Digital Twins

DETAILS

SECTOR | Transport and Energy

STAGE | Procurement and Operations

TECHNOLOGIES | IoT, Sensors, Artificial Intelligence

SUMMARY

A Digital Twin is a virtual replica of a physical object or system. Today, digital twins can digitally replicate large objects like buildings, stations and cities. They are compiled of several layers of real-world data related to the object or system and can produce predictions or simulations of how that object or system will be affected or influenced by certain operational inputs.

Digital Twins can identify and monitor asset interfaces, maintenance, and enhance future asset operations. In that sense, Digital Twins are different from 3D infrastructure models and Building Information Models (BIM) (*see* also the *3D Infrastructure Modelling and BIM use case*), which are today largely used for the design and construction of new infrastructure projects. Digital Twins are built from operational data collected from sensors and IoT and are used to replicate infrastructure already in operation to be used for condition monitoring and asset management. The intention in the future is to integrate Digital Twins into BIM models, in order to complete the chain (from design to construction then operations and asset management) and fully integrate the asset management function into infrastructure models.

Using the Internet of Things (IoT) (connected assets and sensors capturing data on the condition of infrastructure) with “Iotic” types of data sharing (open models non-vendor or network agnostic), more data from various sources can be captured to enhance digital twins, where gaps are identified in data collection and data controls.

Digital Twins were developed by companies, initially constructors/manufacturers with remote operation requirements, to produce a digital replicate of an existing or future physical infrastructure. They enable a comprehensive understanding of an existing infrastructure’s status and operations, and the future potential of integration; visualising all potential optimisation between sectors and their assets.

Essentially any project data can be compiled into a digital twin. Examples include costs, construction schedules, standards requirements, design requirements and expected performance. Compiling the data together enables interoperability in infrastructure projects, using and binding digital twins from several infrastructure projects and additional data from external IoT if there are gaps. The use of digital twins allows a government to start the development of an infrastructure project idea by reviewing how it can integrate with or use existing database infrastructure. It is also a great tool to create a visual representation of a piece of infrastructure and its operational/condition issues

Digital twins are machine readable and enable automatic identification of gaps in the data to make it complete. Thus, engineers can endlessly re-combine digital twins in an additive-subtractive way easily. Additionally, Digital Twins can communicate between different disciplines, thanks to visual supports.

The aggregation of data from various sectors, devices and sources through the use of Digital Twins is one of the ways cities and regions can become more 'connected', enabling more efficient management of infrastructure. Additionally, most infrastructure assets are not always completely tracked and traceable. With the use of digital twins, they can be fully monitored. An example of this, in the context of whole of life asset management, could be where sensors on an asset check the asset condition and its previous inspections ahead of triggering a maintenance visit. Another example would be where a trigger would result in the review of the design specification, which could be used to identify if the asset could be used for additional development. With Digital Twins, simulations can be run without impacting the physical asset (e.g. to test if operations could be increased in order to optimise the asset's use.

Additional potential applications include predicting failures, training staff, optimising individual performance, and enabling relevant IoT integration from planning and design phases. With Digital Twins, the overall objective is to better communicate between disciplines and sectors to maximise the value of the assets, and to apply this to larger infrastructure. Digital Twins are also expected to be developed at a larger scale to replicate cities and countries.

VALUE CREATED

Improving efficiency and reducing costs:

- Maximised value from investment legacy current and planned
- Estimated 10% improvement in construction business effectiveness and more than 20% gains in productivity[1].

Enhancing economic, social and environmental value:

- Create a single source of truth that will enable a reduction in costs, eliminate waste, avoid duplication, unlock hidden value
- Potential to generate new revenue by integrating Digital Twins from different nearby assets (e.g. a station, a mall and a hospital)
- Enhance visibility by reducing time spent finding and contextualising insights and integrate existing reporting systems.
- Better communication across sectors, and with the population, on future infrastructure projects integration into existing infrastructure

POLICY TOOLS AND LEVERS

Legislation and regulation: To enable the wider use of digital twins, governments should make the development of a Digital Twin of all existing and future infrastructure a requirement of any major project. Additionally, the collaboration between various sectors and actors (asset owners, providers, operators, etc.) to share asset data is essential and the right enabling legislation must be developed accordingly.

Effective institutions: Standards should be developed to ensure Digital Twins are consistent and complementary. Government agencies and related private entities should ensure consistency in the use of Digital Twins across all relevant infrastructure assets and services.

Transition of workforce capabilities: Engineering capabilities should adapt to use Digital Twins in addition to traditional plans and processes to enable a consolidated design and considerations of existing assets in their design and construction work. Operators should also be able to use Digital Twins to understand how the assets they operate contribute to meeting their Key Performance Indicators. Contract managers for public infrastructure contracts, should also be able to use elements of the Digital Twin to understand costs/schedules and expected performance and clauses that can be set for construction and for operations.

[1] "Prepare for the Impact of Digital Twins", Gartner, Accessed 20 May 2020.

Procurement: Digital Twins should can be mandated in operations contracts or be a requirement in new infrastructure projects as part of the delivery contracts.

IMPLEMENTATION

Ease of Implementation 	Given the lack of standards and skillsets to enable such extensive integration work, and the complexity of integration without disrupting existing methods of procuring infrastructure projects, it is easier to implement Digital Twins on major new infrastructure projects than existing assets. However, for example, global railway operators, such as Deutsche Bahn, Network Rail, SNFC, have started building their Digital Twins to optimise the visibility of their network and test opportunities to improve their capacities of operations.
Cost 	The costs of developing digital twins are relatively low as they rely on data and digital integration. However, if the existing assets are not 'connected' there will be a need to add IoT to them in order to capture their conditions. The costs of adding IoT to the infrastructure will significantly increase the implementation costs.
Country Readiness 	Most developed countries are already developing Digital Twins for their new major infrastructure projects (buildings, transport, health, water etc.) and are leveraging them to capture existing infrastructure too. However, some developing countries may not yet be ready, from a skillset and policy point of view, to integrate Digital Twins as a requirement in the delivery of infrastructure projects, as they focus their investments on building the infrastructure network.
Technological Maturity 	IoT enabling the connection of assets and data sharing solutions are today well-developed and can be easily used to provide a relevant and accurate use of Digital Twins for planning and operations. The capability for Digital Twins to automatically identify the missing data required to complete them already exists, which enables the decision of where and what IoT or sensors to collect this additional data should be installed.

RISKS AND MITIGATIONS

Implementation risk

Risk: Digital Twins are built based on the data collected from IoT. Poor or incorrect implementation of IoT will result in poor or inaccurate data collected. Additionally, if the Digital Twin is not visualised in a software application, it is possible to miss any gaps that exists in the data.

Mitigation: To ensure consistency of Digital Twins across sectors and eliminate opportunities to miss gaps or errors in data, a standardization of the data collection and identification of gaps processes should be developed. This will ensure the use of software is coordinated across difference sectors.

Social risk

Risk: Staff will be unfamiliar with Digital Twins and training may be required.

Mitigation: Staff should be upskilled in the use of Digital Twins for planning, design and operations. The tools should be simple and user friendly to facilitate this transition. Education programs for all actors involved in the planning, design and operations will also be helpful.

Safety and (Cyber)security risk

Risk: As with other data-based technologies, there is a risk that the system with be breach due to a cybersecurity threat and that the data will be accessed or the Digital Twin will be altered.

Mitigation: To mitigate the risk of data hacking the data used for operations must be secured. The Digital Twin converts data as event streams and can be configured to recognize significant events in real-time receiving data only when an event occurs. Additionally, technology disruptions can be avoided by maintaining 'normal' operations as a base case.

EXAMPLES

Example	Implementation	Cost	Timeframe
SNCF Digital Twin	Currently being built for existing infrastructure, while developing an asset library to capture more granular assets	High investments and a lot of research; great potential foreseen to move to predictive infrastructure maintenance	A full development can be expected by 2022
Tamba City, Hyogo Pulp factory, Japan	Hyogo Pulp introduced a virtual network infrastructure through Digital Twin to strengthen cyber security measures in plant networks and create a safer and more efficient network infrastructure anticipating more IoTs.	Direct operations savings recorded by the Head of Electricity Section of the Facilities Department	With the system, Hyogo Pulp can now better manage the devices connected to the network and the access and security status of each device, to troubleshoot problems easily.
Singapore Digital Twin	Virtual Singapore was created by the National Research Foundation. When completed it will be the authoritative 3D digital platform intended for use by the public, private, people and research sectors.	Virtual Singapore is an R&D programme initiated by the NRF at a cost of $73 million for the development of the platform as well as research into latest technologies and advanced tools.	The development of the Digital Twin took place over a period of five years and was targeted to be completed in 2018.