buildingSMART
International

# Enabling an Ecosystem of Digital Twins

A buildingSMART International
Positioning Paper

How to unlock economic, social,
environmental and business value for the
built asset industry

Introduction

Rapid technological advancements are changing almost all aspects of our lives. Mobile and cloud-based technologies, IoT (Internet of Things), AI (Artificial Intelligence), sensors, robotics and other technological developments are leading to new business models, new ways of thinking and a multitude of opportunities. Under the broad umbrella of Industry 4.0, the process of digital transformation is reshaping entire industries. New terms and definitions, such as *Digital Twins* or the Plan-Build-Operate-*Integrate (PBO-I)* concept arise as a result. This transformation is helping to boost productivity with some industries setting an example. For example, manufacturing has applied digital twins to production lines to analyze and optimize production. This has resulted in productivity improvements and enabled better reliability. Water utilities interact with digital replicas to simulate flow and scenario planning ensuring better network reliability. The automotive industry uses digital technology to simulate material performance, temperature and other properties to develop and enhance products. The whole concept of digital transformation is also being verbalized and embraced in the built asset industry, although tangible examples of its implementation are still rare.
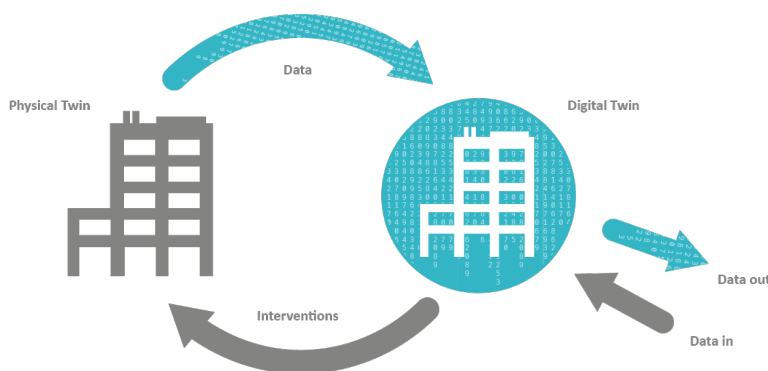
"A digital twin (DT) - also referred to as digital shadow, digital replica or digital mirror - is a digital representation of a physical asset. Linked to each other, the physical and digital twin regularly exchange data throughout the PBOD lifecycle and use phase. Technology like AI, machine learning, sensors and IoT allow for dynamic data gathering and right-time data exchange to take place"

A Digital Twin Linked to a Physical Counterpart

Digital transformation offers the potential to unlock economic, social, environmental, and business value for the built asset industry. There has however been widespread hesitancy for broader adoption and use. This is in part down to the nature of the industry. It is highly fragmented and still operates in a disconnected and transactional manner. There is also a clear lack of common standards and approaches. Underinvestment is prevalent, and often as little as 1% of revenues for firms is invested back into IT. There are many other contributing factors, but the industry is starting to recognize the need for change. While broader adoption of building information modelling (BIM) and openBIM in the built asset industry are promising, other considerations like population growth, urbanisation and climate change further increase the pressure for productivity and quality improvements. Global pandemics also raise questions about how affected businesses and world economies can continue to deliver efficiently. The industry is, therefore, asking itself critical questions. "How can cities contribute to the net-zero objective?" or "How can healthcare facilities prepare themselves for cases of an epidemic outbreak?" Or even "how can building infrastructure be optimised for challenging environmental conditions of the future?". All these questions are at the forefront of the industry today.

These seismic questions need to be answered, but how? when? at what risk? Data could hold the answer to questions like these. Not only could we learn from data gathered in catastrophic incidents, i.e. about the safest cladding to use from a health and safety perspective, but other examples of smart ways to use data day-to-day could focus on helping the industry to better shape the needs for the future. If data could be used to optimise business processes, manage capacity challenges, enhance employee productivity and ultimately drive business performance, these questions may start to be answered. The potential for the industry is that it could start connecting data sources by creating agile and flexible environments based on the existing technologies. Such technologies exist today, but why is the industry hesitant to adopt them more broadly?

The buildingSMART Mission

buildingSMART International (bSI) is the go-to place for developing open digital solutions and standards for the built asset industry. bSI is driving digital transformation for the building and infrastructure industries and aligning the industry to common goals. bSI is committed to delivering digital ways of working by the creation and adoption of open, international standards and solutions. At its core, buildingSMART believes in cooperation, collaboration and innovation and has been leading the way on key topics.

bSI believes the process of digital transformation in the built asset industry affects everyone. It is not limited to a few actors to shape the change required. On the contrary: no one player that can set the direction and speed of innovation. The interdependencies for everybody in the PBO-I lifecycle, spanning countries, cities, government authorities, asset owners, building project participants (designers, engineers and contractors), operators, standard setting bodies, and citizens are complex. Key to this interplay is standardisation as well as simplification. This approach has been proven successful in many other industries and it needs to be applied to the built asset industry.

The entire PBO-I needs an industry body to act as a neutral enabler for change. Neutrality enables broader contributions in a fair and structured process. bSI believes that by focusing on the benefits of better data management and governance, integration of this data based on standardisation will ultimately enable a system of data-driven digital versions of the built asset industry (in other words: a system of Digital Twins) that will, in turn, unlock real value for everybody involved.

Building on its centre of excellence in the core Industry Foundation Classes (IFC) technology, buildingSMART continues to establish relationships with key organizations and other industry bodies to align schemas and integrate technologies. These bi-directional relationships position buildingSMART as the place to develop, manage and advance Digital Twins. This way, bSI's Digital Twin(s) mission pursues the goal to cultivate an environment for mutual development of best practice standards and alignment. bSI focuses on technical aspects (data exchange standards, protocol specifications) as well as definitions of terminology, business processes and identification of typical use cases. Bringing together its established communities with other leading bodies and organizations, bSI has the convening power to deliver Digital Twins alignment.

The Concept – An Ecosystem of Digital Twins

A Digital Twin is a digital representation of a physical asset. It can be created in parallel to its physical counterpart and spans all the phases of the PBO-I lifecycle. Digital Twins exist in the plan and design phase of a project as a method for better planning, design and construction of a project. Digital Twins play a role at later phases of the lifecycle, especially after commissioning and provide long-term benefits for asset performance, optimization and reliability opportunities. Alternatively, Digital Twins can also be created after a physical version of it already exists, during its use phase. Physical assets can, therefore, be digitised when in operation.

Technology like AI, machine learning, sensors and IoT allow for dynamic data gathering and exchange between physical and digital twins. Rather than having resource-intensive, real-time updates, the different data streams are exchanged at right-time intervals. This can include interventions at just-in-time intervals too. Digital twins can learn, update, and communicate with its physical counterpart at any given time and apply data learning. While digital representations of singular physical assets are valuable, the idea of digital twins is not necessarily limited to single instances. The integration of multiple digital twins allows the creation of an ecosystem of digital twins. This extended version can deliver a higher-value, broader context of economic, social and the natural environment.
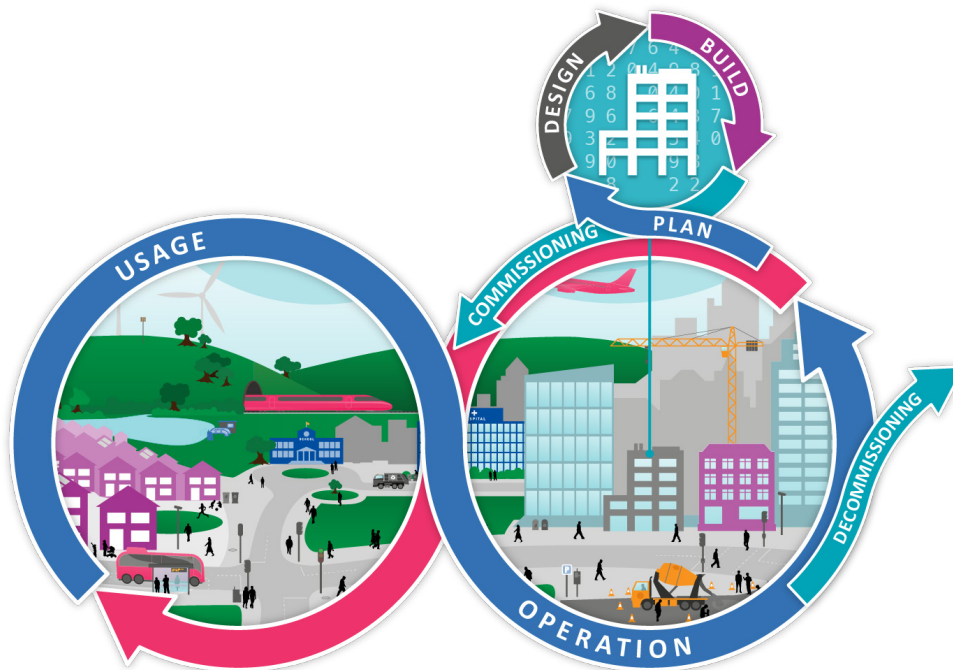
PBO-I view – focus on use: opposed to the well-known plan-build-operate-decommission (PBOD) lifecycle that every asset goes through, the PBO-I view focuses on a broader network - an overall connected system. This perpetual system includes everything, i.e. social and economic infrastructure, built environment, the natural environment as well as citizens. Based on this interconnected view, projects with their PBO-I lifecycle become an intervention to the existing system.

One does not have to read Daniel Kahnemann's "Thinking, fast and slow" from cover to cover to understand that our human mind's capability is limited when it comes to smart decision making. What we may call gut feeling, instinct or even experience is prone to errors through framing, heuristics and misinterpretation. To make the right decisions at the right time, having access to the relevant information is key. Currently, this is a huge challenge for almost everybody involved in the built asset industry, and digital twins could resolve this challenge today. A digital twin and its ecosystem could give access to integrated data, updated regularly, making information visible that is currently unknown. It integrates dynamic and static data, allowing valuable, accurate and up-to-date insights, the basis for better-informed decisions that will lead to improved outcomes and overall better quality of life.

The generated value through integrated data mentioned above is not limited to certain players within the built asset industry. Digital twins also enable alignment for the adoption of other standards, such as ISO 55000. Being able to make the right decisions, knowing those decisions are based on facts, unlocks value for everybody. Digital twins make the built asset industry with all its connected data streams, inter-dependencies, risks, and chances readily available and visible. Intelligent interventions can now be applied to existing infrastructure or buildings. Armed with better data, project participants can optimise an asset or project adding greater value. This leads to improved delivery efficiency, reduced uncertainty, and better risk management, benefiting the whole value chain, including investors, owners, asset managers, contractors, consultants, suppliers, tenants, or users. This delivers better outcomes for society. It leads to improved national productivity and to more resiliency for projects and assets. In the long-term, societies will become more sustainable, more agile, and responsive to growing demands.
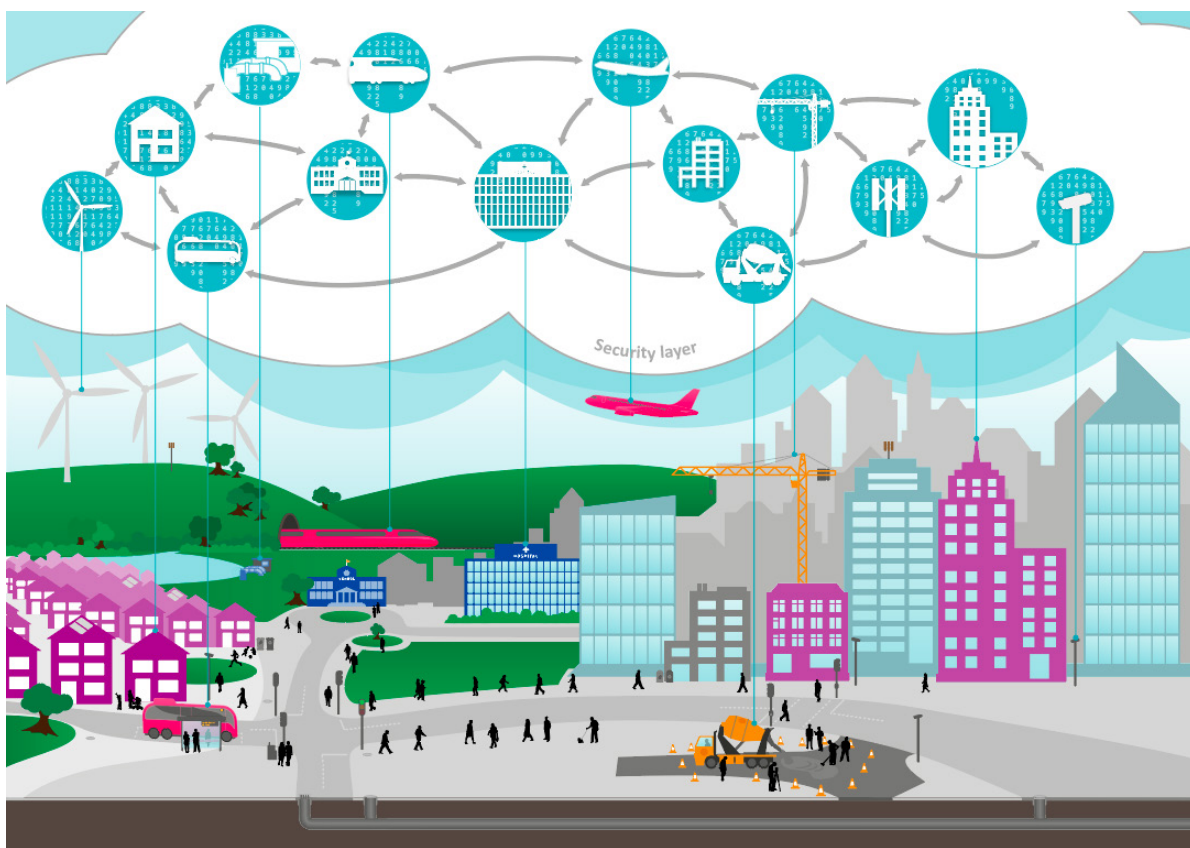
An Ecosystem of Digital Twins

What's the recipe?

Gathering and integrating data to create digital twins and this ecosystem – the technology to achieve these goals is readily available today. The key problem lies in the integration of data coming from different sources in different formats. Gaining an integrated overview of the situation – the holistic view – is hard. Integrating different data streams at different levels of scale is also challenging. Different players in the market still use proprietary formats instead of open ones. This makes it even more difficult for the whole industry. The main gaps lie in:

    a) the awareness of the holistic view, where all components are part of a bigger connected system.

    b) the mapping of information throughout the bigger system to enable interoperability.

These gaps must be viewed as opportunities for the industry to close and doing this is achievable. Closing the first gap, (the raising of awareness), should be achieved through a neutral and open forum. bSI is uniquely positioned to enable such a forum. As an open and neutral body in the built asset industry, bSI engages its network and has the convening power to accelerate awareness into action. It brings together a broad community to discuss and develop a holistic view. Groups of experts from the community engage in this neutral setting for better alignment and working. With this approach, bSI enables its community to address industry challenges and find solutions through open standards.

To fill the second gap (the mapping of knowledge to enable interoperability), several areas need to be addressed. More specifically, bSI has identified three areas to focus further developments. They are closely related to the topic of standardization:

1. **standards for data models.** Today, there are existing established standards for data models that are already in place. The current focus is on extending the scope and deploying established data models. These standards are essential, they allow the collection of data and creation of data models to operate at various levels of scale. An analogy could be made to a layer cake. As Tim Burners-Lee called it, adequate data models exist on different levels, ranging from geospatial information for urban planning to digital engineering models for construction, or even operational data models for asset performance. At each layer of the cake, there are different standards for each part. But these parts are disconnected and not part of a larger ecosystem. Key next steps are going to be about ensuring interoperability between these layers i.e. more in the links between data models and ensuring data from one layer can be understood and valued in another layer. Without this data will be siloed and inaccessible. What is required is a standardized way of creating interoperable systems data. The output should be secure, reliable, and efficient ways of sharing data at an industry-wide scale. It is a bSI Goal to work with other domain standards to facilitate interoperability.

2. **standards for data management and integration**. Standardization in the realm of data management and integration aims to bring two related fields together: data science and information management. To map knowledge between these two fields, it is especially important to focus on semantic precision i.e. the data must be integrated on a common basis to retain its true meaning. Standards that allow the integration of data with a focus on semantic precision facilitate the creation of a robust, transparent, and sustainable system of data – a resilient ecosystem of digital twins. It is a bSI's goal to enable the collaboration for and the development of these standards.

3. **data security and privacy**. By providing a neutral forum for discussing relevant topics, bSI is relevant for parties who wish to work together and have the means and sense of duty to resolve open questions related to data security and privacy. Bridging gaps of knowledge and allowing data to flow effortlessly between projects, lifecycle phases, levels of scale, tools – this innovation will naturally lead to questions around the hosting of data, data ownership and privacy. As the enabler for the industry and ultimately as an enabler of enablers, bSI aims to contribute by defining requirements, developing leadership opportunities and harnessing the industry potential.

Industry-wide digital transformation is within touching distance. There is an opportunity as an industry to collaborate and develop the solutions and standards needed to enable the ecosystem of digital twins.

What now?

You are invited to join the Digital Twin Working Group. The aim is to make this topic, the learnings and outcomes available for the industry. You can be part of the process by bringing expertise and know-how to this subject. bSI is committed to delivering the digital transformation. buildingSMART Rooms will develop domain-specific digital twin topics and aim to apply this to existing projects and activities. A roadmap will be developed in line with the bSI process. This activity will be part of the working group's remit.

This working group will evolve and develop and keep its mission at its core: to recognise the role of digital twins in infrastructure and buildings as a means of improving social, economic and environmental challenges.

"The Digital Twins concept is only limited by our thinking"

Contributors and Working Group
Jakob Beetz, Aachen University
Léon van Berlo, buildingSMART International
André Borrmann, The Technical University of Munich
Mark Enzer, Mott MacDonald/the Centre for Digital Built Britain
Christian Frey, Siemens
Ulrich Hartmann, Oracle
Wolfgang Hass, Siemens
Aidan Mercer, buildingSMART International
Frank Weiß, Oracle
Natalie Weiß, Oracle

Images: David McNamara, Oracle

buildingSMART
International

Comments and questions:

www.buildingsmart.org

Email: communications@buildingsmart.org
Twitter: @ buildingSMARTIn
LinkedIn: buildingSMART International