AIA TAP / 2012 BIM AWARDS

LEVERAGING BIM FROM DESIGN CONCEPT TO FACILITY MANAGEMENT

Category A: BIM Excellence Awards

Introduction

When the news hit the streets that a brand new medical tower was to be built in the Central Washington town of Wenatchee, set in the foothills of the surrounding Cascade mountain range, it was the answer to the community's healthcare needs. It was also just the beginning of the Owner's design and construction journey to leverage new technology and bring a much needed state-of-the-art facility to the area.

Our design and construction team collaborated with the Owner to demolish 30,000 square feet of the existing two-story hospital to integrate a new, forward-thinking, $81 million, six-story patient tower. The tower houses 151 patient rooms, nursery, labor and delivery departments, critical care and post-coronary care unit, as well as a new adjacent Central Utility Plant.

Aside from the traditional MEP coordination challenges that are faced in any construction project, the existing building had been constructed over many phases and several years, resulting in inconsistent foundation elevations and roof heights. With all of the complex issues to coordinate, it was necessary to leverage Building Information Modeling (BIM) to resolve these complex tasks.

The use of BIM allowed the team to create the most efficient solution for MEP routing, as well as temporary shoring necessary to support areas of the building during demolition and construction.

The team developed applications of BIM through implementation of new standards and tools on the jobsite such as wireless access points, mobile computer stations that allowed tablet computers in the field to enhance the quality inspection process, and a touchscreen computer in the jobsite office that provided easy access to the model. When the project was complete, the team provided a touchscreen computer to the hospital's facilities management team that contained a complete as-built model linked to electronic documents, in-wall photos and electronic O&M manuals and shop drawings with the goal of revolutionizing the facility's management experience.

From design visioning, coordination and mock-ups, the use of BIM helped drive the owner decision-making process and became an invaluable tool for the construction team, allowing it to prefabricate certain areas of the building and greatly increase quality of construction through access to the model in the field. Through BIM and the new tools adopted throughout the project, we achieved a schedule savings of 10 weeks and passed on savings of $7 million to the owner. Those additional savings will be used for projects and future improvements to their medical facility. Today, BIM is a tool that is used daily by the Owner's facilities management team.

PROJECT DATA:

Site Area	11 acres
Total GSF (gross square feet)	288,415 sf
Net Assignable Area	227,098 sf
Site Development Costs	$765,000
Building Costs	$81,700,725
Total Construction Cost	$82,465,725
Building Cost per GSF	$376.00

Owner Statement

The vision for this project was a regional medical center that would be designed for optimal patient care with a contemporary partnership with emerging technologies and evidence-based design to serve the community well into the future. It would feature easily accessible services, a healing environment that inspires hope and confidence, promote operational efficiency, and permit cost-effective facility in an acute flexible care delivery environment.

With a collaborative project team and thorough preconstruction process, the Owner, Physicians, Architect and Contractor used BIM to evaluate and update the Campus Master Plan in consideration for the next 15 years. This lead to extensive modeling profiles for the design of the new patient tower and placement in the most efficient location.

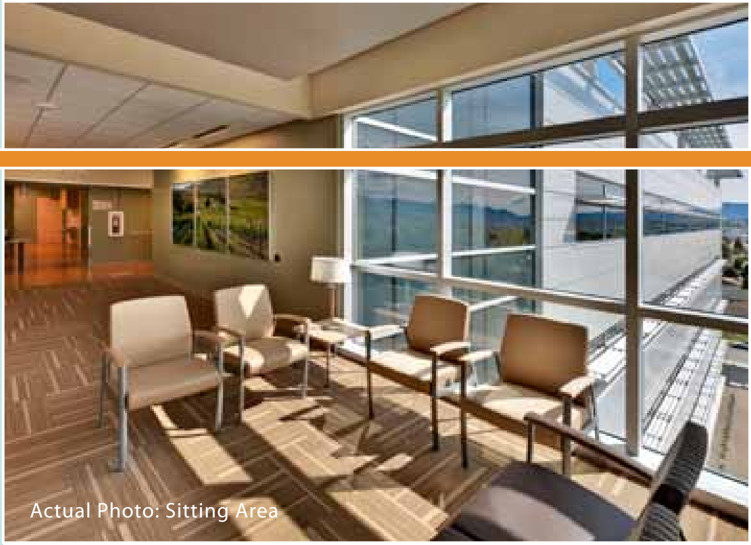
Modeling focused on functional relationships, minimizing disruption to existing departments, and supported feasibility of construction on campus. Virtual mock-ups allowed our client user groups to visualize potential designs for patient rooms and nurse stations, and provide comments to meet the needs and expectations of all stakeholders. This collaborative approach led to the project being completed weeks ahead of schedule and under budget.

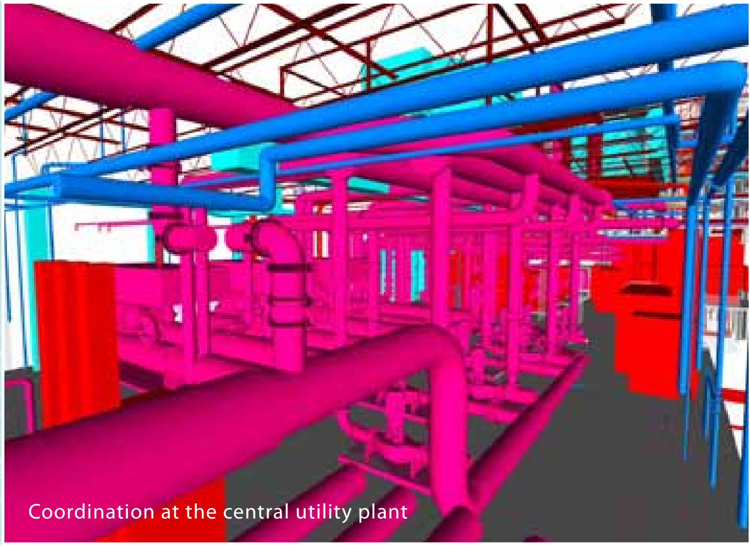
Owner BIM Responsibilities:

- Work with all the stakeholders to use the model and tools to understand the design and make early decisions based on massing models, site planning options and virtual mock-ups.
- Verify in the model prior to construction that operational access required for future maintenance and repair was available for long term operational success.
- Confirm that the post-construction information desired by the facilities management group was included with the touchscreen computers: model, linked electronic documents, in-wall photos, electronic O&M manuals and shop drawings.

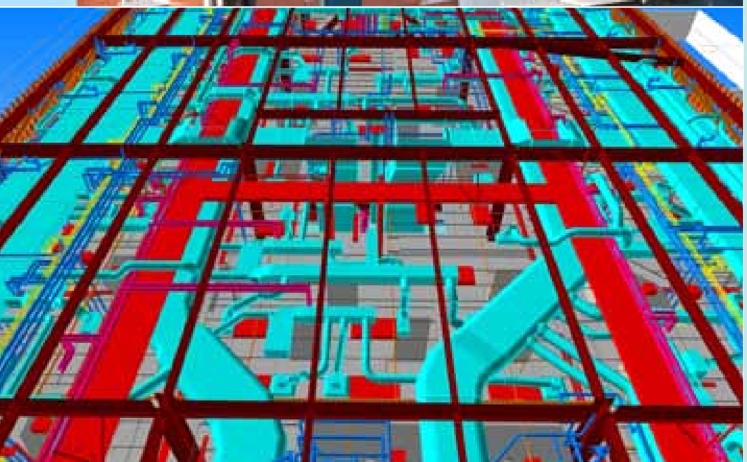
MOST IMPORTANT ADVANTAGE GAINED THROUGH BIM:

The owner said, "We simply could not have constructed this facility and achieved these results without this use of the model. BIM allowed us to anticipate and coordinate extensive electrical and mechanical systems installations with existing integration with virtually no re-work. I used to think this was all good in theory, but real issues are coordinated in the field. This project sure has changed my perspective. I'll never do it the old way again."


Actual Photo: Sitting Area


Coordination at the central utility plant


Actual Photo: Patient Rooms



Overhead MEP on Patient Floors Included in the Model

Architect Statement

The hospital's new six-floor, $81 million tower is a seamless blend of architecture, staff efficiencies and family centered care. Beginning in pre-design, BIM was used to develop a 15 year Master Plan and site the new tower. BIM was also used to:

» Develop the exterior schemes that would be most aesthetic and cost effective

» Model the interior spaces to capture the best views of the nearby Cascade Range foothills and to model the interior schemes and get stakeholders' buy-in phase of the project and played an important role

» Verify design of the curtain wall and exterior envelope. Use of BIM resulted in less redesign, lower costs and better communication during design

Advantage gained through BIM:
The team was able to maintain design integrity by using BIM throughout design development. This allowed the entire team to be involved in decision making and ensured the design met the needs of the owner, was constructable and portrayed the design intent of the architect. Making decisions as a group also resulted in mutual design expectations and a product that adhered to the original concepts.

Architect BIM Responsibilities:

» Model proposed building location through massing and site modeling for ideal building placement

» Create model

» Manage model through construction documents

» Work with design consultants to incorporate consultant designs into the model

» Incorporate finishes of the lobbies, business center, patient rooms and nurse stations into the model making it possible to create virtual mock-ups of these areas

» Share the model with the owner and contractor prior to CDs to allow for constructability review, input from subcontractors and use in the field

» Maintain the model for contract administration

FACT:

The coordinated and collaborative use of BIM allowed the team to function at an extremely high level, resulting in a ***50% reduction in RFIs*** *relative to a project of similar size and complexity completed just two years before.*

Contractor Statement

Designing and building a medical facility is inherently complex, regardless of size or location. When we were selected, the team evaluated possible options for the size and location of the new patient tower. We concluded that the best possibility of success in integrating the new towers seamlessly with the existing facility would be to rely on significant and unique utilization of BIM.

BIM was paramount in design visioning through massing exercises, coordination of MEP, existing facilities and virtual mock-ups, BIM was a valuable tool in driving early owner decision making and its value continued to grow as construction began.

Extensive site investigation and as-built review led the team to model existing spaces and structures adjacent to the planned patient tower. By integrating models of the existing facility and new facility, the team was able to identify four locations that required temporary shoring or underpinning support, including the main penthouse serving over half of the existing facility. As temporary supports were designed the team was also able to finalize pile cap and foundation locations that coordinated with excavations, existing foundations and existing utilities. BIM became invaluable when differing conditions were encountered in the field, such as a larger and deeper utility pit. BIM allowed the team to adjust the model accordingly and make rapid changes to the planned shoring system without delay to the project schedule.

BIM enabled the team to coordinate the exterior wall framing and plumbing systems and enabled the prefabrication of the exterior framing, sheathing and moisture barriers, **cutting the enclosure schedule by 40 percent.** Wireless access points in the field allowed the trades to access the model on mobile computer stations to actually build from the model.

By coupling the 3D model with the construction schedule, our detailed 4D modeling of the interior rough-in progression provided schedule certainty. The first drywall date occurred exactly as planned one year prior and the **final acoustic ceiling tile date occurred eight weeks ahead of schedule.**

BIM was critical to the project team's success and is a primary reason why the project was completed 10 weeks early and $7 million under budget.

BIM responsibilities of Contractor:

- Review model with Architect and Owner for constructability, pricing and design decisions
- Share the model provided by Architect to our subcontractors for additional detail
- Merge models from subcontractors into working model
- Make model accessible to field personnel on the jobsite
- Hand over as-built model for Facilities Management

Model New Construction into Existing Facility

Use of Smart Board in Owner's Meeting

Tablet Computer for In-wall Inspections (Wireless Connection)

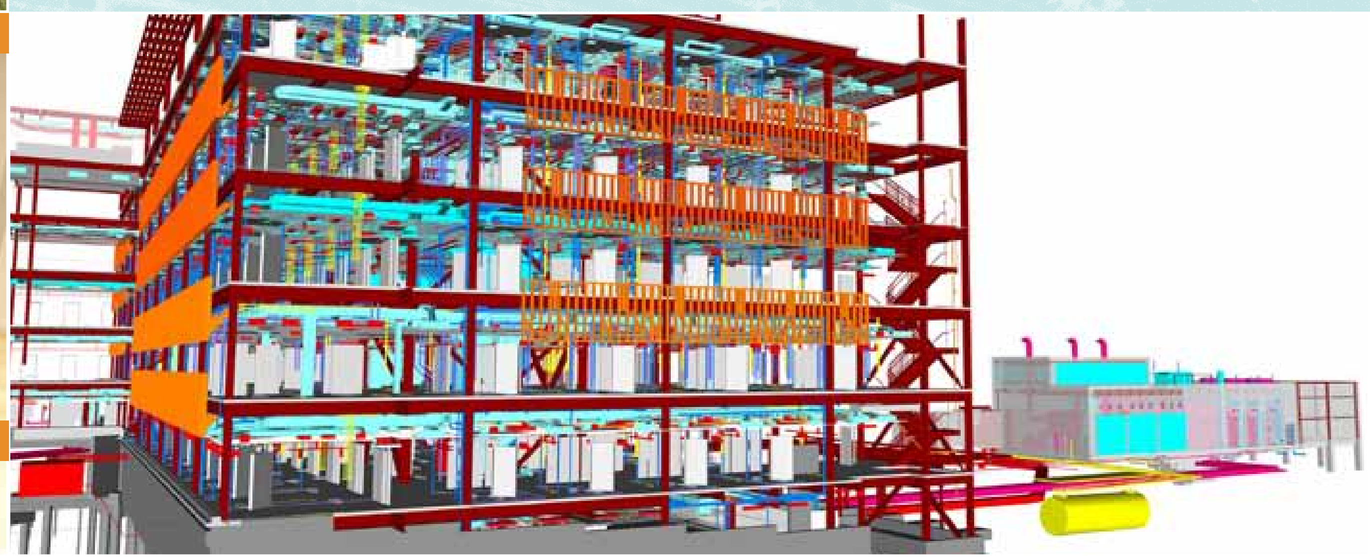
Plan Room Computer

Contractor Statement (cont.)

New concepts, procedures and tools employed:

The collaborative team was continuously searching for new concepts, procedures and tools to employ throughout the entirety of the design and construction process, and many of these tools are still in use by the owner's facilities management team today.

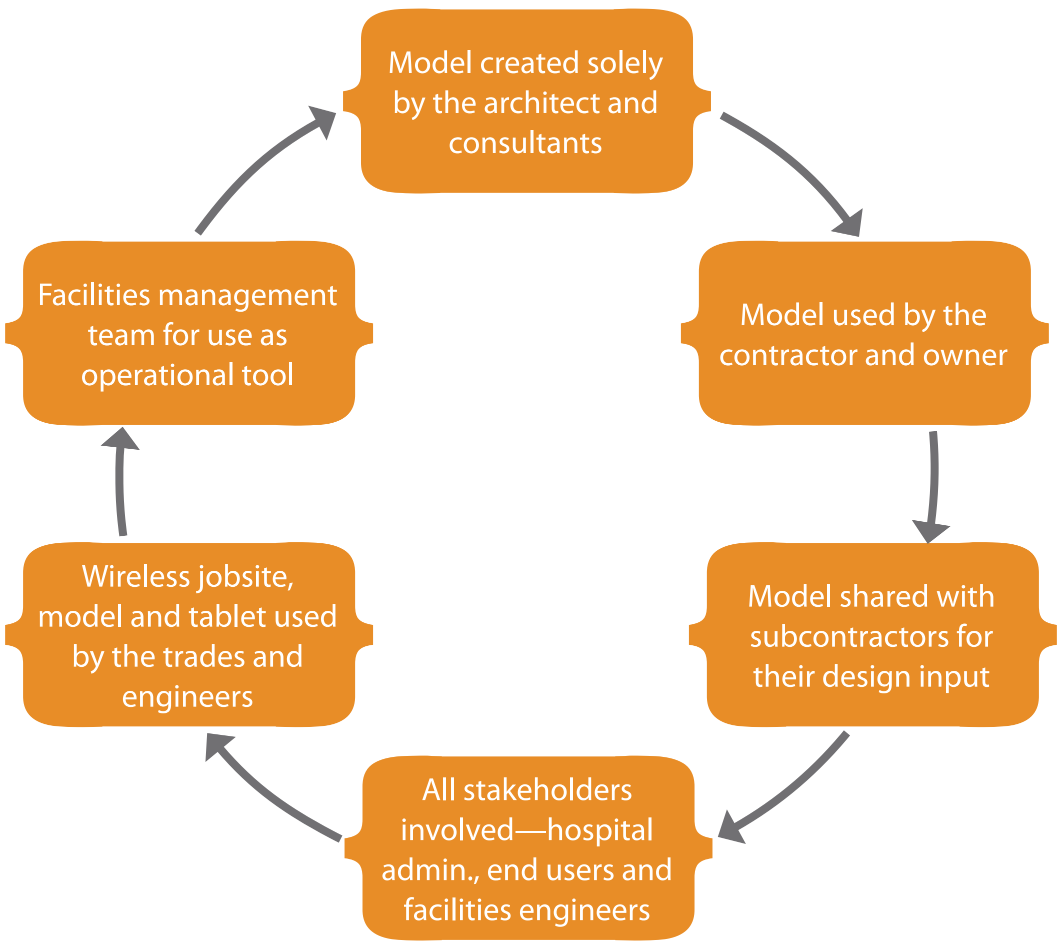
- BIM was used from pre-design concept through facilities occupancy and management
- Wireless access points in the field allowed for use of the model by the trades and team for the following:
  - Reference for field personnel at the mobile computer station
  - Inspections (including in-wall and overhead)
  - Coordination in the field
  - Enhanced quality and adherence to design
  - Punchlist
- The model was shared with the collaborative team before CDs were complete
- Bluebeam software was used for integration of new as-builts
- Smartboard technology was used on the jobsite to interact with model and electronic documents



Most important advantages gained through BIM:

BIM made it possible to share the model with each and every stakeholder and project participant. Our team used the following model sharing process:

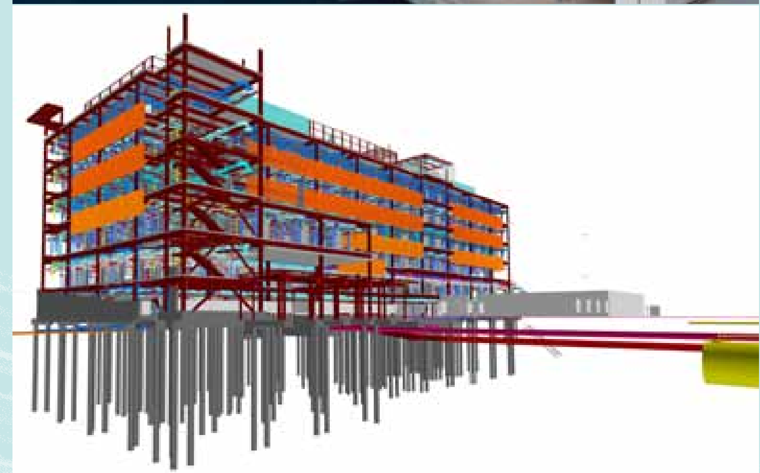
This sharing process aided in our ability to complete the entire project 10 weeks ahead of schedule while saving the owner $7 million!



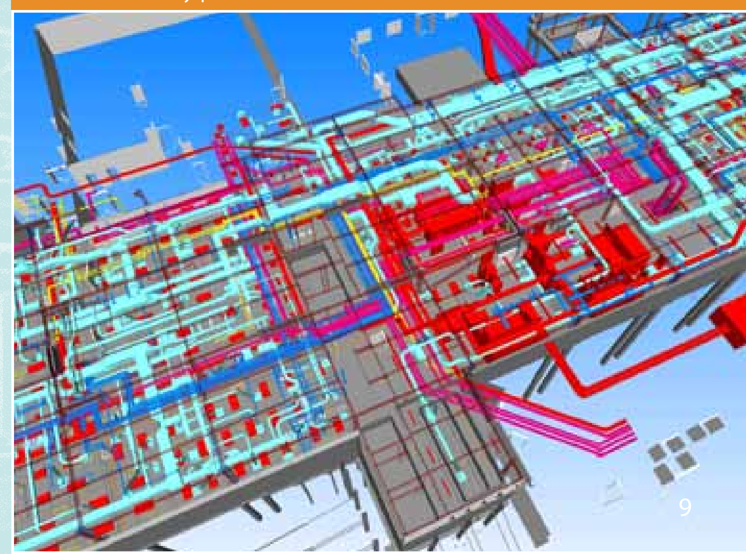
Blend of BIM Model with Actual Photo of Building Enclosure Demonstrates Accuracy of Model and Design Integrity

Greatest Gains with BIM

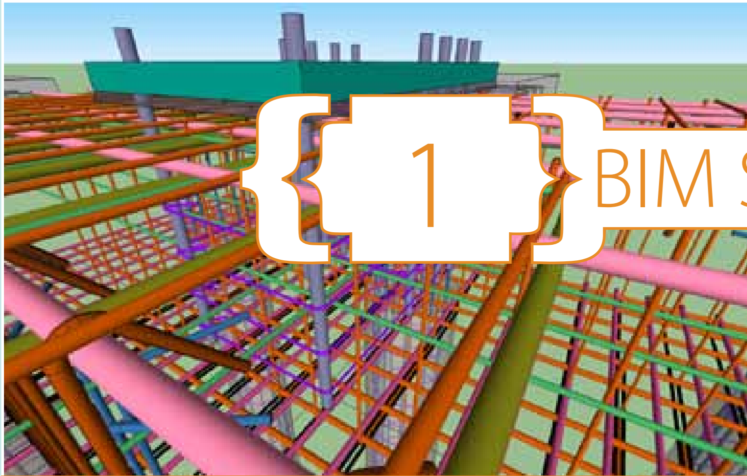
1. BIM Standards and Data Exchange
2. Project Visioning and Design Progression
3. Integrating MEP, Existing Facility and Structure
4. Virtual Mock-Ups
5. Prefabrication
6. Model in the Field
7. Enhancing Facility Management



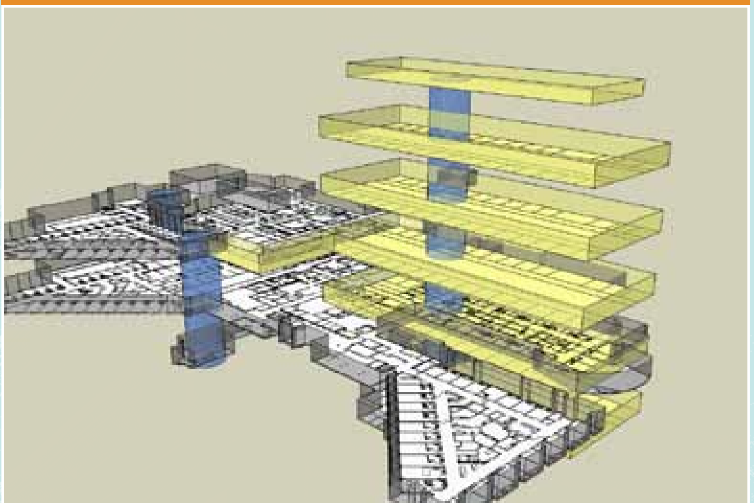
Complete model of all systems included in the medical tower and central utility plant.



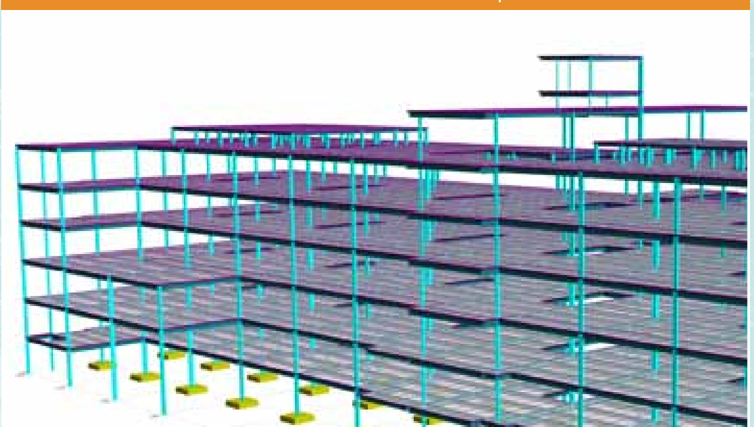
{1} BIM Standards and Data Exchange



Rebar model used to coordinate all embedded metals to ensure constructability.



Expanded Structural Model



Structural Model

BIM standards employed by the team:

From the onset of the project the entire team discussed BIM standards to ensure accuracy and quality of the model as well as sharing of the model. See below for some of the team's BIM standards used on the project:

» Data exchange criteria

» Standard file formats

» Standard file naming convention contiguous through all consultant teams

» Right of reliance allowing the team and trades to actually build from the model

» Don't over-model - to communicate effectively and take advantage of the 3D environment

» Post and upload the model file every week at a designated time to a SharePoint or FTP site for all team access

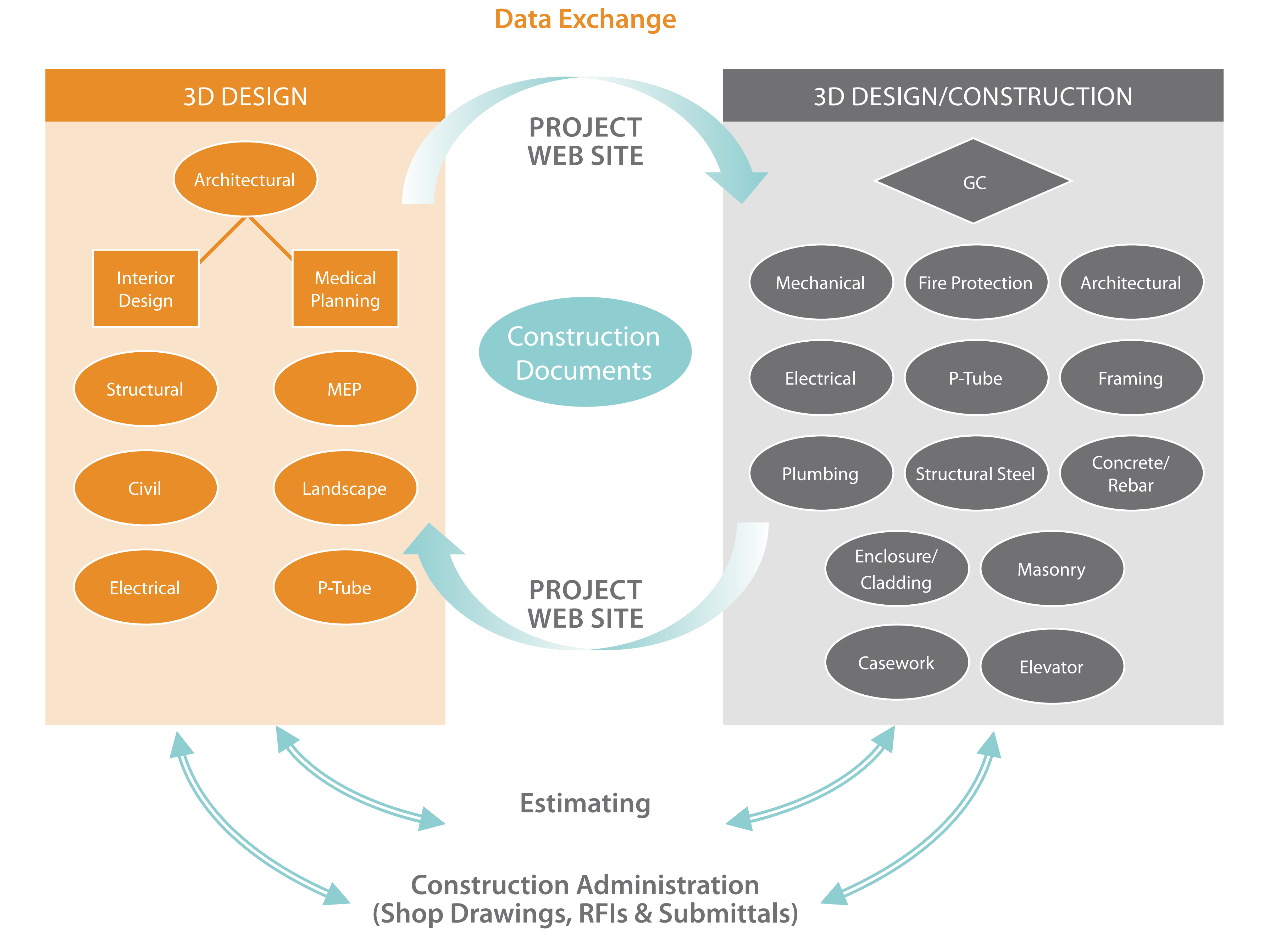
» Clearly assign model responsibilities to team members

What was needed?

» Periodic BIM meetings and communication

» Clear definitions and project standards of what should be modeled vs. detailed

» Wireless jobsite mobile computer station and plan room computer to make model accessible



Data Exchange
3D DESIGN
Architectural
Interior Design
Medical Planning
Structural
MEP
Civil
Landscape
Electrical
P-Tube
PROJECT WEB SITE
Construction Documents
PROJECT WEB SITE
3D DESIGN/CONSTRUCTION
GC
Mechanical
Fire Protection
Architectural
Electrical
P-Tube
Framing
Plumbing
Structural Steel
Concrete/ Rebar
Enclosure/ Cladding
Masonry
Casework
Elevator
Estimating
Construction Administration
(Shop Drawings, RFIs & Submittals)

2 Project Visioning/Design Progression

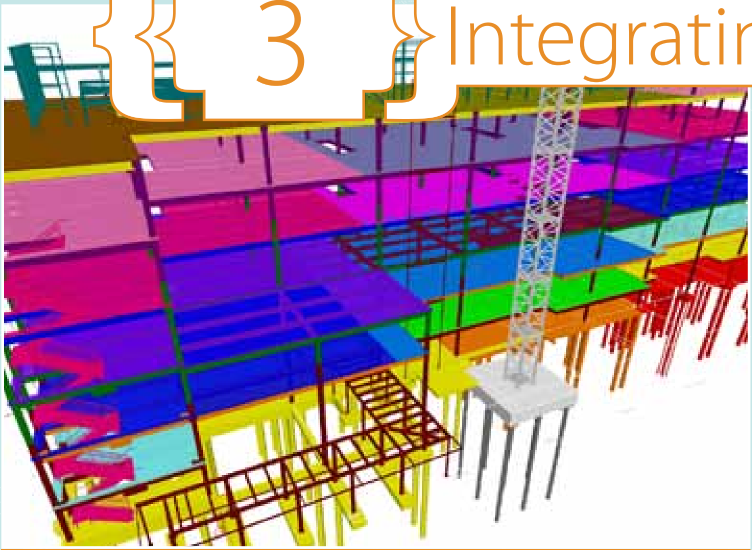
Above you can see a few examples of placements of the facility that were considered. Once the final configuration was decided, the design and model were further developed.

The team's first action was to work with the Owner and Contractor using BIM to start evaluating massing and site design options to determine the best location for the new medical tower in relation to the existing building and develop the 15 year Campus Master Plan. The key elements were to create the best adjacencies from the new hospital to the existing to make best use of the space, existing departments, minimize disruption to the existing 24 hour hospital operation and minimize construction challenges.

Actual Photo

After alternate locations for the tower were considered and a final solution/location was decided upon, the team moved forward in progressing the design and image of the building in this final location nestled into the existing facility. Models on this page illustrate the design progression and the final photo illustrates the final design.

3 Integrating MEP, Existing Facility and Structure



By using the model for structural coordination and sequencing, the team was able to improve the slab on metal deck construction efficiency and improved production resulting in the final slab on metal deck to be placed 2 ½ weeks ahead of schedule.

BIM was used to design and construct complex multi-plane structural connections supported by micropiles within inches of an operating medical vacuum system, under the existing physical therapy department and properly align and connect over 10 different corridor connections to the existing facility on three different levels.

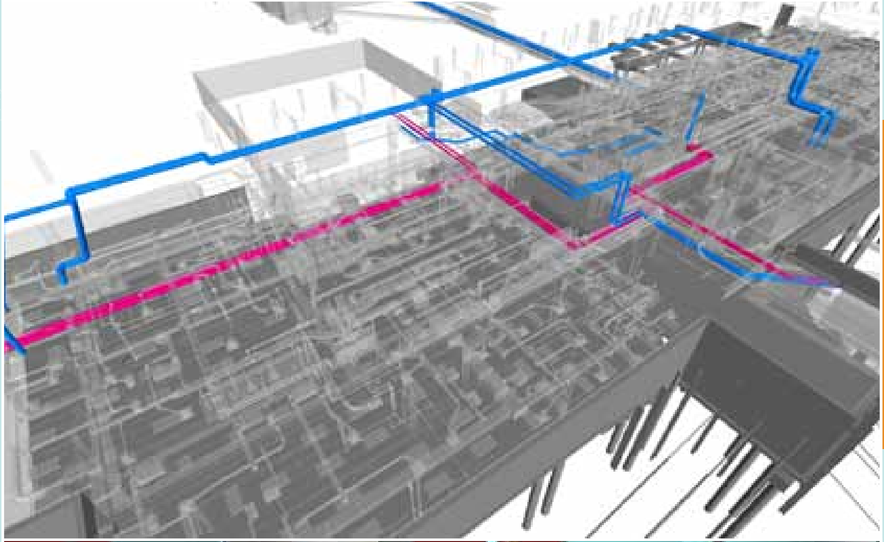
The use of the model for coordination of new and existing MEP as well as tie-in with the existing facility structure was critical due to the multitude of systems that had to be re-routed to make room for the new patient tower. Re-routed systems included: normal power, emergency power, steam, pumped condensate return, chilled water supply and return, domestic water, storm, sewer, fire sprinkler, nurse call, data, telephone, paging, distributed antenna and cable TV, all of which had to occur prior to the first shovel in the ground.

Through the use of BIM, the team was able to create a hybrid approach of exterior and interior routing, allowing many utilities to be permanently rather than temporarily re-routed, overall saving over $200,000 in lieu of a purely temporary approach. Once complete with temporary work, coordination of new building systems and tie-ins began. By modeling a standard worst-case scenario on the upper patient floor, the team was able to reduce the floor-to-floor heights from 16 feet to 15 feet 6 inches on the upper floors, saving an additional $120,000 in enclosure and structure costs.

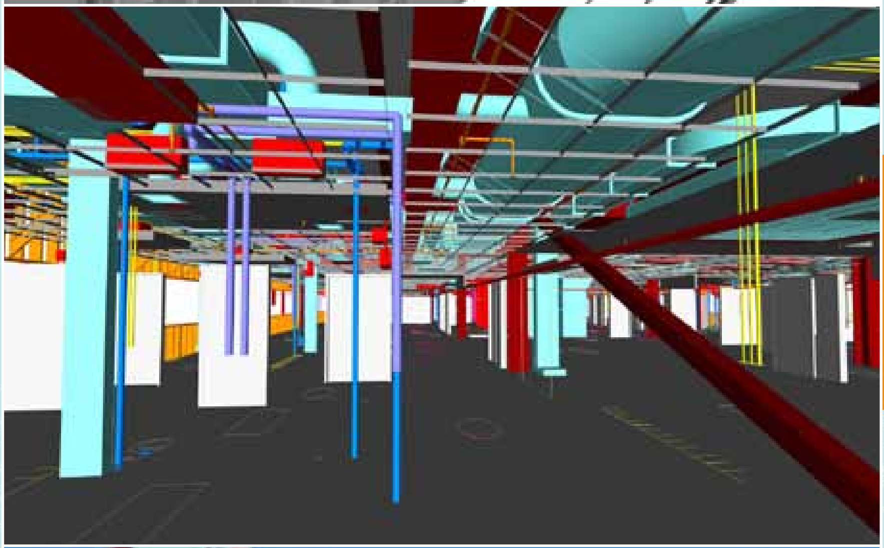
Unfortunately the floor-to-floor heights for the first two floors of the new tower were constrained to 13 feet to match the existing floor elevations, challenging the mechanical coordination efforts. The 12-inch chilled water piping that came from the new Central Utility Plant would not be able to run in the ceiling space of the ground floor due to the limited floor to floor height without dropping the ceilings to 8′-0″ and requiring nearly 30 additional offsets in the pipe. As a result, chilled water piping was re-coordinated to run across the first floor and then branched down to the ground floor. By identifying a clear path and re-routing the lines to the first floor, significant cost, schedule and design impacts were prevented. Not only did BIM aid with the MEP coordination on the project, it also aided the team in structural design and tie-in to the existing facility.

FACT:

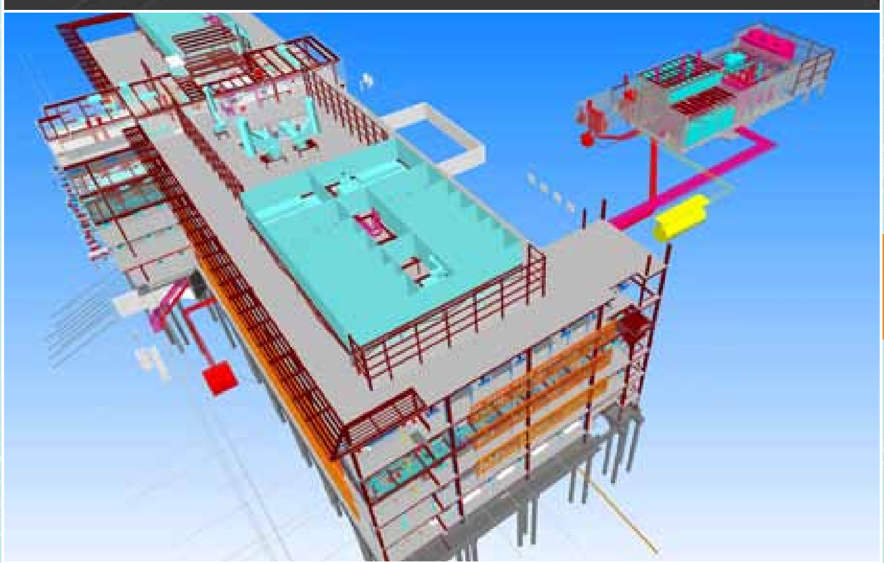
By permanently rerouting rather than temporarily rerouting MEP systems, the team was able to save ***more than $200,000.***



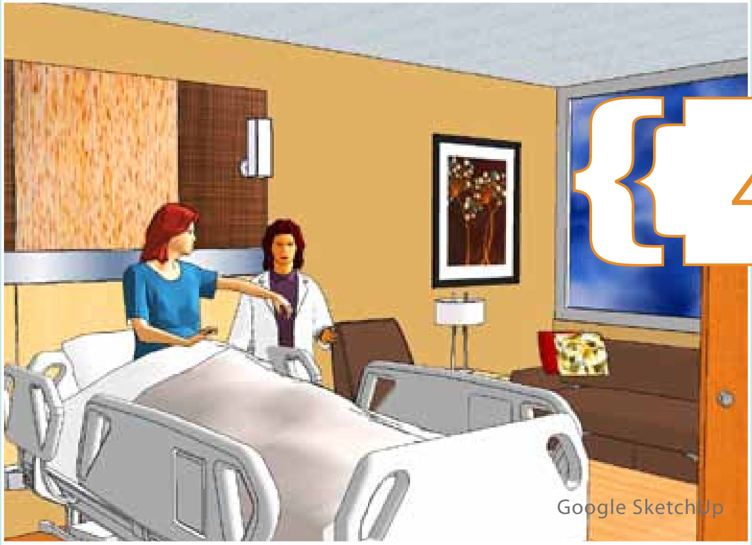
Chilled water line was originally designed to be located through the ceiling of the ground floor. Due to limited floor to ceiling height of adjacent existing facility, the 12-inch chilled water line was instead routed from the CUP and run through the ceiling of level one that has greater ceiling heights.



Overhead MEP that is repeated on levels two through five showing corridors, patient rooms, staff and nurse service areas. Ceiling grid is included in the model to ensure that elevations of MEP systems are not in conflict with ceiling heights.



Construction model of the new tower and central utility plant.


Google SketchUp


Revit Rendering


Actual Photo

4 Virtual Mock-Ups

Virtual mock-ups served as an invaluable tool to portray design options to all stakeholders and drove early Owner decision making. By starting with basic design concepts, virtual mock-ups were used to communicate several different design options which could then be narrowed down to a few that were viable and could meet the needs of the end users. After eliminating some options, the architect would incorporate comments for a next round of options which would then again be reduced to a few possibilities. This iterative process continued until the final design was agreed upon by all stakeholders. The virtual mock-up process was utilized in many different areas.

» Patient rooms

» Nurse stations

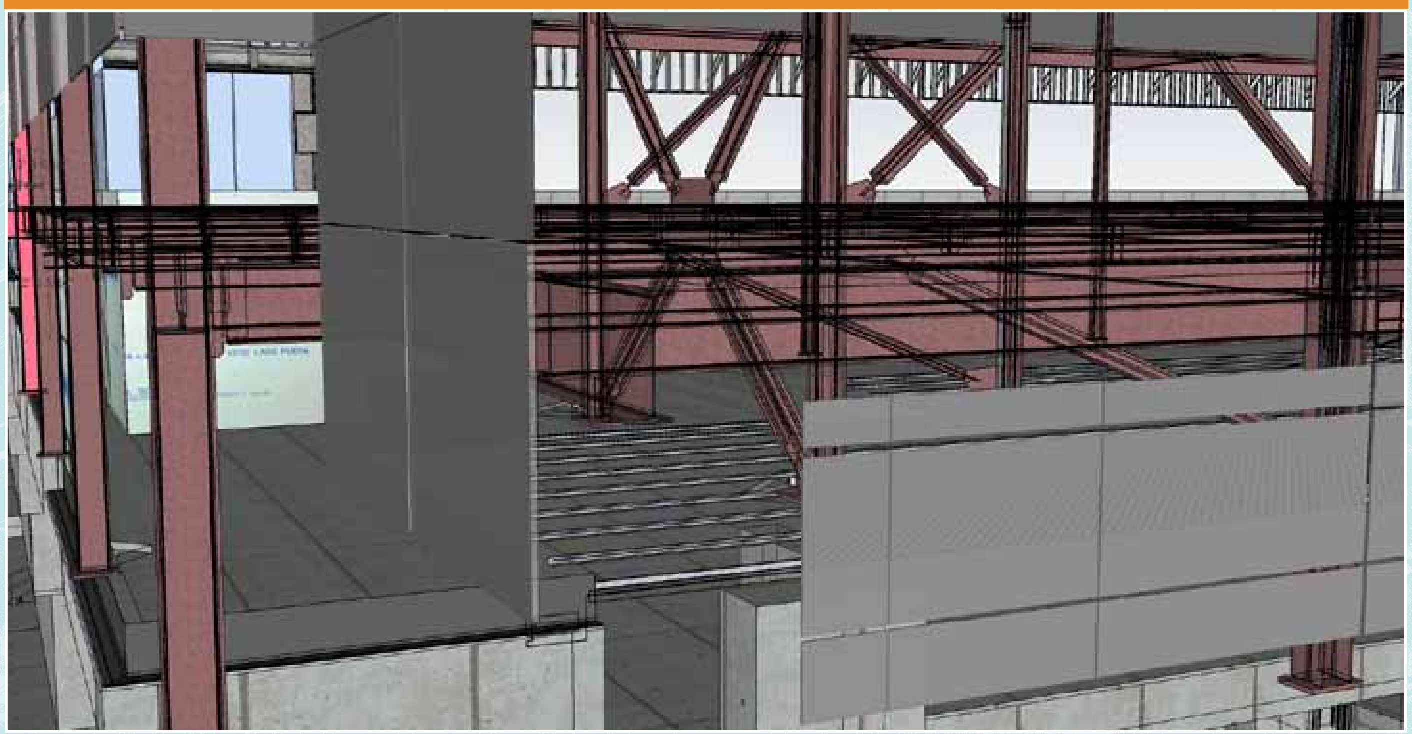
» Business center

» Lobbies

The virtual mock-up for the patient rooms was an exhaustive effort by all stakeholders to land at a design that met everyone's needs and expectations as far as accessibility, services, layout and finishes early in the design process.

Virtual mock-up showing all layers of building enclosure including exterior framing, insulation, vapor barriers, brick and curtain wall window system used to coordinate entire enclosure with the end goal of eliminating conflicts and RFIs. This model was then used with the trades for greater understanding of installation and aided in schedule certainty.

Another owner decision process that was driven by the use of virtual mock-ups was for the design of the enclosure and curtain wall system.



5 Prefabrication

CNC prefabricated head wall template.

Actual Photo: Completed CNC prefabricated headwall installed in patient room.

Patient Room Headwalls

The typical patient room headwall at CWH consists of two sets of medical gas on each side of the bed, wall sconces, outlets, and nurse call, which all extend into wood casework that sit off the wall. To maintain quality and eliminate the risk of locating boxes incorrectly in the field, we chose to prefabricate a total of 144 headwalls.

The headwall was first modeled, with all stakeholders involved, to determine the most efficient way to pipe the utilities. Then we completed a mock-up and the Owner client approved final locations for all utilities. Through this process we were able to fully coordinate standard headwalls that supported prefabrication to an accuracy within 1/8", allowing for prefabrication and all cutting by automated CNC of all headwall casework in the factory.

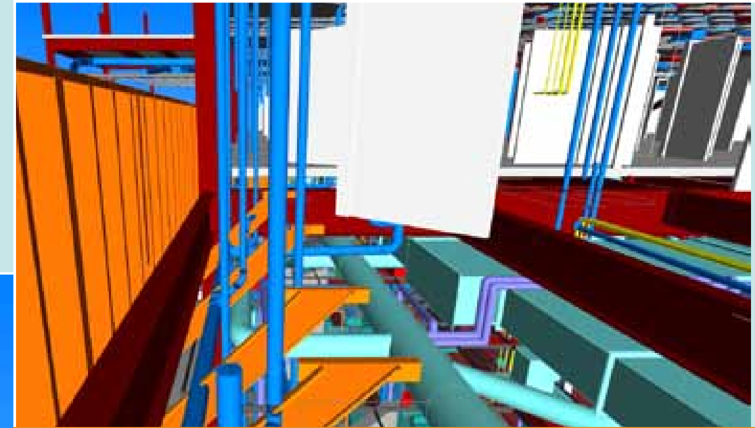
Using the model to create the layout and templates ensured exact installation and eliminated conflicts with MEP rough-in and casework installation. The model greatly reduced the time required to rough in the utilities as well as install the casework as all cut outs were complete when the headwalls arrived on site. Coordinating and prefabricating the head walls saved 18% in man hours, four weeks on interior rough-in and three weeks on casework.

By coordinating MEP systems for the headwalls through the ceilings of the patient rooms rather than down the main corridors, this routing resulted in shorter drops and runs to the headwall, left the corridor ceilings open and allowed for ease of MEP installation.

Enclosure

Through coordination by the team to incorporate the exterior framing and enclosure of the new tower into the model we were able to collaborate with the exterior framing subcontractor to prefabricate the enclosure system off site. The exterior wall panels had four, six-inch kickers on each 20-foot panel. By incorporating the panels and kickers into the model, the team was able to eliminate conflicts between the kickers and the mechanical exhaust duct and plumbing by adjusting the location of 35% of the kickers and making them only four inches rather than the full six inches. Had these systems not been modeled, this conflict alone could have caused a delay of two weeks to the schedule. **Overall, prefabricating exterior framing saved six weeks on the exterior framing schedule.**

Coordination of building enclosure saved the team six weeks on the exterior framing schedule.



This image above shows how the enclosure braces conflicted with the original MEP configuration. MEP systems and enclosure were further avoided to avoid conflicts at time of install.

Prefabricated enclosure panels with waterproofing membrane ready for installation.

Enclosure panels installed on building.

By including the building envelope and all MEP systems in the model, it was possible to prefabricate the enclosure of the building. The orange panels shown above are a portion of the enclosure sytem.

6 Model in the Field

Given the value and successes that our project team was experiencing through the use of the model during design and in the jobsite offices, it became evident that getting the model and construction documents into the field to be used by the tradespeople actually building the project would likely result in greater success.

Wireless Jobsite and Mobile Computer Station

In order to make the jobsite a source of up-to-date project information, the team created wireless access points in the field and created a mobile computer station available to all trades as a reference tool to the model and electronically linked documents. This tool saved countless hours on the job team members and craft workers did not need to go back and forth from the job site to the trailer to access the information. For example, lift drawings could be printed at the mobile computer station right in the field.

The photos shown to the left demonstrate the wireless connectivity to the field, allowing all trades to build from the model.

In-wall Inspections

Tablet computers containing the model, were utilized in the field to plan out sequencing of the trades and to ensure systems were installed correctly. As conflicts arose, the model was reviewed on the tablet to find which system was not coordinated. Prior to installation of ceiling tiles or hanging drywall, the model was used for final inspection. Utilizing this system improved the quality of the finished product and increased the productivity of the crews.

Punchlist

The tablet computer with the model was also used to create the punchlist. It also allowed the team to resolve any questions or disputes that arose. For example, if there was a question on the location or color of a fixture, it was possible to reference the drawing or submittal on the tablet to confirm. The model was also available when needed to confirm mechanical or electrical routing above ceiling or in the walls. This ability to access the model and documents right on the tablet eliminated the time to verify punchlist items per design. Collaborating with the Architect to create the punchlist in the field reduced the time that would been spent inputting the list afterwards.

QUOTE:

The Architect said, "Because of the model, tolerances were better and resulted in fewer punchlist items".

Engineers used tablet computers for field inspections.

Engineers used tablet computers for verification in the model during punchlist walk with the architect.

{7} Enhancing Facility Management

Facilities maintenance engineers using the smart board.

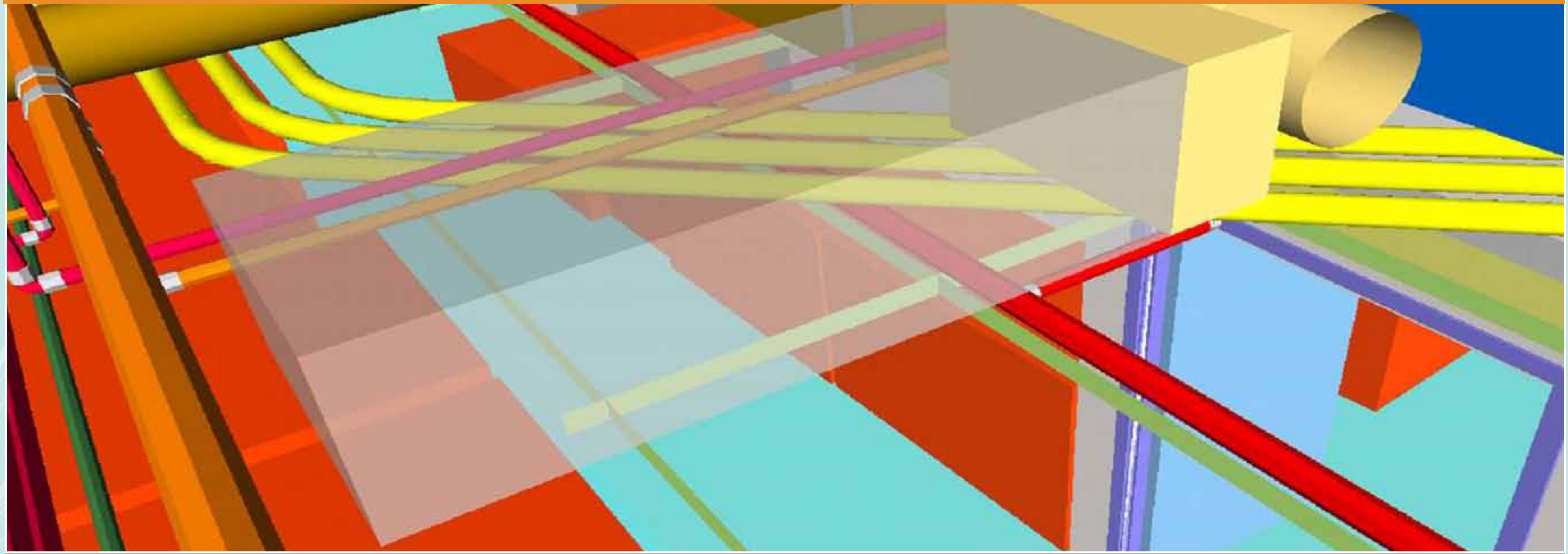
The use of BIM continued long past construction as the hospital transferred to sustainable operation. After witnessing the success and unmatched value of the model throughout the design and construction process, a touch screen computer like the one used in the construction trailer was setup for the Owner's facilities management team. The touch screen includes the model, linked electronic documents, photos, O&M manuals, shop drawings and training information. These tools have accelerated the learning curve of the facilities management engineers and have provided a reference similar to having the construction team on site as the facilities management team adjusts to managing the "nuts-and-bolts" of the new facility and systems.

The facility engineers and maintenance staff have already experienced the following benefits as a direct result of the model:

- Looking into not only complex MEP issues and locations but also simple casework and accessory adjustments.
- Easily assessing the impact of maintenance, changes, and shut-downs by coupling the model with the electronic, linked documents, loaded with pictures of in-wall MEP and systems.
- By coordinating all systems in the model and creating blocked out masses representing the access space needed for VAV, j-boxes, fire and smoke dampers, etc., facilities engineers are ensured easy access as maintenance or repairs are required.
- The touchscreen and smartboard in the facilities management office provides a way for the facilities engineers to complete training on their new building and systems.

Photos shown to the left: Hospital facility engineers are able to use the touch screen computer to access the as-built model, electronic documents, in-wall photos, electronic O&Ms and shop drawings.

In order to provide ample access to VAV boxes, J-boxes, fire dampers and smoke dampers for operational maintenance and repair, space was blocked out in the model as shown above.



QUOTE:

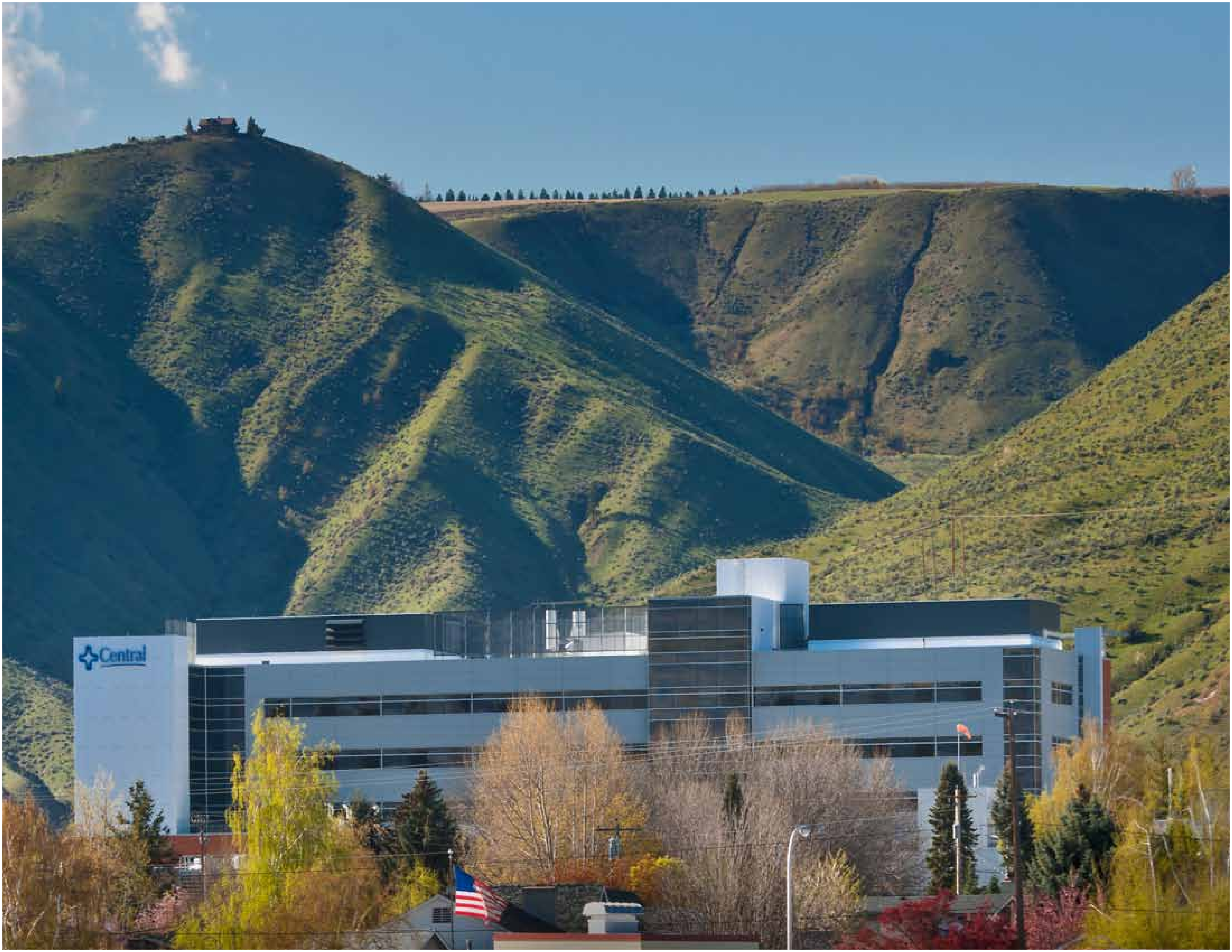
I would highly recommend this project team to any health care facility and owner as they understand our objectives in delivery of patient care and they bring a new level to the process with innovative thinking, excellent planning and outstanding execution to the construction process.

- Owner, Central Washington Hospital

How Did We Do It?

In the process of building this world class, 200,000-square-foot medical center with 151 patient beds, **we were able to complete the project 10 weeks early and save the owner $7 million with 50% fewer RFIs.** How did we do it?

1. Created an integrated project environment of collaboration between the Architect, Owner and Contractor
2. Shared the model with the entire team from the onset of the project
3. Used the model to explore options in order to determine the most efficient site plan with the best adjacencies related to the existing building
4. Utilized BIM to determine the best way to integrate the new 200,000-square-foot building and associated systems into existing facilities, structures and systems with the best adjacencies
5. Created virtual mockups of the building enclosure, patient rooms, architectural finishes, nurse stations and lobbies to allow the team to understand design intent, make decisions and procure in more timely manner
6. Subcontractors added design details to model for enhancement
7. Aimed to increase efficiencies and save costs by going paperless with our use of the model, linked with electronic documents, use of the smart board, mobile computer stations and tablets in the field
8. Made the model accessible in the field by a wireless jobsite, a mobile computer station and tablet computers
9. Created a touch screen computer for Facilities Management containing the model with linked documents, O&Ms, as-builts and shop drawings
10. Embedded pictures in the model so that facilities can refer to a specific wall in the model and also click the link to the photo of that wall prior to drywall being hung


Central