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Digital Lean as a Lean Tool in Facility Management

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***Abstract*— Digital twin technology and lean methodologies are two approaches that improve operational efficiency in facility management. While digital twins provide real-time data and simulation, lean focuses on eliminating waste within organizations. This paper argues that combining and integrating these approaches creates a synergy whose benefits exceed those of either approach alone. The case studies below demonstrate that digital twins enhance core lean methodologies.**

Keywords—Digital Twin, Lean, VSM

I. Introduction

Modern facilities face challenges that are often unplanned for and unprecedented. This risk is now even more severe, given the growing prevalence of complex infrastructure. Digital twins are replicas of physical assets and processes that serve as real-time and agile copies [1]. The main difference between digital twins and the assets they replicate is that they are virtual and dynamic. Digital twins use real-time sensor data to enable and ease decision-making [1]. This data is the basis for analytics that are then used to simulate characteristics and behaviors of physical components, easing analysis and optimization. It is important to note that, since the data is in real time, digital twins enable on-time decision-making and reduce inefficiencies before they become costly. These help improve operational efficiency and preventive maintenance in facility management by powering and enabling the shift from reactive to proactive, reducing costs.

Lean is a management tool and philosophy that maximizes value by reducing waste. Lean is part of a larger philosophy and process, Lean Six Sigma, but can be used independently. Lean is focused on eliminating waste emanating from processes and activities that are largely non-value-adding to an organization and its processes. The core principles of lean include understanding customer value, mapping value streams, and creating pull systems through continuous improvement. The most common tools in Lean are the 5S methodology and root-cause analysis. Furthermore, the political elite has exacerbated inflation when they divert public funds. This deliberate theft of taxpayer money undermines the effectiveness of fiscal policies and projects to stimulate and maintain economic growth. Instead of investing in infrastructure, healthcare, or education to stabilize the economy and improve productivity in the long run, taxpayer money is often routed and diverted into schemes with no economic return, such as the new healthcare coverage known as SHA or Housing projects in remote areas. This results in a gap that is currently widening between government spending and economic output, which is contributing to inflation in the country.

This paper argues that the integration of digital twins with lean methodologies in facility management, which improves operational efficiency and reduces costs through proactive maintenance and data-driven decision making, reinforces organizational continuous improvement, which is necessary for long-term success.

II. Facility Management and Digital Twins

Digital twins, as a concept, are new to facility management. However, digital twins, in their fundamental form, have been part of facility management since the 1960s. In the 1960s, CAD systems were introduced in facility management and engineering to produce precision, efficient designs compared to manual drafting [3]. This was the first step in the digitization of facilities. This developed into building informational modelling, which was able to create a digital representation of characteristics, physical and functional, of facilities. This enables better collaboration among stakeholders to improve project and facility management throughout a building's lifecycle.

The rise of sensors and IOT in the 2000s revolutionized facility management. They enabled and improved real-time data collection from sensors in physical buildings [4]. This change enabled facility managers and building owners to continuously monitor systems and make changes proactively. Currently, digital twins are virtual replicas of processes, assets, and systems. They collect a lot of data and, through simulations and regression models, they can replicate and mimic characteristics, which improves the optimization of facility management.

III. Lean-Digital Twin Synergy in Facility Management

While digital twins leverage real-time data and virtual modeling, their impact is even stronger when combined with Lean. Lean requires precise identification of waste, accurate mapping of value streams, and continuous monitoring of process flow [2]. Digital twins provide the live operational data, system-wide visibility, and simulation capability that traditional Lean tools often lack.

A. Disadvantages of Traditional Systems

Traditional methods rely on manual processes and reactive maintenance, which often lead to inefficiencies. Technologies facilitate and enhance proactive maintenance, thereby improving operational efficiency. Additionally, as stated earlier, traditional systems are reactive systems. This means that they wait for problems to appear and then solve them. These fixes can often be expensive. Additionally, in complex and interconnected facilities, such inefficiencies cost physical, fiscal, and personnel damage. These costs accumulate over time as traditional systems ignore the data and its insights. This creates blindness in operations that are unable to identify inefficiencies and processes, limiting flexibility to change.

B. Shortfalls of Traditional Lean

Lean in itself is a valuable tool to have in facility management. However, the majority of the applications within facility management are based on traditional lean tools, which are vital, such as 5S, Kanban, Kaizen, Poka-Yoke, and VSM. While essential and valuable, these tools suffer from critical gaps. They have limited real-time data applications and rely on historical data and observations. In complex, modern facilities where operations are dynamic and agile, this lack of real-time data use can lead to misinformed decisions for an organization. Again, modern facilities use tools such as VSM and 5S during setup and organization. However, these tools become slowly ineffective when processes evolve within organizations.

Traditionally, lean is reactive, meaning it identifies waste sources reactively. This can cause inefficiencies that escalate before they are addressed. Without proactive and digital tools such as digital twins, it becomes challenging to mitigate potential problems. Furthermore, lean is based on group processes rather than team functionality. Groups are people or a collective of persons who work individually with individual goals towards their personal metrics. For instance, in a manufacturing line, each station could be an individual, with the whole line being the manufacturing line group. Teams, on the other hand, are groups of people within an organization who share the same goal. This is seen in organizations with a matrix structure. Lean works well in groups, leaning out to other departments that could be related to systems and processes. The lack of visibility can prevent the identification and solving of system-wide inefficiencies.

Lastly, lean works best in smaller situations and operations. Currently, many organizations are complex, connected, and intricate, and this is an arena where lean tools may struggle to keep up. This is further compounded by its limited capability to promote simulation. The lack of visualization and simulation within a facility makes it difficult for people and decision-makers to see how changes in one area can affect others. This makes decision-making suboptimal.

These challenges highlight the need for connecting digital twins and lean methodologies. This is important because it enables decision-makers to have a system-wide view of waste identification, line visibility, and value stream mapping, thereby improving efficiency in facility management.

IV. Digital Twins and Lean

A. Waste Identification

Leveraging lean and digital twins enables the use of real-time data from sensors and IoT devices, enabling organizations to identify inefficiencies and waste faster than with traditional methods [5]. This aligns with lawn principles, which focus on eliminating waste and non-value-adding activities. This is further compounded and enhanced by using simulation scenarios that predict potential waste points before they occur, increasing proactiveness in waste management. This is a difference from how lean tools work post-waste creation.

B. Line Visibility

Digital twins allow decision makers and managers to have a complete view of operations, offering real-time data on operations, equipment status, and workflow processes [5]. This will enable managers to identify bottlenecks that are not apparent through manual observations. Again, this is compounded by the fact that it breaks down the aforementioned group of workers, who are focused on individual work rather than teamwork. This is important for a system-wide view of inefficiencies within a value stream.

C. Value Stream Mapping

Traditional VSM relies on static data, whereas digital VSM continuously updates based on real-time data [2]. This makes it easier for organizations to visualize current-state processes and identify areas for improvement with precision. Again, with simulation, these changes can be simulated in the value stream to assess the potential effects pre-implementation. This improves VSM effectiveness, allowing for different scenarios and processes to be tested based on the data obtained.

It is inherently important that digital twins be integrated with lean, as this improves waste identification, line visibility, and value stream mapping optimization. The use of real-time data and simulation can help organizations move away from reactive strategies, thereby improving operational efficiency and long-term success in the industry.

V. Case Studies of Digital Twins

A. Bayer Crop Science

Through an initiative known as Shaping Business Strategy and Future Operations Through Virtual Factory, Bayer has increasingly integrated digital twins into its operations. They use simulation to model each of their nine seed processing plants in North America [6]. These simulations include equipment layouts, process flows, bill of materials, and detailed operating rules. Because corn seeds move through these facilities immediately after harvest for processing and bagging, having accurate virtual versions allows the company to understand and optimize every stage of

production [6]. This has permitted Bayer to collect data from different sources, including the physical factories themselves. This has enabled Bayer to develop more than 300 rules and operational strategies that continue to govern the movement of seeds in its facilities.

Again, using digital twins, Bayer can run scenarios to evaluate seed treatments, pricing strategies, operational changes, and long-range plans. This has reduced their planning and decision-making from 10 months to less than 5 minutes, as simulations can be run 100 times over 24 hours [6]. The use of digital twins has increased decision-making capabilities, equipment purchasing, and scheduling.

While the benefits are mostly operational, the new data they have obtained has helped Bayer's internal teams make better decisions on a company scale. It has eliminated the silos within the organization that were based on site location. It has created a cross-functional team matrix across all Bayer substations, enabling greater communication. It has also helped them with their investments, which have increased their productivity and mergers.

B. Lowe's

Lowe's has adopted digital twin technology to enhance store operations and improve the experiences of employees and customers. They have been used to develop virtual replicas of individual stores using real-time data and product location and inventory movement information [7]. They have gone a step further and made these simulations update several times a day to maintain an accurate representation of stores around the world. This has created employees who have been labelled as psychics and mentalists by improving their operational planning and problem-solving.

Unlike many companies, they have done this venture in-house using Lowe's Innovation Labs. The lab has fed AI product data and details, such as dimensions, size, and weight. While this is impressive, they have integrated augmented reality headsets for their employees, allowing them to see the digital model of the store while in the store [7]. Since the AI has a massive amount of data, it enables employees to see shelf layouts and visualize hard-to-reach inventory. This has increased the store's functionality when it comes to resetting and restocking shelves. While this seems simple, it has increased the accuracy of product placement and identification [7].

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C. Windover Construction - Endicott College

Windover Construction and Endicott College best illustrate the use of digital twins in facility management. Initially, the construction company used physical documentation as part of its handover to clients, and they were really used to it. As a result, they decided to switch their approach to the handover process with their client, Endicott College. In their last project, they converted their BIM deliverables into formats that were easily usable by clients. This was done using Autodesk's Tandem [8]. Tandem is a digital twin platform that creates and stores building models. They used the system to document facility management information, such as installation dates, warranties, and manufacturer specifications, within the three-dimensional model, making it foolproof for the college's management.

Through extensive laser scans, the construction team imported the model into Tandem, added facility management data, and delivered it to the college. This was done pre-construction, during construction, and after construction. This set the standards for all their buildings from the very beginning.

This process and integration of digital twins improved handover experience for facility managers and their construction partners. Since clients can update data over time, they can note when systems are replaced or upgraded, and when they fail. As the Tandem ecosystem continues to improve and grow, it is expected that IoT integration will enable predictive analytics to run faster and more efficiently.

VI. Lessons Learned from Case Studies

All three case studies show that digital twin technology can transform operations. Facility management and decision-making in different industries. One thing remains common: facilities have benefited from integrating digital twins. Bayer shows that digital twins are scalable. By having the capability and ability to simulate different seed packing factories, the company has been able to change its operational rules within the organization. Simulation has hastened their decision-making process and planning. On an organizational level, this technology has reduced silos, improving the use of cross-functional teams across all sites.

For Lowe's, there has been a significant increase in employee efficiency and customer experience. The use of these replicas is to improve inventory tracking and employee work output. The main takeaway from Lowe's is that all physical retail stores could be turned into data-driven environments. This enhances customer navigation and operational efficiency. Lastly, the collaboration between the college and its construction partners has highlighted the importance of digital twins in lifecycle asset tracking. Handover documents have always been bulky, and their size has

been proportional to the project's scale. The collaboration has shown that this need no longer be the case. Building and facility management can be based on a living document that evolves alongside the building. This ensures that systems can be tracked throughout their lifecycles. As IoT integration grows, digital twins have exponential possibilities. Digital twins enhanced Lean outcomes by improving flow, reducing waste, and enabling continuous improvement. Bayer's scenario testing aligns with Lean's striving for perfection, while Lowe's improved store layout supports Lean's emphasis on workplace organization and 5S; and Endicott College's lifecycle asset tracking strengthens preventive maintenance and eliminates waste in documentation processes.

VII. Challenges with Digital Twin Integration

Integrating digital twin technology and facility management has several challenges. Data sources and their integration remain a critical issue. It is important to note that facilities can vary in age, and some still use analog sensors, which makes data integration increasingly difficult. Ensuring that these systems effectively communicate remains an uphill task. Again, there is a lack of skilled personnel who have a combination of facility management and digital twins. This knowledge gap is hindering implementation. More importantly, the initial investment for digital twin integration is high and beyond the reach of smaller organizations with limited budgets.

VIII. Growing Opportunities

There are endless opportunities to integrate AI and Industry 4.0 with digital twin technology. As organizations and companies adopt Industry 4.0, characterized by automation and data exchange, unique opportunities arise. Furthermore, AI integration enables deeper data analytics, helping facility managers see and anticipate issues before they occur. This increases the proactiveness that is characteristic of digital twin technology. This synergy will improve asset management and decision-making processes.

IX. Conclusion

The integration of digital twin technologies with lean methodologies in facility management highlights a much-needed approach for operational efficiency and cost reduction. While organizations digitize and move from analog systems, the availability of a digital twin-lean philosophy can improve decision-making and operational efficiency. Digital twin technology does not seek to replace Lean. It makes it stronger by enhancing the core Lean tools through data availability in real-time, making facilities Lean-digital twin compliant. Looking forward, the integration of Industry 4.0 and AI shows the potential of digital twins as the next frontier in facility management, advancing it to a data-driven science and art.

X. References

[1] Khallaf, R., Khallaf, L., Anumba, C. J., & Madubuike, O. C. (2022). Review of digital twins for constructed facilities. Buildings, 12(11), 2029. https://doi.org/10.3390/buildings12112029

[2] Sepasgozar, S. M. E., Hui, F. K. P., Shirowzhan, S., Foroozanfar, M., Yang, L., & Aye, L. (2020). Lean practices using building information modeling (Bim) and digital twinning for sustainable construction. Sustainability, 13(1), 161. https://doi.org/10.3390/su13010161

[3] 3D Pattern & Mould Makers Ltd. (n.d.). The history of cad – how it has revolutionized the construction industry. 3D Pattern & Mould Makers Ltd. Retrieved November 14, 2025, from https://www.3dpatternandmouldmakersltd.co.uk/guides/the-history-of-cad-how-it-has-revolutionised-the-construction-industry

[4] Foote, Keith D. (2022). A brief history of the internet of things. Dataversity. https://www.dataversity.net/articles/brief-history-internet-things/

[5] Barkokebas, B., Al-Hussein, M., & Hamzeh, F. (2023). Assessment of digital twins to reassign multiskilled workers in offsite construction based on lean thinking. Journal of Construction Engineering and Management, 149(1), 04022143. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002420

[6] CIO. (2020). Bayer uses digital twins to reshape business strategy. CIO. https://www.cio.com/article/201985/bayer-uses-digital-twins-to-reshape-business-strategy.html

[7] Lowe's. (n.d.). Store digital twin. Lowe's Innovation Labs - Building the Future of Home Improvement. Retrieved November 14, 2025, from https://www.lowesinnovationlabs.com/projects/store-digital-twin

[8] Autodesk. (n.d.). Solving the handover gap from construction to facilities management. Autodesk Tandem. Retrieved November 14, 2025, from https://intandem.autodesk.com/resource/solving-the-handover-gap-from-construction-to-facilities-management/