# Digital Twins for Healthcare Facilities

## A tool for smarter, more connected buildings

Healthcare facilities are complex environments in which clinical care, technology, operations, energy use, and the patient experience intersect every hour of every day. The volume and variety of data within such settings is driving the emergence of a powerful tool for owners and operators: the digital twin.

More than just a model, a digital twin offers a way to see a building more clearly, understand its operations and systems more completely, and manage it more intelligently and holistically. This living, data-rich representation of a real facility often evolves from design through construction and into long-term operations. For owners and operators, it offers a better way to connect building systems, physical assets, performance information, and operational insight into a single digital environment that enables informed decision-making.

The opportunities and benefits provided by a digital twin are significant for healthcare facilities, which are among the most complex and resource-intensive building types. They depend on reliable MEP systems, precise space planning, resilient infrastructure, and constant operational coordination. They also must support critical patient care while accommodating complex clinical workflows, advanced technology, and highly regulated systems. A digital twin brings these moving parts together and creates a bridge between the physical facility and the data that describes how the facility was designed to work, is working, and could work. It is often the difference between reacting to problems versus planning for them before they affect patients, staff, or building performance.



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# COMPONENTS AND TYPES

A digital twin may include data from building information models (BIM), design documents, asset records, reality capture (site data gathered by drone, 3-D laser scanner, GIS, etc.), sensor inputs, energy usage, maintenance history, and real-time performance metrics. It also can come in the form of visual tools that help users navigate spaces, understand system relationships, and inspect infrastructure that is difficult to physically access.

As powerful and all-encompassing as a digital twin can be, not every project needs a fully integrated, enterprise-scale solution. In such instances, a focused digital model may be all that is needed for a specific use case. For example, if the goal is to help caregivers test the functionality of a proposed new clinical space, an accurate 3D representation or immersive virtual reality experience may be the right tool. If the goal is to analyze a central utility plant, a system-level model may deliver the insight needed. If the goal is to support controls design or equipment configuration, a targeted digital environment may be most effective.

For those who do seek a robust, building-wide digital twin, such a platform will evolve over time. It begins with design intent, gains accuracy through building commissioning and reality capture, and matures as more operational data is added over the years. This evolution is especially important in healthcare, where buildings must remain adaptable, dependable, and ready to support future change.

While digital twins are never identical from institution to institution, their levels of development fall into four main categories.

**Level 1: Descriptive Twin**

High-quality BIM models (delivered as part of new project handover) aggregate site geometry, specifications, digital operations and maintenance manuals (O&M), and asset data and serve as the foundation for a Level 1 digital twin. Commissioning and reality capture ensure these models reflect actual site conditions and are ready for use on Day 1.

## DAY 1 MODEL



Descriptive Twin

Upon completion of the new Emerson world headquarters fit out in St. Louis, IMEG provided the owner with highly detailed building Revit models, equipment specification data, O&M manuals, additional building and infrastructure metrics, and mechanical and electrical commissioning data. This information was crucial to the operation and automation of building infrastructure and technologies, including $CO_2$ demand control ventilation, lighting occupancy sensors integrated into HVAC controls, motorized shades on time-of-day sequence, and advanced submetering.

**Level 2: Informative Twin**

"Internet-of-things" (IoT) integration of sensors and building systems (e.g., HVAC, clinical operations, supply chain, lighting, security, elevators) advances a descriptive twin into an informative twin. These models reflect real-time conditions and are used by owners and building operators to monitor performance, optimize energy use, and react quickly to emergent issues.

## REAL-TIME DATA



Informative Twin

For Denver Water's Operations Complex Redevelopment, IMEG implemented several intelligent building strategies that provide operators with crucial real-time data. Lighting, mechanical, and data loads are metered independently in all campus buildings; sub-meters in the administration building also track solar power production and consumption, kitchen loads, lighting loads, mechanical loads, data loads, and general power. Additionally, the central utility plant calibrates water of different temperatures so it can be sent through a vast array of tubing within concrete slabs to keep the campus buildings comfortable year-round. Plug load control and occupancy sensors also were provided.



**Level 3: Predictive Twin**

Analytics platforms, calibrated simulations, monitoring-based commissioning, and predictive maintenance strategies enable clients to shift from reactive to proactive facility management. Industry-wide tools such as **SkySpark** and **IMEG's EcoMeter** identify inefficiencies before they escalate.

## STRATEGIC MANAGEMENT



Predictive Twin

Since 2019, a strategic energy and water management plan for several of Parkview Health's campuses in Indiana has resulted in utility incentives of $145,000, annual energy savings of nearly $1.2M, and projected annual greenhouse gas emission reductions of 42.4M pounds of $CO_2$. IMEG developed and implemented the plan and provided the owner with energy and decarbonization planning, utility and energy management, BAS advisement, as well as proactive data from commissioning, retro-commissioning, and monitoring-based commissioning.

**Level 4: Comprehensive Twin**

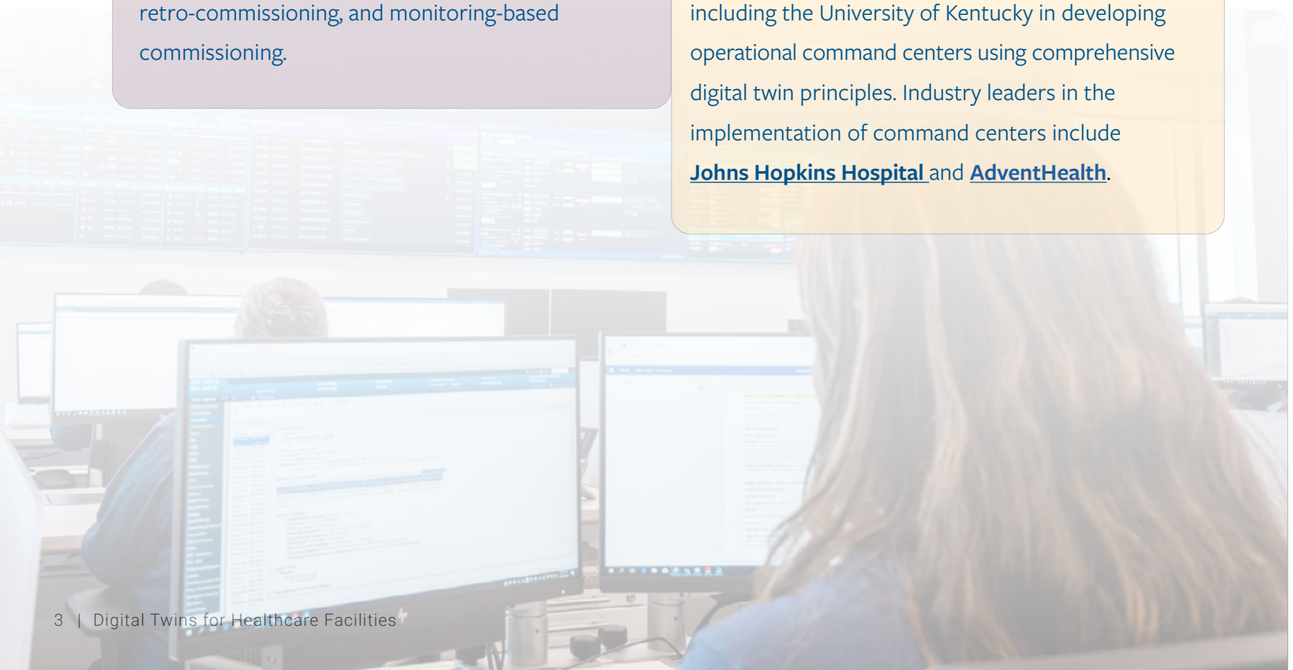
The highest level of a digital twin simulates "what-if" scenarios and integrates enterprise-level systems, GIS, controls programming, and scenario modeling. This comprehensive twin supports large campuses and mission-critical facilities and includes the development of an operational command center—linking site conditions, building systems, operational data, and user experience into one navigable environment.

## COMMAND CENTERS



Comprehensive Twin

Much like air traffic control, digital twin-driven "healthcare coordination command centers" employ a team of experts who manage a holistic patient experience of care, ensuring the best outcome for each individual and the most efficient use of resources for the healthcare system. Though still an emerging strategy, IMEG has supported clients including the University of Kentucky in developing operational command centers using comprehensive digital twin principles. Industry leaders in the implementation of command centers include **Johns Hopkins Hospital** and **AdventHealth**.



# HEALTHCARE USE CASES

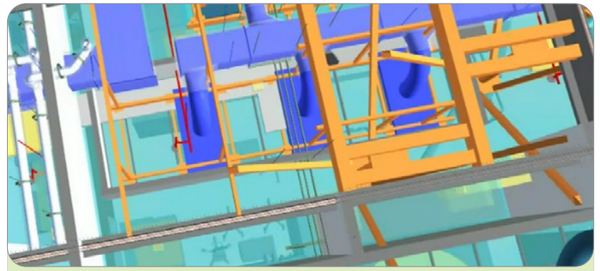
Healthcare applications of digital twin technology range from focused models to solve a specific problem to enterprise-wide twins that show how spaces, systems, and users interact. A comprehensive twin also supports short- and long-term strategic planning and can serve as a foundation for future technologies, including ever-evolving AI-driven analysis and more advanced operational intelligence.

The following healthcare applications include brief examples illustrating digital twin use cases. Taken together they show how a digital twin can evolve over time from a descriptive model to full level 4 maturity.

## Organizational support

A digital twin gives healthcare leaders a way to align facilities with operational goals and to make more informed decisions about maintenance, capital planning, and system performance. It also supports planning as facilities adapt to changing business and care delivery models.

During design and construction of a new project, for example, a digital twin improves coordination across disciplines and enables early clash detection, reducing rework that can represent from 5 percent up to 12 percent of project costs. Projects using digital twin workflows also have resulted in up to 15 percent shorter construction schedules, allowing earlier occupancy and reduced financing costs.  Digital twin technology also can provide immersive milestones such as a virtual ribbon cutting, allowing stakeholders to experience a space or site before construction.



## ONE MODEL FOR THE TEAM

For the new **UW Health Eastpark Medical Center** in Madison, WI, the project team (including IMEG) utilized a "One Model" approach, allowing the engineers, architect, and contractor to work in the same 3D model versus each team using its own model and not seeing the exact same information. The model was updated throughout construction, with the contractor ultimately populating it with fabrication parts. This reflected in real time for all parties any alterations, such as routing or fabrication changes; allowed for quick understanding and resolution among the team; ensured material quantities were correct; and helped avoid extra costs and delays. At the end of construction, the team reviewed the model to ensure all data matched the final physical building and infrastructure and added tags, annotations, and O&M manuals. The final model was turned over to the owner, providing a tier 1 digital twin of the building on day 1. This is of great benefit to the facilities staff for operations and maintenance; provides "as-built" data for updates or expansions; and can serve as the basis of a tier 2 digital twin in the future should the owner eventually desire.



## REALITY CAPTURE

State-of-the-art drone and 3D laser scanning technology can capture an immense amount of data and current views of sites, buildings, and infrastructure to create high-accuracy 3D point cloud models and 360-degree imagery. This provides millimeter-level accuracy for mapping interior spaces, underground systems, and external areas to aid in project planning and design. IMEG has provided reality capture services for several healthcare projects, including **flying our drones and conducting 3D scanning** to aid in a master plan development for a Veterans Administration medical center (pictured at right).



## Building operations and systems

AI-enabled digital twins combine a dynamic virtual representation of a physical facility with artificial intelligence and machine learning. Benefits include helping facilities staff optimize energy use, improve predictive maintenance and maintenance tracking, and monitor critical systems such as HVAC, medical gas, and emergency power.

By analyzing real-time and historical data, the twin can:

- Simulate operations, predict performance, detect anomalies, forecast equipment life, and recommend or automate operational improvements
- Locate equipment and troubleshoot issues, flag danger areas, access work orders and equipment information, display drawings of interior and site infrastructure routing, and facilitate remote support
- Strengthen resilience and emergency planning by giving operators clearer knowledge of how systems and spaces work together and respond under various scenarios

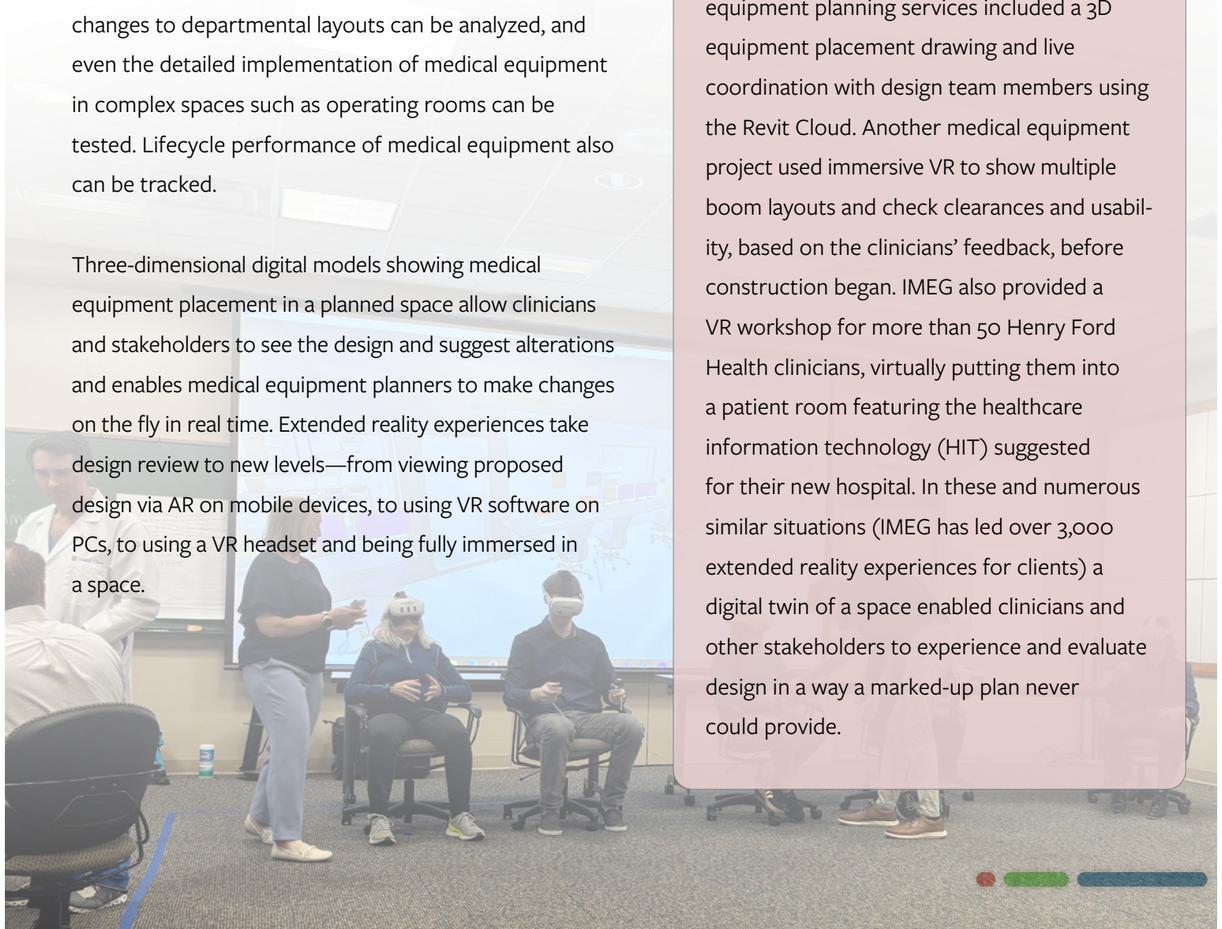
Digital twins also support Immersive Asset Visualization (IAV), the use of interactive 3D "extended reality" (virtual, augmented, or mixed) environments to explore and interact with the physical assets and systems represented within a digital twin. IAV allows facility owners, operators, designers, and maintenance teams to virtually navigate a facility to identify issues and better understand building-system performance without being physically present in the real space.

The use of augmented reality (AR) also allows operators to see how planned new equipment such as boilers or chillers will fit into existing mechanical spaces, providing advance confirmation of design or the opportunity to make necessary changes before construction begins.

## Clinical operations and technology

Digital twin technologies can support analysis of patient movement, departmental adjacency, equipment placement, and space functionality. Patient flow and changes to departmental layouts can be analyzed, and even the detailed implementation of medical equipment in complex spaces such as operating rooms can be tested. Lifecycle performance of medical equipment also can be tracked.

Three-dimensional digital models showing medical equipment placement in a planned space allow clinicians and stakeholders to see the design and suggest alterations and enables medical equipment planners to make changes on the fly in real time. Extended reality experiences take design review to new levels—from viewing proposed design via AR on mobile devices, to using VR software on PCs, to using a VR headset and being fully immersed in a space.



## 3D DRAWINGS AND EXTENDED REALITY EXPERIENCES

For Piedmont Atlanta's 2023 ASHE Vista Award-winning Marcus Tower, IMEG's medical equipment planning services included a 3D equipment placement drawing and live coordination with design team members using the Revit Cloud. Another medical equipment project used immersive VR to show multiple boom layouts and check clearances and usability, based on the clinicians' feedback, before construction began. IMEG also provided a VR workshop for more than 50 Henry Ford Health clinicians, virtually putting them into a patient room featuring the healthcare information technology (HIT) suggested for their new hospital. In these and numerous similar situations (IMEG has led over 3,000 extended reality experiences for clients) a digital twin of a space enabled clinicians and other stakeholders to experience and evaluate design in a way a marked-up plan never could provide.



## Patient experience

A healthcare facility, particularly a hospital, is never just a building. It is an environment that shapes patient comfort, provides wayfinding, delivers care, and augments healing. A digital twin can help owners and clinicians visualize, monitor, and optimize the systems and technologies that support and enhance this patient, family, and staff experience.

The complete patient experience encompasses the journey to the hospital, the care experience, and the trip back home. All these touchpoints come with an expectation and must be considered during design. In addition to enabling patients to control their environment via mobile app or voice command (to adjust lights, shades, and temperature), digital twin technologies include artificial intelligence for proactive patient monitoring and alerting; virtual, augmented, or mixed reality devices for education or therapy; RTLS for situations such as caregiver presence and hand hygiene compliance; and sensors for air quality monitoring. Smart patient beds can provide continuous heart rate and respiratory monitoring, and robots can deliver food and medications.

Caregivers and staff, the building and its systems, the floors/units/departments, and more are all also part of the patient experience—and a digital twin can greatly support providing the best experience possible.

### BUILDING INTELLIGENCE

Mayo Clinic is in the planning stages of a $5B, 2.4 million square foot expansion of its flagship location in Rochester, MN. The five-building project—part of the organization's system-wide **"Bold. Forward. Unbound."** initiative—will create an integrated "neighborhood" offering continuous care for patients, many of whom come for extended periods to receive treatment for complicated issues. Patients will have access to labs, imaging, consultations and clinics, all designed to be flexible. The neighborhood will integrate intelligent building/digital twin technologies, including artificial intelligence, predictive analytics, and robotics, to streamline and enhance the patient experience and deliver care quickly and efficiently. Plans also call for a new logistics center. IMEG is providing Building Intelligence/Integration and HIT services for the project and is working with the systems integrator on master systems integration.

## A MORE CONNECTED FUTURE

Healthcare owners face daunting challenges: complex systems, high expectations, mounting data, and constant pressure to do more with less. In this environment, a digital twin can be a tremendous asset.

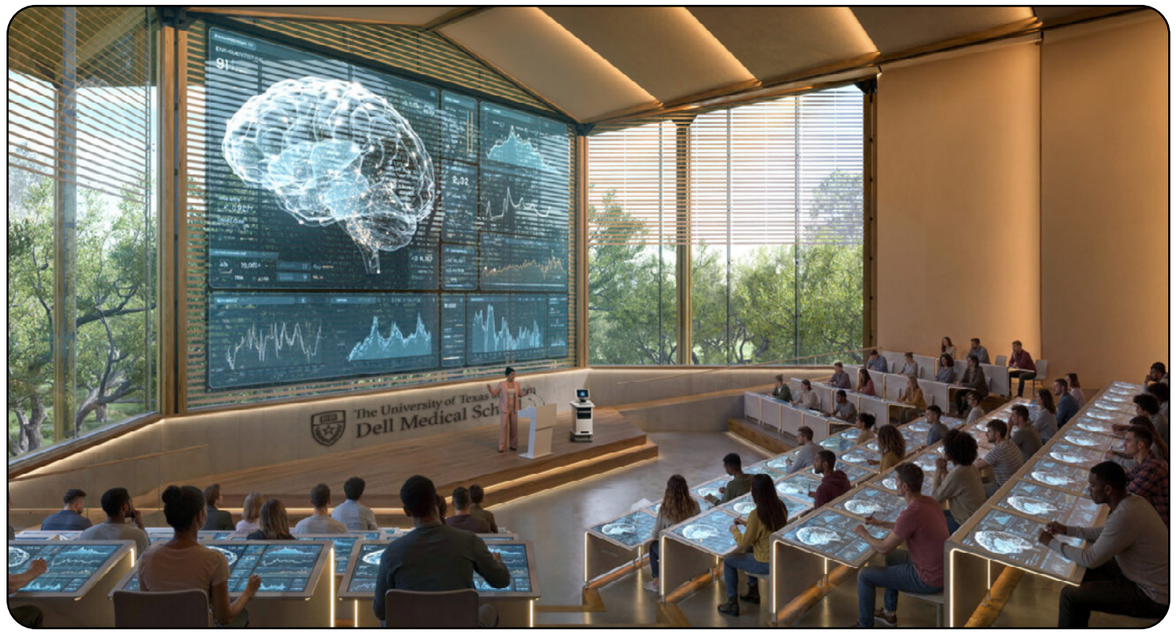
What the scope of this asset could look like at its fullest potential can be gleaned from the University of Texas/Dell Medical Center's planned $750M "AI-native" hospital in Austin. According to Health Tech HotSpot, the design of the UT/DMC facility will be based on an Intelligence Performance Center (IPC), essentially the hospital's brain and nervous system. "The IPC merges raw sensor data with EHR and supply chain platforms to enable real-time monitoring of hospital operations, deliver just-in-time intelligence, and support continuous operational improvement including real-time review of surgical video and clinical workflows."

HotSpot added that every patient also will have a living digital twin—a model built from genomic, imaging, and wearable device data—to flag clinical deterioration 24 to 72 hours before it happens.

IMEG is providing Building Intelligence/Integration, HIT, Medical Equipment Planning, and Security Advisory services for the UT/DMC project. When complete, the hospital's IPC will monitor, analyze, and act on data from tens of thousands of information feeds from five key areas:

**Patient & Clinical:** EHR, vitals & monitoring, medical devices, labs & imaging, genomics, patient reported

**Operations**: Bed management, OR & procedure, scheduling, staffing & timekeeping, supply chain, transport & logistics



**Building & IoT**: Environmental sensors, HVAC & energy, security & access, elevators & equipment, location services, asset tracking

**People & Behavior**: Staff interactions, patient flow, experience feedback, wearables, voice & chat, observations

**External & Context**: Weather, traffic & transit, public health, news & social, payer & policy, market data

"UT/DMC is treating this truly as a really a living, breathing entity," says Corey Gaarde, IMEG's HIT Advisory Services Leader. "This is the first project that I've ever been involved in where the entire organization has embraced that. They are creating a digital twin that will be as critical to the operations of the building as it will be to clinical operations, the patient experience, and outcomes."

The UT/DMC project is the ultimate example of what should drive the creation of any digital twin of any level: a strategy. It is critical to remember, however, that the majority of digital twins begin with a partial model of a critical space. Sometimes it focuses on operations, energy, controls, or patient flow. Sometimes it expands into a full-facility digital twin. The right approach depends on the problem being solved or the need at hand. In all cases, it should start with a clear strategy.

In addition to having a strategy, all organizations seeking a digital twin of any level need to have good data and an understanding of the expansive value of connection. When data, design, systems, and operations come together, healthcare owners gain something far more useful than just a model. They gain a clearer view of their facility, a smarter way to manage it, and a stronger foundation for the future.




# MORE INFORMATION

IMEG's comprehensive engineering and consulting services include MEP, structural, civil, medical equipment planning, HIT, security advisory services, building intelligence, and sustainability and energy services, all directly supporting the development of healthcare digital twins. Whether for new construction or existing buildings, the nationwide firm creates the engineering foundation, connects building systems and data sources, and develops meaningful workflows that turn building data into actionable insights throughout the facility lifecycle.

IMEG also creates visual digital twins of critical spaces that allow owners and clinicians to be immersed in an extended reality experience of the proposed design well before construction begins. (See the following page for a list of the tools we use to create digital doppelgangers.) In addition, IMEG Labs, an in-house testing site available to clients, provides owners with early validation of the technologies and integrations that have been specified for new or renovation projects.

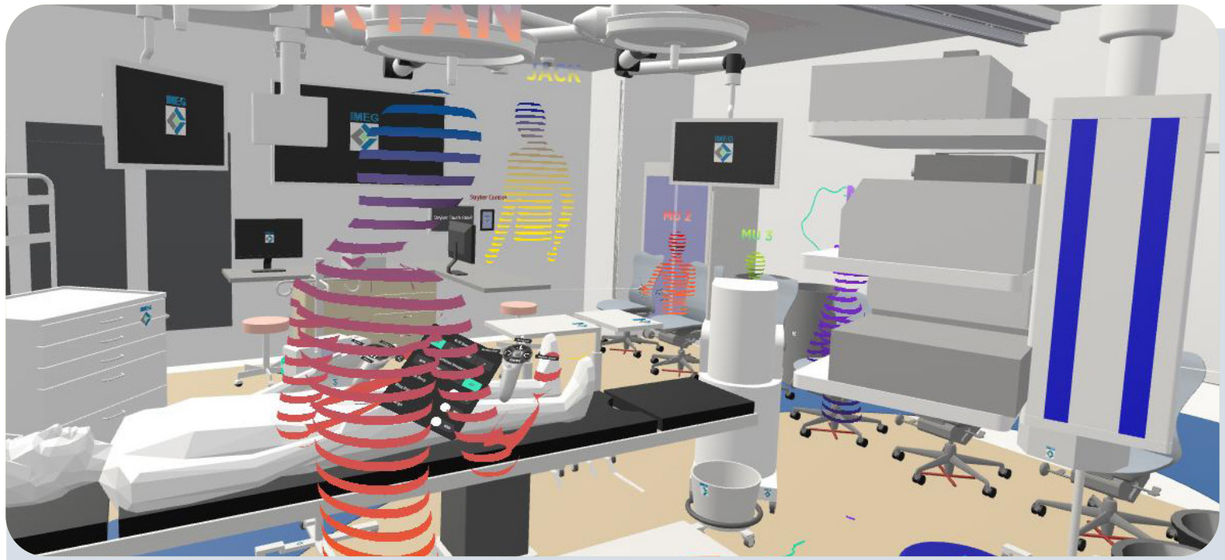
To learn more, visit us **online** or contact Vice President of Healthcare Eric Vandenbroucke at **Eric.J.Vandenbroucke@imegcorp.com.**

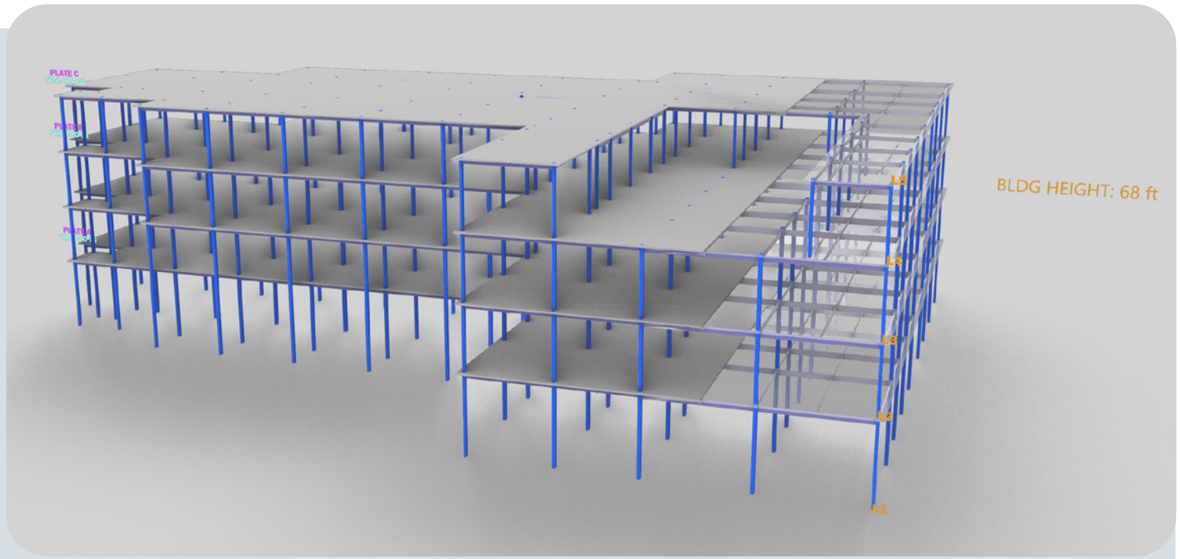
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- Building Intelligence: **Brendon Buckley**
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# THE TOOLS THAT HELP IMEG BRING DIGITAL TWINS TO LIFE

IMEG employs multiple tools that can be utilized, solely or in combination, to assist in creating the data-driven digital representations required for any level of a digital twin. Web-based viewers and spatial platforms make the data accessible and navigable.

Some tools establish the foundation, including:

- Energy modeling platforms such as Design Builder/EnergyPlus, IES Virtual Environment, eQuest, and Trace 3D. Simulation of a building's energy use is a critical step in making information-based design decisions and one of the first steps in creating a digital twin.
- Reality capture tools such as drones, laser scanning, lidar, photogrammetry, and 360-degree imagery. These are used to generate 3D models and point clouds to document accurate existing special data and serve as the basis of design or as a reference for future projects at the same site or in the same space.
- Extended reality experiences (above left) of a proposed design puts end-users into a virtual representation of a new space, allowing them to provide feedback and suggest changes early in a project.
- Parametric modeling (above right) enables fast iterations of structural models to show how various changes in design affect project characteristics such as materials, cost, and embodied carbon.
- IMEG Labs provides early validation of the technologies and integrations that have been specified for new or renovation projects. The third party, vendor-neutral team includes experts in IT, clinical, and facility systems integration, application development, and testing, as well as building intelligence.
- ArcGIS Indoors creates a realistic 3D model from BIM or CAD, is floor aware, and can be used as a wayfinding or asset management tool. It provides space planning and occupant information and goes beyond visualization to make the data actionable.
- ArcGIS Urban uses 3D building data for site planning, shadow simulation, and viewshed analysis.
- ArcGIS Velocity integrates IoT sensors into the 3D space in GIS.
- ArcGIS Dashboards utilizes 3D data to monitor activities or planned projects.
- 3D GIS datasets can be derived from existing data or developed from scratch. It may be used for asset tagging in a 3D space, assigning work orders, or tracking maintenance.
- Oriented imagery provides a view corridor in GIS that shows the extent of the images and allows the user to pan through a 360-degree view.

Other tools bring a digital twin to life during operations. These include:

- Monitoring-based commissioning, utility submetering, performance dashboards, analytics platforms, and energy benchmarking tools provide a feedback loop that transforms a static model into a living operational resource.
- Augmented reality (below) can enable project teams, end users, and others to view proposed placement of new buildings, infrastructure, and new equipment within a mechanical space. AR remote collaboration tools help operational staff identify and diagnose problems in areas that are hard to access such as above ceilings, in shafts, and below the slab.




Viewing the architectural model on a job site