# Digital Twin-Enabled Facilities Management for Shopping Malls: Integration of BIM, IoT, and Real-Time Operational Data

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***Abstract- Shopping malls are complex commercial facilities in which building services, tenant operations, visitor experience, safety, energy consumption, and maintenance performance interact continuously. This review examines how digital twins can strengthen mall facilities management by integrating building information modelling, Internet of Things sensing, building management systems, computerized maintenance platforms, and real-time operational data. A structured synthesis of recent built-environment research was undertaken to identify enabling technologies, operational applications, expected benefits, implementation barriers, and governance requirements. The evidence shows that a useful digital twin is not merely a three-dimensional model. It is a connected decision environment that links verified asset information with live conditions, historical records, analytical models, and work-management processes. For shopping malls, the most valuable applications include plant monitoring, predictive maintenance, energy optimization, indoor-environment management, space and occupancy analysis, emergency coordination, tenant service management, and lifecycle planning. Benefits depend on data quality, semantic interoperability, clear asset ownership, cybersecurity, staff capability, and integration with existing facilities workflows. The paper proposes a phased framework that begins with high-value use cases and a reliable data foundation before expanding toward portfolio-wide simulation and automation. This approach enables mall owners and facilities teams to improve operational visibility, reduce avoidable disruption, and support evidence-based asset decisions.***

***Keywords: Digital Twin; Shopping Malls, Facilities Management, Building Information Modelling, Internet of Things, Real-Time Data, BIM-IoT Integration***

## I. INTRODUCTION

Shopping malls function as miniature urban systems. They combine retail units, food courts, cinemas, parking facilities, public circulation areas, vertical transportation, security systems, fire and life-safety equipment, high-capacity cooling plants, electrical distribution, water services, and extensive tenant interfaces. Demand varies by hour, season, promotional event, prayer time, and holiday period. A local fault can therefore create consequences beyond the failed component: thermal discomfort can reduce dwell time, an escalator outage can interrupt circulation, poor indoor air quality can affect visitors and staff, and an electrical or fire-system problem can threaten operational continuity. Traditional facilities management tools provide important control and recordkeeping, but data are commonly separated among building management systems, computerized maintenance management systems, energy meters, BIM files, contractor reports, tenant portals, and spreadsheets.

Digital twin technology has emerged as a means of connecting these fragmented information sources. Current research describes a digital twin as a dynamic digital representation that maintains a meaningful relationship with a physical asset through data exchange, analysis, and decision support, rather than as a static visual model (Shahzad et al., 2022; AlBalkhy et al., 2024). BIM can provide spatial and asset context, while IoT devices and building automation systems provide live operational signals. When these components are connected to analytics and facilities workflows, the twin can support monitoring, simulation, diagnosis, prediction, and coordinated intervention (Eneyew et al., 2022; Sun et al., 2022; Olimat et al., 2023).

The shopping-mall context deserves specific attention because most published building-twin studies concern campuses, offices, laboratories, or individual mechanical systems. Malls involve multiple stakeholders, mixed ownership of equipment, variable tenant fit-outs, public-facing service

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expectations, and requirements for safety and uninterrupted trading. This paper therefore reviews the integration of BIM, IoT, and real-time operational data for digital-twin-enabled mall facilities management. Its objectives are to clarify the technological architecture, classify high-value applications, evaluate operational and strategic benefits, identify implementation and governance barriers, and propose a phased framework suited to large retail facilities. The guiding question is: how can a digital twin be organized so that it improves practical facilities decisions rather than becoming an visualization platform disconnected from work? The review also considers how facilities leaders can sequence investment, protect operational control, and demonstrate value to owners, tenants, and service partners. This managerial emphasis is important because technically capable platforms often fail when users cannot connect information to authority, budgets, service levels, or measurable outcomes. It also identifies priorities for scalable portfolio implementation.

## II. FACILITIES MANAGEMENT CHALLENGES IN SHOPPING MALLS

Mall facilities teams manage assets under conditions of high utilization, limited shutdown windows, and customer visibility. Central chilled-water plants, air-handling units, ventilation fans, pumps, switchgear, generators, lifts, escalators, lighting, fire systems, water networks, and controls must operate across extended trading hours. Maintenance must be coordinated around tenant activities and public access, while emergency work can require rapid communication among security, engineering, cleaning, contractors, and mall management. These characteristics make asset criticality dynamic: the importance of equipment depends not only on technical function but also on time, location, occupancy, redundancy, and commercial impact.

Information fragmentation intensifies the challenge. Design BIM may be incomplete or outdated after fit-out changes. BMS point names may not match asset registers. CAFM records may contain duplicated or generic asset descriptions, while contractor data may remain in proprietary portals. Sensor histories often lack spatial and maintenance context, and technicians may spend more time locating equipment information than diagnosing the fault. Studies of BIM-IoT integration repeatedly identify inconsistent data structures and weak lifecycle information transfer as central constraints on smart facilities management (Altohami et al., 2021; Dahanayake and Sumanarathna, 2022).

Mall operations also require balancing competing outcomes. Aggressive energy reduction can undermine comfort; maintenance deferral can reduce short-term expenditure but increase failure risk; and extensive sensing can improve visibility while creating cybersecurity, calibration, and data-management burdens. Tenant equipment complicates accountability because ownership, access, and maintenance obligations can differ across leases. A digital twin must therefore represent technical relationships and organizational responsibilities. It should distinguish landlord and tenant assets, connect alarms to service-level priorities, preserve evidence of interventions, and provide role-specific information without overwhelming users. The central problem is not a lack of data. It is the inability to convert heterogeneous data into reliable, timely, and accountable decisions. Contractor governance adds another layer. Different service providers may use separate maintenance codes, inspection forms, and escalation rules, making portfolio comparison difficult. A twin can standardize evidence requirements, link attendance and closure records to specific assets, and show whether service-level compliance produced a satisfactory result. This supports fairer performance evaluation and prevents rapid closure from being mistaken for durable resolution.

## III. CONCEPTUAL FOUNDATIONS

A digital twin for mall facilities management is best understood as a layered socio-technical system. BIM supplies information about spaces, systems, components, relationships, and documents. It answers questions such as where an asset is located, what space it serves, how it connects to other equipment, and which specification or manual applies. BIM alone, however, usually describes intended or

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recorded conditions rather than performance. Data feeding is required to transform a model into an operational resource (Villavicencio Moreno et al., 2022).

IoT and building automation technologies provide that dynamic connection. Sensors can measure temperature, humidity, carbon dioxide, particulate matter, occupancy, vibration, current, power, flow, pressure, differential pressure, water leakage, and equipment status. Existing BMS and supervisory control systems already collect many of these signals, while wireless devices can fill gaps where wired points are unavailable. The value of sensing depends on calibration, time synchronization, sampling frequency, metadata, and maintenance. Fialho et al. (2022) show that the practical integration of BIM and IoT requires procedural decisions as well as technical development, including sensor identification, maintenance responsibilities, and information exchange.

A genuine twin also needs a data and integration layer. Gateways, message brokers, databases, application programming interfaces, and semantic mappings connect live telemetry with asset identifiers. The data layer should preserve raw observations, validated values, calculated indicators, events, work orders, and model versions. Semantic interoperability is important because different systems may describe the same asset differently. Open standards, consistent classification, and relationships help the twin recognize that a temperature sensor, an air-handling unit, a maintenance task, and a retail zone are related (Roxin et al., 2022; Eneyew et al., 2022; Dlesk et al., 2023).
The analytical layer converts connected data into information. It may contain rules, thresholds, fault-detection logic, energy baselines, physics-based simulations, statistical models, or machine-learning algorithms. Digital-twin capability therefore exists on a continuum. A descriptive twin displays current conditions; a diagnostic twin explains abnormal behaviour; a predictive twin estimates future states; and a prescriptive twin recommends or executes actions. Hosamo et al. (2022) demonstrate this progression through an air-handling-unit framework combining BIM, IoT, fault detection, condition prediction, and maintenance planning.

Finally, the user and workflow layer determines whether the twin produces operational value. Dashboards, mobile interfaces, three-dimensional views, alerts, and natural-language tools should connect directly to roles and decisions (Wang and Chen, 2024). Facilities managers need portfolio and risk views, technicians need precise asset context and procedures, energy teams need performance trends, and executives need verified outcome indicators. The twin should integrate with CAFM or CMMS so that an insight becomes a prioritized work order, an assigned responsibility, a recorded intervention, and a verified result. Without this closed loop, the system remains an informative display rather than an operational digital twin. The distinction between a dashboard and a twin is therefore functional, not cosmetic. A dashboard may aggregate current indicators, whereas a twin maintains relationships among physical objects, digital representations, observed states, expected behaviour, and actions. It should also preserve temporal continuity, allowing users to reconstruct what changed, which intervention followed, and whether performance recovered.

Table 1. Roles of Core Technologies in a Mall Facilities-Management Digital Twin

| Technology | Primary role | Typical mall data | Decision supported | Key control |
|---|---|---|---|---|
| BIM | Spatial and asset context | Spaces, systems, asset properties, documents | Locate assets, understand dependencies, support handover | Maintain model revisions and persistent IDs |
| IoT sensors | Live observation | IAQ, occupancy, | Detect abnormal | Calibration, battery, |

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| Technology | Primary role | Typical mall data | Decision supported | Key control |
|---|---|---|---|---|
| | | vibration, leakage, temperature | conditions and service demand | network and metadata plan |
| BMS/BAS | Operational monitoring and control | Equipment status, alarms, setpoints, trends | Operate plant and diagnose control problems | Network segmentation and verified point mapping |
| CAFM/CMMS | Work and lifecycle management | Work orders, PPM, labour, cost, spares, SLA | Assign, track and verify interventions | Consistent asset register and closure evidence |
| Analytics/models | Interpretation and prediction | Rules, baselines, simulations, learned patterns | Prioritize risk, forecast condition, test scenarios | Validation, uncertainty and approval thresholds |
| Integration layer | Data exchange and semantics | APIs, gateways, event streams, mappings | Create one governed decision context | Open interfaces, access control and audit logs |

## IV. REVIEW METHODOLOGY

This paper used a structured evidence-synthesis method guided by the transparency principles of PRISMA 2020, while recognizing that it is an applied review rather than a registered clinical-style systematic review (Page et al., 2021). Searches were designed around combinations of "digital twin," "facility management," "shopping mall," "commercial building," "building information modelling," "BIM," "Internet of Things," "IoT," "building operations," "real-time data," "smart building," and "predictive maintenance." Publisher databases and scholarly discovery services were examined for peer-reviewed journal articles, conference papers, and relevant standards published mainly from 2020 to 2025.

Sources were retained when they addressed at least one of five themes: definitions and architectures of building digital twins; BIM-IoT integration during operations; facilities-management applications; implementation evidence from occupied buildings; or organizational, information, and cybersecurity challenges. Studies focused exclusively on manufacturing, product design, construction progress, or city-scale modelling without transferable building-operations content were excluded. Because direct shopping-mall case studies remain limited, evidence from campuses, offices, public facilities, multipurpose buildings, and HVAC systems was included when the operating principle could reasonably transfer to malls. This approach avoids claiming that findings from one building type automatically generalize, while still using the strongest available operational evidence.

The final synthesis comprised twenty-three substantive academic sources, one information-management standard, and one review-method source. Evidence was coded under technology, data flow, application, benefit, challenge, and governance categories. Particular weight was given to studies demonstrating live-data integration, real-world prototyping, or user evaluation, including occupancy-oriented twins, dynamic BIM data feeds, predictive maintenance, and smart-campus platforms (Seghezzi et al., 2021; Asare et al., 2024; Manokeaw et al., 2025). Review and conceptual papers were used to identify common patterns and research gaps (Siccardi and Villa, 2023; Ghansah, 2024).

The synthesis is interpretive rather than statistical because methods, building types, system boundaries, and performance measures differ substantially. No pooled effect size was calculated. Instead, the review compares mechanisms: what information is connected, how it is contextualized, which decision it

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supports, and what organizational conditions are required. This mechanism-based perspective is appropriate for mall facilities management, where operational value depends on integration with people, contracts, workflows, and risk priorities as much as on algorithmic accuracy. Quality appraisal considered whether each source defined its twin boundary, explained data acquisition and integration, described the operational decision supported, and reported limitations. Conceptual claims without a workflow were treated cautiously. Greater confidence was assigned to studies that documented occupied-building deployment, calibrated models, user testing, or closed-loop maintenance processes.

## V. DIGITAL TWIN ARCHITECTURE AND SYSTEMS INTEGRATION

A mall digital twin can be organized into six connected layers. The first is the physical layer: buildings, spaces, MEP assets, meters, tenant interfaces, visitors, and environmental conditions. Asset selection should follow criticality and use-case value rather than attempting to connect every device immediately. High-priority assets may include chillers, cooling towers, primary pumps, main electrical boards, generators, lifts, escalators, fire pumps, smoke-control equipment, and high-risk water systems.

The second layer is sensing and control. BMS points should be inventoried before new devices are purchased. Data-quality testing should check naming, units, ranges, timestamp consistency, missing values, sensor drift, and communication reliability. Wireless sensing can extend coverage for vibration, leakage, indoor environmental quality, occupancy, and tenant areas, but devices require battery, network, calibration, and cybersecurity plans. Seghezzi et al. (2021) emphasize that occupancy-oriented twins depend on sensor assessment and validation, not merely installation.

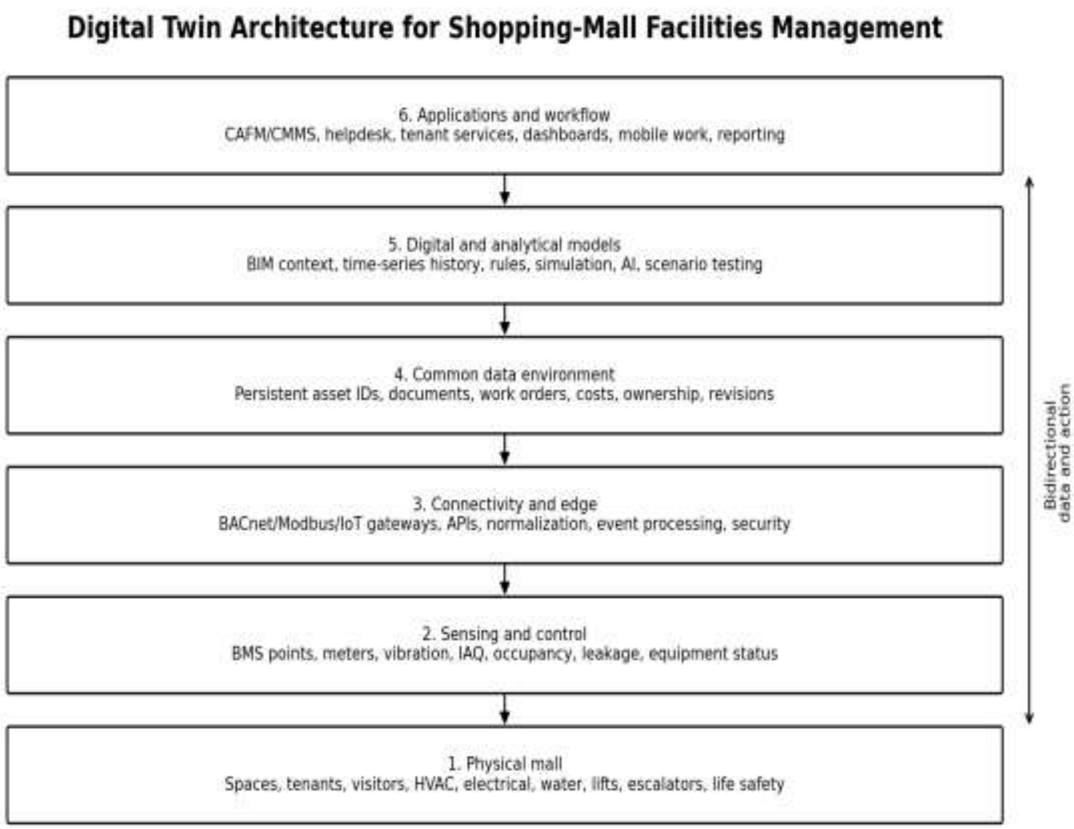
The third layer is connectivity and edge processing. Protocol gateways connect BACnet, Modbus, meters, elevators, lighting controls, access systems, and IoT networks. Edge devices can filter noise, normalize units, detect communication faults, and continue processing during cloud interruption. The architecture should separate operational-control networks from analytical access and apply secure interfaces rather than unrestricted direct connections. Data latency must match the use case: emergency alarms require seconds, plant optimization may require minutes, and lifecycle decisions may use daily or monthly aggregation.

The fourth layer is the common data environment. Asset identifiers link BIM objects, sensor points, alarms, documents, work orders, warranties, costs, and service histories. ISO 19650-3 (2020) provides principles for managing information during the operational phase, including defined information requirements, controlled exchanges, and maintained records. The mall twin should use a master asset hierarchy with persistent identifiers, ownership fields, system relationships, location codes, and revision control. Open data structures reduce dependence on one vendor and support future integration.

The fifth layer is the digital and analytical model. BIM provides geometry and system context, while time-series databases preserve operational behaviour. Rules and models compare actual performance with expected states. Energy models can test schedules and setpoints; fault logic can identify simultaneous heating and cooling, excessive pump operation, or abnormal temperature differences; occupancy models can connect visitor patterns with ventilation and cleaning demand. Yoon et al. (2024) show that operational virtual models can be calibrated and updated using real building data, improving fault detection and decision support. Three-dimensional visualization should be used where spatial context improves action, such as locating isolation valves, identifying affected zones, or guiding emergency teams.

The sixth layer is applications and workflow. The twin must exchange information with CAFM, CMMS, helpdesk, tenant-service, energy, and reporting systems. An anomaly should generate a traceable process: validation, risk scoring, work-order creation, assignment, access coordination, intervention, closure evidence, and post-repair verification. Bujari et al. (2021) demonstrate the role of twins as decision-support environments, while Yan et al. (2022) illustrate web-based integration for asset and facility management. Role-based dashboards should prevent information overload. Executives need outcomes and risk; engineers need system trends; technicians need actionable tasks; and tenants need service status relevant to their premises. The result is a federated architecture in which no single platform must perform every function, but all participating systems share reliable identifiers, governed interfaces, and decision logic. An event structure should distinguish alarms, anomalies, incidents, maintenance requests, and notifications. Correlation rules can group downstream alarms under one upstream cause, reducing alarm fatigue. A digital thread should preserve the sequence from design intent and commissioning through operation, modification, failure, repair, and renewal. This continuity helps teams understand whether a recurring problem arises from equipment condition, control logic, tenant change, or inadequate original information.

Figure 1. Layered Digital Twin Architecture for Shopping-Mall Facilities Management




## VI. DIGITAL TWIN APPLICATIONS IN SHOPPING-MALL FACILITIES MANAGEMENT

Predictive and condition-based maintenance is the most direct application. Live vibration, temperature, current, pressure, runtime, and alarm data can be compared with asset history to detect deteriorating fans, pumps, bearings, filters, belts, electrical connections, and control devices. The twin adds location, system dependency, warranty, redundancy, and trading impact, enabling risk-based prioritization instead of alarm counting. Real-world prototypes indicate that user-friendly visualization and

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integration with maintenance tasks are essential for acceptance (Asare et al., 2024).

Energy and utility management is another high-value use case. The twin can relate electricity, chilled water, domestic water, gas, and tenant submetering to weather, occupancy, schedules, and equipment states. Facilities teams can identify baseload waste, abnormal nighttime operation, poor chilled-water temperature difference, simultaneous heating and cooling, inefficient tenant schedules, and water leakage. Scenario testing can evaluate revised setpoints, equipment staging, operating hours, or retrofit options before implementation. Chen et al. (2023) link BIM-IoT integration with sustainable building decisions, while Manokeaw et al. (2025) demonstrate multiscale energy and environmental dashboards in an occupied facility.

Indoor environment and visitor experience can be managed through spatially contextualized temperature, humidity, carbon dioxide, air-quality, noise, lighting, and occupancy information. Hot or congested zones can be linked to air distribution, tenant heat loads, entrance conditions, or event patterns. Occupancy information can also guide cleaning, security deployment, ventilation, and restroom servicing. Privacy-preserving aggregation is necessary; visitor management should focus on operational patterns rather than unnecessary personal tracking.

Space, tenant, and lifecycle management benefit from a shared model of areas, leases, assets, and changes. Fit-out modifications can be recorded against the base building, reducing the gradual loss of as-built accuracy. The twin can support handover by verifying asset data, testing live point connections, and attaching commissioning evidence. During operations, tenant requests can be associated with zones, service responsibilities, and recurring technical causes. Cairoli and Tagliabue (2023) show how twins can support facilities with changing configurations, a characteristic relevant to event areas, cinemas, food courts, and seasonal mall installations.

Safety and emergency coordination require carefully governed integration. Fire alarms, smoke control, emergency power, lift status, access control, crowd conditions, and incident locations can be presented in a common spatial view. The twin can show affected systems, isolation points, evacuation routes, and dependencies, but it should support approved emergency procedures rather than replace certified life-safety controls. After an incident, synchronized records can improve investigation and corrective action.

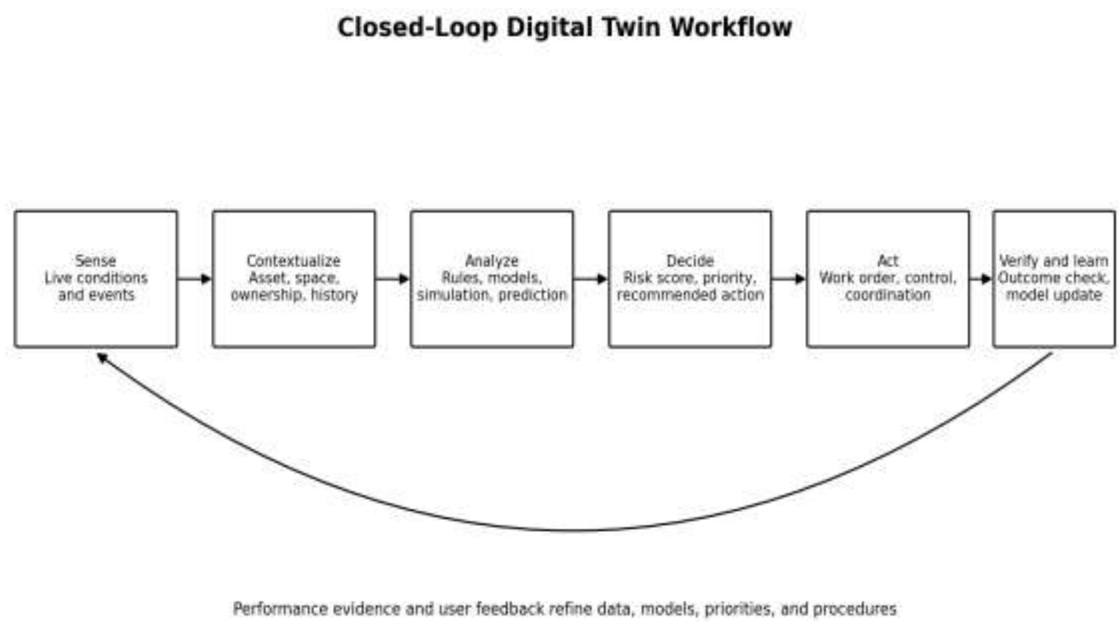
At portfolio level, owners can compare malls using normalized indicators for energy, downtime, comfort, work-order response, asset risk, contractor performance, and capital renewal. This shifts the twin from a single-building viewer to an evidence platform for investment planning, benchmarking, and standardized operating practices across regions. Cleaning and security operations can also benefit from real-time information. Occupancy and event data can guide restroom servicing, waste collection, patrol allocation, and queue management, while access and incident data can improve coordination with engineering teams. Contractor supervisors can receive location-specific tasks, safety requirements, permits, and asset history through mobile interfaces., because automated task generation without capacity planning can simply create a larger backlog.

Table 2. Priority Digital Twin Applications, Data Sources, and Performance Indicators

| Application | Connected data | Operational output | Example KPI | Mall-specific value |
| --- | --- | --- | --- | --- |
| Predictive maintenance | Condition signals, alarms, runtime, work history | Risk-ranked inspection or work order | Avoided downtime; repeat-failure rate | Protects trading continuity for critical MEP assets |
| Energy | Meters, weather, | Baselines, anomalies | kWh/m2; peak | Balances comfort with |

| Application | Connected data | Operational output | Example KPI | Mall-specific value |
|---|---|---|---|---|
| optimization | occupancy, schedules, plant states | and tested setpoint scenarios | demand; chiller efficiency | long operating hours and variable demand |
| Indoor environment | Temperature, humidity, CO2, PM, complaints, zones | Spatial comfort and air-quality diagnosis | Comfort compliance; complaint recurrence | Supports visitor experience and tenant service |
| Space and occupancy | Counts, zones, events, leases and layouts | Demand-informed ventilation, cleaning and security | Utilization; queue time; service response | Adapts services to changing footfall and events |
| Safety and emergency support | Fire, smoke, power, lifts, access, incident location | Common situation view and dependency map | Response time; corrective-action closure | Improves coordination without replacing certified controls |
| Lifecycle and portfolio planning | Asset age, condition, cost, risk, energy and work history | Renewal priorities and cross-mall benchmarking | Lifecycle cost; risk exposure; backlog criticality | Supports consistent capital allocation across regions |

Figure 2. Closed-Loop Digital Twin Decision and Work-Management Process




## VII. OPERATIONAL AND STRATEGIC BENEFITS

The principal operational benefit is situational awareness. Instead of consulting separate screens and files, users can view an asset's location, current state, history, dependencies, documents, and open work within one decision context. Dynamic data feeding into BIM has been shown to improve access to operational information and reduce the separation between models and real building conditions (Villavicencio Moreno et al., 2022). Faster diagnosis can shorten disruption and help technicians arrive with the correct tools, access requirements, and replacement parts.

A second benefit is improved maintenance quality. The twin supports earlier identification of abnormal behaviour, risk-based prioritization, and verification after repair. It can reveal recurring faults that are hidden when work orders are treated individually. Maintenance performance can be evaluated through reliability, repeat failure, response time, closure quality, energy impact, and user effect rather than through activity counts alone. Digital-twin predictive maintenance research shows that combining operating data with models and records can improve planning and reduce avoidable failures (Hosamo et al., 2022).

Third, integrated information strengthens energy and sustainability management. Operational changes can be tested, compared, and documented. Energy savings can be linked to actual interventions and comfort outcomes, supporting credible reporting. Better occupancy and condition information can also reduce unnecessary ventilation, lighting, cleaning, and equipment runtime.

Strategically, the twin creates a lifecycle evidence base. Owners can compare continued maintenance with replacement, prioritize capital expenditure, assess contractor performance, and preserve knowledge despite staff changes. The model also improves communication among engineering, IT, security, leasing, finance, sustainability, and senior management because each group works from a governed information source. Dahanayake and Sumanarathna (2022) identify multiple FM functions that benefit from BIM-IoT integration, including maintenance, energy, space, emergency, project, and quality management.

These benefits are not automatic. Value arises when the twin changes a decision or workflow and the outcome is measured. A business case should therefore connect each use case to baselines such as downtime, utility consumption, comfort complaints, repeat failures, contractor response, or capital risk. Decision speed is a measurable benefit: time spent collecting information, confirming asset identity, locating documents, and coordinating access can be compared before and after implementation.

## VIII. IMPLEMENTATION CHALLENGES AND GOVERNANCE

Interoperability is the most persistent technical challenge. Legacy BMS, proprietary equipment platforms, BIM authoring tools, CAFM systems, and tenant technologies use different identifiers and data models. Semantic mapping is labour intensive, and a visually impressive model can still contain unreliable relationships. Eneyew et al. (2022) and Roxin et al. (2022) therefore emphasize structured integration and machine-readable semantics.

Data quality presents an equally serious risk. Missing points, incorrect units, sensor drift, duplicated assets, outdated BIM geometry, and unclosed work orders can produce misleading conclusions. Governance should assign owners for asset data, telemetry, models, documents, and business rules. Changes to tenant layouts or equipment must trigger controlled updates, and automated recommendations should display confidence and evidence.

Cybersecurity and privacy require joint ownership by facilities and information-technology teams. The architecture should apply network segmentation, least-privilege access, secure APIs, device inventories, patching, logging, backup, and incident response. Occupancy analytics should minimize personal data and comply with applicable requirements. Safety-critical control must remain within certified systems unless rigorous assurance supports additional automation.

Economic and organizational barriers include uncertain return on investment, vendor lock-in, skills gaps, resistance to new workflows, and unclear responsibility across capital projects and operations. Reviews consistently report that digital-twin adoption is constrained by organizational and governance issues as well as technology (Shahzad et al., 2022; Ghansah, 2024). A mall owner should therefore establish a cross-functional steering group, define use-case owners, maintain open export rights, train users, and measure benefits. Procurement should specify data access, interface documentation, cybersecurity obligations, model-update responsibilities, and exit arrangements before platform selection. Governance should define approval thresholds for automated actions. Low-risk recommendations may be converted directly into inspections, while changes to plant sequencing, life-safety interfaces, or tenant services should require authorized review. A model-validation schedule is needed because building behaviour changes with ageing, retrofits, occupancy, and operating policy.

## IX. RESEARCH GAPS AND PROPOSED MALL DIGITAL-TWIN FRAMEWORK

Research remains dominated by prototypes, individual systems, and non-retail buildings. More evidence is needed on multi-tenant governance, commercial outcomes, visitor experience, portfolio scalability, long-term model maintenance, and cybersecurity in operating malls. Future studies should compare digital-twin interventions with baseline performance and report implementation cost, data preparation effort, user adoption, and sustained benefits.

A phased mall framework is proposed. Phase one defines business outcomes and selects two or three critical use cases. Phase two establishes the asset hierarchy, data ownership, interfaces, and quality rules. Phase three connects priority BMS, meter, IoT, BIM, and CAFM data. Phase four develops descriptive and diagnostic dashboards with work-order integration. Phase five adds calibrated simulation, prediction, and scenario testing. Phase six scales proven functions across tenants, systems, and portfolios. Each phase ends with verification against operational indicators and user feedback. This incremental method reflects evidence that practical twins succeed through focused integration and real-world evaluation rather than through immediate creation of a complete virtual building (Asare et al., 2024; Yoon et al., 2024). The framework treats three-dimensional visualization as one interface, while governed data relationships and closed-loop action remain the core. Research should examine twins that deliver value without geometric detail for malls with BIM records.

## X. CONCLUSION

Digital twins can provide a powerful operating environment for shopping malls when BIM, IoT, building automation, real-time data, analytics, and facilities workflows are integrated around clear decisions. The review shows that the technology is most valuable when it connects physical conditions with verified asset context, historical performance, organizational responsibility, and measurable action. High-priority applications include predictive maintenance, energy and utility optimization, indoor-environment management, occupancy-informed services, tenant coordination, emergency support, and lifecycle investment planning.

The main implementation lesson is that a mall does not need a perfect, all-encompassing twin at the beginning. It needs reliable identifiers, governed data, secure interfaces, and a small number of use cases that solve important operational problems. BIM provides spatial and asset meaning; IoT and BMS provide live conditions; analytical models provide interpretation; and CAFM integration closes the loop through accountable work. Benefits should be demonstrated through reduced downtime, lower consumption, improved comfort, stronger compliance, better maintenance quality, and more informed capital decisions.

Future progress depends on open interoperability, long-term model maintenance, cases, cybersecurity, and collaboration between facilities, IT, contractors, tenants, and management. Under these conditions, the digital twin becomes not a promotional visualization, but a practical management system for resilient, efficient, and customer-focused commercial facilities.

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