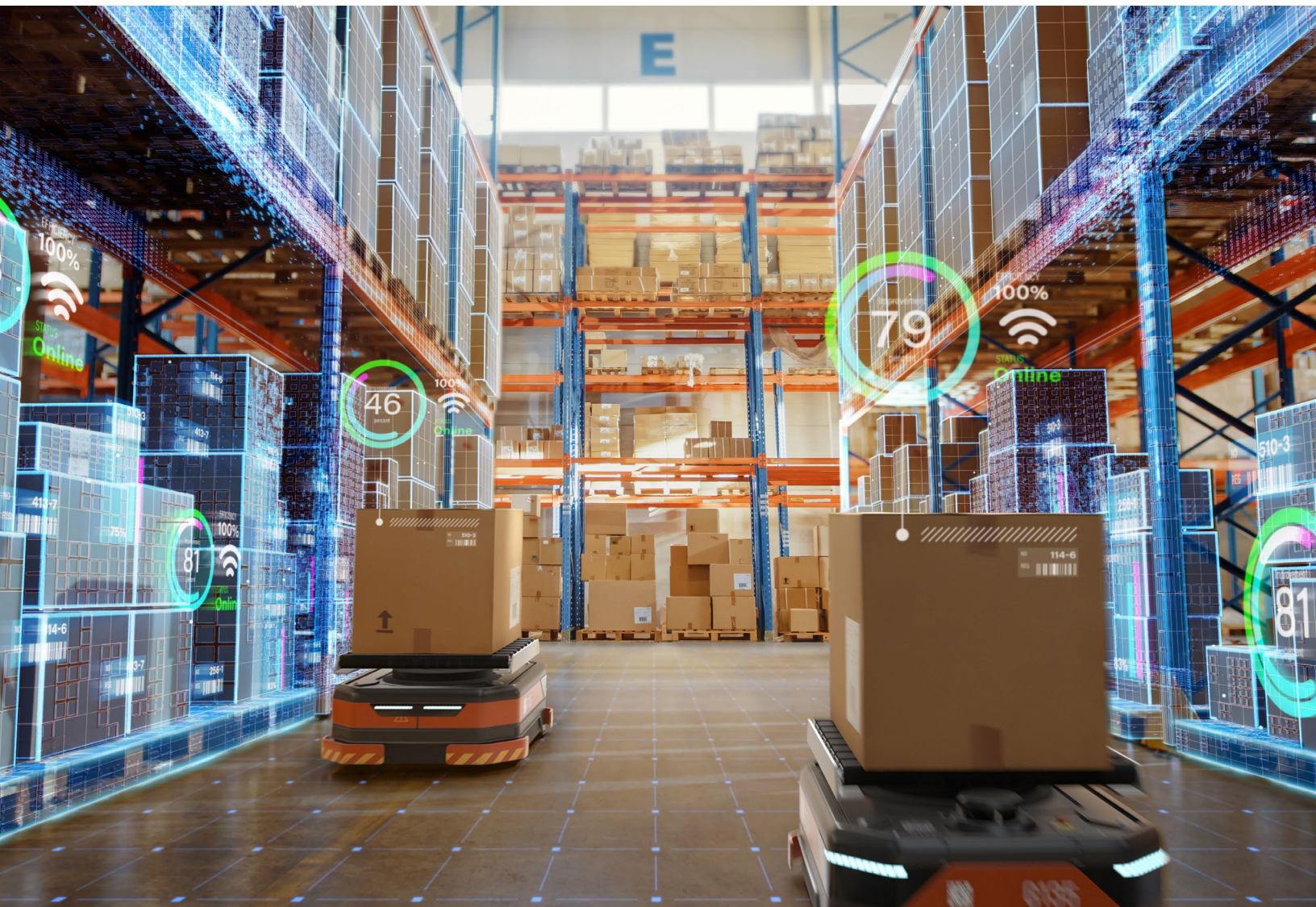


Digital Twins in the Material Handling Industry



Developed by the Solutions Community

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A digital twin is a virtual representation of a physical asset, process, system, or facility that is continuously updated with real-world data. In the material handling industry, digital twins are becoming increasingly valuable as warehouses, distribution centers, ports, factories, and logistics hubs grow more complex, automated, and data-driven.

Material handling encompasses the movement, storage, control, and protection of goods throughout manufacturing, warehousing, and distribution operations. A digital twin enables organizations to understand, monitor, simulate, and optimize these activities without disrupting day-to-day operations.

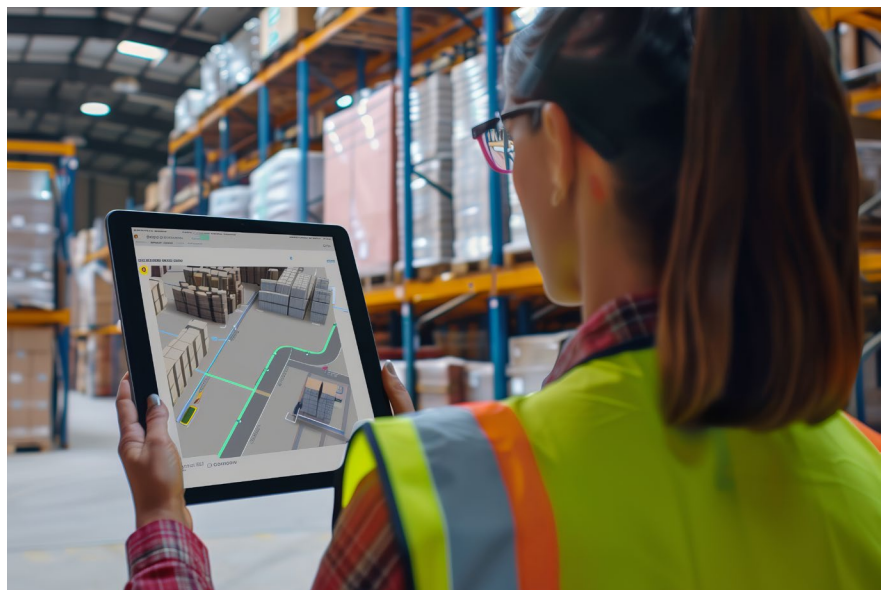
In simple terms, a digital twin creates a digital counterpart of a material handling environment. This may include conveyors, automated storage and retrieval systems (AS/RS), forklifts, autonomous mobile robots (AMRs), cranes, palletizers, sorters, packaging equipment, storage racks, inventory, and even workforce activities. Data collected from sensors, warehouse management systems (WMS), enterprise resource planning (ERP) systems, programmable logic controllers (PLCs), machine vision systems, and Internet of Things (IoT) devices continuously feeds the model. The result is a dynamic digital environment that mirrors what is happening on the warehouse floor or throughout a manufacturing facility in near real time.

SYSTEM DESIGN AND PLANNING

One of the most valuable applications of digital twins is system design and planning. Before investing in new facilities, automation technologies, or material handling equipment, organizations can simulate various layouts, workflows, and operational strategies.

For example, companies can evaluate whether robotic picking will reduce labor costs, determine the optimal conveyor configuration, or assess alternative storage designs to maximize capacity and throughput. Rather than relying solely on static drawings or spreadsheet-based calculations, stakeholders can visualize how products, equipment, and personnel will interact under varying demand scenarios.

This capability significantly reduces project risk, improves design confidence, and helps prevent costly mistakes before physical implementation begins.



PERFORMANCE OPTIMIZATION

Digital twins also play a critical role in operational performance optimization. Material handling systems often experience bottlenecks that impact throughput, productivity, and customer service levels.

By continuously analyzing operational data, a digital twin can identify where delays are occurring and why. It may reveal overloaded conveyor sections, inefficient forklift travel patterns, robot congestion, excessive worker travel distances, or underutilized equipment.

Organizations can test corrective actions in the virtual environment first, validating improvements before implementing them physically. This approach leads to increased throughput, faster order fulfillment, improved resource utilization, and lower operating costs.



PREDICTIVE MAINTENANCE

Another major benefit of digital twins is predictive maintenance.

Material handling equipment, including conveyors, cranes, lifts, sorters, automated guided vehicles (AGVs), and robotics systems, must operate reliably to support business operations. Unexpected downtime can disrupt production, delay shipments, and increase maintenance costs.

By combining sensor data with digital twin technology, organizations can monitor equipment health in real time. Parameters such as vibration, temperature, motor load, operating hours, and energy consumption can be analyzed to detect early indicators of equipment degradation.

Rather than responding to failures after they occur, maintenance teams can proactively schedule service interventions at the optimal time. This increases equipment availability, extends asset life, and reduces emergency repair expenses.

SUPPORTING AUTOMATION AND ROBOTICS

As adoption of AMRs, AGVs, robotic arms, and automated storage systems continues to grow, digital twins provide a powerful platform for validating automation strategies.

Organizations can simulate robot traffic patterns, charging schedules, workflow assignments, and interactions between automated systems and human operators. This allows them to identify congestion points, safety concerns, and utilization challenges before deployment.

For example, a simulation may demonstrate that increasing the number of robots does not necessarily improve productivity if aisle widths, charging infrastructure, or process design create operational constraints. The digital twin provides the insight needed to make informed investment decisions before capital is committed.



INVENTORY VISIBILITY AND MANAGEMENT

Digital twins can also improve inventory management by creating a real-time representation of inventory locations, stock levels, material flow, and order status.

In high-volume distribution environments, this visibility is essential for maintaining service levels and operational efficiency. When integrated with warehouse management systems, RFID technology, barcode systems, and machine vision solutions, digital twins provide enhanced visibility into where products are located and how they move throughout the facility.

Benefits include improved inventory accuracy, reduced misplaced inventory, increased picking efficiency, and faster replenishment cycles.

ENHANCING SAFETY

Safety remains a top priority in material handling environments where employees work alongside vehicles, moving equipment, robotic systems, and heavy loads.

Digital twins allow organizations to model and analyze safety risks before incidents occur. Simulations can identify unsafe traffic patterns, congested intersections, overloaded storage areas, and ergonomic concerns.

Digital twin environments can also be used for workforce training, enabling operators and maintenance personnel to safely practice responses to equipment failures, traffic incidents, and emergency situations without exposing employees or assets to risk.



ENERGY AND SUSTAINABILITY MANAGEMENT

Material handling operations consume significant amounts of energy through conveyors, automation systems, lighting, HVAC equipment, battery charging stations, and compressed air systems.

A digital twin can track and analyze energy consumption across the operation, identifying opportunities to improve efficiency and reduce waste. Potential improvements may include optimized charging schedules, dynamic equipment shutdown during idle periods, reduced travel distances, and improved asset utilization.

These efforts help organizations lower operating costs while supporting sustainability and environmental objectives.

BETTER DECISION MAKING

Traditional reporting systems generally explain what happened in the past. Digital twins provide visibility into what is happening now and what may happen next.

This predictive capability enables organizations to evaluate “what-if” scenarios and prepare for changing business conditions. Examples include spikes in customer demand, labor shortages, supply chain disruptions, equipment failures, or facility expansion plans.

By modeling these scenarios within a digital environment, decision-makers can better understand potential impacts and select the most effective course of action.

ROI ACROSS THE FULL ASSET LIFECYCLE

One of the most compelling aspects of digital twin technology is its ability to generate value across the entire asset lifecycle, from the earliest planning stages through long-term operation and continuous improvement.

During the pre-concept and conceptual design phases, digital twins help organizations evaluate alternatives before major investments are made. Multiple layouts, automation strategies, and process flows can be simulated and compared, reducing the risk of selecting an ineffective design. This early-stage visibility often leads to lower project costs, faster implementation timelines, and improved confidence in capital investment decisions.

As projects move into engineering, deployment, and commissioning, digital twins help validate system performance before equipment is installed. Potential bottlenecks, capacity limitations, safety concerns, and integration issues can be identified and corrected virtually rather than after construction. This can significantly reduce change orders, project delays, and startup challenges while accelerating the time required to achieve operational targets.



Once systems are operational, digital twins continue delivering measurable returns through improved throughput, predictive maintenance, better labor utilization, enhanced inventory accuracy, reduced downtime, and optimized energy consumption. Because the digital twin evolves with the operation, it becomes a long-term strategic asset that supports continuous improvement initiatives throughout the life of the facility. The result is ongoing value creation that extends far beyond the initial implementation, helping organizations maximize return on investment while improving resilience, flexibility, and operational performance.

IMPLEMENTATION CONSIDERATIONS

While the benefits of digital twins are substantial, successful implementation requires accurate data, reliable connectivity, skilled personnel, and clearly defined business objectives.

Without high-quality data, a digital twin cannot accurately reflect physical operations. Many organizations must also address challenges associated with integrating legacy equipment and ensuring cybersecurity across connected systems.

For this reason, most successful digital twin initiatives begin with a focused use case rather than attempting to model an entire enterprise at once. Organizations often start with a single process, automation system, production line, or warehouse operation, then expand as value is demonstrated.

The most effective digital twin programs combine operational expertise, engineering knowledge, software capabilities, and strong data governance practices.

CONCLUSION

Digital twins are transforming the material handling industry by connecting physical operations with intelligent virtual models. They enable organizations to design better systems, optimize workflows, improve uptime, enhance safety, support automation initiatives, increase inventory visibility, and make more informed decisions.

As supply chains and facilities become increasingly automated and data rich, digital twins will become an essential tool for improving efficiency, resilience, and competitiveness. For the material handling industry, digital twin technology is not simply a technology trend, it is a practical pathway toward smarter, safer, and more adaptable operations.



THE MHI ECOSYSTEM

MHI is uniquely positioned to support organizations on their digital twin journey through its broad network of member companies spanning material handling equipment, automation, software, systems integration, consulting, engineering, and advanced technology solutions.

Whether an organization is exploring digital twin concepts, evaluating automation investments, designing a new facility, optimizing existing operations, or implementing enterprise-wide digital transformation initiatives, MHI member companies offer expertise across the entire project lifecycle.

More information about MHI Solutions Community and its member companies can be found here: www.mhi.org/solutionscommunity.



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