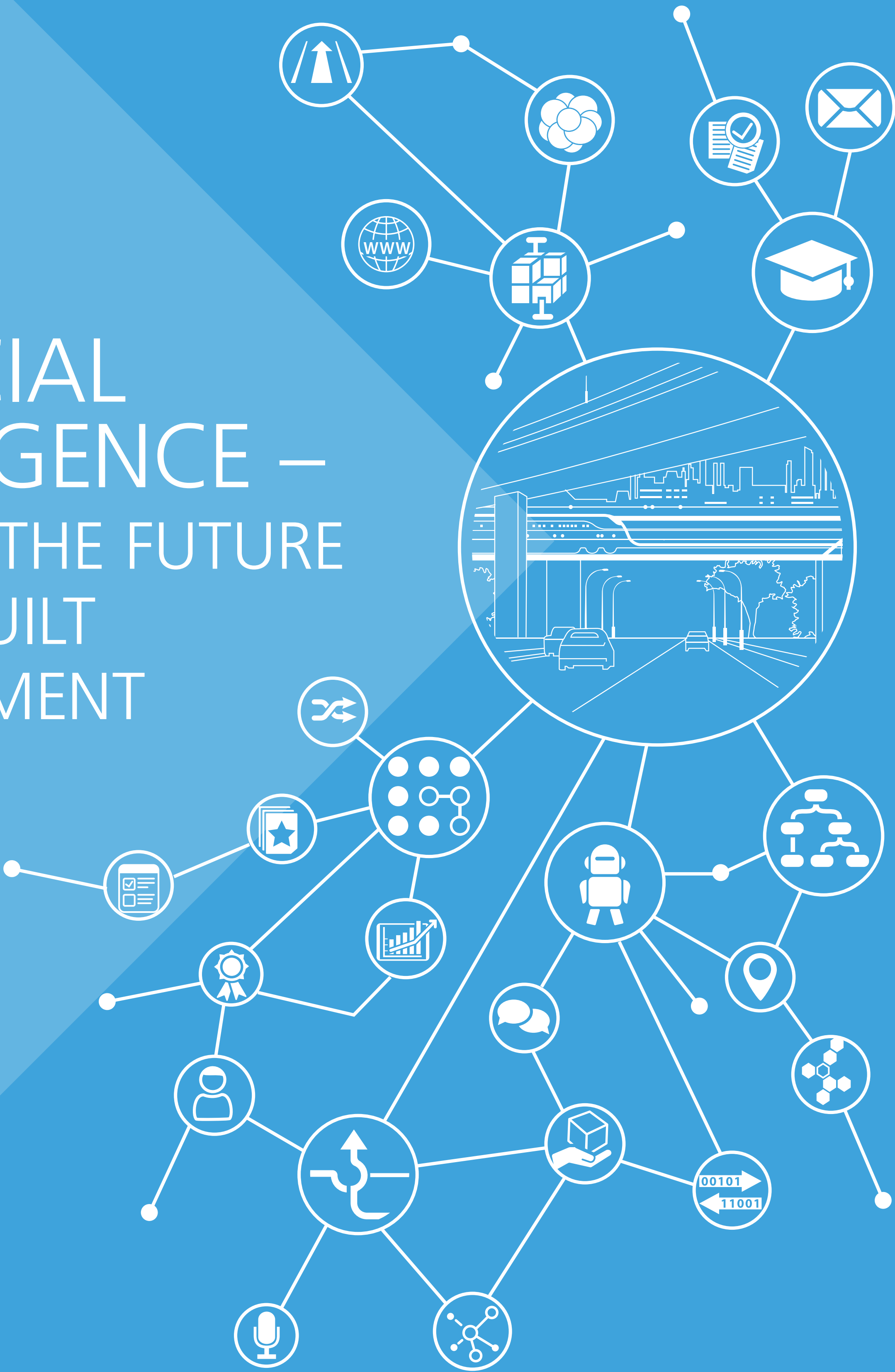
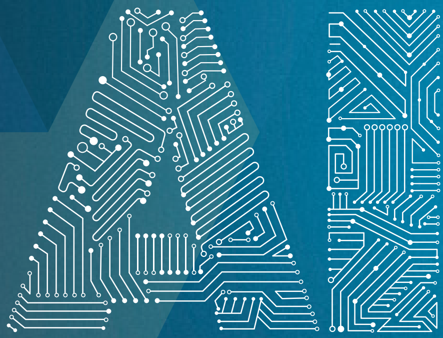
ice Thinks

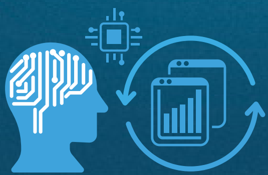
ARTIFICIAL INTELLIGENCE – SHAPING THE FUTURE OF THE BUILT ENVIRONMENT



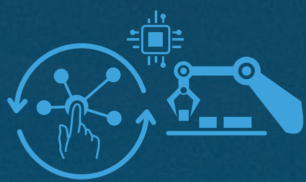
Artificial Intelligence
shaping the future of the built environment



The ability of computers is transforming our lives at an increasing rate. The prospect of machines that can think, rather than just do, is something we are beginning to take for granted. The transformative power of artificial intelligence (AI) to change the infrastructure sector is only just beginning, but now is the time to assess and analyse how we can best take advantage of it.

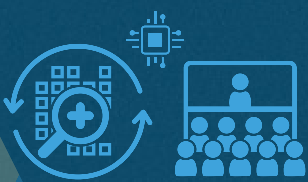


All stakeholders with an interest in tomorrow's infrastructure need to come together to identify the challenges and opportunities presented by this impending AI revolution. This will ensure we are better equipped to develop the engineers of tomorrow, harness the transformative power of AI and ensure that future infrastructure technologies are delivering the best outcomes for people around the world.



ICE and the National Infrastructure Commission recognised this need and convened a workshop on AI in the built environment to address four key areas:

1. **PERFORMANCE;**
2. **TRANSITION;**
3. **GOVERNANCE AND DATA; AND**
4. **SKILLS AND ETHICS.**



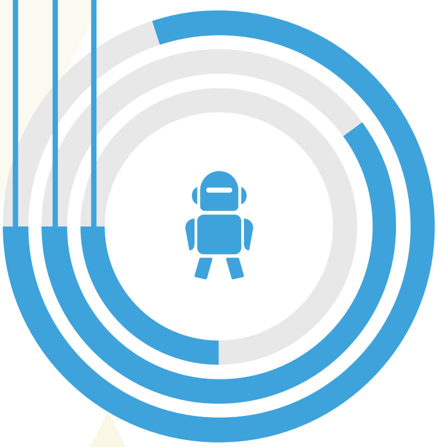
The workshop was attended by representatives from the tech sector, civil engineering consultancies and contractors, the legal profession, academia and world-leading research centres.

The drafting of this paper was also supported by Eleanor Earl, civil engineer at Arup and one of the 2017 ICE President's Apprentices.

Nearly **80%** of built environment professionals think AI will have a positive impact on the sector

Over **60%** think AI will help improve productivity

Less than **25%** think AI will improve dispute management, consenting and project approval



1. Performance

How can AI improve the performance of the built environment sector in the UK?

It is anticipated that AI will increase the efficiency of infrastructure design, delivery and maintenance.

Computer systems that can analyse large volumes of data to highlight patterns in the performance and use of existing infrastructure assets will enable better decisions to be made on the type of infrastructure that is required and how it can best be delivered.

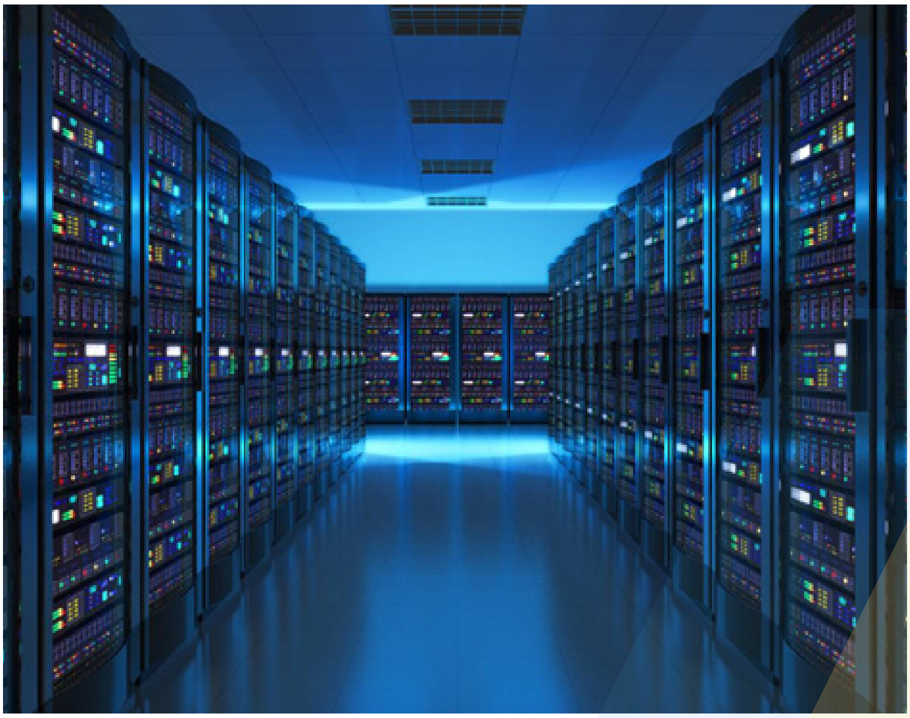
ICE surveyed more than 150 built environment professionals[1] to understand where current thinking on AI sits. Nearly 80% of those surveyed felt that AI would have a positive impact on the built environment sector.

Table 1 shows that 71% of respondents believe that AI will improve design and optioneering, while 69% think it will improve construction operations. Conversely, less than 25% of respondents think that AI will improve dispute management, consenting and project approval.

Process	Percentage of respondents (>150)
Design and optioneering	71%
Construction operations	69%
Risk and crisis management	58%
Project communications	55%
Business case planning	40%
Procurement	37%
Dispute management	23%
Consenting and approval	22%

Table 1: Built environment processes that artificial intelligence technologies will improve

The survey also revealed that over 60% of respondents think that AI will help to increase productivity in the construction industry, while enabling better connectivity and integration of infrastructure networks.



1 Respondents to the survey were built environment professionals working in both the UK and internationally. The survey was conducted by the ICE in July 2017.

What would be the benefits of a digital twin of the built environment and what are the steps we need to take to get there?

The data and information we create about an asset for its whole life-time can become a rich source of analysis. This concept has become known as – the digital twin.

The digital twin of a physical asset helps us to monitor and improve its performance. By realising the value of our data resources through digital twins, we can deliver more productive infrastructure, and optimise our existing assets.

Digital twins should be predictive and adaptive, meaning they can reflect changes that occur in the physical environment and respond to them providing greatly improved modelling for assets. The benefits include: harmonisation of operations to deliver optimal user outcomes; clash identification and automated remediation; and reduced costs and risk.

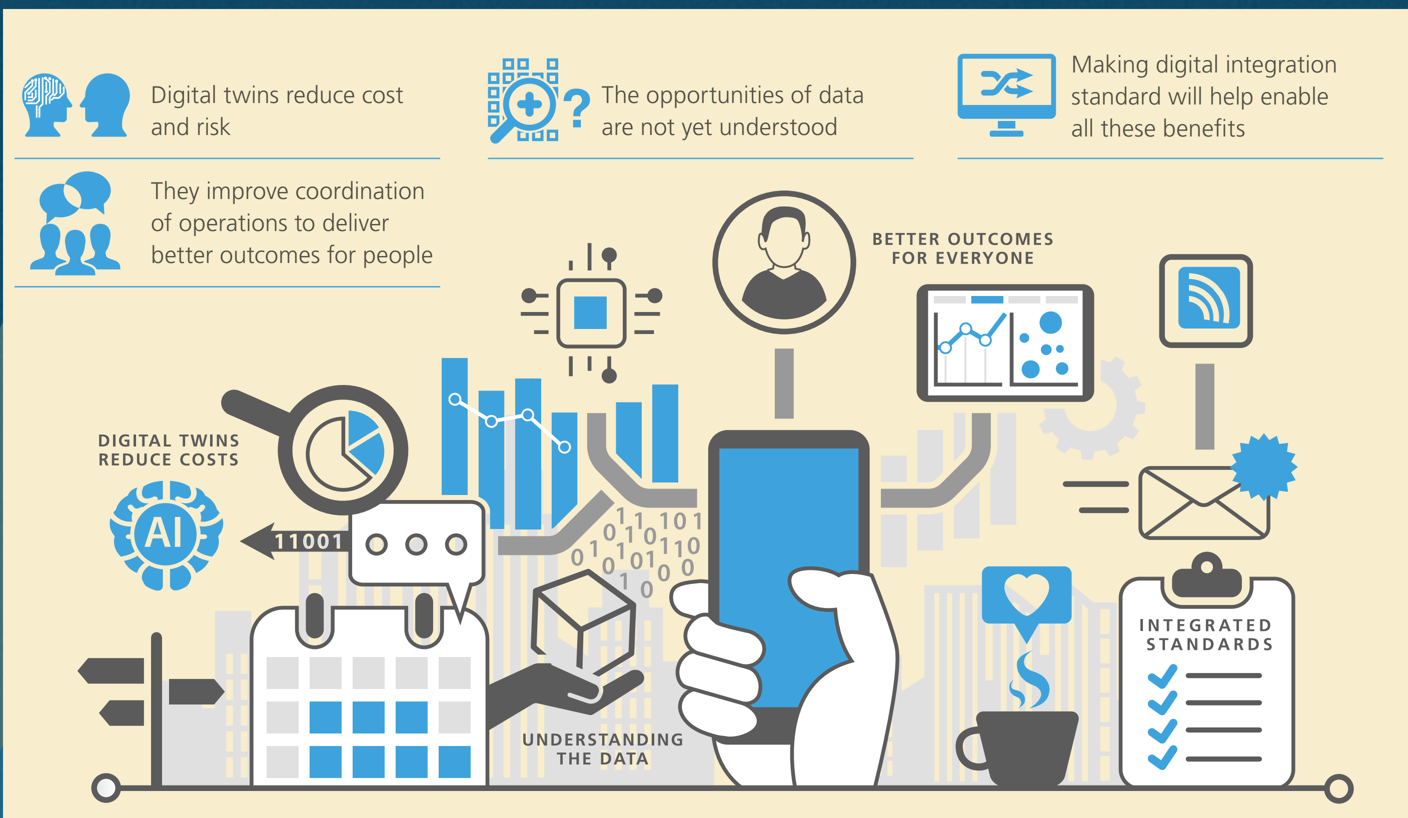
Managing and analysing the volume of data required presents a significant challenge. Most industries analyse little of the data that they gather. However, the benefits are clear. Google realised savings of 40% on its own data centres using DeepMind analysis on its assets.[2]

To realise these savings and benefits infrastructure delivery needs to harness available knowledge. The built environment sector needs to fully integrate data expertise into its teams, as well as working more closely with the technology sector. This means going beyond traditional alliancing models.

Clients need to start seeing digital integration as standard, whilst drawing on other sectors experience, like social sciences. This will enable them to avoid replicating existing problems that have already been overcome elsewhere such as design biases from the physical environment into the digital environment.

Before the true benefits of digital twins can be unlocked there are blockades that need to be overcome. There is a need to identify and address the policy and regulatory incompatibilities that are currently preventing the realisation of digital twins.

Managing the common data environment is important but far more pressing is agreeing the data governance, risks and liability at the outset of each project. It is also necessary to acknowledge that data security is unlikely to ever be 100%, so risk management - rather than a risk prevention mind-set - is required to ensure innovation is not inhibited.



2 DeepMInd (2017) DeepMind AI reduces Google Data Centre Colling Bill by 40%

2. Transition

How and when will we move from automating existing practices to using AI to drive radical changes?

AI is already being used on construction sites to automate tasks like bricklaying and concrete pouring,[3] but it is difficult to predict when their application across more complex design and delivery tasks will become the norm.

Machine learning and AI technologies, together with robotics and virtual reality, could transform the built environment.[4] However, each of these technologies is at a different stage of development and maturity. As a result, the point at which they will each become ready for commercial use is also likely to differ.

The size of construction and infrastructure companies has a significant impact on the speed at which they are able to embrace new technologies and ways of working. Large client bodies with dated asset bases and challenging business models are also not primed for rapid change.

Procurement in the built environment sector is typically driven by lowest cost, rather than the long-term value that an infrastructure owner will gain from an investment.[5] The higher costs associated with technologies like AI – whether actual or perceived – can therefore act as a barrier.

Digital data is a prerequisite for the effective use of AI in any industry; it underpins the development of technologies and their practical application. In construction, this includes data on the design and operation of infrastructure assets, construction products, logistics, health and safety and the like. At present this data either doesn't exist or isn't being shared.

It is clear, then, that there are early steps that need to be taken if the built environment sector is to fully harness the new powers of AI.

How do we move from our current way of doing things to practically using AI in the built environment?

Successful piloting of practical uses for AI is required in order to demonstrate to infrastructure owners, contractors and the whole supply chain the positive impact on their businesses.

Organisational cultures that champion disruptive innovation are needed to drive fresh approaches to the way in which the design and delivery of infrastructure takes place. Large companies must accept that in a digital age, current project management methods need updating, and that developing their capabilities in technologies like AI will improve the effectiveness of the services that they offer.

Strong leadership is necessary to bring about this shift in organisational culture. Creating a vision and instilling this across an organisation is something that must be led from the top-down. It is not possible to change the operating model of an organisation without the buy-in of its employees.

- AI has huge potential to transform the supply chain
- However the technologies are all at different stages and the benefits are not yet fully understood
- Variation in terms of company sizes affect ability to embrace new tech quickly
- Leadership and top-down organisational change is key to success

Developing and maximising the relationship between AI and Building Information Modelling (BIM) will speed up the adoption of AI in the built environment sector. The widespread use of BIM in business case development, optioneering and construction operations will create the quality data that is necessary to inform the development of AI technologies and their practical use.

It is important to acknowledge that there isn't necessarily a universal desire throughout the supply chain for AI. The value will not be shared equitably and as the large contractors develop their capabilities in AI there is a risk to the future role of smaller construction businesses. There is a need to support these organisations as the use of AI becomes more common.

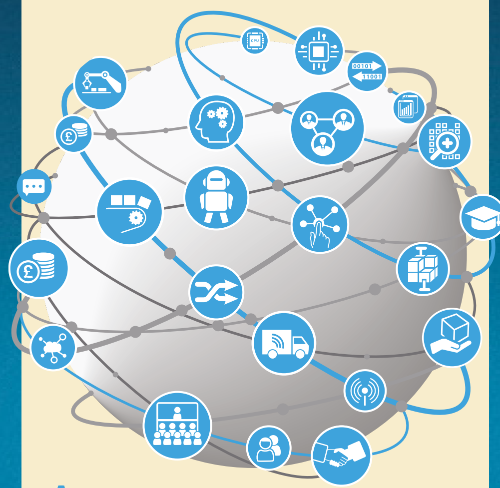
3 AEM (2016) How Artificial Intelligence Could Revolutionize Construction
4 NIC (2017) Driving innovation in infrastructure through artificial intelligence
5 ICE (2017) From Transactions to Enterprises (Project 13)

3. Governance and data

What governance arrangements are needed to encourage the effective deployment of AI technologies in the built environment?

A major challenge is developing governance frameworks while being mindful of the broad scope of AI technologies, and the possibility that it may aid the development of products for the built environment that we cannot yet conceive of today.[6] These frameworks are also dependent on what aspects of AI are being employed and how they are integrated e.g. a single project, a programme of work or a company. The dangers, therefore, lie in creating a governance framework that is too constricting or so open as to be redundant within days.

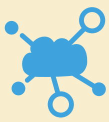
Privacy is a crucial aspect of governance. The medical industry has developed best practice and the infrastructure sector should seek to learn lessons from this. Previously, Intellectual Property (IP) has not been fully exploited as there has been an understanding that, as every project is different, there is limited need. However, as technology develops, it is possible for projects to have significantly similar designs and to be driven by the same data simultaneously – so the need for sharing IP has developed and increased over time.



AI will enable infrastructure products we can't even imagine yet

But this makes creating a governance framework challenging

Privacy and intellectual property will be vital to any framework



Ecosystems of collaboration are needed to encourage diverse ideas around open data and challenge the status quo

Skills will determine our ability to manage and curate huge amounts of data

Rapid advances in IT are enabling open data to move so quickly that those products developed yesterday quickly become inadequate. There has been significant debate on the use of open data in the built environment sector. However, it is generally agreed that greater collaboration and idea sharing is needed to establish solutions and challenge norms across the industry.

There are also mixed views on the role of standardisation. Some research suggests interoperability concerns may be reduced as computers have the intelligence to translate data platforms and software. Generally, we work in a structured language which makes it easier for computers to decode.

How should we manage the huge amounts of data necessary in the development and application of AI?

It is important that a high level of security and data governance is developed and maintained. Conversations at project inception should consider the impact of data governance, risks and liability. This means that data management skills will play an increasingly integral part in infrastructure delivery.

When managing large data sets it is critical that we minimise data bias. This needs to be well understood to avoid misinformation. We also need to question whether we have enough digital data.

Data centres are energy intensive. As mentioned in ICE's State of the Nation 2017: Digital Transformation[7] it is important that policymakers consider the demands for retaining energy and sustainability more readily in both the physical infrastructure and the digital twin.

It is also necessary to understand how we identify and manage these issues to ensure that the social data element is included in the answers which AI will provide. This brings us back to the importance of skills and security.

Where we store data is also critical to policy. There is a debate between clouds and data protection focusing on challenges like security and capacity concerns. There are also question marks around different data sharing and ownership models.

Taken together this highlights the risks inherent in collecting, collating and controlling large quantities of data. This should not, however, stop us trying to establish best practice models and a framework for addressing these issues.

6 PwC (2017) The economic impact of artificial intelligence on the UK economy
7 ICE (2017) State of the Nation 2017: Digital Transformation

4. Skills and ethics

Do we understand which engineering skills are next in line to be automated – and what will we do with the freed up brain power?

One of the most pressing questions around the rise in AI is its future impact on jobs. Over 50% of respondents to ICE's survey said that AI poses a threat to jobs in the built environment sector.

Naturally, some jobs will change and some will become obsolete. But in the longer term, the reality is that in the main, different training and different skillsets are what will be required. There is also a requirement to future-proof this training to keep pace with developments. This could include the creation of new support roles, new programmers and professional development programmes.

AI offers the opportunity for civil engineering skills to become augmented and assisted, with manual handling an obvious candidate for automation, freeing up engineers' brain power to allow them to focus on their core function, which has remained the same throughout history: solving problems. So while the skillset of the engineer may change, the basic principles should remain the same.

However, this in itself brings about a further – arguably even greater – change. Is a civil engineer who no longer needs to perform calculations, for example, still a civil engineer? You could argue that having an understanding of the principles of calculation is still essential, in order to validate a robot's high speed (far higher than a human's) work. Engineering judgement should remain intact. But if a system is so intelligent that it begins to 'self-learn', would our infrastructure

- AI will mean civil engineers need different training and new skillsets
- Civil engineering judgement will still be needed and engineers will still solve problems
- A more rounded education will be needed, with lessons learned from social sciences
- AI can both mitigate the engineering skills shortage and boost productivity
- Ethical issues around public trust aren't going away any time soon – all stakeholders must work together to try and develop standards

eventually require less and less human expertise to create it? Or will engineers be freed up to build more infrastructure and spend more time on real value added?

The infrastructure challenges the UK faces are very real, and if intelligent machines are able to enable higher numbers of engineers to deal with these challenges, then there are significant socio-economic benefits on offer. In other words, AI has the potential to both help deal with the engineering skills shortage and boost productivity.

How will we develop the experienced engineers of the future if many of the tasks that are currently part of professional formation are automated?

How the experienced engineers of the future will need to develop in this brave new automated world will depend on the ability of universities and employers to provide a more rounded, multi-disciplinary understanding of civil engineering and 'the art of the possible'. Course content should be altered, and include more crossover and interaction with other disciplines such as social sciences. The engineer of the future will need to be more inquisitive, challenging and questioning than ever. Adopting a systems approach can identify the skills that might be falling through the gaps.

However, there is also a risk that as AI is able to perform more 'traditional' civil engineering duties, engineers at all points in their careers but particularly at the start, may believe they have the competence to perform a task but don't, generating issues around accountability and liability. The need for specialist engineers may also evolve.

How do we deal with the ethical issues arising from coding computers to do tasks that currently require human engineering judgement?

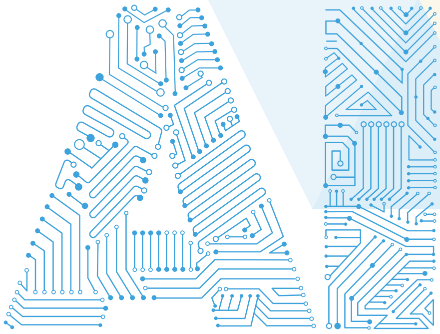
There is fierce debate around the ethics of how data is used and curated and the rise of 'intelligent machines'. Research[8] shows that the benefits of data collection and data-enabled technologies must be tempered by ensuring governance challenges are addressed 'in a timely manner' if public trust is to be maintained in the system.

Ethical issues around AI cannot be approached and dealt with in a 'tick box' manner - the public trust issue in intelligent machines and data collection is not something that can be dealt with overnight. Everyone with a stake must be brought round the table and reach tangible conclusions in order to set the standards that will define how machines behave in certain positions, and the agreed model for ethical situations involving the use of AI more generally.

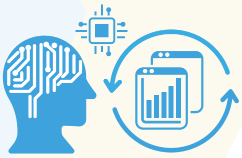
However, even accepting that decision, morally and ethically, is by no means straightforward, living as we do in a litigious society with no universally agreed human set of ethics. In addition, any single standard is too static, so the ability to challenge such decisions is essential.

8 British Academy and The Royal Society (2017) Data management and use: Governance in the 21st century

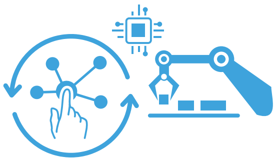
What next for AI in the built environment?



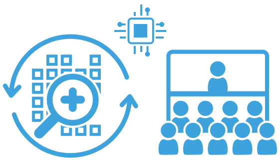
To fully harness the transformative powers of AI, we recommend that the government, built environment professionals and the technology sector work together on the following recommendations:



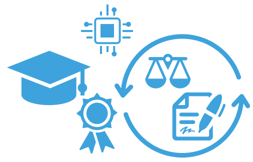
Performance:
AI can increase the efficiency of infrastructure design, delivery and maintenance, thereby boosting UK productivity. Exploit this potential by speeding up the development of digital twins and fully integrating data expertise across the supply chain.



Transition:
Machine learning and AI technologies, together with robotics and virtual reality, could transform the sector - but each one is at a different stage of development and maturity. To realise the benefits of AI for more complex engineering processes, cultural change and leadership within the industry is needed now.



Governance and data:
Creating a governance framework for AI within infrastructure is difficult because of the pace of technological change and challenges posed by the huge amounts of data AI requires. It is important that issues around privacy, security and intellectual property are adequately addressed.



Skills and ethics:
AI will mean that a different, more rounded civil engineering training, education and skillset is required, with greater crossover with social sciences. All interested parties must now work together to create models of ethical situations. Use of AI will help government address the engineering skills shortages the UK faces.

What do YOU think?

ICE Thinks will continue its exploration of AI in the built environment, this year and beyond.

To do this, we need to know what you think are the most important issues shaping the AI agenda.

- In what areas should the built environment sector concentrate efforts to pilot AI?
- How can an approach to project procurement that favours long term value over lowest cost be incentivised?
- How should the application of AI in the built environment sector be taught in civil engineering degree courses?

Get in touch

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About ICE Thinks

ICE Thinks, ICE's thought leadership programme, is an initiative bringing together groundbreaking thinkers from across a range of sectors in order to identify the megatrends and disruptors that will have the biggest impact on future infrastructure design and delivery. Our webpages, ICE Thinks, offer insight via blogs, social media, webinars, events and videos.

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