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How Building Information Modelling (BIM) is to shape the delivery of Infrastructure Projects Leading to 2030

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Purpose of this whitepaper:

Following the release of the Infrastructure and Projects Authority's 'Transforming Infrastructure Performance (TIP): Roadmap to 2030' publication, this whitepaper will explore how BIM can help achieve particular focus areas and goals set out by the strategy.

This will be specific to the BIM process/standard methods and procedures, and high-level when exploring options and implementation techniques.

Discussion Points:

Place-based regeneration and delivery

Emphasis on opensource data at a regional level – connect to various organisations (discuss the issue of privately owned utilities. Use of metrics (previous information exchanges) for regional decision making – emphasis on OIRs, AIRs, and EIRs aligned to national or centralised organisation set KPIs.

Addressing the need for social infrastructure using a platform approach

Specifying components using a catalogue adopting a rule-based system as opposed to including a specific product and manufacturer (in addition: how this data help automate design processes). Standardisation of information delivery – for example, consistent application of ISO 19650 naming codes – link to Government Agency standards such as Network Rail and Environment Agency.

Retrofitting existing buildings to achieve net zero greenhouse gas emissions by 2050

How BIM can aid in achieving carbon targets such as via the use of building analysis (thermal, structural, etc) reinforcing and repurposing already built assets.

Optimising the performance of our existing built environment

Heavily influenced by digital twins, Government Soft Landings, Interoperability / IFC; also links back to knowing the information required by an asset / AIRs.

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Executive Summary

Looking back at the lead up to the April 2016 UK Government BIM mandate, a lot of what was defined was clearly very ambitious, however with technology still catching up, challenging to achieve. The difference now however is that software capability and hardware capacity has caught up with that ambition.

The industry perception of BIM has also matured, no longer do we look at it as a cost-effective delivery mechanism for providing and maintaining asset data. We now use BIM to solve broader social, economic, and environmental challenges.

As its implementation has widened through much of the sector, we can begin to understand its scalability and impact at different levels, from regional local authorities and small practices to central government departments and large contractors.

With the fast-paced change in Environmental issues, technology and societal needs and expectations, the sector is under greater pressure than ever to innovate and evolve rapidly.

We're now entering a new digital era in the construction industry, a period where we must use technology to make a difference.

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Geographic regeneration and delivery

With the TIP Roadmap to 2030, there is an emphasis on regional, place-based delivery of infrastructure projects as opposed to purely centralised government management and decision making. This doesn't just consider how a project is delivered and operated but also how an asset is financed and funded. An example of this reformatted funding stream is the 'One Public Estate' programme.

The main principles regarding geographic regeneration and delivery that are outlined in the TIP Roadmap to 2030 are as follows:

1. Place-based delivery

This includes interventions to the built environment sculpted at a local or regional level and delivered in unison with local stakeholders including local government, industries, and communities.

2. Regeneration

An outdrawn process performed collaboratively to seek progression on strengths and assets of a location, improving outcomes of a locality for both people and nature.

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3. Local priorities and outcomes

Relate to the translation of societal outcomes, in particular the UN 17 Sustainable Development Goals or SDGs *(Department of Economic and SocialAffairs, 2015)*, and UK national policies redefined at a local context.

4. Integrated funding and financing

Enable the alignment of funding and financing sources to any defined outcomes and interventions to aid in the support of efficient and effective delivery, in other words, ‘good value for money’.

5. Placemaking and design quality

All new developments shall be conceptualised and designed befitting to the life and texture of its locality. This can relate to both regeneration of a location for the physical and natural environment and be adapti-ve to aspects such as the pressures of climate change *(Infrastructure and Projects Authority, 2021).*

Opensource data derived from digital twins will provide benefits for regional and national infrastructure projects. This isn’t just for the operation of pre-existing assets but for the capital expenditure of proposed or to be improved/refurbishment of neighbouring assets. It allows for aspects such as surveys be it environmental impact assessments, geotechnical studies, topographical and bathymetric data, and more from neighbouring projects and assets that have already been undertaken to be used on subsequent projects.

One of the more labour-intensive parts of surveying and mapping on an Infrastructure type project are the utilities aspects. Poor design data regarding utilities can lead to both expensive damages, and worse, lead to harm or worse for construction site staff. Incredible care is required when construction involves works to or near high voltage cables or high-pressure gas mains. Of course, well surveyed, and clearly mapped utility corridors alleviate the danger of cable or pipework strikes when performing tasks such as earthworks or boreholes. An example of a utility company implementing a digital twin is Anglian Water.

From their perspective *‘the twin accommodates for systems thinking. This combines both internal and external data sources throughout the asset serving to provide predictive analytical techniques, enabling improved insights that subsequently aid in better decision making, thus leading to improved outcomes in the physical world’ (BIM+, 2019).*

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Addressing the need for social infrastructure using a platform

Our current delivery of infrastructure projects is inefficient, bespoke, and siloed at individual projects. This is reinforced and illustrated by fragmented approaches regarding standardisation. It is felt that the construction industry is missing opportunities of standardisation when looking at design delivery such as utilising standardised, interoperable elements at an industry wide scale, not siloed at sector or client based. This has led to inefficiencies in design, production, logistics and assembly.

These missed opportunities have further led to the hinderance of:

1. The creation of disaggregated manufacturing bases and associated stable employment

2. Continuous improvement

3. The ability to deliver high quality, high performing, energy efficient assets at scale

(Infrastructure and Projects Authority, 2021)

A vast majority of standardisation issues will start during the design process. However, if we look at construction projects past and present, a positive aspect that the UK construction industry has traditionally done well regarding standardisation is the use of design standards, in particular The British Standards Institution or BSI. If the same level of adoption was applied to digitisation and building information modelling, there is no end to the efficiencies that could be achieved during the design stages of a project.

Large strides have certainly been taken on how we deliver information on projects with the implementation of BS 1192 and its predecessor ISO 19650. By mandating how data is named, managed, and transferred, the construction industry now has a standard there to promote standardisation, and familiarity, both of which will lead to efficiencies.

Standardisation of deliverables and project products is imperative, the crucial part that is currently missing is the standardisation of the design elements within these files. A good example of design standardisation is the Department for Environment Food & Rural Affairs (Defra) Environment Agency's Data Requirements Library.

'The purpose for the Data Requirements Library is to document and standardise terminology and categories used to classify Environment Agency assets. Furthermore, it also specifies data attribution used to describe the properties of each asset and element type' (Environment Agency, 2021).

This is a good example of a steppingstone towards achieving the TIP Roadmap to 2030 view of standardised model elements across the construction industry, though it must be emphasised that this is still very much a concept in its infancy.

Where the construction industry needs to be at to achieve more progressive standardisation is a centralised element library, harnessed and utilised at an inter-sector level. A widely used standard inside of infrastructure projects is the *'Manual of Contract Documents for Highway Works – Volume 3: Highway Construction Details'* (Highways Agency, 2008).

This document was produced primarily for the standardisation of construction details affiliated with roads and highways projects. However, it contains aspects relating to barriers, fencing, and drainage and is therefore widely adopted in other sectors such as maritime, rivers, utilities, and rail projects.

The notion would be to 'digitise' the standard transforming it to a centralised element library containing interoperable, vendor neutral, parametric, rule-based objects for designers to utilise inside of infrastructure projects.

Using standardised design objects then leads to more prefabrication and manufacturing of construction elements.

'By increasing the use of factory conditions at the construction stage, platform approaches lead to a series of simplified, repeatable, productive activities' (Infrastructure and Projects Authority, 2021).

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The convergence of manufacturing and construction both at design and onsite are becoming more prevalent with time. The benefits of offsite construction certainly outweigh the negatives including:

- **Efficiency and Predictability**

Repetitive tasks and repeat processes allow for quicker outputs and improved production management with better control and analysis of fabrication tasks. Weather becomes less of an issue such as frozen, wet, or overly hot conditions as elements are produced inside a controlled environment, allowing for all year-round production *(Offsite Hub, 2017).*

- **Safety**

Factories allow for a controlled, and therefore, more predictable environment *(Offsite Hub, 2017).* Eight common causes of injury on a construction site include fires and explosions; falls; getting stuck or confined spaces; electrocution; being struck by an object; overdoing it, heat stroke or hypothermia; trench collapses; and repetitive motion or strain injuries *(ThorneyCroft Solicitors, 2017).* By utilising factory conditions, these risks can be further mitigated against as aspects such as working from height, working in confined spaces, and working near a water course can be reduced or eliminated *(Offsite Hub, 2017).*

- **Sustainability**

Although offsite production does require transportation of building elements to the site once fabricated, the other environmental benefits counteract this. Site generators and plants can be inefficient when it comes to energy usage and can also heavily rely on fossil fuels such as diesel (which also exhausts hazardous fumes and carbon dioxide). Factory conditions result in controlling energy usage and can rely more on renewable electricity. Material wastage is certainly lessoned in a manufactured environment; a broader range of materials can also be adopted as opposed to those used in-situ on site. Therefore the use of greener alternatives can be increased. Material requirements become refined as they can be more accurately calculated subsequently making financial savings on material and disposal costs *(Offsite Hub, 2017).*

- **Reduced Labour**

By utilising machinery and robots, a smaller workforce is required. Although this could be construed as less employment opportunities, less workers do result in reduced wage costs, keeping project prices at a more affordable level *(Offsite Hub, 2017).*

- **Less Training**

Becoming an onsite expert is a lengthy process eg training to become a bricklayer or electrician. Inside a factory facility, general roles and skill requirements are lessoned as offsite construction is repetitive, simplistic, and faster. This allows for a broader employment pool inside of the local vicinity and mitigates against the problems relating to staff turnover. Less training requirements result in faster delivery and lowered costs for all stakeholders *(Offsite Hub, 2017).*

- **Reduced Disruption on Location**

Building sites can be dirty, noisy, polluters especially with a lot of bespoke in-situ working. This can cause disruption in the locality due to noise from plant and machinery, vehicle movements both from construction plant and material deliveries, access routes blocked especially in congested urban areas and so forth. With offsite construction, these factors are reduced heavily and time onsite is decreased only for part deliveries and installation, having a positive impact on the local community *(Offsite Hub, 2017).*

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Retrofitting existing buildings to achieve net zero greenhouse gas emissions by 2050

‘One third of the UK’s total greenhouse gas emissions stems from buildings, with houses making up 22% of this, predominantly from heating. In 2050, most buildings that we will use shall already exist, most haemorrhage heat and money’ *(Infrastructure and Projects Authority, 2021)*. ‘Go/No Go’ decision matrixes should be implemented at the start of all infrastructure assets. The real impact of a construction project should be thoroughly assessed, and decisions are then to be made on whether to do nothing; refurbish; or demolish and rebuild.

Advanced smarter designs are why many of us opt for new build construction, learning from past experiences leading to optimised space usage, energy efficiencies, and social wellbeing outcomes. But new builds can come at a greater environmental cost during the capital expenditure, even if there are efficiencies gained during the operational life of an asset.

A report by the Royal Academy of Engineering has urged the government to stop buildings being demolished. It highlights the concerns surrounding “embodied emissions”, which refers to the carbon dioxide emitted during the manufacture of building materials such as brick, cement, and steel. The production of bricks and steel creates a substantial amount of CO2, with cement accounting for 8% of global carbon dioxide emissions alone. It alludes to a lack of awareness in the minds of the public when it comes to understanding embodied carbon, as aspects such as plastic waste and vehicle emissions take the forefront.

An estimated 35% of the carbon in a typical office development’s lifecycle is during the capital expenditure, before the operational phase has even begun, according to the Royal Institution of Chartered Surveyors (RICS). This figure increases to 51% when looking at a residential premises’ *(Harrabin, 2021)*.

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Rather than rebuilding or building from scratch we should be harnessing technology and modern construction techniques for us to reuse. By further refining and adapting to how we use technology, the following areas will benefit:

- **Better decision making**

Use advanced technology to monitor existing assets looking at aspects such as heat loss and energy usage to provide evidence for more informed decisions.

- **Generative design**

This harnesses the power of artificial intelligence when looking at the design of an asset. Generative design can be utilised when assessing or reconfiguring an existing space or site and can optimise a layout using inputted parameters based upon user requirements.

- **Legislation and governance**

Be stricter when it comes to a building's performance, for example, Energy Performance Certificates (EPCs).

- **Partial reuse and remodel aesthetics**

Where existing assets can be partially reused, for example an old office building is of a good size, but the interior layout doesn't work, the building shell can be saved, and a full refurbishment can begin on the interior. After the Grenfell Tower tragedy, the cladding of buildings has a bad name in the press, but with lessons learned and via the use of safe environmental materials, assets can be given a new lease of life via the use of modern cladding, design, and construction techniques.

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