Identifying and Aligning the Stakeholders

A Digital Twin Consortium User Guide

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1 CONTEXT

The Digital Twin Consortium's AECO Tiger Team published a white paper on 17 February 2023 with the title *"*Decarbonizing the Built World: A Call to Action.[1]*"*

The Team started with a vision to "author a series of user guides to assist an owner or occupier-led implementation of the digital twin-related capabilities that are required in supporting overall new or existing building decarbonization throughout the lifecycle.*"*

Through workshops with experts in the field, this was resolved into five questions:

1. Why should we do this? What are the objectives for sustainability, efficiency, resiliency, health, risk mitigation, performance, reliability, accountability? (outcomes)
2. Who are the stakeholders and how should they participate? (who and when)
3. What is the recommended building lifecycle? (requirements/content)
4. How does the project delivery process need to be changed? (physical process)
5. How does the Digital Thread need to be enabled? (virtual process)

So much material was developed that it was decided to publish it separately.

This paper addresses Question 2, "Who are the stakeholders and how should they participate?"

2 INTRODUCTION

This paper has been written and developed in support of Decarbonizing the Built World: A Call to Action, an owner or occupier-led implementation of digital twin-related capabilities required to support the decarbonization of new and existing buildings.

It specifically addresses the role of the stakeholder in this process. The order of stakeholder engagement is a function of when key decision makers identify goals relating to the improvement of building performance.

Why does the built environment have such a profound effect on the overall use of carbon and yet have relatively fewer committed decision makers addressing 41%[2] of the problem? Can this be changed? One of the most vexing challenges to decarbonization is the disparate nature of the built environment and the need for collaboration in making environmentally conscious decisions that are well-executed throughout the entire building lifecycle.

This is not a problem that can be addressed transactionally. Reaching efficient and effective decarbonization requires a strategic, focused, and calibrated effort across a broad group of stakeholders. Figure 2-1 provides an illustration of the phases involved in our building lifecycle.

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[1] *https://www.digitaltwinconsortium.org/decarbonizing-the-built-world-a-call-to-action-download-form/*
[2] *https://www.buildinggreen.com/blog/energy-use-buildings-and-built-environment*

How this evolved, and a description of each phase, can be found in the original paper, Infrastructure Lifecycle: A Case for Change.[3]

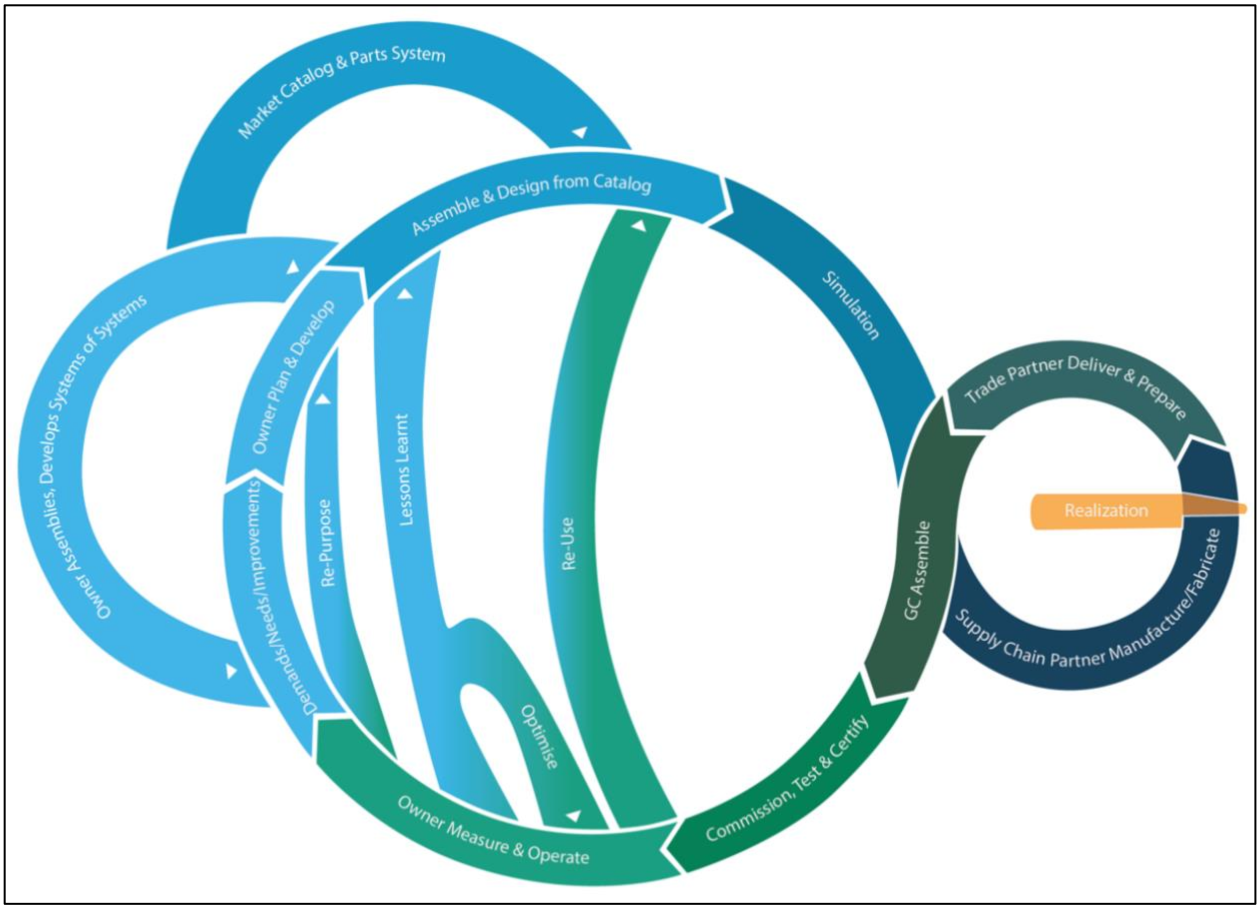

Figure 2-1: Digital building lifecycle. *(Source: Digital Twin Consortium.)*

3 Building Ownership Stakeholders

3.1 Building Owners and Developers

The point at which building owners and developers identify an opportunity to improve or optimize building performance could be anywhere along the continuum of built environment projects as referenced in Figure 2-1. The starting point of any project is irrelevant but the first step, "turn on the lights" for data transparency, is critical and best served by utilizing a performance-based digital twin to democratize their building data as early as possible.

Building owners and developers looking to automate reporting requirements relating to energy disclosure ordinances and corporate sustainability reporting will find digital twins essential. Companies using carbon accounting in the form of taxes or shadow prices will find investing in

[3] *https://www.digitaltwinconsortium.org/infrastructure-lifecycle-a-case-for-change-form/*

performance-based digital twins a perfect use of funds as they predict future performance before investing.

3.2 Investors

Investors interested in utilizing a building performance digital twin typically have stated goals in socially responsible and impact investing. Environmental, Social and Governance (ESG) investing benefits from the use of tools like performance digital twins which reduce financial risk and increase performance confidence.

Additionally, the U.S. Securities and Exchange Commission's newly implemented rules require registrants to include certain climate-related disclosures in their registration statements. This requires periodic reporting metrics, including information about climate-related risks that are reasonably likely to have a material impact on their business, results of operations or financial condition, and certain climate-related financial statement metrics in a note to their audited financial statements.

The required information about climate-related risks also would include disclosure of a registrant's greenhouse gas emissions (GHG), which have become a commonly used metric to assess a registrant's exposure to such risks.

3.3 Tenants

Tenants are the beneficiaries of the use of performance digital twins. Typically, owners and investors are aligned on goals such as low energy (reduces utility costs) and healthy indoor environmental quality (IEQ) which benefit tenants, becoming elements of competitive advantage for building owners and building managers.

Figure 2-1 references where tenants can benefit along the digital building lifecycle journey at the various nodes of implementation and closed-loop analysis. Continuous monitoring of indoor air quality and the implementation of programs like, RESET Air, have become a priority due to the COVID-19 pandemic and the push to return to the office.

3.4 Facility Managers

Facility managers are the beneficiaries of the use of performance digital twins. Connecting the digital asset to advanced data analytic platforms to access capabilities like visualization, fault detection and diagnostics, condition-based maintenance, computerized maintenance management systems, optimization cycles, machine learning and artificial intelligence and other analytics is far more efficient than ever before.

Once a performance digital twin is integrated to a calibrated physics-based simulation model, the information can be used over the life of a building during operations. Figure 2-1 demonstrates the life cycle of this process in greater detail.

Facility managers, with the dynamic performance context of a calibrated physics-based simulation model used with sub-hourly trended meter and sensor data, can compare trended performance to predicted performance based on a building's optimum performance expectations.

A performance digital twin creates a marketplace innovation opportunity for future advanced data analytic platforms to address building performance, command and control, model-based commissioning, integrated facilities management and building decarbonization in ways never contemplated before. This sets up a foundation for a proactive digital twin, identifying potential risking conditions before they become costly problems.

3.5 Building Occupants

As early as possible in a building performance project, the economic buyer of the building must identify important internal stakeholders, including but not limited to tenants, finance (tax, accounting, insurance, risk), legal, IT, facilities management, human resources and communications. This weaves consistent touchpoints to the digital building lifecycle as shown in Figure 2-1. Special focus should be put on finding open-minded, progress-oriented, change agents in these roles.

More than a project or two have been derailed by nay-sayers who are simply unable to try new approaches. To reach the goals of the global building community, we must ensure teams are populated with open, creative minds. Designers must also consider how to design with the human in mind. Rather than simply meeting energy code compliance, design for human comfort as building occupants will typically dictate usage patterns and therefore energy consumption and associated downstream direct costs.

3.6 Upstream and Downstream Supply Chain

Building owners using facilities to manufacture or assemble products now understand the importance of the facility's carbon-footprint relating to operational carbon emissions, referred to as greenhouse gases Scopes 1 and 2 and embodied energy carbon defined under Scope 3, associated with building materials identified in their environmental product declaration (EPD). An EPD tells the life cycle story of a product in a single, comprehensive report.

The EPD provides information about a product's impact upon the environment, such as global warming potential, smog creation, ozone depletion and water pollution. These should all be critical factors taken into consideration that help determine what is prioritized within the digital building lifecycle as referenced in Figure 2-1. The buildings used to create products directly impact upstream and downstream supply chains and cut across industries.

3.7 Owner's Performance Advocate

An Owner's Performance Advocate (OPA) is a contemporary version of an Owner's Representative. The first step an OPA will take is to create an Owner's Project Requirements (OPR) which converts owner's performance goals to specific metrics that guide the design team's choices.

The OPA will develop a performance-based digital twin and will provide the expertise required early in project planning to support the project team in the achievement of goals. Various factors determine those goals and will dictate when and where to prioritize critical decision-making within the digital building lifecycle as seen in Figure 2-1.

Informed by the performance-based digital twin, an OPA will simultaneously develop a detailed Owner's Control Estimate to define first costs for construction associated with optional scopes of work that relate to building performance.

Lastly, the OPA will calculate expected energy consumption and carbon accounting (CO2e). With that information, building owners and developers and their supporting teams have everything they need to prioritize investments within a building or across a portfolio of buildings. The role of OPA may be played by a third-party expert or a trusted member of the existing team. The greatest advantage of a third-party OPA is that they represent the owner's needs without bias, and they possess the skills required to hold the rest of the team accountable to the goals set in the Owner's Project Requirements (OPR).

4 AEC Community

4.1 Architects and Engineers

In the built environment, it's important to assess the timing at which architectural and engineering teams should be brought onto the project. Typically, any decision to improve the performance of an existing building or deliver aspirational building performance in a new building requires specialized experience and expertise not normally associated with traditional design practices.

When onboarding design professionals, the goals of the project as reflected in the Owner's Project Requirements (OPR) should be included in any RFP as this simple step will ensure the team possesses the alignment and understanding to deliver the goals. Special consideration should be given to structural, mechanical, electrical, plumbing and system integration engineering firms with related skills and expertise. According to the Rocky Mountain Institute (RMI)[4], a project can reduce its embodied carbon by an average of 50% during design with little to no increase in cost.

[4] *https://rmi.org/insight/reducing-embodied-carbon-in-buildings/*

4.2 BUILDING CONSULTANTS

Building consultants provide the owner and design team the skills and experience necessary to support the use of a performance digital twin to mitigate risks and ensure a smooth transition into operations from design through construction and into lifecycle operations. The role of building consultants on project teams tends to be less than the design team and more focused on specific areas of support. Some areas of consultancy might be sustainability program certifications, master systems integration, smart building infrastructure design, building science envelope optimization and systems commissioning.

4.3 CONTRACTORS, SUBCONTRACTORS, MATERIAL SUPPLIERS, AND EQUIPMENT VENDORS

Depending on the nature of projects relating to complexities and schedule, key contractors, subcontractors, material suppliers and equipment vendors may be onboarded early to provide critical inputs into the processes and decision-making criteria. The concepts of lean and integrated project delivery are project delivery processes that use methods of maximizing stakeholder value while reducing waste by emphasizing collaboration between teams on a project. These concepts are further articulated with the MacLeamy Curve[5] as seen in Figure 4-1, which illustrates the escalating cost of design modifications as a project team progresses in the design process. The goals of early integration are to increase productivity, profits and innovation in the industry.

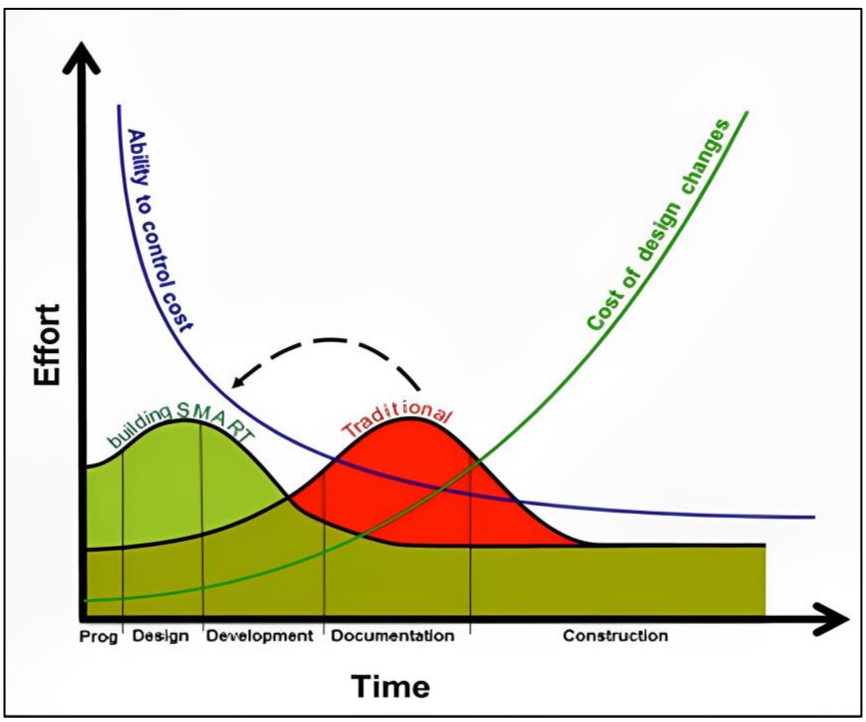

Figure 4-1: MacLeamy curve. *(Source: Daniel Davis.)*

[5] *https://www.danieldavis.com/macleamy/*

4.4 UTILITY PROVIDERS

Utility providers have been developing and implementing intelligent technology for the modern electrical grid. The modern electrical grid includes real-time pricing networks, performance-based modeling, sensors, controls and simulation for microgrids, improving resiliency for energy systems and reducing the carbon footprint. A key component of the modern electrical grid is connectivity to buildings. This intersection between the utility grid and smart building infrastructure is key to the mutual success of utility providers and building owners and developers.

5 SMART BUILDING VENDORS

The components of smart building infrastructure commonly break down to five (5) key components: Operational Technologies, Building Networks IT/OT/IoT, Data Layers and digital twins, Advanced Data Analytics Layer and Building Optimization Technologies. The following infographic represents the five (5) key components of the smart building infrastructure. Figure 5-1 depicts the varying levels of data integration, data sources, aggregation and simulation that will all impact operational performance of the building.

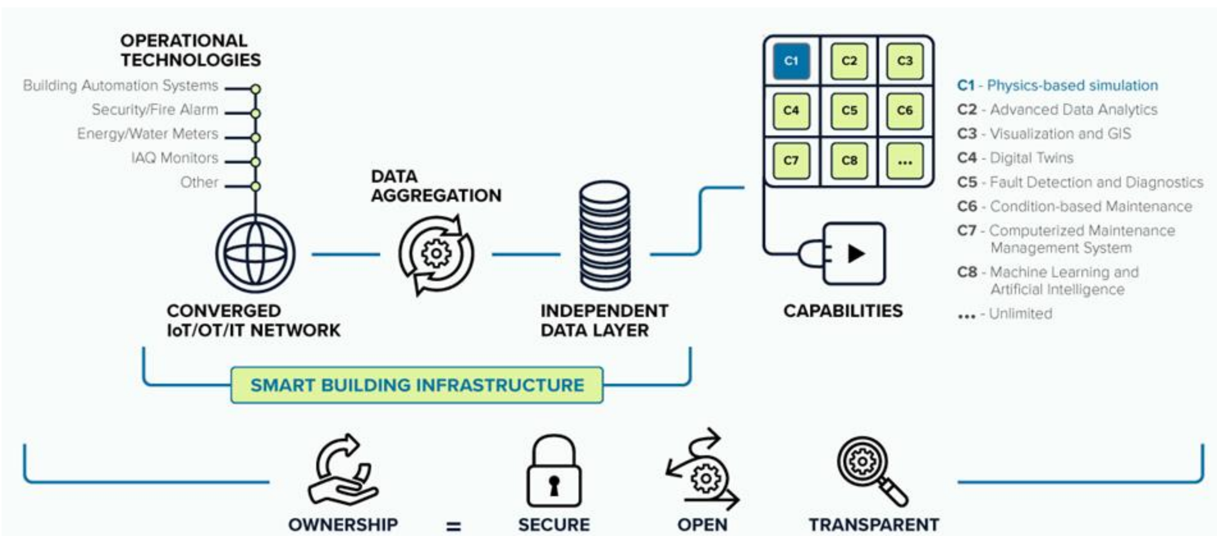

Figure 5-1: Data democratizing process map. *(Source: ©AUROS Group).*

5.1 OPERATIONAL TECHNOLOGIES

Operational Technologies (OT) use hardware and software to monitor and control physical processes, devices and infrastructure in buildings. Common OTs include building management systems (controls), indoor air quality and outdoor air quality, weather station, utility energy and water metering, security/access control/CCTV, density analytics/occupancy & vacancy controls, lighting control, fire alarm, elevator, generator, photovoltaic array, enterprise networks (telephone, data, Wi-Fi) and others. In the world of performance digital twins, open-integrated

OTs with high level of interoperability are the key to the democratization of building performance data as referenced in Figure 5-1.

5.2 BUILDING NETWORKS IT/OT/IOT

Historically, OTs were installed in buildings in separate, disparate, closed-looped networks with zero or limited interoperability. Modern deployment of OTs includes converging networks to save costs on structured cabling without sacrificing security, transparency and access to data. It is also possible to converge OT networks with building enterprise networks including telephone, storage data and information technology (IT).

Building networks that comprise IT/OT and IoT must be considered holistically, as opposed to silos, when incorporating a performance digital twin because the digital representation of a physical building needs to be as protected and secure as the building itself as represented in Figure 5-1. Cybersecurity is a shared discipline including operational technologies and information networks. Network infrastructure deliverables should include user authentication, secure data transport, facility device communications, encryption, redundancy and backup.

5.3 DATA LAYERS AND DIGITAL TWINS

Data is the key to controlling building operations. Real-time, time-series data in the built environment is typically managed by an integrated interface, commonly known as a data layer that engages and is populated by all project stakeholders from planning, design, construction, commissioning and handover into operations to complete the digital building lifecycle.

Data layers include, but are not limited to data lakes, independent data layers, time-series databases, etc. Digital twins serve the purpose of digitizing physical assets in real-time and time-series databases incorporate metadata and historize the data according to owner data standards. The data layer should ensure that data is transparently accessible and owned by building owners and developers irrespective of the addition or deletion of distinct data layers.

Data layers may reside in numerous locations across the smart building infrastructure. For example, operational technologies can store data on-premises or in a proprietary cloud and advanced data analytics layer and building optimization technologies can store data in a proprietary cloud or in some instances in an independent data layer.

Best practices dictate the implementation of an independent data layer to give building owners control and ownership of its building performance data. The use of a data layer embedded in an advanced data analytics layer is commonly accepted as long as a transition plan from the contractual agreement is preplanned. Building owners are no longer tolerating a relationship wherein they cannot control their building data.

5.4 Advanced Data Analytics Layer and Building Optimization Technologies

Data, to be usable, needs to be understood by everyone at first glance. Finding better context for data and displaying it for easy comprehension is the greatest challenge. We expect an effective dashboard to quickly demonstrate a building's performance, ideally, with the context to show if it is performing as it was invested in to perform. With the right context, the visualization becomes the cornerstone of measuring and verifying the performance of new or existing buildings.

Advanced data analytics layer applications and building optimization technologies provide an almost limitless number of analytics capabilities that can be customized using machine learning and artificial intelligence. Additionally, there are many applications with prebuilt functionality to deliver building optimization technologies including, but not limited to, energy management systems, asset management toolkits, construction and project management, occupant experience apps, space utilization, fault detection and diagnostics, condition-based monitoring, computerized maintenance management system or CMMS that centralizes maintenance databases and other analytics.

The visualization interface is technically the easiest of all the elements to solve and has the most options, so owners and project teams are lured into making visualization decisions first, understanding they are backed by data intelligence. However, best practices dictate that the visualization should be chosen last after the rest of the smart building infrastructure is established to ensure the visualization delivers the necessary functionality highlighting the most critical components.

6 Community

6.1 People

The role buildings play in human health and well-being has never been more evident or more important. There are volumes of evolving evidence underscoring the relationship between the physical environment and human health. The evidence shows direct links to design, policy and built environment strategies and health and well-being outcomes. The knowledge base exists to create spaces that enhance, rather than hinder, health and well-being. Using building performance digital twins, we can measure and improve the quality of our air, water and light. Building owners and developers are transforming buildings in ways that advance health and well-being to help people thrive.

6.2 International Environmental Groups

International environmental groups serve their organizations by ensuring corporate sustainability remains as a key lever that creates long-term stakeholder value. The inclusion of performance digital twins ensures that corporate sustainability performance reporting benefits from evidence showing irrefutable progress against goals.

6.3 FEDERAL, STATE, AND LOCAL GOVERNMENTAL REGULATORS

Local, regional, national and global governmental bodies have unique opportunities to lead the discussion on reducing energy consumption, improving occupant health and wellbeing and decarbonization. It is critical governments share evidence of the importance and ease with which these goals may be achieved. Sharing examples of best practices serves to reduce the anxiety of investing in the environment and human health.

It is essential that governments use the tools they have through good leadership, productive communications and tax incentives to drive building owners and developers to make better decisions. It’s equally essential that governments support the innovation that will remain necessary from the private sector. Ensuring that governmental bodies and private foundations do not use public funds to compete with the private sector remains an important point of consideration.

6.4 STANDARDS ORGANIZATIONS

Key standards organizations like ASHRAE or ISO, should be expected to continue to raise the bar for acceptable building performance. Standards organizations set the bar for the “worst buildings we are legally allowed to build” so they have a responsibility to require improved performance as it is possible considering both technology and costs.

6.5 SUSTAINABILITY CERTIFICATION PROGRAMS

Sustainability Certification Programs are broad and vary by country and region. The use of a performance-based digital twin provides important feedback demonstrating the ease or difficulty of pursuing various sustainability certification programs. Using the outputs of a performance digital twin reduces the financial risk of pursuing these types of programs and improves the likelihood of successful certification.

Examples of sustainability certification programs include, but are not limited to, BREEAM, EcoDistricts, Fitwel, Living Building Challenge, Passive House (PHI & PHIUS), RESET Air, USGBC LEED, WELL Building, Green Star and others. As technologies like performance-based digital twins become more prevalent, standards should be expected to require proof of ongoing performance using continuous monitoring to achieve and maintain certification.

6.6 NGOS AND INDUSTRY ASSOCIATIONS

There are literally hundreds of Industry Associations and NGOs that each bear the responsibility of educating membership on best practices and approaches to delivering low energy consumption and decarbonization for new and existing buildings. These organizations should require thought leaders to educate their memberships on the benefits and best practices of performance based digital twins.

7 CONCLUSION

In summary of the content included in this user guide, it sets up the foundational elements that digital twins need to consider in order to develop a robust tool that adds value throughout the entire digital building lifecycle. It is critical to note that digital twins need to be viewed as a holistic system of systems that are housed in a common digital thread. Without the connection to solving specific use cases as mentioned throughout this document, digital twins will lack the ability to provide value. Subsequent user guides drill deeper into how digital twins provide that value to communicate, collaborate and correlate data in a meaningful way.

8 AUTHORS & LEGAL NOTICE

This document is a work product of the Digital Twin Consortium Building Performance Subgroup, chaired by John Turner (Gafcon Digital).

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