The Institution of Engineering and Technology

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Digital twins for the built environment

An introduction to the opportunities, benefits, challenges and risks

Digital twin – A realistic digital representation of assets, processes or systems in the built or natural environment. The complexity of that representation, and degree of connectedness, varies depending on maturity.

The global digital twin market was valued at USD $3.8bn in 2019 and is expected to reach USD $35.8bn by 2025[1]. Half of all large industrial companies are predicted to be using digital twins in some form by 2021, which is expected to result in a 10% increase in effectiveness[2].

The engineering industry now largely sees the need for digital twins, but varying definitions and interpretations of what constitutes one is complicating development and adoption.

We're putting forward a clear and industry-agnostic maturity spectrum to address this, with requirements and outcomes defined by six elements of development.

Our white paper also highlights the latest developments in the UK, driven by the NIC (National Infrastructure Commission) and CDBB (Centre for Digital Build Britain), and the key applications within the built environment.

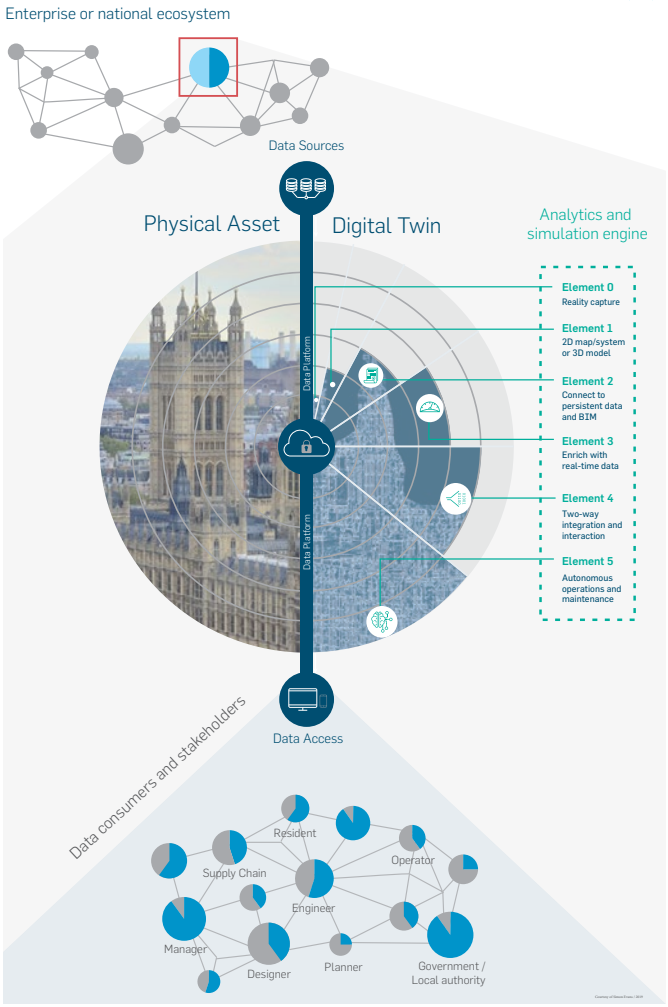
Adoption is not necessarily sequential, a twin might possess features of higher order, more complex elements before lower ones.

Element (logarithmic scale of complexity and connectedness)	Defining principle	Outline usage
0	– Reality capture	– As-built survey
1	– 2D map/system or 3D model	– Design/asset optimisation and coordination
2	– Static data, metadata and BIM Stage 2	– 4D/5D simulation
3	– Real-time data	– Operational efficiency
4	– Two-way data integration and interaction	– Remote and immersive operations
5	– Autonomous operations and maintenance	– Self-governance, oversight and transparency

> We recognise that for digital twins to serve all of society they will need to be created by a community. We must work together with a shared vision, sharing lessons alongside data.

Foreword by:
Alexandra Bolton, Executive Director,
Centre for Digital Built Britain (CDBB)

> The earlier a twin is developed in an asset's life, the more effective it will be…



Opportunities

- Reduced construction and operating costs.
- More effective design.
- Short and long-term efficiency and productivity gains.
- Better understanding of asset condition.
- Digitally rehearsed and refined work resulting in safer, faster work delivery.
- Improved collaboration.

Risks

- Cyber security.
- Over-selling and inflating expectations.
- Costs to develop complex twins.
- Lack of standardisation and collaboration across industry.
- Insufficient workforce upskilling.

Three key applications in the built environment

Improving places

The global population is urbanising*, and we need smarter places to manage the concentrated demand this causes. Digital twins can enable more outcome-centric and sustainable resource consumption through the optimisation of mobility and energy networks, aiding collaboration and enhancing wellbeing and security.

- Real-time performance tracking of whole cities on a range of metrics.
- Responsive adaption of infrastructure to deal with extreme events.
- Minimised disruption by coordinating utility maintenance.
- Optimised joint energy and mobility services reflecting user behaviour.
- Improved urban design.

*More than 68% living in cities by 2050[3]

Retrofitting existing assets

Deep retrofits of existing buildings have a vital role to play in meeting global carbon reduction targets*. Digital twins could improve outcomes by:

- Creating efficient repair and maintenance schedules.
- Offering information on savings to reassure investors.
- Providing large data sets to fuel research and innovation.
- Securely tracking materials and moving them faster.
- City-level understanding of effects to inform strategies.

*The UK is committed to 80% reduction by 2050[4]

Resource management

To minimise environmental degradation and make human habitats more sustainable, twins can assist in the measurement and management of risk. A 'single version of truth' provides transparency in regulatory compliance, asset stewardship and capital allocations. Allowing for smarter 'what if' scenario planning, which can balance human needs with sustainable natural resource allocation.

- Better management of the food-water-energy nexus.
- Virtually monitoring the real world to gather data to improve design, maintenance, operation and safety.
- Task computers to learn about the urban organism's patterns and preferences.
- Optimise a circular economy, where resources are cycled efficiently.
- An AI-enabled digital twin could reassure us of abundance so we abandon ownership and opt to share.
- Lifecycle understanding of assets, including their impact on the natural environment.

How do we move forward with digital twins

Embrace the concept now:
All new projects should adopt a digital twin approach, and ensure that the principles are not value-engineered out. For retrofitting to fully succeed, it must also embrace the benefits a twin approach provides.

Respect the journey:
The creation and management of a digital twin is a journey relevant to the entire project life-cycle. We should focus on purpose at each stage, understand the benefits of each milestone and expect value to increase along the journey.

Collaborate:
Overall success will only come through collaboration between government, industry, academia and society. We must all be actively involved in the conversation and push for industry standardisation. We should unify around common organisations, such as CDBB in the UK, and standard definitions and models, such as the maturity spectrum.

Regulate:
Governments must take the lead and drive national policy to create shared frameworks and ecosystems.

Get out of silos:
Although this paper focuses on application in the built environment, digital twins transcend sectors. We must learn from each other and contribute to a common good, working collectively to meet global challenges.

Be sustainable:
Adopting a digital twin approach now will enable society to make the necessary shift to more sustainable operations, making us better equipped to meet the UN Sustainability Development Goals (SDGs).

1 MarketsandMarkets, *Digital Twin Market | Industry Analysis and Market Forecast to 2025*, 2019.
2 Gartner, *Prepare for the Impact of Digital Twins*, 2017. www.gartner.com/smarterwithgartner/prepare-for-the-impact-of-digital-twins
3 Vanzi, *Digital Built Australia*. www.vanzi.com.au
4 BEIS (UK Government), *UK becomes first major economy to pass net zero emissions law*, 2019.

The full report: *Digital twins for the built environment* is available at:
theiet.org/digital-twins

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