The Institution of Engineering and Technology

Good data for the public good

Realising our influence in moving from paper to data

theiet.org/good-data

In partnership with

ARCADIS ARUP ATKINS BURO HAPPOLD Norconsult SWECO

Good data for the public good is published by the Institution of Engineering and Technology.

Please note that the views expressed in this publication are not necessarily those of the IET. It is not intended to be a guidance note with a specified set of recommendations or actions but rather seeks to add understanding and debate around the topic.

The Institution of Engineering and Technology

The Institution of Engineering and Technology (IET) is working to engineer a better world. We inspire, inform and influence the global engineering community, supporting technology innovation to meet the needs of society. The Institution of Engineering and Technology is registered as a Charity in England and Wales (no. 211014) and Scotland (no. SC038698).

Contents

About this report

This IET report looks at the transition of the built environment from document-centric to data-centric. Written for technology providers and users within the built environment's engineering and design community, it also considers the changing focus around project delivery; moving away from short-term towards whole-life value propositions.

To deliver operational benefits for owners, operators, occupants and users of built assets throughout their whole life, we need data that's perpetually accessible while also being securely managed. Simultaneously, to deliver wider social, economic and environmental benefits, we also need data to be open. This doesn't mean free; the openness of data is about its interoperability and ease of distribution.

These aspirations inevitably challenge existing industry practices and some entrenched commercial positions. As industry practice has begun to shift from document sharing to data sharing, the role of established technology providers may also need to change. Today's architecture, engineering and construction (AEC) software providers will need to review how they might best capitalise on the rapidly changing nature of built environment data in the 21st century.

This IET document seeks to provide insight into key issues, views and recommendations and has been reviewed by the IET Built Environment Panel.

The IET Built Environment Panel and authors of this report would welcome any comments or suggestions on this report or for future publications. Please send these to **sep@theiet.org**.

The authors of this report are as follows:

Marius Jablonskis
Technology Manager, Norconsult

Cathrine Morch
Chief Digital Officer, Sweco

Dr Joop Paul
Director, Europe Region Digital Executive, Arup

Neil Thompson
Director, Digital Construction, UK & Europe, Atkins Global Ltd
Member of the IET Built Environment Panel

Andrew Victory
Global Digital Transformation Lead, Arcadis NV

Alain Waha
Global Lead, BIM & Digital Transformation, Buro Happold Ltd

1. Recommendations

Truly effective architecture, engineering and construction (AEC) responses to population growth, urbanisation and climate change will deliver and maintain better assets for the public good. Complementing these built assets, we also need to create, maintain and securely share the associated data for the public good[1]:

To deliver operational benefits for owners, operators, occupants and users of built assets, we need data to be:

- **Maintained obligatorily** throughout their whole life,
- **Aligning asset** and asset data ownership, and
- **Perpetually accessible** while also being securely managed.

Simultaneously, to deliver wider social, economic and environmental benefits, we also need data to be:

- **Mutualised**: to be open, connected and easily shareable, and
- **Long term** accessible.

To achieve this, stakeholders in the built environment will have to reconsider their strategic choices, especially software providers that may overhaul their current technology business models.

[1] https://www.nic.org.uk/wp-content/uploads/Data-for-the-Public-Good-NIC-Report.pdf.

2. Introduction and methodology

Since the 1980s software applications have moved from the periphery to the centre of professional AEC industry practice.

Initially, most organisations focused on digitising common and previously laborious, manual and often repetitive office activities. Word-processing replaced typing, spreadsheets replaced manual book-keeping, email gradually started to replace postal correspondence and faxes – aided by parallel developments such as the Internet.

In parallel with similar advances across other industry sectors, AEC-specific processes also began digitisation – in particular, computer-aided design (CAD) and analysis applications accelerated the creation and development of design deliverables.

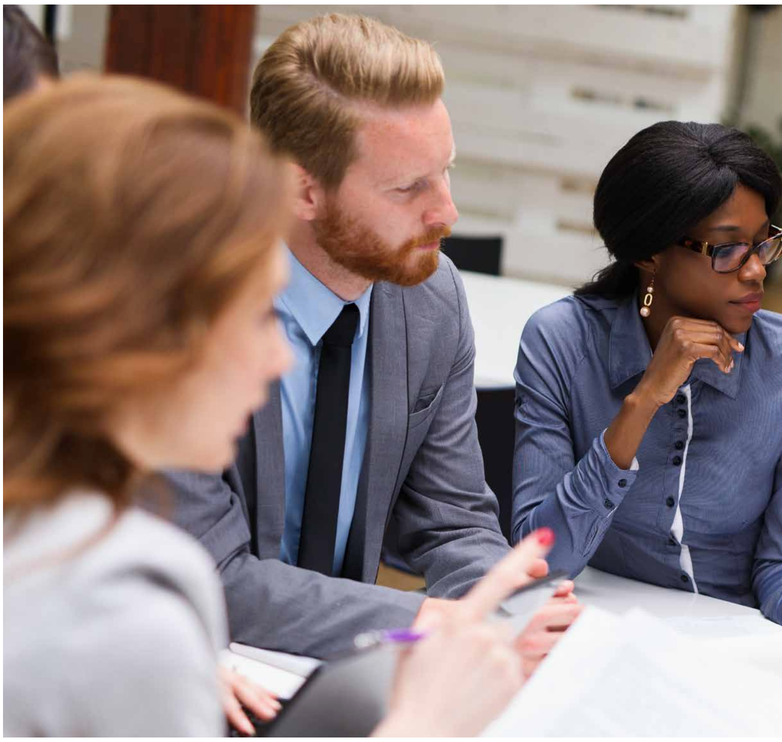
Arguably the world's oldest industry, construction has historically been characterised as conservative and risk-averse. Even in developed markets such as those in western Europe, its business structures and processes are often parochial and have been slow to change over the past century. Small wonder then that, according to McKinsey[2], industry productivity has barely changed since the 1960s, while manufacturing doubled productivity over the same period, and in Europe construction is bottom of the league when it comes to digitalisation[3].

While some clients and teams work in alliance-type relationships, large parts of the construction industry still work within traditional procurement processes, contracts and insurance arrangements that have changed little over the years, with exchanges of documents still key.

Today, population growth and urbanisation are challenging the industry's capacity to deliver future accommodation and infrastructure, while climate change demands new thinking to meet shelter, food, water, energy and other basic human needs.

Faced with a range of increasingly global political, economic, social, technological, legal and environmental challenges, the AEC industry will need to adapt. We believe digitalisation; which Gartner describes as "*the use of digital technologies to change a business model and provide new revenue and value-producing opportunities: the process of moving to a digital business*" could transform the sector.

Construction has historically often been characterised as **conservative and risk-averse.**

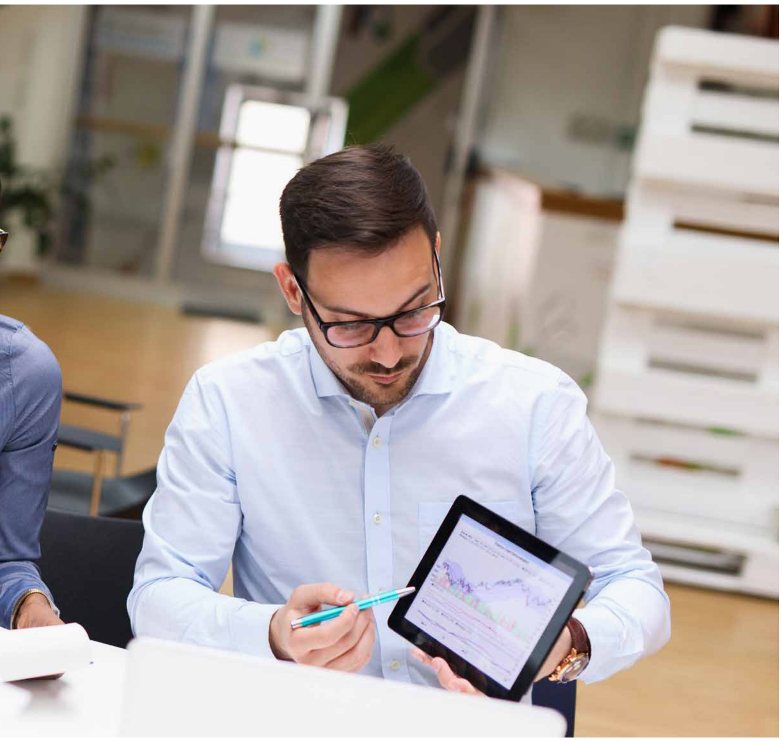


[2] McKinsey Global Institute, The construction productivity imperative, July 2015.
[3] McKinsey Global Institute, Digital Europe: Pushing the frontier, capturing the benefits, June 2016.

Potential game-changers include[4]:

- emerging international process standards such as ISO 19650
- building and component standardization
- offsite manufacturing techniques
- alternative models of procurement, such as the UK Infrastructure Client Group's Project 13[5]
- new forms of contracts and insurances
- increasingly globalised corporations (clients, consultants, contractors, suppliers and technology vendors)[6].

As the AEC sector shifts towards more data-driven approaches, it will need to overhaul outdated processes founded on the exchange of documents. Some foundations are already in place: cloud and mobile computing, reality capture and building information modelling (BIM) enable better collaboration and faster and more accurate communication.



However, efficiently meeting the future digital needs of owners, operators, occupants and users of built assets, while also achieving wider societal goals, will require the application of new and more consistent principles covering how data is created, shared, owned, managed, stored, accessed, reused and analysed.

During research for this report, discussions covered everything from open, linked and big data through to interoperability, data standards, data security and privacy (at rest and in transit), data analytics, artificial intelligence, machine learning and digital twins.

Through interviews, desk research, a workshop and follow-up email discussions, we developed a set of interconnected principles or long-term aspirations similar to, and in some cases overlapping with, the Centre for Digital Built Britain's (CDBB) Gemini Principles[7]. These broadly defined what might constitute 'good data:

To deliver operational benefits for owners, operators, occupants and users of built assets throughout their whole life, **we need data that is perpetually accessible while also being securely managed.**

Simultaneously, to deliver wider social, economic and environmental benefits, we also need data to be mutualised: **to be open, connected and easily shareable.**

The remainder of this paper outlines some of the issues to be addressed in delivering both broad operational and societal benefits. Across the two there is a strong ethical drive to create trust in the data, in the organisations managing that data, and for them to be demonstrably maximising the public good.

[4] In Shaping the Future of Construction (May 2016), the World Economic Forum and Boston Consulting Group proposes an Industry Transformation Framework detailing how future best practices might evolve.
[5] The UK Infrastructure Client Group's Project 13 seeks to develop a new business model – based on an enterprise, not on traditional transactional arrangements – to boost certainty and productivity in delivery, improve whole-life outcomes in operation and support a more sustainable, innovative, highly skilled industry. See p13.org.uk
[6] In Shaping the Future of Construction (May 2016), the World Economic Forum and Boston Consulting Group proposes an Industry Transformation Framework detailing how future best practices might evolve.
[7] The UK's CDBB Digital Framework Task Group, in November 2018, published "The Gemini Principles" – nine foundations for 'digital twins', aimed at delivering the National Infrastructure Commission's objective of 'Data for the public good'.

3. Delivering operational benefits

Current technologies can deliver realistic digital representations of physical assets, but digital twins are distinguished from other digital models by having data connections to their physical twins. Creating a digital twin of a built asset, therefore, presents opportunities for industry to better serve the needs of owner-operators throughout their use of that asset while also providing assurance about the built asset itself.

3.1. Whole-life open asset data

Following the Grenfell Tower fire in London, Dame Judith Hackitt proposed the creation of a Golden thread: a digital record for all new high-rise residential buildings "*from initial design intent through to construction and including any changes that occur throughout occupation*"[8]. If enacted, this will create whole lifecycle data obligations that can be scrutinised by regulators and others.

Hackitt expressly specifies that government should "*mandate a digital (by default) standard of record-keeping*" covering design, construction and subsequent refurbishments. These digital records would "be in a format which is appropriately open and non-proprietary with proportionate security controls".

This would replicate practices in Nordic European countries which mandate the use of open non-proprietary data-format Industry Foundation Classes (IFC), for data exchange to enable regulatory scrutiny. Singapore and Hong Kong authorities have also been exploring the potential to use digital outputs for planning applications and building control regulatory purposes, while also increasing the transparency of public service operations.

If such approaches were more widely extended, we considered that a mandatory cradle to grave digital record, while meeting legal and insurance requirements as to provenance, could also add financial value to built assets. This would encourage clients such as developers, who build and then sell on their developments, to insist on digital record-keeping as part of their organisational information requirements.

[8] Dame Judith Hackitt, Building a Safer Future: independent Review of Building Regulations and Fire Safety: final report, May 2018, chapter 8, pp.102-105.

3.2. Client data ownership

As the built asset's data will have a financial value, it would seem sensible for asset ownership and data ownership to be aligned. In this manner, in the event of a sale of the physical asset, its digital twin would be included, incorporating the service history and details of any refurbishments or improvements as well as the initial as-built data.

When new projects are instigated, clients should be supported in establishing a common data environment (CDE); granting access to designers, constructors, manufacturers and other suppliers to help build, maintain and update the asset record while respecting their respective intellectual property rights in perpetuity. Current copyright protections, where design authors provide restrictive licenses for clients use of their design data, would also be maintained.

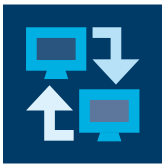
Planning, design, construction and commissioning information will be digitally captured and – if digital record-keeping becomes mandatory – will, post-handover, then need to be maintained by the asset owner or by a service provider appointed by the owner.

3.3. Security

Digital records will also need to be securely managed. Since the publication of PAS 1192-5 in 2015, built asset security management has had increased scrutiny and will be critical for digital twins.

The CDDB's Gemini Principles stresses that "*data security and thereby personnel, physical and cyber security are essential for [trust]*". We endorse its secure by design approach, as well as GDPR-style privacy by design ethical principles to protect participants, occupants and end-user's personal information.

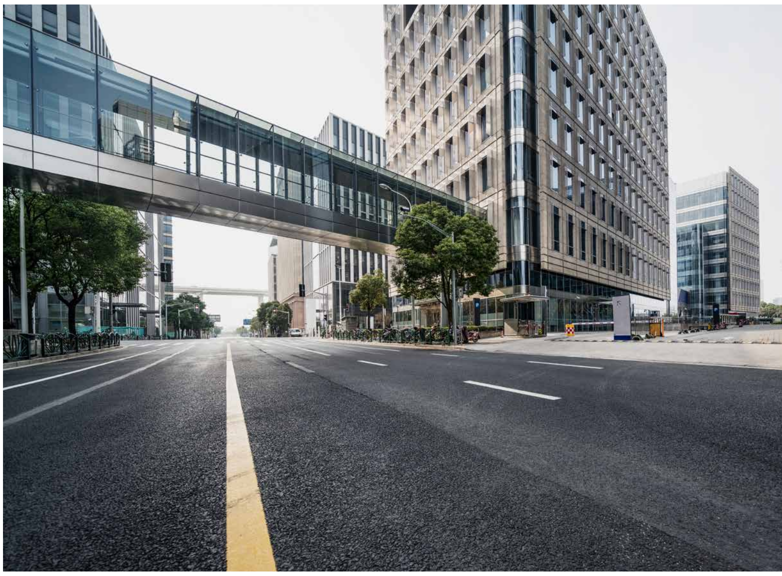
3.4. In-service data sharing



In a currently under-digitised industry, there are few current examples of smart buildings[9] or digital twins, but we looked at experiences in other sectors.

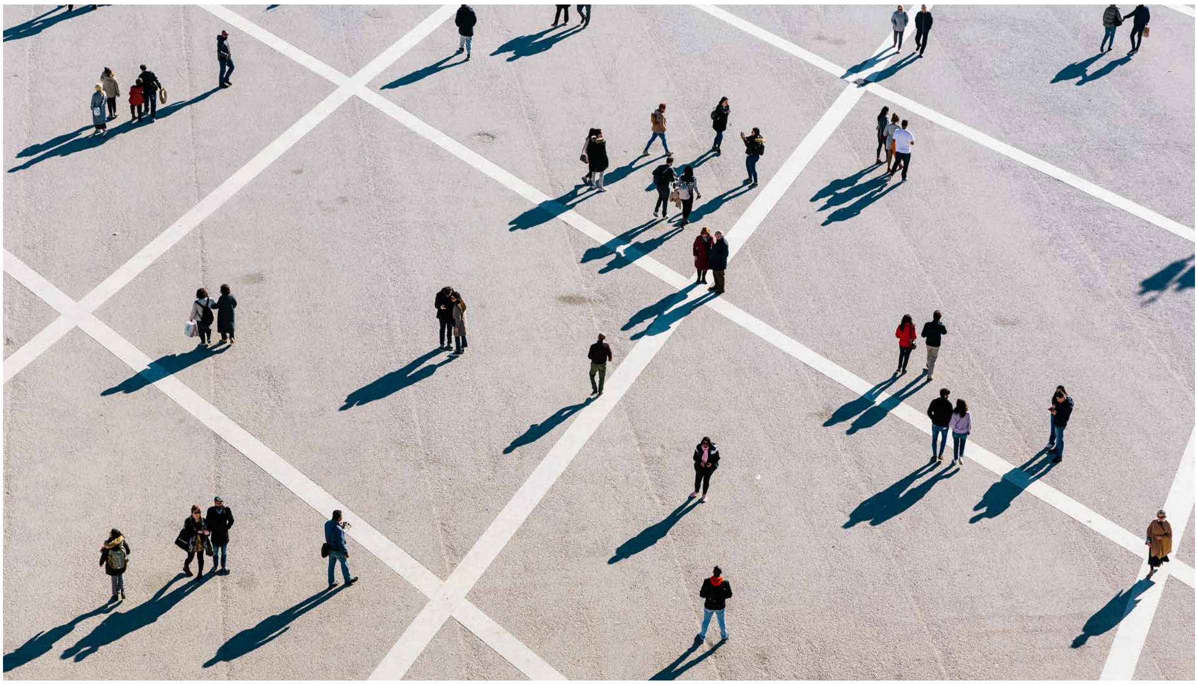
For example, a Mercedes F1 racing car has over 200 sensors connected in real-time to pitlane telemetry, providing over 300GB of performance data during a race to the team's pit crew. Similarly, Rolls-Royce captures rich data from every aircraft flight using its jet engines. These may be extreme examples, but even a simple dashboard view of a built asset's in-service performance could deliver high value to its owner-operator – infrastructure examples might include power stations, water treatment works, etc.

Furthermore, if something goes wrong, such data might also be interrogated to establish the cause(s) and prevent future repetition, just as manufacturing faults can trigger product recalls, helping maintain owner-operator and wider public confidence.



[9] Deloitte's Edge Building in Amsterdam was one example discussed by the EXC – see https://www2.deloitte.com/ru/en/pages/about-deloitte/articles/gx-the-edge-of-tomorrow.html.

4. Delivering societal benefits



4.1. Removing data silos

Historically, architectural, engineering and construction (AEC)-specific software was often developed in isolated pockets, designed to support specific tasks within disciplines. As a result, many design applications focus on silos – architecture, mechanical, electrical and public health systems (MEP), structures, civils, etc. – and often produce file-based design deliverables such as drawings and models in proprietary formats or stored in proprietary databases. These deliverables may need to be converted for use by supply chain partners such as manufacturers, or owner-operator asset or facility management applications.

In parallel, businesses may also use some industry-specific tools in fields such as finance and accounting, estimation, project cost control and payment management – often disconnected from planning, design, fabrication and construction delivery.

Building information modeling (BIM) has the potential to create a more collaborative end-to-end or whole-life process based on the forming and sharing of data, but its effectiveness is hampered by silo mentalities, poor interoperability and variable support for open data models such as Industry Foundation Class (IFC) and BIM Collaboration Format (BCF). Ongoing developments in database management systems (DBMS) are helping users to exploit IFC models, but reliable export/import of BIM models to IFC, and vice versa, must be critical for any BIM technology company.

Internet and web standards are classic examples of how open approaches can foster efficient communication and data exchange, but with standardised AEC data approaches still in their infancy, some short-term workarounds will be needed. However, the long-term aspiration has to be an open digital twin model architecture rather than proprietary data scheme solutions.

> *"If the past was document sharing, the future is **data sharing**."*
>
> Tim Berners-Lee

[10] AEC Delta Mobility, UCL Bartlett.

[11] The CDBB says: "Secure, resilient interoperability... is fundamental for creation of a national digital twin."

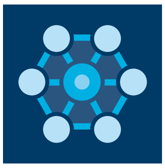
[12] Particularly on major infrastructure projects, clients and teams may be using multiple common data environments (CDEs). This raises the prospect of models and other information being duplicated, for example, across a supplier's in-house system, a contractor's CDE and the client's asset management CDE. Data-efficient synchronisation is essential to ensure effective version control, etc.

Buro Happold is involved with an Innovate UK-funded research project, AEC Delta Mobility[10], which is exploring the potential of an application programming interface (API) that enables differences ('deltas') between models to be exchanged quickly and efficiently using an open-source object model.

This approach would promote interoperability[11] by eliminating wasteful file export/import processes while enabling earlier engagement with fabricators and data reuse during asset operations[12].

It's recognised that open formats pose challenges to some developers of proprietary software who have sought to lock-in users to their technologies. AEC digitalisation potentially makes silo-oriented tools and deliverables obsolete. Owner-operators and industry professionals will need tools that create accurate, reliable and easily reusable data across the asset lifecycle – non-proprietary data formats they cannot control, and which will change over time. EU policy strongly favours open data schemas such as IFC; industry and wider societal interests will be best served by more open-source and open format approaches.

4.2. Linked data

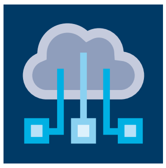


We debated business models based on large pools of data, and whether this would be practical in the built environment. While global players such as Google and Amazon have (to date) shown little interest in construction-specific services, this may be because the global AEC sector is not (yet) sufficiently attractive commercially. It's under-digitised, has low levels of product and data standardisation, and is highly fragmented.

Moreover, current technological capabilities tend towards centralising and combining data from multiple parties. Such organisation can result in considerable and time-consuming duplication of information between businesses. A more logical approach might be to manage source information and, assuming reliable connectivity, enable its assembly on the fly through the adoption of application performing interfaces (APIs) and/or linked data approaches. Distributed data held in multiple databases could then be securely and agilely aggregated, queried and accessed by authorised users as per the AEC Delta Mobility example.

Industry and wider societal interests will be best served by more **open-source and open format approaches**.

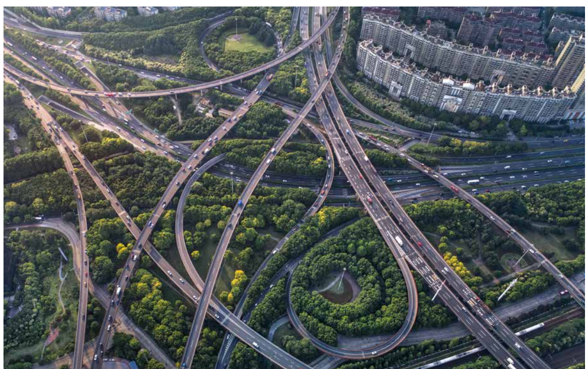
4.3. Long-term data accessibility



The growth in use of building information modeling (BIM), has led to an increased focus on delivering long-term business outcomes rather than short-term design and construction of built assets. The abbreviation AEC was symptomatic of an industry-focused primarily on asset delivery with little regard for the decades of service that those assets will need to provide.

Built asset and related business operation data, therefore, needs to be collected and stored in a form that ensures it remains securely accessible by asset owners and their partners over the long-term – resiliently and reliably outliving changes in hardware, storage media, software and operating systems.

Data will also need to survive corporate changes, including insolvency events among suppliers. For example, data related to the manufacturer, product and its operation and maintenance that might be incorporated into models via APIs, or linked from manufacturers' systems, may be backed up. Just as software source code can be deposited with a third-party escrow agent to protect software users, product data might also be stored to ensure its continued availability.



4.4. Open access data

Some data might also be openly shared for the public good.

During design, construction and operation of built assets, clients and their teams often learn lessons that they can apply to future projects. Some of these may be commercially sensitive; innovations which deliver competitive advantages, but some may have wider industry importance.

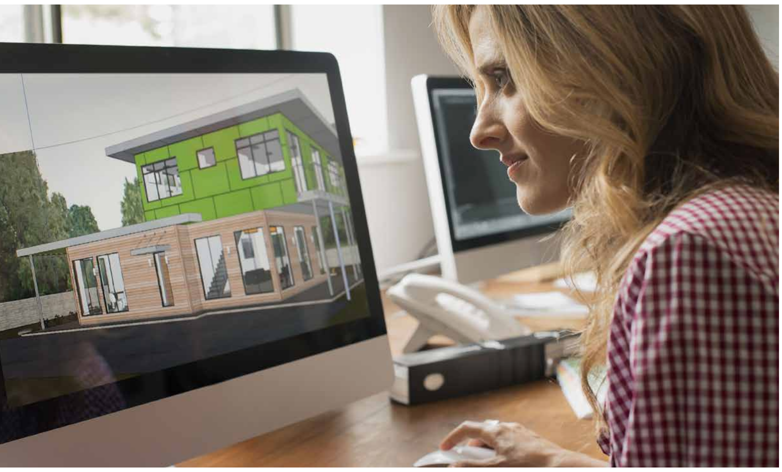
For example, where teams have identified a previously unknown health, safety or environmental issue that might be experienced on other projects, it should be obligatory to highlight such data to regulators or other industry organisations. Particularly where it might save lives, prevent injuries or illness, or reduce or eliminate environmental damage.

There is also the potential for some built asset data to be shared as open data. In the UK, some data is already shared through the Land Registry, Ordnance Survey and local planning portals. Basic non-sensitive geospatial and other data might then be re-used to provide public information and to develop new information products and services.

Enabling industry or public access to some as-built and in-service performance data may challenge citizens and businesses unused to such approaches. For example, recent debates about surveillance capitalism illustrate the common unease about unfettered commercial use of data.

Clients and industry teams might consider working with data trusts: legal entities which provide independent third-party stewardship of data[13], while protecting security, confidentiality and privacy. Such trusts might also mediate in the event of disputes[14] and/or provide data escrow agent services (see data accessibility in 4.3).

> The National Infrastructure Commission found that digitising the UK's rail network's asset information could **save up to £770m** over the next eight years and **£8.9bn in direct benefits** to the UK through public sector open data.
>
> BEIS Minister, Richard Harrington MP, foreword to 'The Gemini Principles'



[13] As defined by the Open Data Institute; the Mayor of London, Royal Borough of Greenwich and ODI are engaged on a project enabling the collection and sharing of live data, for example: energy use, parking space occupancy and weather, while maintaining the privacy and security of Londoners. In Canada, Sidewalk Labs has proposed the creation of an independent, government-sanctioned Urban Data Trust to oversee all collection and use of data from the physical environment ('urban data').

[14] The EXC was reminded of the Mott MacDonald v Trant legal dispute where one party's extranet access was blocked.

5. The future of applications of data and stakeholder response

The construction industry is starting to break out of its silos and recognises that its software tools and data need to be better integrated.

Cloud and mobile computing, BIM, data analytics, lean thinking, digital twins and other developments are shaking established paradigms, while governments and other industry clients are looking for increased industry productivity and more long-term thinking.

The time is right to reconsider current data practices and to explore new business models and relationships. Technologies developed to support short-term, fragmented, discipline-based delivery processes are increasingly inappropriate, particularly for owner-operators and their financiers, who are looking to maximise whole-life value from their built assets.

The time is right to reconsider current data practices and to **explore new business models and business relationships.**

Stakeholder response

For all stakeholders in the built environment, there are some interesting strategic choices arising from this ongoing digital transformation/disruption in the sector. As dialogues concentrated around data, the focus was especially about the possible changing role of AEC Industry Software providers, with the following possible roles within the eco-system:

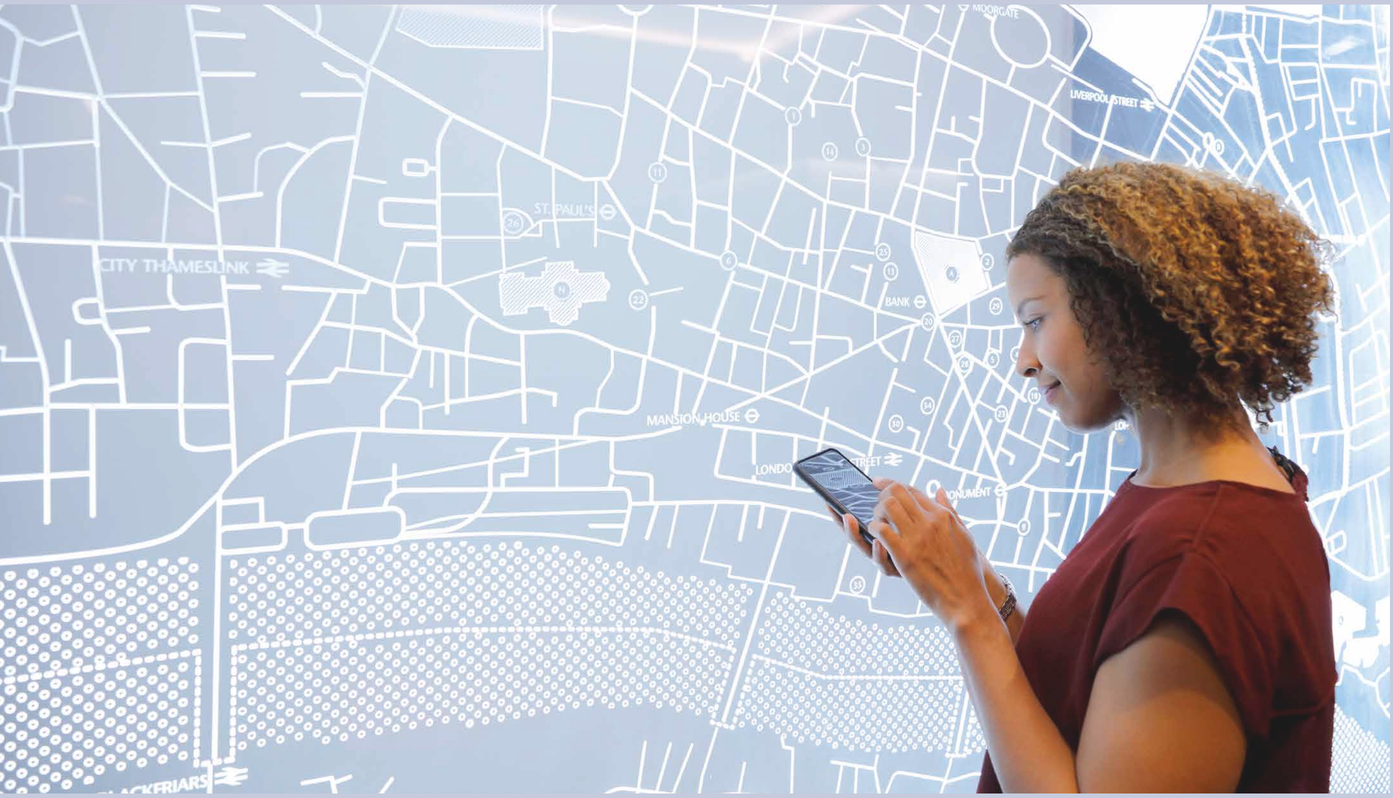
1. **Tool-maker** – do software providers want to remain focused on helping industry professionals create and combine design inputs?
2. **Market/integrator** – should software providers be the technology platforms used by teams to integrate design inputs into built asset outcomes?
3. **Data holder/broker** – could software providers become the 'digital twin' hosting hub, connecting, aggregating and delivering whole life data about built assets?
4. **Technology hub** – could software providers be a GitHub, a place to manage public and private repositories of built environment and data software?

Another conversation considered AEC software providers current position on data and an alternative 'visionary' shift:

1. **Status quo** – do software providers remain a strong defender of its proprietary data format, viewing this as centre of a life-cycle platform to which others can contribute?
2. **Visionary** – do software providers become an advocate of open data formats, backing database management systems (DBMS) research, and making all products fully Industry Foundation Classes (IFC)-compatible?
3. **Evolutionary** – do software providers adopt an 'in-between' option, reluctantly bending to external pressure to be more open?

AEC software providers like Autodesk are uniquely placed to influence how operational outcomes can be enhanced through innovative use of applications and data. However, in an increasingly globalised and connected world that faces major urban, social, economic and environmental challenges, late 20th century technology business models may need to be overhauled.

6. About the IET



We are the IET - a charitable engineering institution with over **167,000 members in 150 countries** – working to engineer a better world.

Our mission is to inspire, inform and influence the global engineering community to advance technology and innovation for the benefit of society.

As a diverse home across engineering and technology, we share knowledge that helps make better sense of the world in order to solve the challenges that matter. It's why we are uniquely placed to champion engineering.

We bring together engineers, technicians and practitioners from industry and business, from academia and research, and from government and the third sector. We are member-led, independent and impartial.

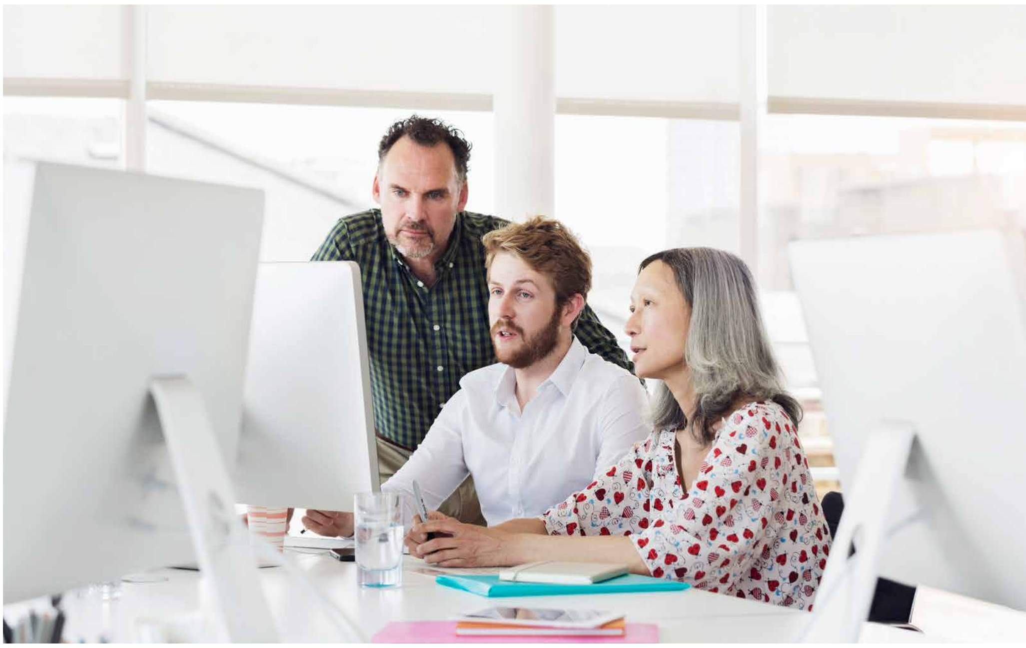
We cover engineering across industry from design and production, digital and energy to healthcare, transport and the built environment. We champion engineers and technicians by offering networking, volunteering and thought leadership opportunities.

To find out more contact **sep@theiet.org**

7. Acknowledgements

The IET would like to thank the Engineering Executive Council of Autodesk, the organisation that the authors of this report are part of. Formed in 2017, it's composed of a select group of high-level executives from a variety of engineering consultant and contracting firms throughout Europe, Middle East and Africa (EMEA). With a focus on the MEP and structural disciplines, the group regularly convenes to network, explore issues affecting the field, and share best practices among peers.

The purpose of the council is to identify and discuss industry-agnostic transformative technology trends and key business challenges and opportunities, and to better understand and react to the impact of these forces on their business.



The Institution of Engineering and Technology

Our offices

London, UK
T +44 (0)20 7344 8460
E faradaycentre@ietvenues.co.uk

Stevenage, UK
T +44 (0)1438 313311
E postmaster@theiet.org

Beijing, China
T +86 10 6566 4687
E china@theiet.org
W theiet.org.cn

Hong Kong
T +852 2521 2140
E adminap@theiet.org

Bangalore, India
T +91 80 4089 2222
E india@theiet.in
W theiet.in

New Jersey, USA
T +1 (732) 321 5575
E ietusa@theiet.org

@TheIET

theiet.org

E6D20002/Built Environment/0720