construction Strategy as:

"Part of a system that commences at the inception stage of a project, and is concluded only when the facility has been brought into use with proper arrangements made for asset management"[6]

Many of the assets currently in operation will – at some point – need to be partially, progressively or completely replaced in order to ensure the service they provide is not lost.

An infrastructure Lifecycle Management Plan can enable the lifecycle expectations to be defined. This allows designers to include facilities for accessing and monitoring the most critical sub-systems and assets through an asset management based design.

This, along with increased use of technology e.g. BIM (see section 07 below) can allow maintenance issues to be recognised and addressed before catastrophic failures occur.

(iii) Commissioning principles
Setting out important principles at the commissioning stage of a project can create an environment in which all potential benefits are recognised from the outset and realised throughout the project. These can include:

- documenting lifecycle-based considerations to justify materials and equipment selection based on service life requirements, in-service climatic conditions and forms of construction
- identifying critical construction steps which have potential to put long-term performance at risk
- network or systems design involving multiple stakeholders with a complementary range of knowledge and expertise
- providing "infrastructure Lifecycle" Management Plans as part of design output
- favouring output/performance-based principles when procuring maintenance

iv) Asset life extension
Assets are normally designed and built to allow for increased capacity over time (e.g. traffic flows, load cases on structures etc.) The asset manager's role is to ensure that capacity continues to meet demand, with an appropriate additional contingency to mitigate a level of risk judged acceptable by the organisation. This gives rise to the following outcomes:

- restricting demand, e.g. by placing weight limits on bridges
- restoring existing capacity, e.g. by local repairs to deterioration
- adding local capacity, e.g. plate-bonding to strengthen bridge deck beams
- adding network capacity, e.g. widening a motorway by hard shoulder running.

(v) System-wide and whole asset lifecycle considerations
At the system/network level, decisions on the prioritisation and timing of expenditure on maintenance, repair or replacement will have to be made across sizeable asset portfolios. This requires evaluation of not only the likelihood, timing and costs of the interventions being required, but also the consequences of delaying the intervention. An example of this could be postponing a road resurfacing operation into the next year. Consequence-based risk evaluation techniques can then be used.

[6] UK Government Construction Strategy

Both quantitative and qualitative risk techniques to assess the likelihood of failure can be used to compare options for allocating funds according to risk appetite. At the system or portfolio level, this enables risks and mitigation options to be effectively compared between asset types.

In order to ensure our interconnected systems and networks are resilient, it may be appropriate and financially preferable to build in redundancy and spare capacity to assets. This would help prevent a substantial failure in one network cascading, having unforeseen consequences.[7]

(vi) Cross-system resilience and beyond

When applying the above techniques we must also consider how nearby systems are affected by each other. For example how does the flooding of a river affect roads, bridges and the telecommunication networks embedded within them.[8]

The interconnected nature of infrastructure requires greater clarity on how budgets are allocated and spent. This is especially important to ensure essential assets, with societal benefits, are recognised as such and funded appropriately.

There are a number of initiatives progressing in this area. In particular the ICE is currently leading the production of an Engineering the Future report to look at infrastructure development over the next 50 years and how projects, policies and future planning may impact across sectors.

[7] ICE (2009) State of the Nation, Defending Critical Infrastructure
[8] An innovative approach for improving infrastructure resilience Proceedings of the ICE, Civil Engineering Volume 165, Issue 6, 01 November 2012

07. Information technology for asset management

Utilising evolving technology presents challenges in ensuring that management, methods and processes for delivering and utilising information are fully embedded in common industry practices and standards.

(i) State of the art

The ready availability of increasingly sophisticated technology provides asset managers with an unprecedented ability to capture, store, analyse and exploit information across a portfolio of assets, to better understand their condition and predict their future performance.

Data from the design and construction process can now readily be made available in the operate-and-maintain phase of an asset's life through the use of BIM techniques.[9] Meters and sensors can provide real-time information on the asset's performance. Enterprise Asset Management (EAM) systems can operate across the whole of an organisation's assets and relate them to mapping and other geospatial information.

EAM systems can support a technology-enabled workforce charged with asset maintenance, from scheduling tasks, routing crews and managing inventories to providing on-site support via handheld devices that both provide existing information to the workforce and update records with the work that is performed.

All this data in turn can provide the basis for a strong foundation of asset managers: predictive asset management. The tools and techniques now exist to strengthen predictions of asset degradation and failure with a high degree of confidence, with the main limitation being the availability of a sufficient volume of high-quality historic information to refine the algorithms.

Advanced analytics can relate initial, maintenance and operational failure costs to derive optimal investment scenarios as well as modelling the likely impact of under-investment at any stage in the asset lifecycle.

(ii) Practical considerations

It is becoming increasingly important to define an information strategy for assets. This will determine what information is required throughout the asset's life to facilitate the subsequent analysis that will in turn help to optimise the asset's performance. This data will not only be that directly related to the physical structure of the asset, but typically include contextual data such as loading or occupancy, environmental conditions and extracts from finance systems.

The data itself is of little value if it cannot be turned into actionable information, so the way in which it will be exploited, and the systems used to do so, are key elements of such a strategy.

A 'single version of the truth' needs to be constructed in place of the plethora of separate and sometimes contradictory data sources that often exist today. This need not reside in a single database, but is typically drawn from a number of live and consistent sub-systems as required. However, as the data is ever more centralised, and the ability to monitor and control assets remotely increases, security provisions to prevent malicious misuse will need to become more robust and resilient.

(iii) Building Information Modelling

Building Information Modelling (BIM) refers to the tools and processes which have the potential to realise substantial efficiencies from the design stage and throughout the infrastructure lifecycle to demolition or decommissioning. One of the obstacles for the widespread adoption of BIM is the perception that it is mainly a tool for the design and construction of buildings, rather than for the cradle-to-grave lifecycle management of all forms of infrastructure.

As BIM technology develops and is used to improve the management of assets through their lifecycles, asset owners will need to fully understand:

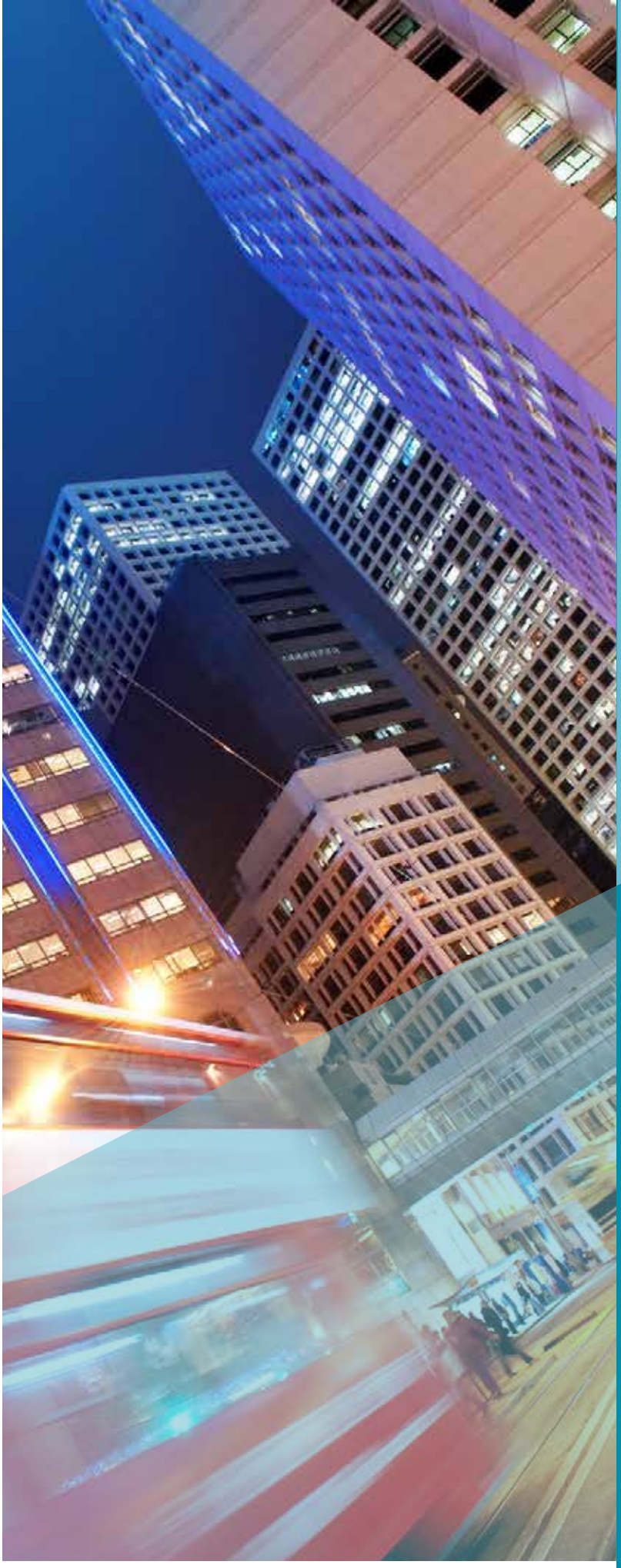
- the information needed post construction completion
- the interaction between BIM, asset management and maintenance management systems.

[9] ICE BIM Policy Position Statement, www.ice.org.uk/getattachment/topics/ informationsystems/Building-information-management-BIM/ICE-BIMM-PPS_v5.pdf

BIM provides a great opportunity for the construction industry and infrastructure owners to develop new methods of working. CAD packages that can handle multi-dimensional graphical and non-graphical data, EAM systems, inter-enterprise collaboration tools and common data exchange protocols all have their part to play. However, they are just tools that support more time and resource efficient ways of working in an information rich environment.

A strategy for the lifecycle information requirement of assets will support the adoption of BIM and support its continuing development. Issues related to ownership of BIM data throughout the lifecycle of an asset, how data is certified and to whom, are current areas of debate.

The ICE is providing thought leadership on these and is working with the UK BIM Task Group (www.BIMtaskgroup.org).



08. Summary

As Government rightly recognised through its Cost Review and National Infrastructure Plan, the UK's current infrastructure has not received adequate investment and is often running at capacity. A greater focus on how current infrastructure and its performance are maintained is essential. Equally when constructing new infrastructure it is important to fully understand its intended use, capacity and how evolving climate, financial, political and socio-demographic changes will affect it in the future. Work such as the Procurement Routemap, industrial strategies and engagement with the supply-chain serve to create a strong vision for investment in economic infrastructure and the UK construction sector over the long-term.

An effective asset management framework can provide the tools and processes for doing this. Using standards such as PAS 55 a client and operator can effectively manage their assets ensuring they keep running and providing the essential service to the community.

Good asset management has both financial and non-financial benefits. In summary good asset management can:

- deliver exceptional services for citizens aligned with local investment priorities
- reduce carbon emissions and improve environmental sustainability
- increase co-location, partnership working and sharing of knowledge
- generate efficiency gains, capital receipts or an income stream
- increase intelligent use of assets to deliver organisation/cultural goals
- improve governance, effective leadership and change management.

This guide has aimed to give a brief overview of this important topic. ICE is working closely with government and industry, and will establish stronger relationships with other professional bodies – such as the Institute of Asset Management- in order to provide further guidance and best practice to civil engineers world-wide. ICE will work to facilitate discussions between academia and industry in developing the necessary skills for young engineers to manage assets as well as develop state of the art technologies to assist this work.

This guide will act as the focal point for ICE's future work on this important topic. Further guidance, best practice and case studies will be produced with input from the ICE's expert panels, external organisations and the professional bodies. Alongside this will be the production of ICE Publishing's Infrastructure Asset Management Journal in late 2013.

If you would like to know more about this work or have any comments on this guide please email management@ice.org.uk.

09. Acknowledgements

The Institution of Civil Engineers would like to thank the authors of this document, who gave freely of their time, as well as their employers for releasing them for this activity. In particular:

Jay Doshi
AMEY

Simon Parsons
IBM UK Ltd

David Pocock
Halcrow – CH2M HILL

Matthew Parker
ICE

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/Our vision

Civil engineers at the heart of society, delivering sustainable development through knowledge, skills and professional expertise.

/Core purpose

- To develop and qualify professionals engaged in civil engineering
- To exchange knowledge and best practice for the creation of a sustainable natural and built environment
- To promote our contribution to society worldwide

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Registered charity number 210252.
Charity registered in Scotland number SC038629.

Design by Adam Peter, May 2013.
www.adampeter.co.uk
Printed on paper made from sustainable resources.