

# USING **BIM AND IPD** TO DESIGN & BUILD THE HOSPITAL OF THE FUTURE





## PALOMAR MEDICAL CENTER WEST

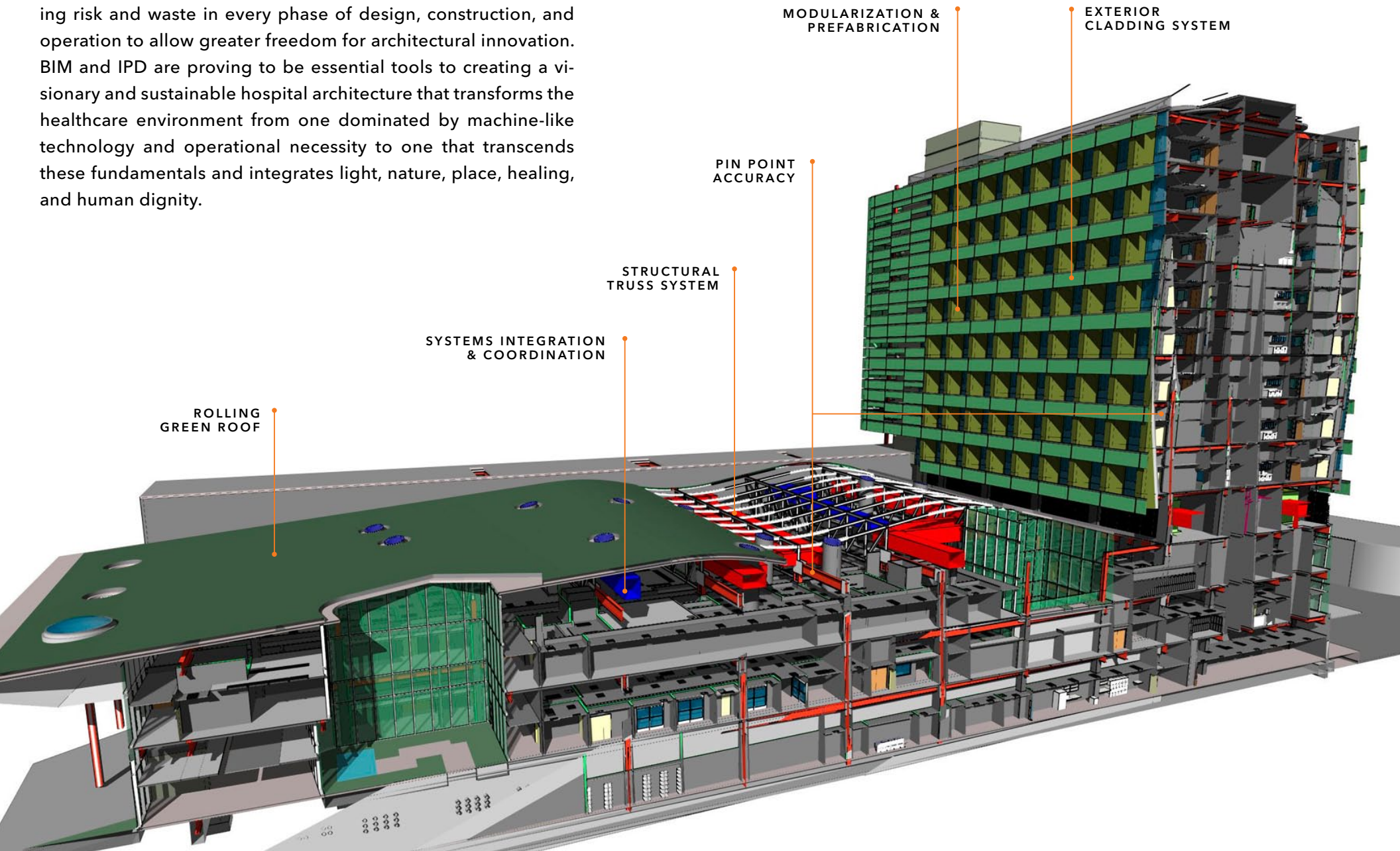
The **Palomar Medical Center West** design and construction process is transforming healthcare architecture and is establishing a new vision and expectation for the industry. Working from the premise that existing conditions of design, technology and project delivery must change in order to advance the building type, PMCW used a BIM-enabled, Integrated Project Delivery (IPD) design and construction process. This process has instigated a game-changing development in the national dialogue on the future of healthcare architecture.





A significant component of national healthcare reform lies in the design and construction of hospitals. Truly sustainable and healing environments, in which the building supports healthcare providers in their work and improves medical outcomes in patients, will be infused with nature, planned for operational efficiencies, and readily accommodate changes in clinical technology and procedures. PMCW achieves a sustainable model by eliminating risk and waste in every phase of design, construction, and operation to allow greater freedom for architectural innovation. BIM and IPD are proving to be essential tools to creating a visionary and sustainable hospital architecture that transforms the healthcare environment from one dominated by machine-like technology and operational necessity to one that transcends these fundamentals and integrates light, nature, place, healing, and human dignity.

*Within this context, the use of Building Information Modeling (BIM) and Integrated Project Delivery (IPD) is imperative to a visionary and sustainable hospital architecture.*



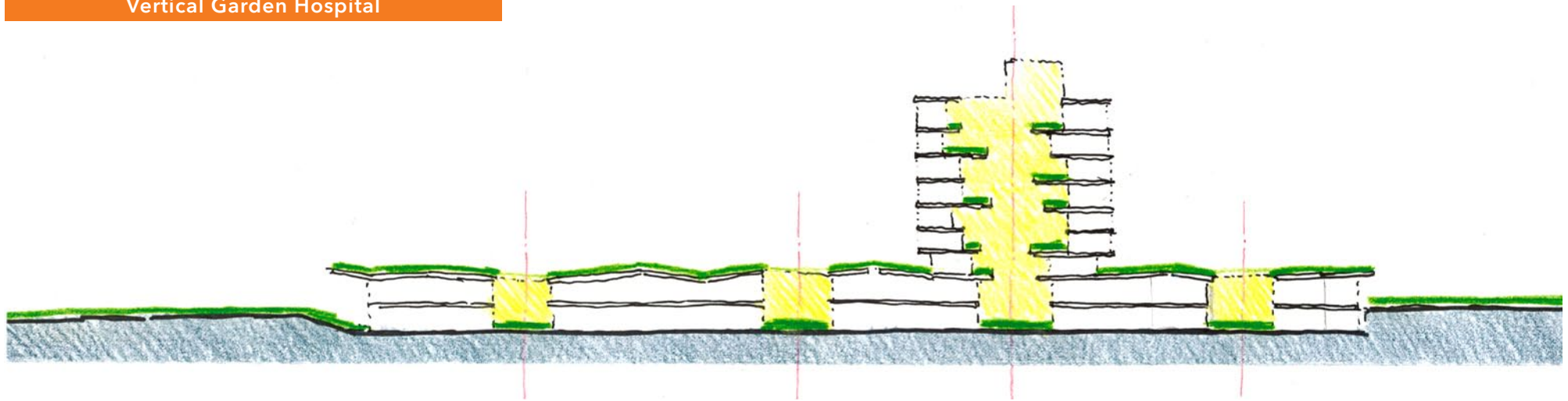


*This nationally recognized, award winning project which employs innovative healthcare planning and design concepts uses components of the natural world - gardens and landscape - as counterpoints to the technological world of medical science.*



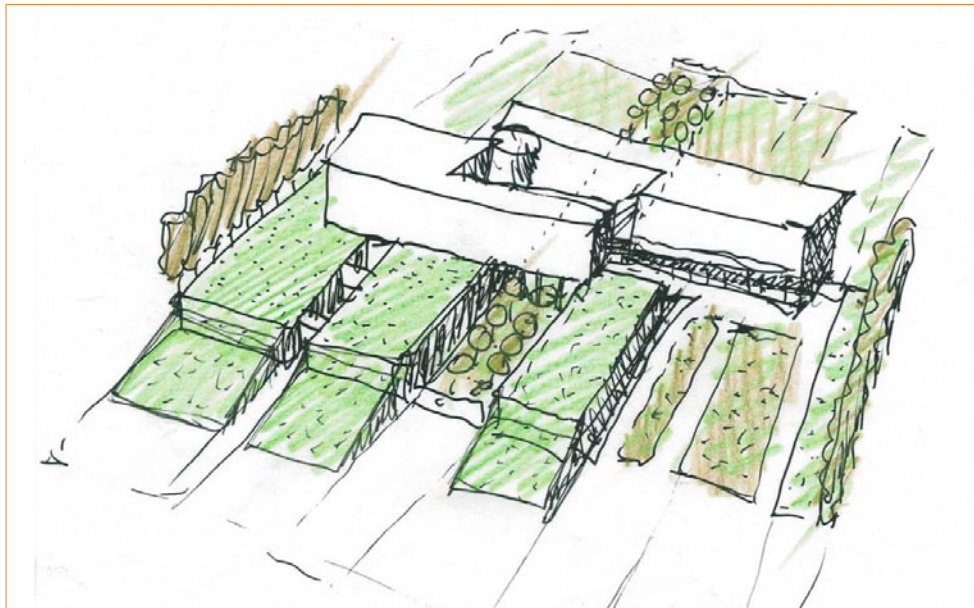
View of Vertical Garden from Third Level Terrace





Palomar Medical Center West is a new 11-story, 360-bed, 740,000 GSF tertiary care medical center in southern California. This nationally-recognized, award-winning project, which employs innovative healthcare planning and design concepts, also uses components of the natural world - gardens and landscape - as counterpoints to the technological world of medical science. Located on a bluff overlooking the city of Escondido, the project is master planned as a 35-acre landscaped campus. The site is anchored by an extensive central garden that surrounds the north and east sides of the hospital and provides a welcome

respite for patients, visitors and staff. A pedestrian spine, terminating in this garden, connects through the hospital to the southern extent of the site, linking the phased components of the medical center. A 1.5 acre green roof and public terrace above the surgery floor in the diagnostic and treatment (D&T) wing brings the landscape onto the building and engages the patients in the tower above. Double height garden terraces on each floor of the patient tower overlook the green roof and extend the gardens the full height of the building, creating a vertical garden hospital.



Landscaped Campus



Patient Tower Garden Terrace



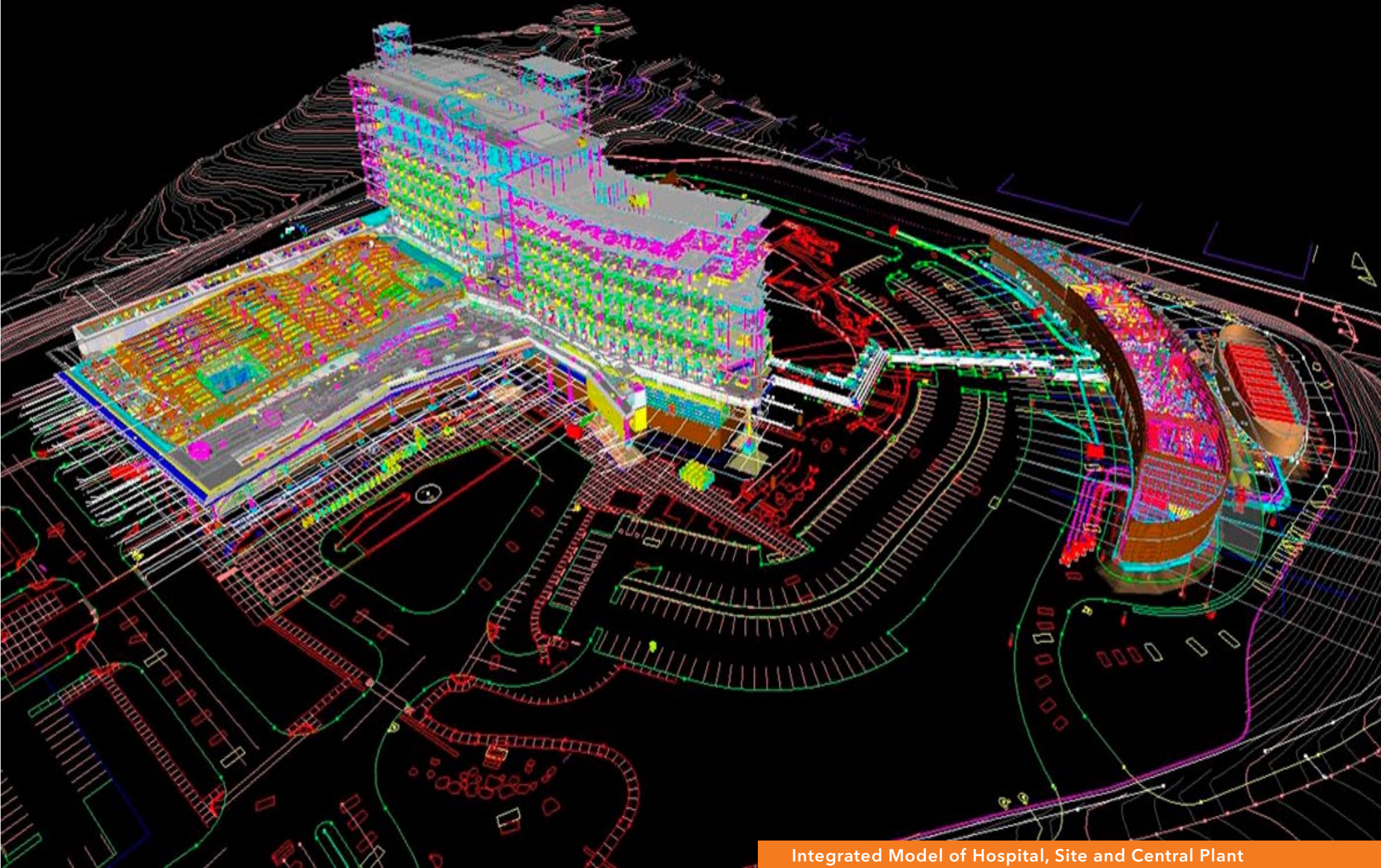
The basic organization of the hospital incorporates change and growth as inevitable and necessary conditions of a complex, technology-driven building. The two-story D&T wing is pulled out from the patient bed tower to allow the building systems of each to be designed independently and in specific response to their different functional criteria. As needs and technology change over time, transformations can be accommodated in one without impacting the other. The undulating green roof over the D&T wing is supported on long span trusses to maintain a column-free surgery floor plate while providing the equivalent of an interstitial floor for mechanical system routing. The roof is integrated into the storm water management system and also contributes to energy efficiency by reducing ground reflectance and solar heat gain in the tower's interiors. Outdoor courts cut into the D&T wing bring welcome natural light to the functionally determined deep floor plates and add a soothing element of nature to this high-stress area.

The patient tower is oriented to minimize east/west exposures in its arid, inland valley context, but designed to take maximum advantage of daylight. A perforated metal screen system on the south façade provides shade to patient rooms while allowing maximum views and natural light.





*The PMCW project's use of BIM began during the technology's infancy, which pushed the project team's BIM expertise to a position of national leadership by requiring a 100 percent commitment to Revit implementation in 2004.*

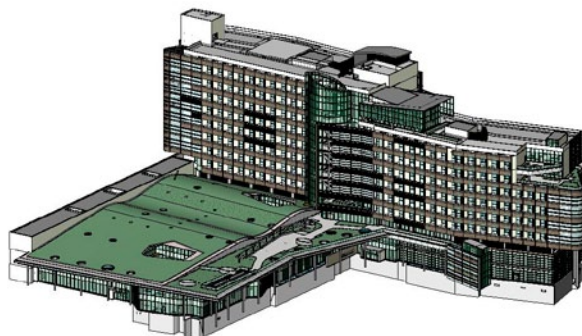


Integrated Model of Hospital, Site and Central Plant

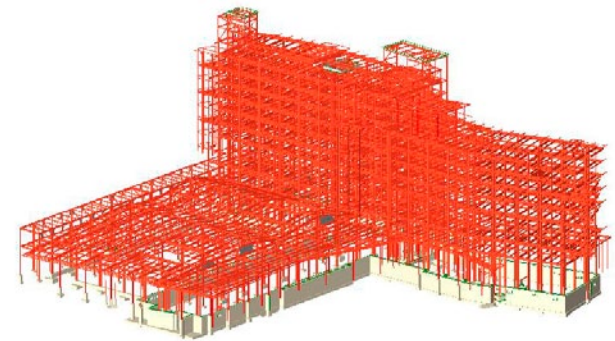


PMCW is the first healthcare system in the nation to adopt IPD and BIM on a large and highly complex healthcare project. The PMCW project's use of BIM began during the technology's infancy, which pushed the project team's BIM expertise to a position of national leadership by requiring a 100 percent commitment to Revit implementation in 2004.

In the past, the complexity of large healthcare projects, their lengthy design and construction schedules, strict agency reviews, non-repetitive and highly specialized character, and large capital investments have acted as divisive influences on design and construction teams. In this case, the promise of a collaborative BIM environment attracted quality contractors in an otherwise risk averse construction market. The BIM-enabled-IPD team which included trade contractors, equipment and material vendors, and regulatory agencies invested construction expertise directly into the design phase through the virtual information pool. This resulted in benefits in process, material savings, reduction of field labor, and offsetting of complexities inherent to the building typology, while reinforcing and enhancing the architecture. And, because BIM reduces field revision costs and schedule overruns, it controlled both cost and risk for all parties, thereby giving the PMCW project design team greater freedom to innovate architecturally.



Architectural



Structural

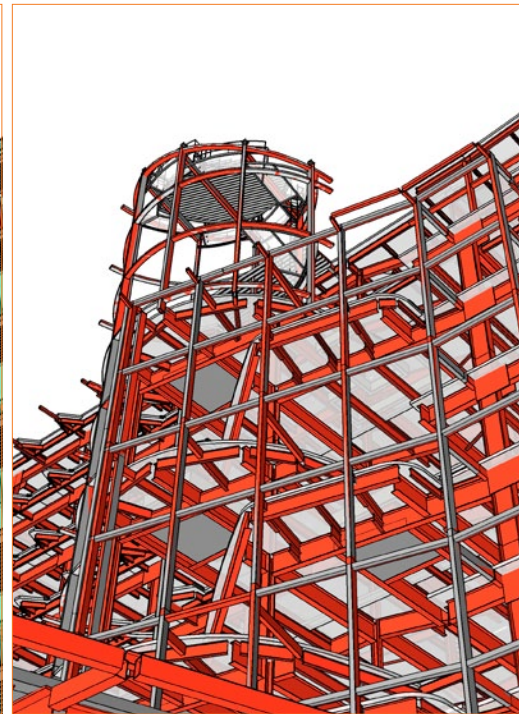




Rendering



Architectural



Structural



Construction

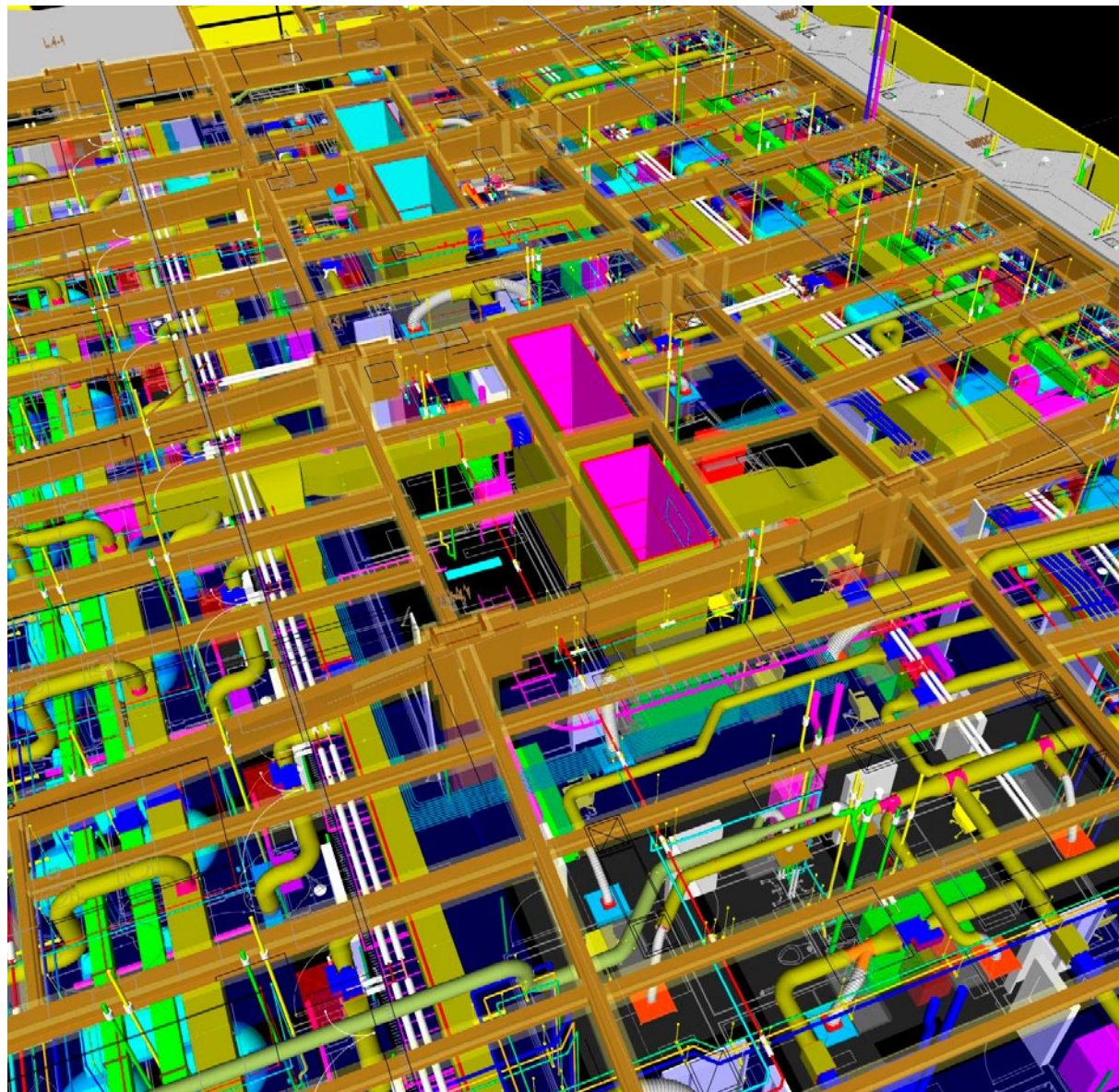
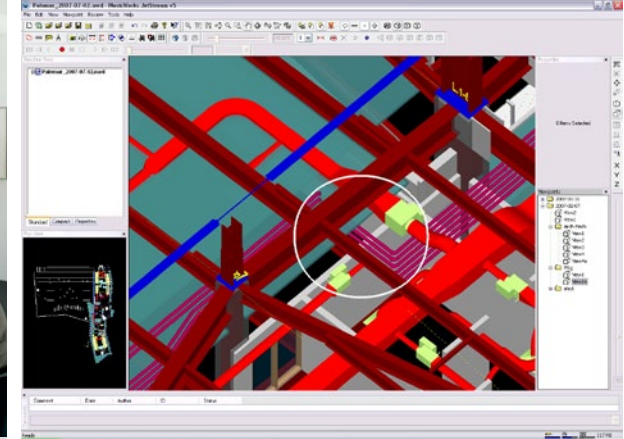


During the design phase, architects, engineers, and MEP contractors used the model(s) to validate design concepts, share expertise, identify conflicts, and resolve issues. Trade contractor feedback also allowed for resolution of issues prior to permitting. The MEP trades began 3-D modeling and collision detection during the construction documents phase. Weekly web meetings with key representatives of the owner and the design and construction teams identified conflicts and solutions. During construction, MEP contractors used BIM to generate shop drawings and prefabricate building components to streamline installation. PMCW is the first healthcare project to prefabricate 100 percent of piping off-site, an innovation made possible through BIM.

PMCW's use of BIM-enabled-IPD in the healthcare arena resulted in a risk-reduction and value-added equation that is pivotal to convincing the healthcare marketplace to expect architectural innovation and quality within its economic parameters. Giving healthcare organizations confidence to innovate without the threat of uncontrollable risk also contributes meaningfully to the current debate over healthcare's future. PMCW championed the coupling of IPD's philosophy of integrated team self-improvement and the technological benefits of BIM, with the goal of reducing construction risk and responding to the challenges of achieving an innovative and inspiring healthcare architecture.

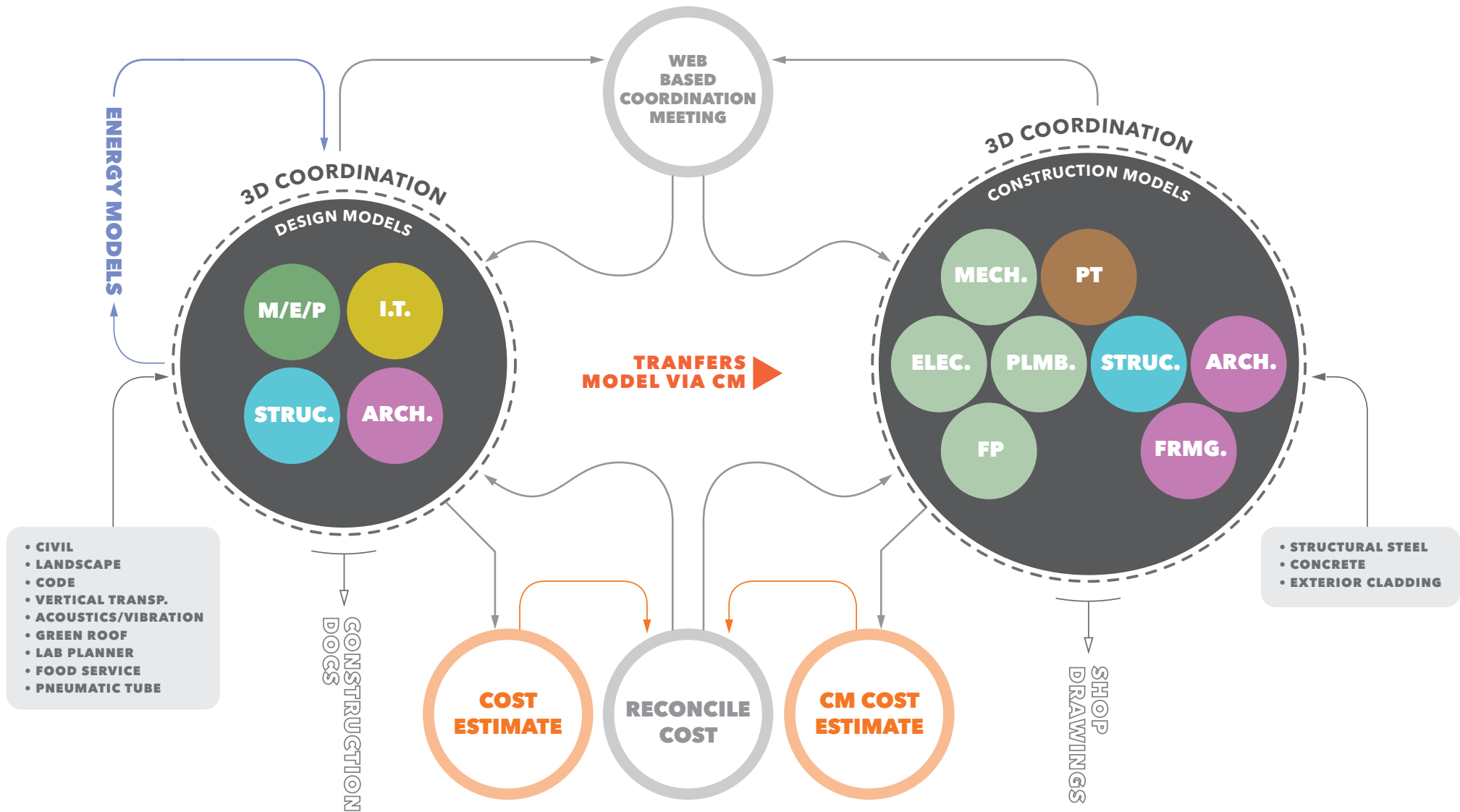
#### BIM Summary:

- Largest healthcare project in the country, at inception, to use Revit
- Healthcare project with design, documentation and approval phases extending over four years
- Architectural team grew as large as 25 people
- BIM software upgraded through four versions of Revit during design and construction phases
- Architectural model split into three models (shell and core, interior D&T, interior tower) to maximize file size efficiency and facilitate specialty team structure

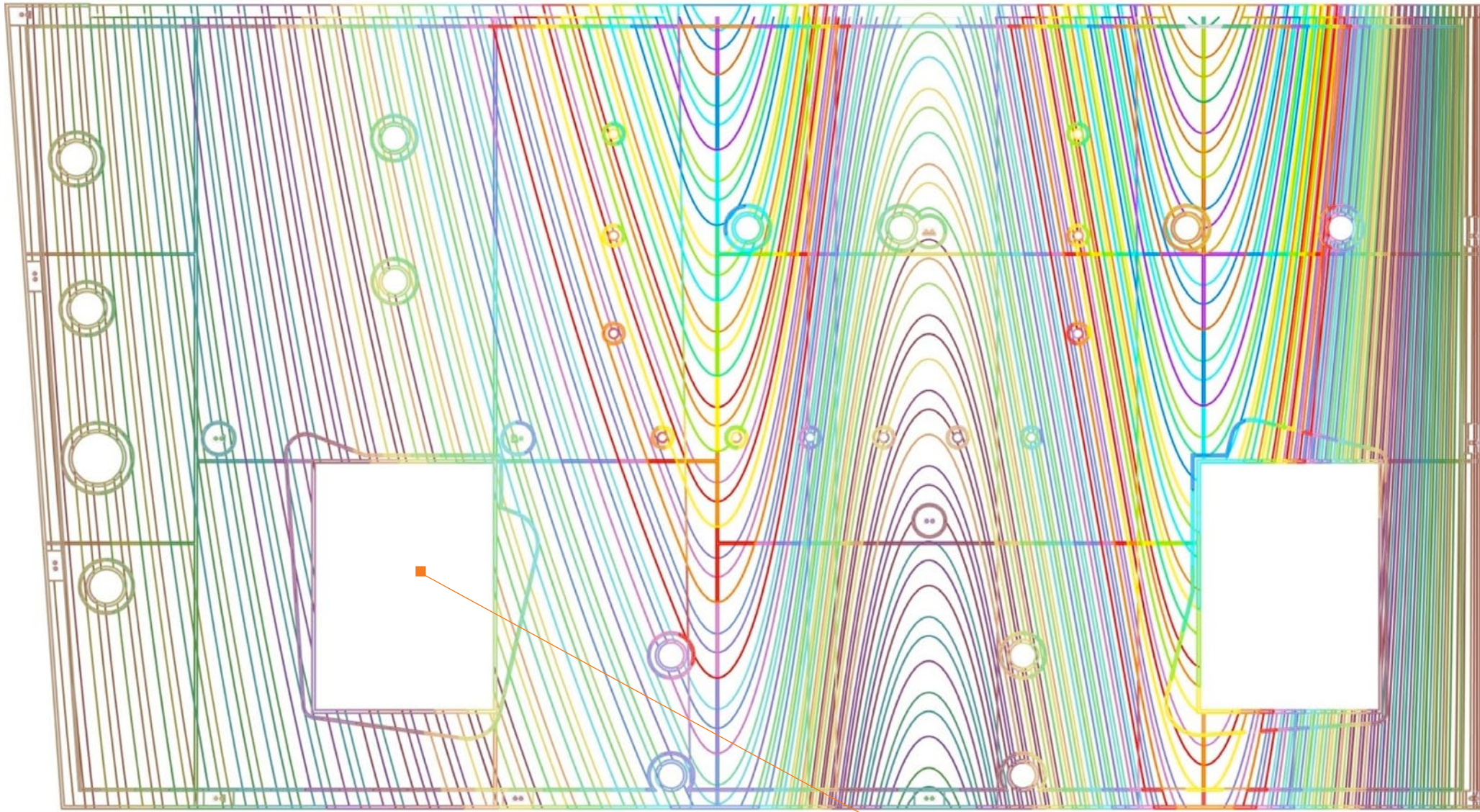




# PROJECT DATA EXCHANGE







## THE ROLLING GREEN ROOF

*BIM was used to model a geometric construct that resolved the contextual requirements of the exterior and the functional requirements of the interior.*

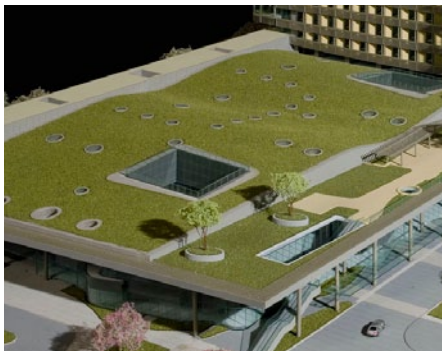




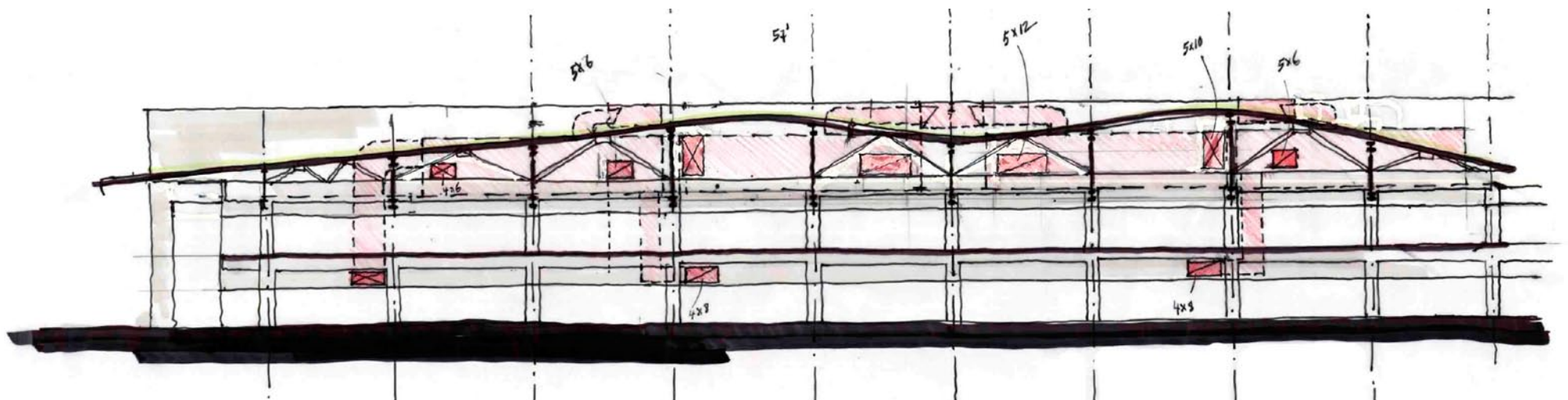
On the outside, the green roof was a contextual idea: a visual extension of the ground plane that softens the impact of the massive D&T building footprint. For occupants of the patient tower, it provides a connection with nature as it blends with views of the surrounding hills. Modeling originally facilitated the integrated engineering of the roof's complex drainage scheme as well as the irregular system of structural trusses that shape it. Later, the model turned out to be a vital tool in a cost saving design-assist refinement of the structural design.

On the inside, beneath the free-form rolling green roof, a carefully modeled system of long span undulating trusses gives the roof its form, and provides an enormous expanse of unobstructed floor area (105' x 303'). This makes possible the single-floor integration of surgery and interventional radiation, which streamlines and consolidates patient care and optimizes staff utilization. The clear floor area and long span overhead structural framework serve several key functions:

- Complete space planning freedom (no columns, shafts, or permanent pipes)
- Adaptability for future planning needs
- Overhead structure and access for the vast array of elements in need of support (walls, ceilings, skylights, fire separations, catwalks, utilities, and hospital equipment)
- Adaptability to re-engineer overhead supports and services as new hospital equipment inevitably replaces old (this typically occurs even before construction is completed)
- As-built model documents conditions to facilitate design and construction of future changes











## **STEEL TRUSS SYSTEM**

*Through a design-assist process, collaboration with the steel contractor lead to a shift from the initial concept, and resulted in a cost savings of about \$8 million.*



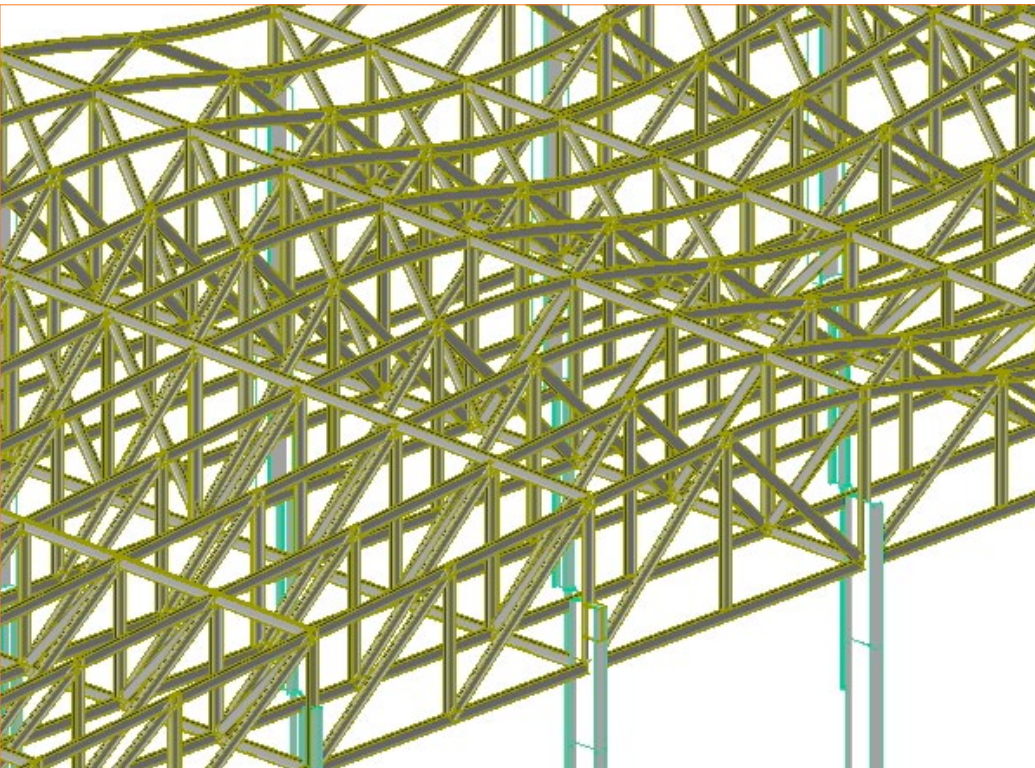
The original “two-way” truss system was evaluated by the steel subcontractor with the goal of maximizing shop labor, minimizing field labor, and optimizing transportation. Taking these factors into account, the design-assist team eliminated the secondary trusses’ diagonals and used a “one-way” system instead. This, along with other more detailed refinements, significantly reduced the scope and schedule, without compromising the design integrity.

Quantifiable benefits after construction:

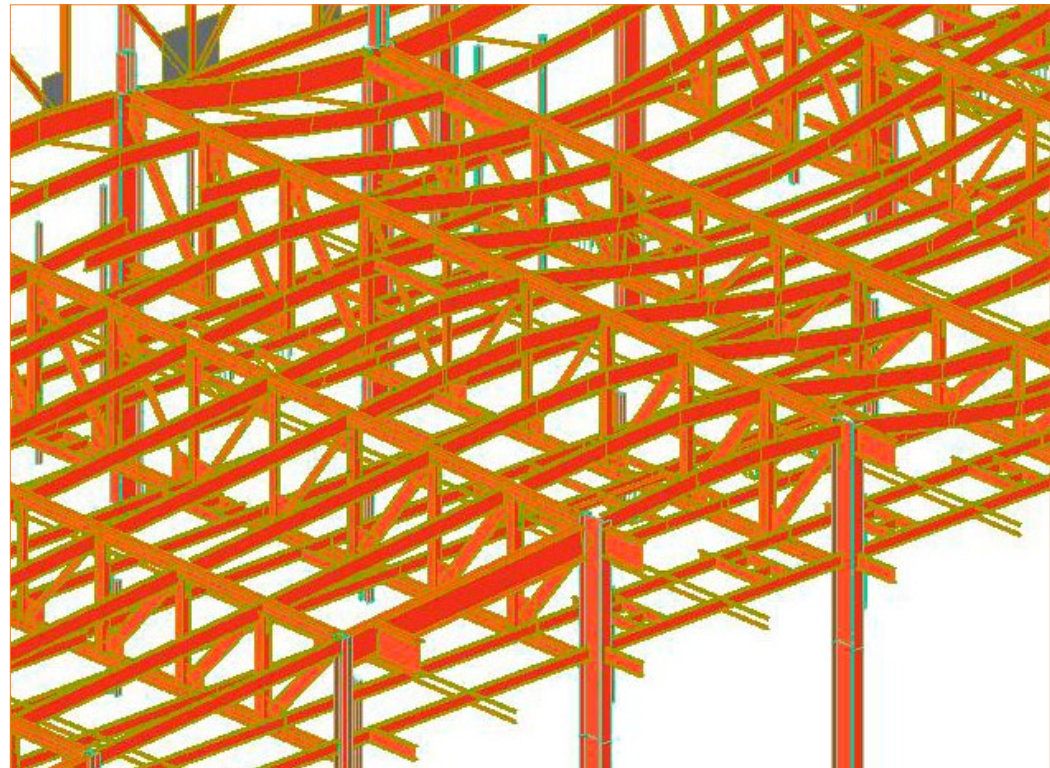
- Approximately \$2 million saved for material and labor directly associated with the redesign of trusses.
- Steel contract was finished four weeks ahead of schedule.
- Approximately \$6 million of steel contract was returned to the owner, per the conditions of a modified incentive contract.
- Zero structural steel change orders were required





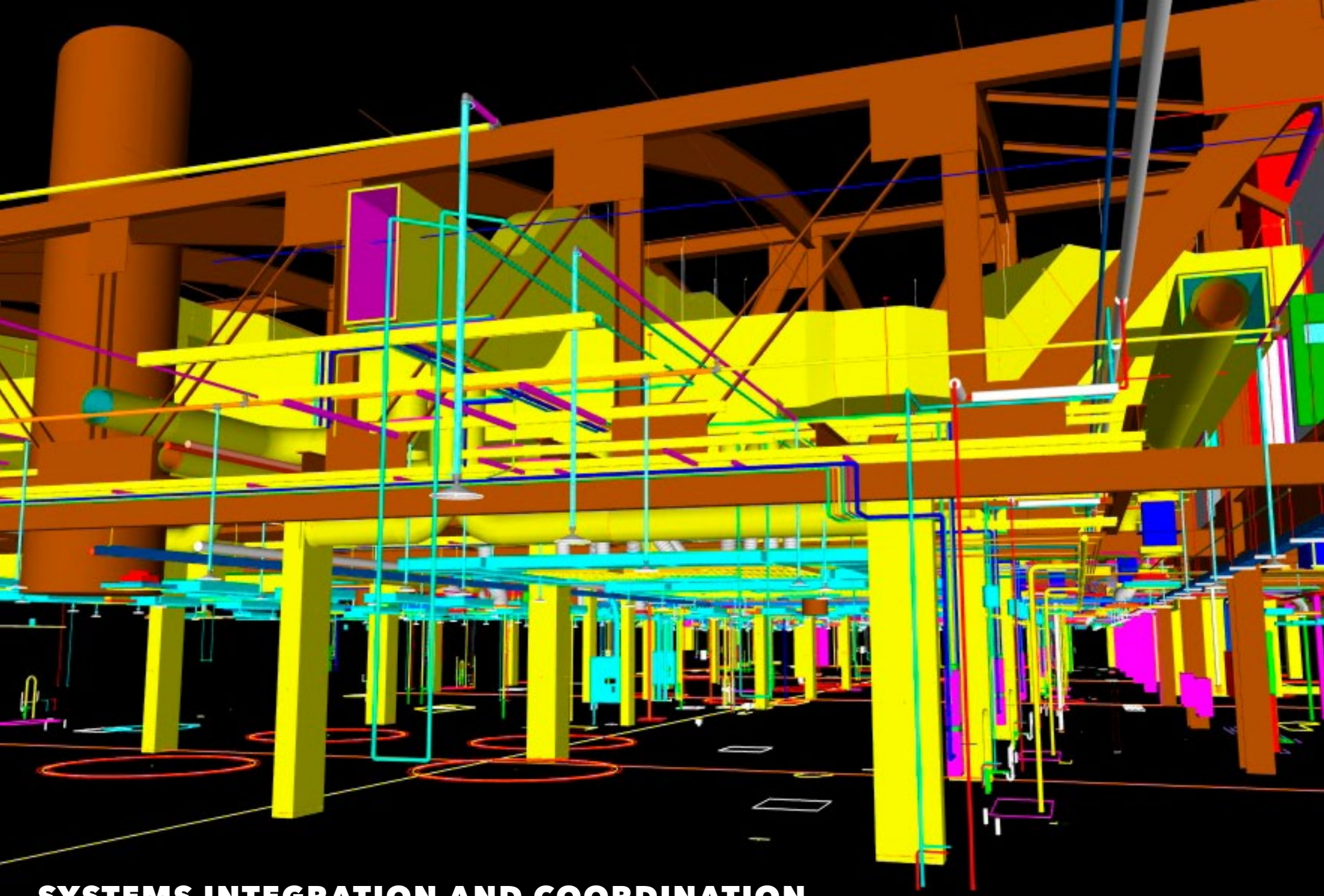


Two-Way Truss



One-Way Truss





## **SYSTEMS INTEGRATION AND COORDINATION**

*An intensive 3-D collaboration merged models generated by ten independent organizations, using 14 different BIM software programs, and brought to light the essential role of the architect.*

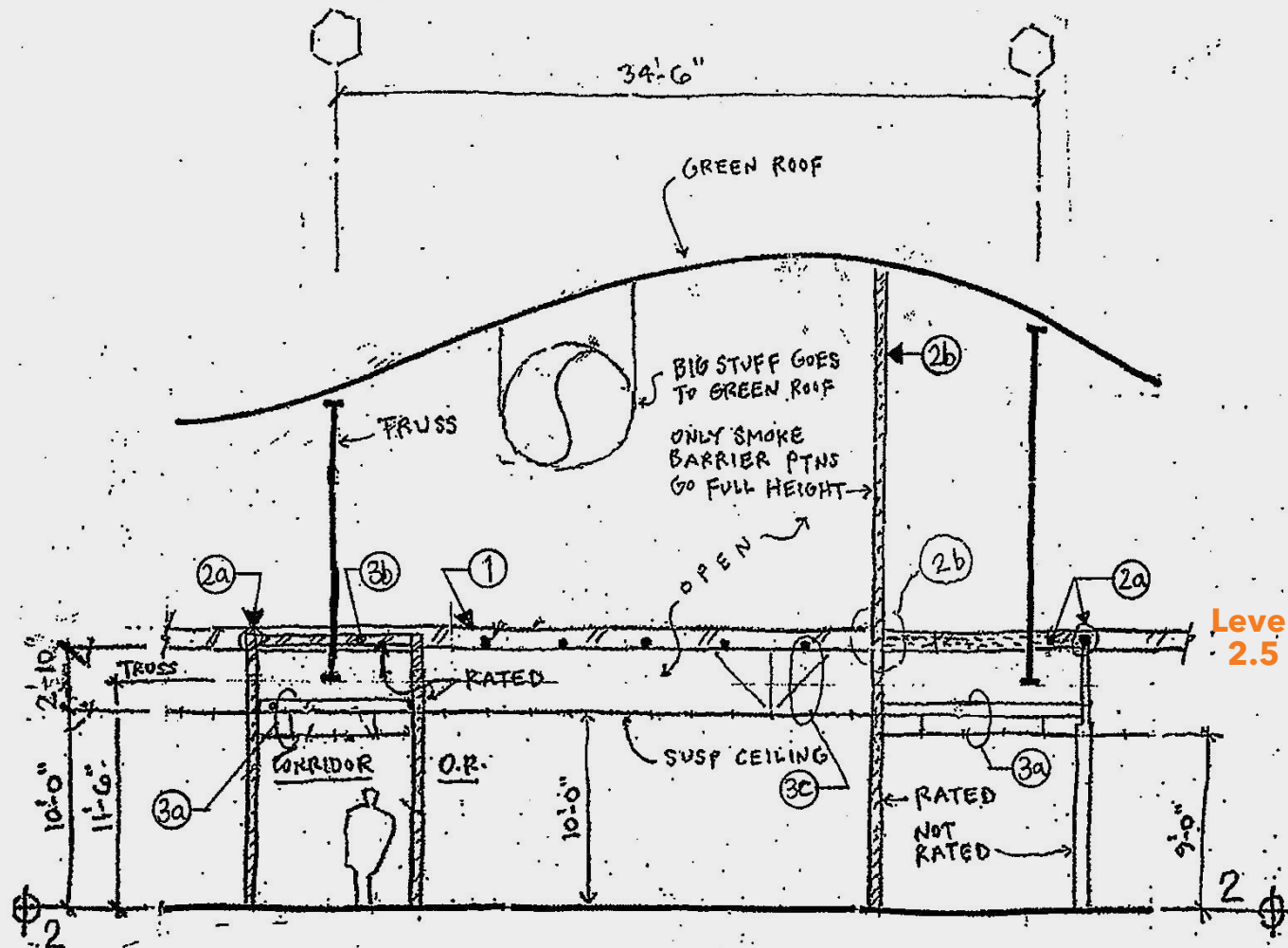


The following disciplines participated in modeling and shared those models as part of a collective BIM process:

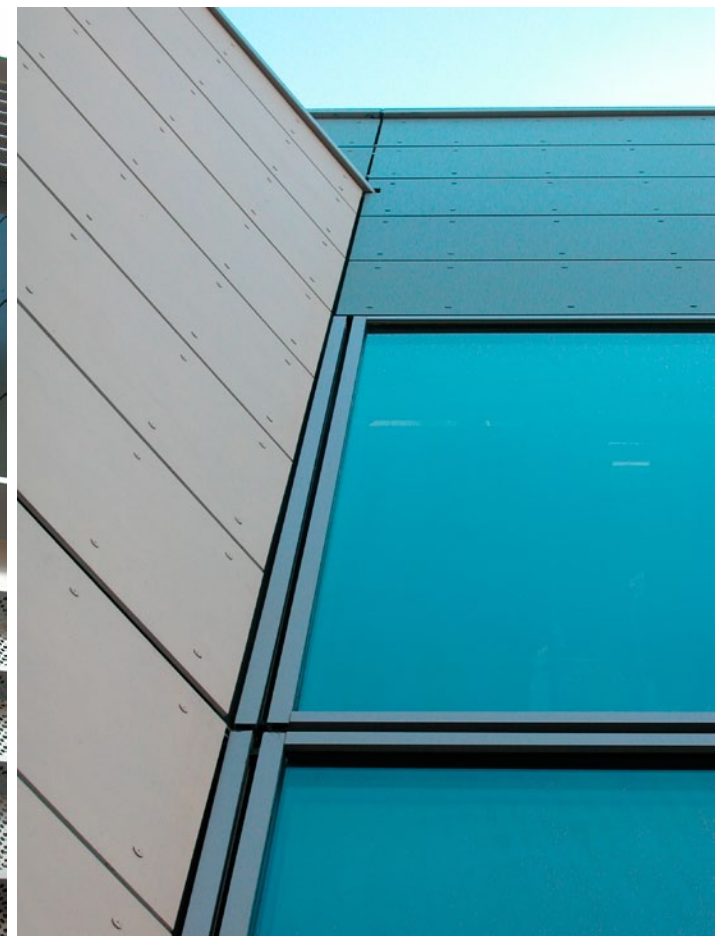
- Architect
- Structural Engineer
- M & P Engineer
- Electrical Engineer
- Telecom Engineer
- M & P Contractor
- Electrical Contractor
- Pneumatic Tube Contractor
- Framing Contractor
- Fire Sprinkler Contractor
- Fire Alarm Contractor

Weekly "clash" meetings revealed a depth and diversity of issues and expertise that the architects had not seen so early in any design process. While at times chaotic, the process reinforced the architect's vital role as the lead builder who provided, updated, and enforced big picture organizational and design priorities, not only for the building, but also for the exchange of data.

The best example of this is the long span green roof of D&T surgical floor. The high interstitial volume in this space exceeded the limits of conventional framing and suspension details and demanded a creative solution. The architect and structural engineer devised a system of secondary ("Level 2.5") overhead beams, along with a complete package of framing and fire-rated details for walls, ceilings, skylights, and hospital equipment. This established an organizational framework for the overhead services that followed.







## THE EXTERIOR CLADDING SYSTEM (ECS)

*The critical-path schedule demanded a true design-build delivery. BIM produced a simple yet reliable bridging document, which supported the parallel design activities of the architect and ECS contractor, eliminating the need to rework the drawings.*



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To meet the plan check schedule, a design-build contract bridging document went out to bid early in the design development stage. Even as the overall envelope design was still under review by the owner, the ECS contractor completed a carefully defined set of engineering responsibilities, leading to a product that was submitted for review by the state's plan check agency, and ultimately included as part of the record construction documents.

A saturated and risk averse construction marketplace combined with the added jurisdictional burden that accompanies hospital construction produced a shortage of ECS bidders. The BIM model, with a corresponding performance specifications, provided a simple, quantifiable baseline description of the work on a unit basis. The clarity of this information was instrumental in the architect's ability to secure an overseas bidder at the right price. The process outlined in the bridging document assigned design responsibilities appropriately, so that the contractor understood the status of the ongoing architectural design, and could feel secure in his ability to schedule and perform the work. Also, the simple unit structure it used to assign costs engendered confidence on all sides when costs had to be adjusted.





The architect also used BIM for the following ECS tasks:

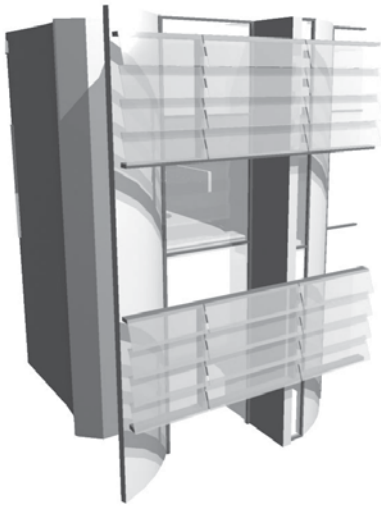
- 3D sun studies to achieve the optimal sunscreen profile and transparency
- Assembly of wall types for quantity take-off and unit rates
- Wind tunnel analysis
- Visual evaluation of color, texture, and scale

The ECS contractor used BIM for the following tasks:

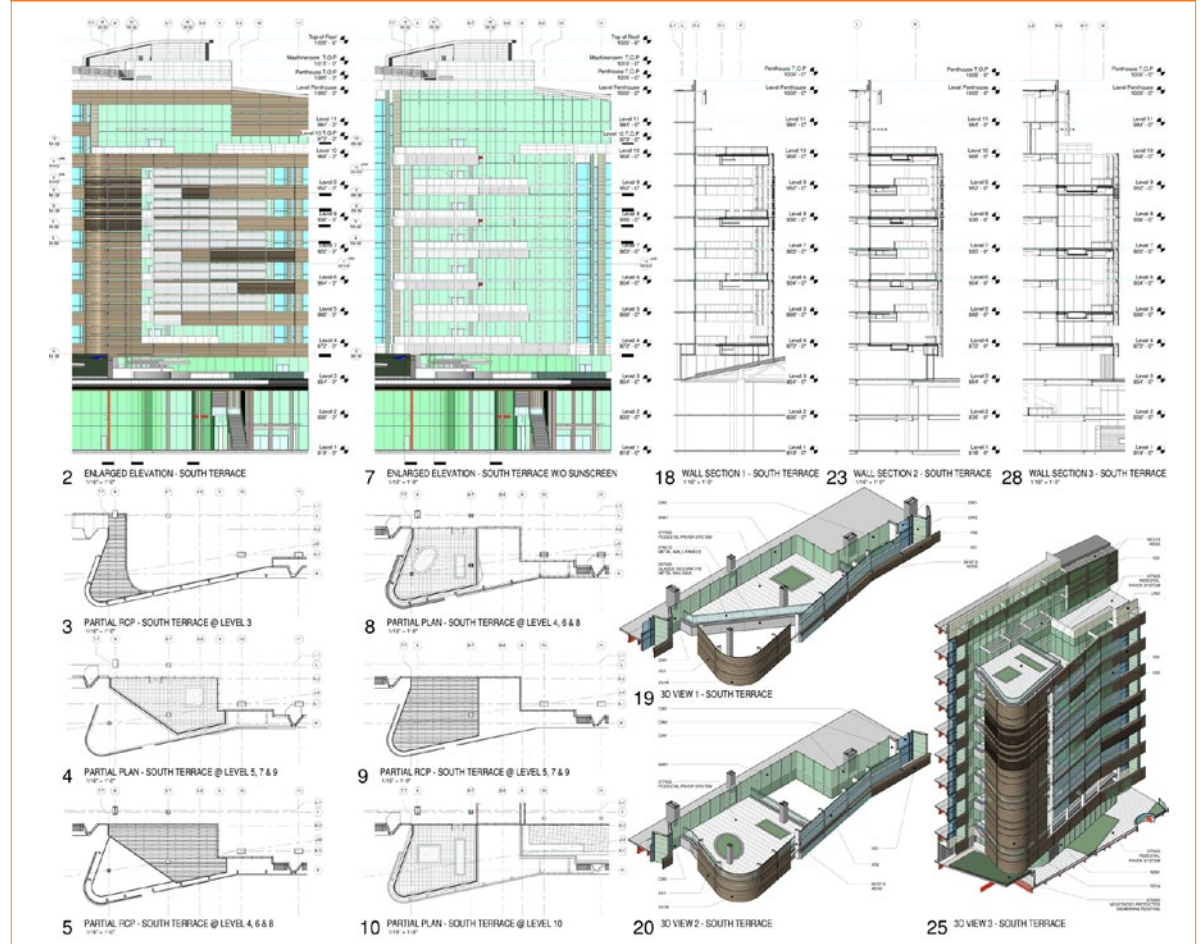
- 3D detailing of critical waterproof junctions
- System assembly sequence drawings
- Installation sequence drawings
- Slab embed layout drawings



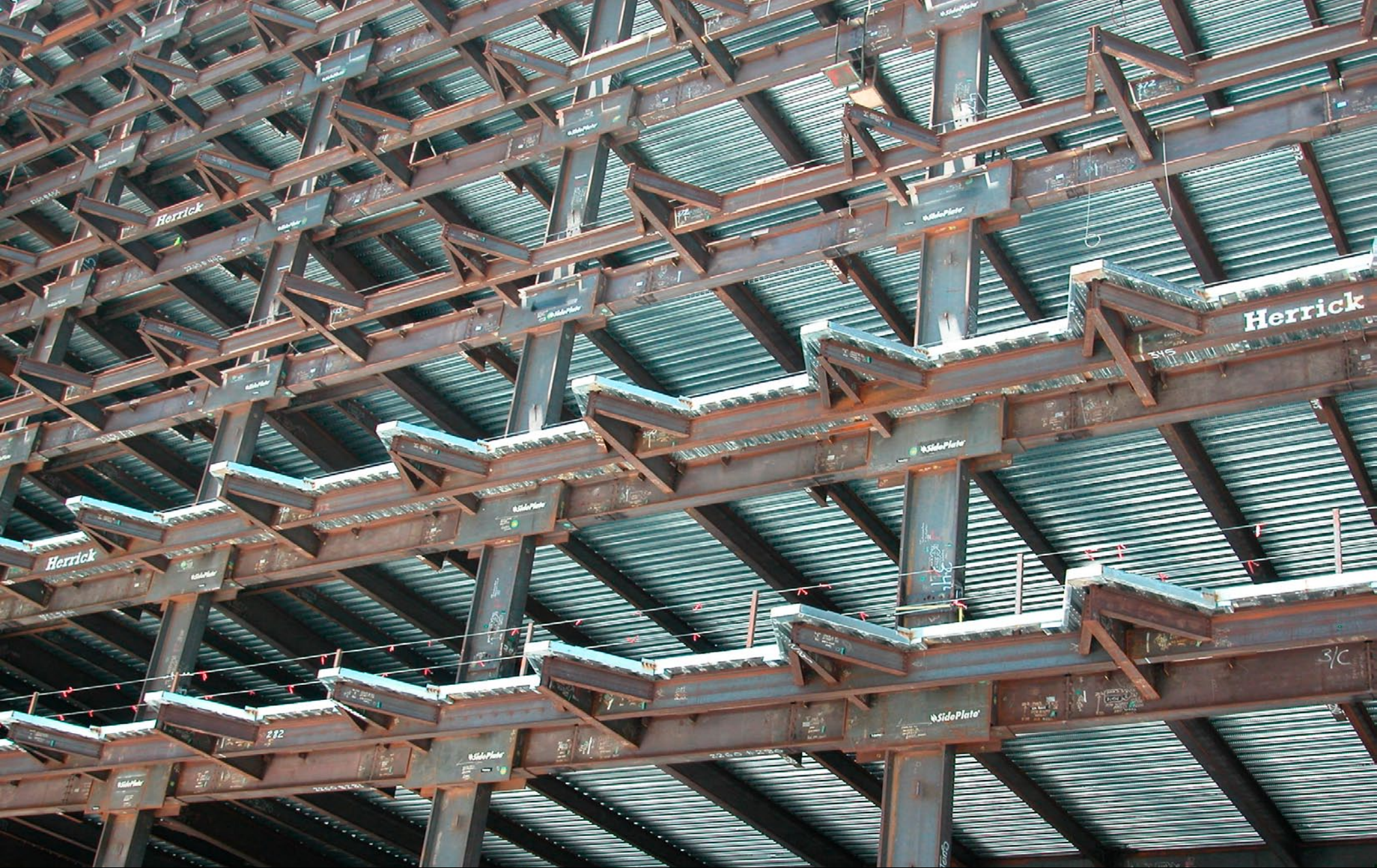
### 3D Sun Study



### Design Intent Bridging Document







## **MODULARIZATION & PREFABRICATION**

*The ECS, mechanical and plumbing contractors used BIM to prefabricate and prepackage building components to improve quality, minimize waste, and speed up installation.*



## PREFABRICATED PIPING



Finished Plumbing Pipes



Warehouse Staging

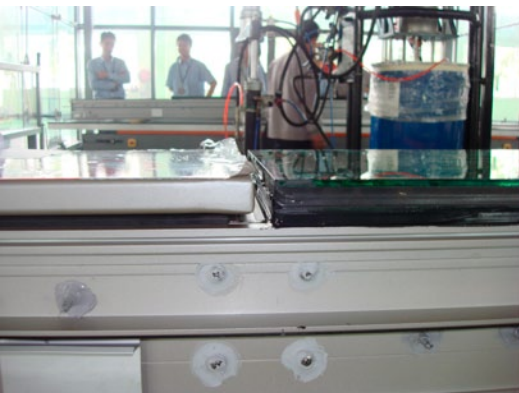


Loading the Racks



Flying the Racks

## UNITIZED CURTAIN WALL



Assembling the Panels



Factory Assembly Line



Unloading the Panels



Flying the Panels



## PREFABRICATED PIPING



- Estimated 66% reduction of RFIs compared to a non-BIM/traditional delivery healthcare project
- Productivity ratio shop vs. field at 4:1

## UNITIZED CURTAIN WALL



- Construction schedule estimated at placing 12 panels per day, actual pace over 20 panels per day
- All panels to date of acceptable quality



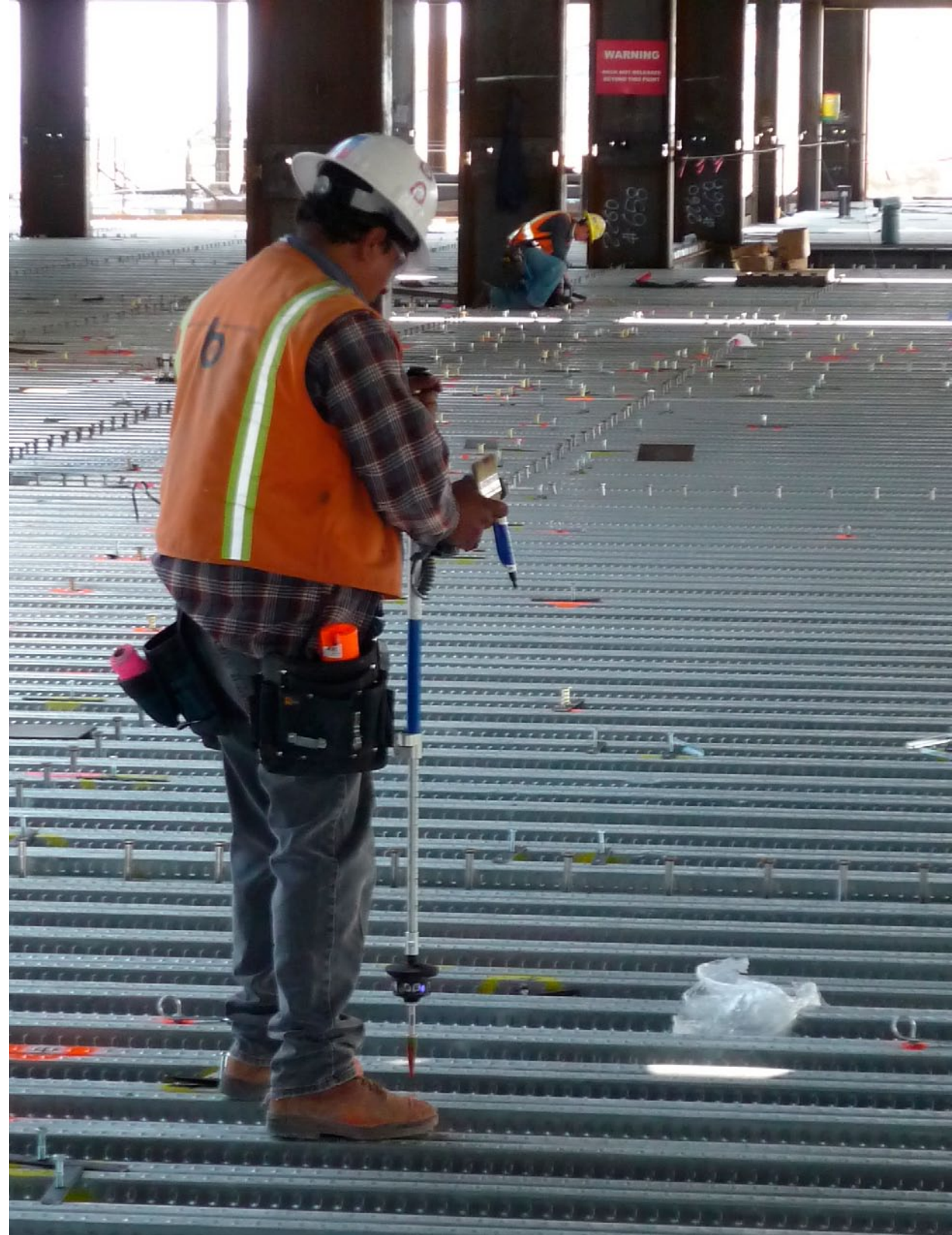


## **PIN POINT ACCURACY**

*Thousands of hanger inserts of varying types were placed with a single operation, to an accuracy within  $\frac{1}{4}$  inch.*



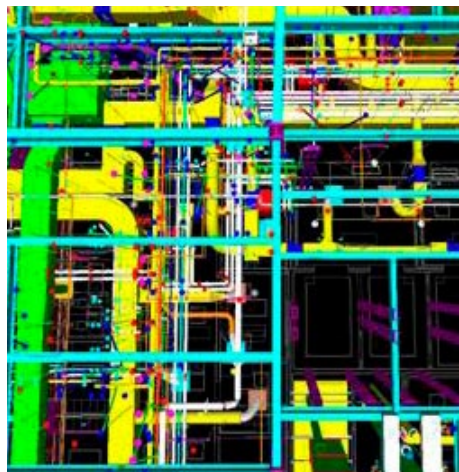
The layout of overhead utility hangers is traditionally a free-for-all, involving multiple teams of sub-trades, often competing for “territory” above the ceiling. Here, the contractor used an electronic/optical surveying platform called “Total Station” to streamline the process. With all hanger points pre-coordinated and pre-located in BIM, site personnel used an electronic distance meter (EDM) to read infrared signals that linked back to the BIM-generated CAD file. All the points were then located and color-coded in a single pass, resulting in a much-improved, efficient and organized process.



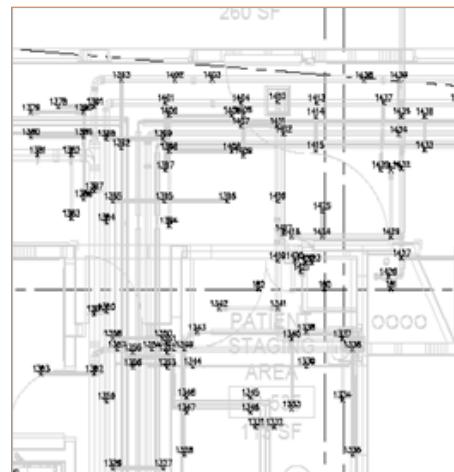




Concrete Hanger Insert DWG



Inserts modeled in BIM



GPS Nodes in *Total Station*



Direct download from *Total Station* to laser scanning & survey equipment





*"As an industry, we have a tremendous preoccupation and protectiveness with managing the many revenue streams. However, real reform lies underneath the cost curve, and is achieved by eliminating waste, duplication, redundancies, inefficiencies, and unnecessary variations wherever they might exist."*

- David Hefner, former president of the University of Chicago Medical Center