SUTTER MEDICAL CENTER CASTRO VALLEY

Early Results from Sutter's $320M Hospital Replacement Project in Castro Valley

<u>Project Description</u>

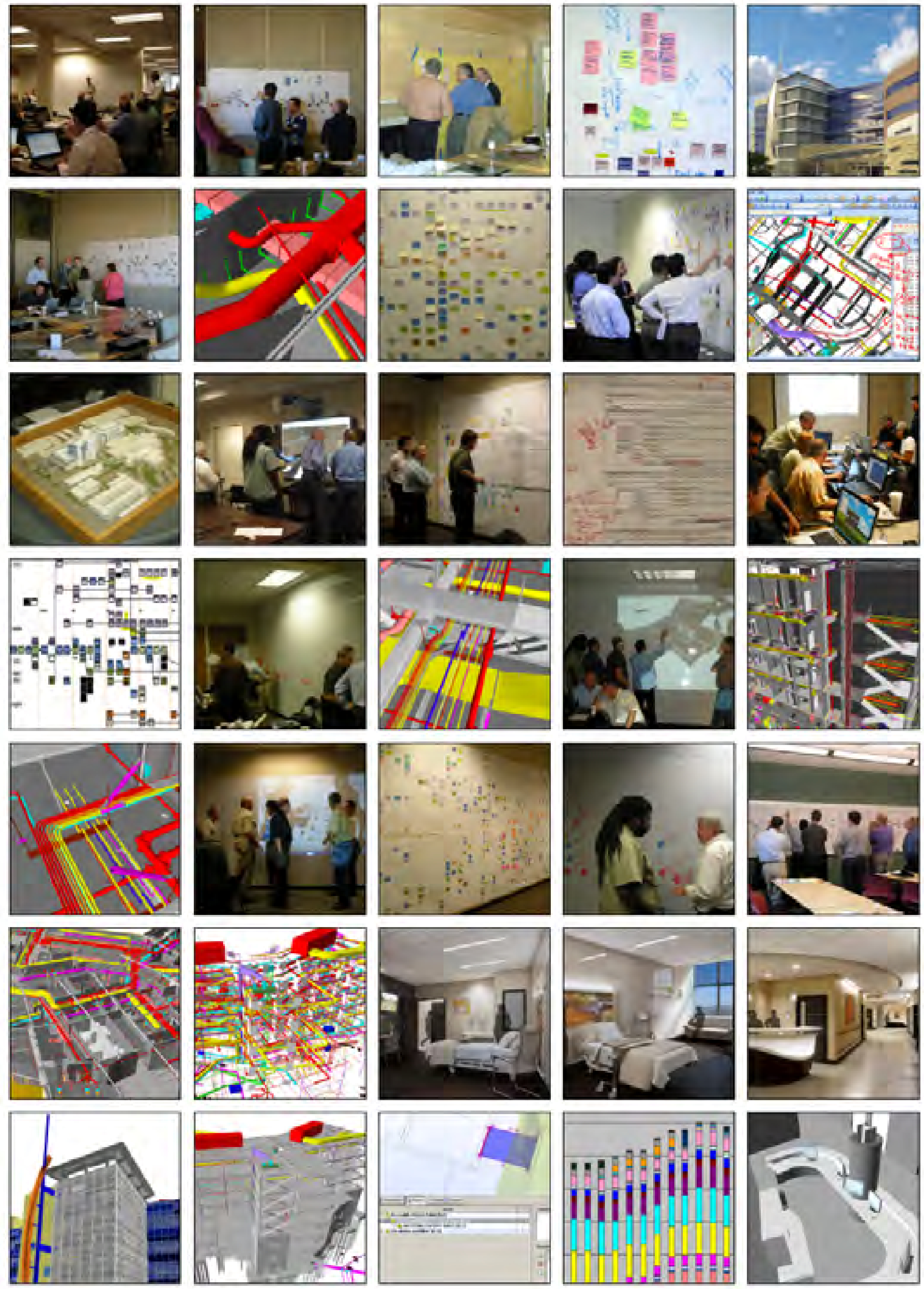
An Integrated Project Delivery (IPD) team including the owner, architect, design consultants, and trade partners is challenged with designing and delivering a new 130-bed, $320 million hospital project for Sutter Health in Castro Valley, California. The hospital, when completed, will be one of the first for Sutter Health to feature a new highly efficient model for clinical care centered around the patient. The IPD team includes the following core members:

-Sutter Health: Owner
- Devenney Group Ltd.: Architect
- DPR Construction: General Contractor
- Capital Engineering Consultants Inc: Mechanical Engineer
- The Engineering Enterprise: Electrical Engineer
- Superior Air Handling Co.: Mechanical Trade Partner
- J.W Mclenahan: Plumbing Trade Partner
- Morrow Meadows: Electrical Trade Partner
- Transbay Fire Protection: Fire Protection Trade Partner
- TMAD – Taylor and Gains: Structural Engineer
- GHAFARI Associates: Lean and VDC Project Integrator.

<u>Contract Method: Sutter's Integrated Form of Agreement (IFOA).</u>

The project utilizes for the first time a 10 party IFOA where the owner, the architect, the GC, key design consultants, key trade partners, and the Lean/VDC consultant are all co-signatories of the agreement and members of the core team. In previous versions of the IFOA the owner, the architect and the general contractor signed the agreement to form the core team. The IFOA requires the team to work collaboratively, use 3D BIM technologies, and to implement lean practices to drive waste from the delivery system. The IFOA signatories share risk or savings if the project is delivered above or below its target cost.

<u>Key Project Goal:</u> Design and deliver a facility of the highest quality, at least 30% faster, and for no more than the target cost. Since the total project budget cannot be exceeded, it is driving the team to implement strategies for increasing certainty and reducing risk as they transition from design to construction.



KEY PROJECT CHALLENGES

Site: The project site is very challenging, with a steep grade and limited space for the activity of construction. In addition, the existing hospital must remain fully operational during the construction of the new hospital.

Schedule: The current legislative requirement to comply with new seismic safety standards in California creates new challenges for design and construction. The project team is working to meet fixed deadlines for design, permitting, and construction in order to satisfy those new codes. As a result, the hospital must be designed and built at least 30% faster than comparable projects in California have been completed in the past.

Budget: The budget for the new hospital is set to a fixed target of $320 million. The team must design and build a state of the art facility with an aggressive schedule and a very challenging site within this cost target. Under no circumstances is the target cost to be exceeded.

Phased Plan Review (Permit Process): The project is one of the first to use OSHPD's phased reviews to accelerate the permitting process. Typically in California hospitals take over 24 months in OSHPD reviews after the completion of the design documents. Using the phased plan review process, the team was able to deliver the complete structural package on time at the end of 2008 and is on target to receive a construction permit six months later to start construction. This amounts to almost a 12 month acceleration of the start date of construction. In order to deliver a highly coordinated and complete structural package, the team completely revised the traditional design workflow of schematic, design development, detailed design approach and created a new delivery approach that supported intense early 3D model-based design coordination that aimed at minimizing the risk of downstream changes.

TOOLS, PROCESSES, AND IMPLEMENTATION STRATEGIES

The team identified a number of strategies to achieve the project objectives. Notable among them:

1. PROJECT AS LABORATORY: to create opportunities to assess various evolving tools and technologies quickly and adopt what is appropriate to meet project goals. (Examples: Model based estimating, and automated code checking.)

2. UNDERSTAND THE PROCESS: before starting design, the team will allocate adequate time to plan the design process. The `team used Value Stream Mapping, a lean tool, to map their workflow steps at appropriate levels of detail to have meaningful cross discipline discussions to identify value added steps and reduce rework loops.

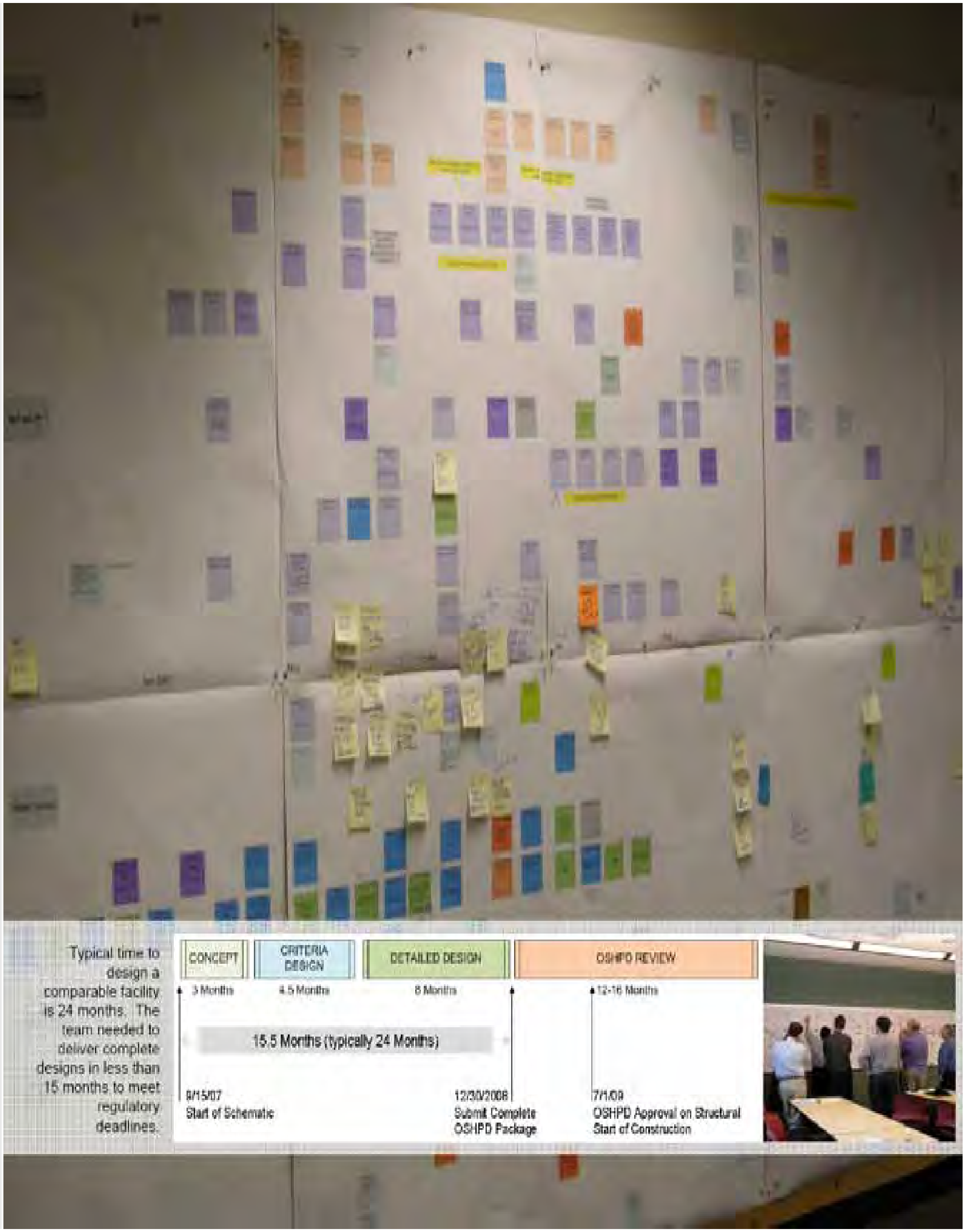
3. MANAGE BY COMMITMENTS: once flow of value is understood (via value stream mapping) members of the team make commitments to each other to complete the released activities and remove constraints to release downstream activities.

4. OFFSITE FABRICATION AND PREASSEMBLY: designers work with the trade partners to make design decisions that lead to increased use of offsite fabrication and pre-assembly.

5. BUILDING INFORMATION MODELING: the IPD team will use BIM to the extent possible to coordinate constantly, share information, and increase the reliability and certainty in the design so it can be directly used for fabrication and pre-assembly.

6. DIRECT DIGITAL EXCHANGE: information will be reused rather than recreated to the extent possible (Examples: model based estimating, detailing, coordination, automated fabrication, and scheduling).

7. REAL-TIME ACCESS TO INFORMATION: all team members will be able to access the most recent project information at any time and regardless of where this information is created or stored.



THE BIG ROOM CONCEPT

The project team is distributed in various cities including Sacramento, Pasadena, Redwood City, Utah, Phoenix, Dearborn, among others. As a result, strategies needed to be developed for collocation (a big room) without having to relocate the entire team into one location for an extended period of time which is impractical given that there are over 240 people working on the project.

Currently, the entire team collocates in the big room once every two weeks for 3 days to review the design, assess the design schedule, value stream map the workflow, and update the project budget. The MEP team meets in the big room at least twice weekly for their detailed and 3D-model based design coordination.

It is interesting to note that at the start of the project the team had to work hard to move away from conventional compartmentalized concepts for the layout of the big room (see original big room concept sketches, lower left) and to recognize that we needed to let the ideal layout emerge as we started to use the space.

<u>Key Findings/Conclusions for Big Rooms:</u>

-Not everyone needs to be at the big room meeting all the time but when team members are not present, we seem to need them the most.

- Large configurable meeting space to allow 30+ people to work comfortably.

- Space for planning the process (a big wall) with enough room for 30+ people to stand and work)

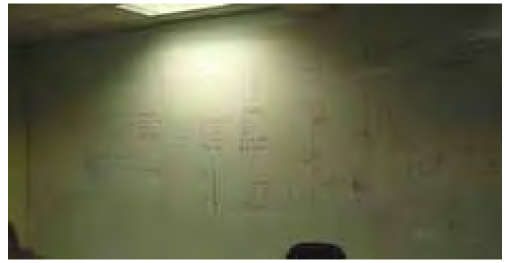
-Space for planning the design (wall sized marker board) that can be used for both planning and sketching design ideas.

-Smartboard (s) – two or more to project the 3D model, plans, schedule, and be able to share them remotely with other team members.

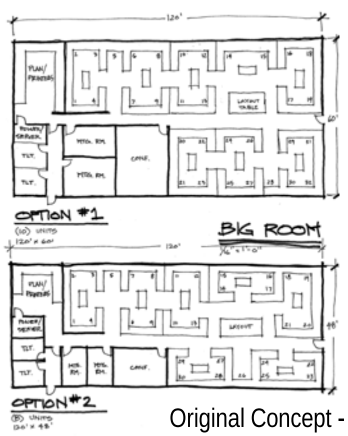
-Planning tables so small teams can focus on refining their plans.

-Small team meeting rooms.

Permanent marker board (wall to wall)



Smart Board



Original Concept - abandoned

Planning Tables

KEY SUCCESSES AND LESSONS LEARNED

Design not only the facility but also the processes of the design

Tools:

Value Stream Mapping is a tool for documenting all the steps in the workflow that add value to the final deliverable from the perspective of the customer. The team as they create the map discuss their understanding of the design, their own work, and how their work connects to the work of others on the team. The team negotiates what they need to produce and at what level of detail so that downstream work can proceed with more certainty. The plan is reviewed on a regular basis. As more information becomes available and as the design evolves, the plan also evolves: new tasks are added, existing tasks are made more specific, and tasks that no longer add value are eliminated.

Navisworks is a tool for multi-discipline design reviews that allows the entire team to participate and review all the current design information as it is created and regardless of its authoring application. The entire team meets at least once a week to review the design using the 3D model. In addition, the MEP team meets at least twice a week to do full MEP coordination/clash detection using the 3D model. During the model review multi-discipline design issues are identified, discussed, resolved, or added to the plan depending on the type and complexity of the issues.

Successes. With time, the team is becoming more effective at identifying and solving problems that would normally have been addressed only during the construction phase. In recent weeks, the team was able to conduct very detailed room-by-room reviews using only the 3D model, clarifying the design and resolving many detailed design issues.

Challenges. Most teams are accustomed to receiving drawings in order to review the design at key milestones. Adjusting to a model-based and more frequent multi-discipline design review process was not an easy transition to many team members initially.

KEY SUCCESSES AND LESSONS LEARNED

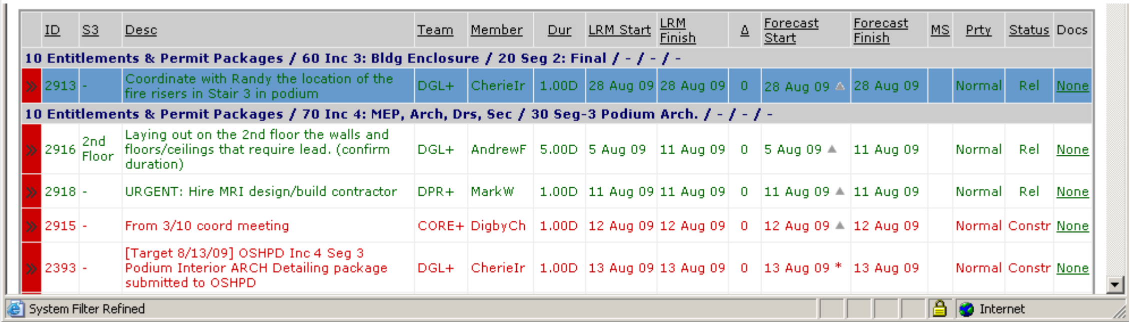
Managing by Commitments

Rather than managing the project by tracking high level milestones, this project is managed at the task level based on the plan emerging from the value stream mapping process. Tasks are assigned to milestones and if their forecast start date starts affecting the due date for the milestone, the team must re-plan the work to get back on track.

The team meets regularity and only works on tasks that have no constraints in front of them and completes as many of those tasks as possible before the next planning cycle. At each planning meeting team members make public commitments that they will complete their specific tasks before the next meeting. If they are missing information, they will negotiate with other team members to remove those constraints so that they can complete their work. At the next planning meeting each team member will update the status of their committed tasks. If a task is not complete, the responsible team member must provide a root cause for why the work could not be completed – this typically uncovers new constraints. Following this process, the team only produces what is required and will move with more certainty towards completing the deliverables.

<u>Tools</u>: After evaluating various commitment based tools to support the design process, SPS|Production Manager was selected. The software, originally developed as a commitment management system for construction, lacked the visual aids and flexibility to allow the team to visualize the links between tasks. Those features were later added in partnership with the software developer and continue to be developed as the project progresses.

<u>Challenges:</u> The most difficult part of planning design at the task level is that designers are not accustomed to planning their work at this level of detail and frequency. Design activities typically have very long durations. The team relies on gate reviews (e.g., at SD, DD, CD, and construction side coordination) to identify missing information and make corrections even through construction. Trying to plan design so that it can proceed with more iteration up front and less rework towards the end of the process can seem counter intuitive at first.



ID	S3	Desc	Team	Member	Dur	LRM Start	LRM Finish	Δ	Forecast Start	Forecast Finish	MS	Prty	Status	Docs
10 Entitlements & Permit Packages / 60 Inc 3: Bldg Enclosure / 20 Seg 2: Final / - / - / -														
2913	-	Coordinate with Randy the location of the fire risers in Stair 3 in podium	DGL+	CherieIr	1.00D	28 Aug 09	28 Aug 09	0	28 Aug 09	28 Aug 09		Normal	Rel	None
10 Entitlements & Permit Packages / 70 Inc 4: MEP, Arch, Drs, Sec / 30 Seg-3 Podium Arch. / - / - / -														
2916	2nd Floor	Laying out on the 2nd floor the walls and floors/ceilings that require lead. (confirm duration)	DGL+	AndrewF	5.00D	5 Aug 09	11 Aug 09	0	5 Aug 09	11 Aug 09		Normal	Rel	None
2918	-	URGENT: Hire MRI design/build contractor	DPR+	MarkW	1.00D	11 Aug 09	11 Aug 09	0	11 Aug 09	11 Aug 09		Normal	Rel	None
2915	-	From 3/10 coord meeting	CORE+	DigbyCh	1.00D	12 Aug 09	12 Aug 09	0	12 Aug 09	12 Aug 09		Normal	Constr	None
2393	-	[Target 8/13/09] OSHPD Inc 4 Seg 3 Podium Interior ARCH Detailing package submitted to OSHPD	DGL+	CherieIr	1.00D	13 Aug 09	13 Aug 09	0	13 Aug 09 *	13 Aug 09		Normal	Constr	None

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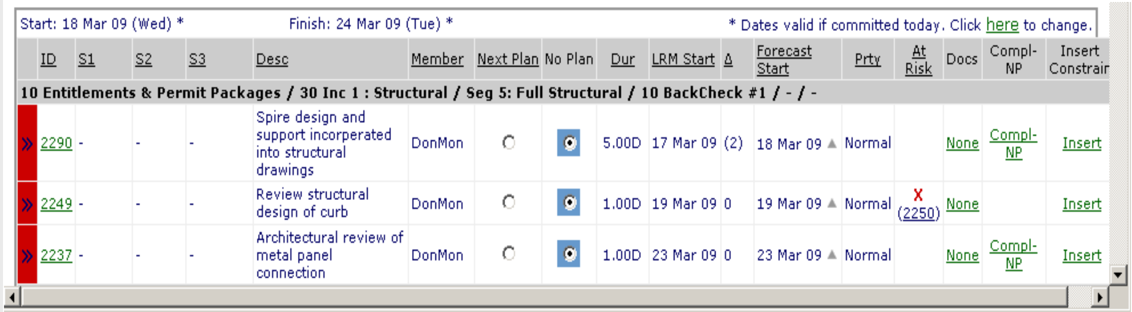


Start: 18 Mar 09 (Wed) *   Finish: 24 Mar 09 (Tue) *   * Dates valid if committed today. Click here to change.

ID	S1	S2	S3	Desc	Member	Next Plan	No Plan	Dur	LRM Start	Δ	Forecast Start	Prty	At Risk	Docs	Compl-NP	Insert Constrair
10 Entitlements & Permit Packages / 30 Inc 1 : Structural / Seg 5: Full Structural / 10 BackCheck #1 / - / -																
2290	-	-	-	Spire design and support incorperated into structural drawings	DonMon			5.00D	17 Mar 09	(2)	18 Mar 09	Normal		None	Compl-NP	Insert
2249	-	-	-	Review structural design of curb	DonMon			1.00D	19 Mar 09	0	19 Mar 09	Normal	X (2250)	None		Insert
2237	-	-	-	Architectural review of metal panel connection	DonMon			1.00D	23 Mar 09	0	23 Mar 09	Normal		None	Compl-NP	Insert

Evolution of the SPS|Production Manager interface from a simple task list based interface (above) to a more flexible planning tool for visualize workflow (right). The same tasks in the value stream view are displayed to the team as a task list at each planning meeting to make and update commitments.

KEY SUCCESSES AND LESSONS LEARNED

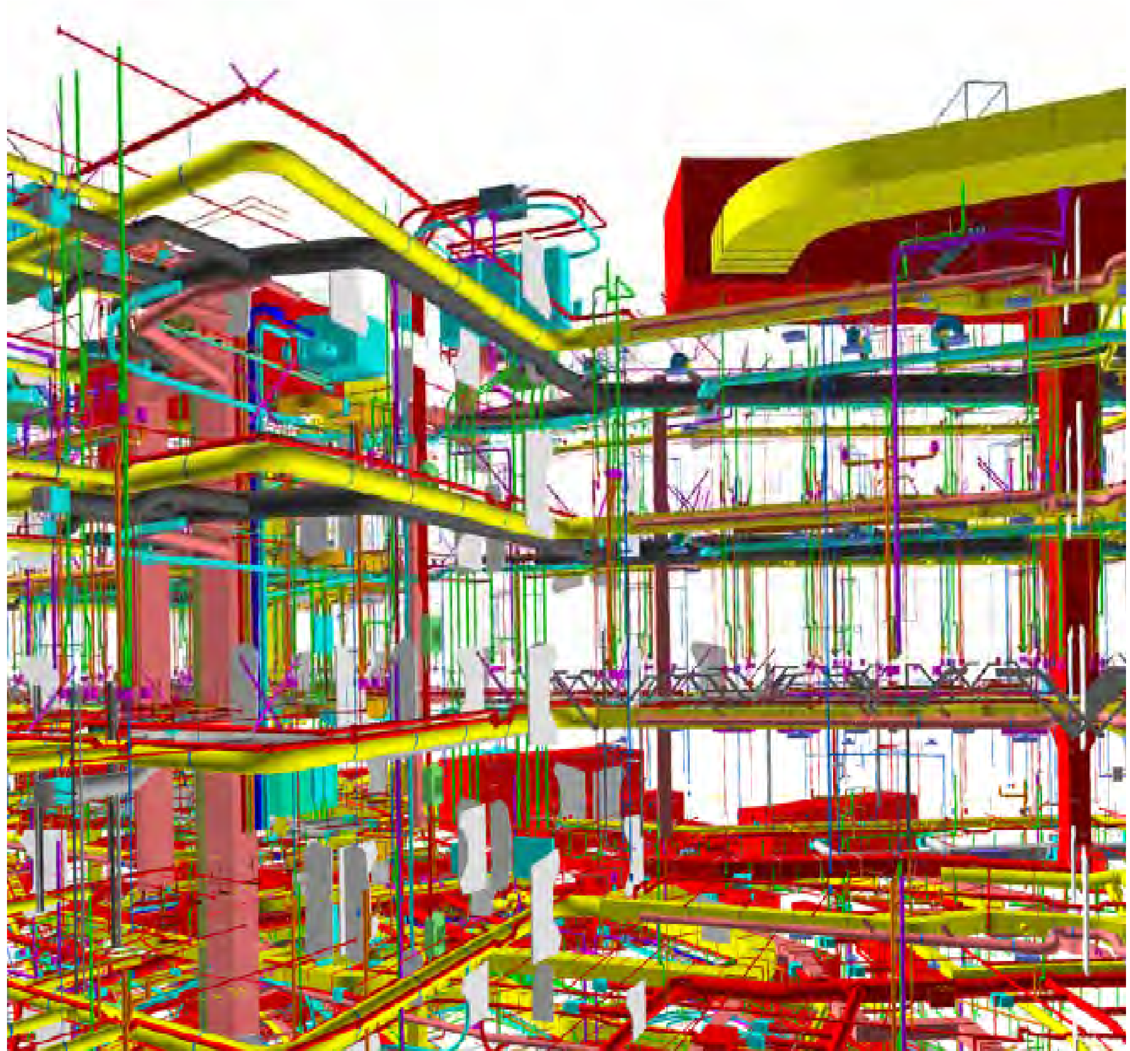
Building Information Modeling

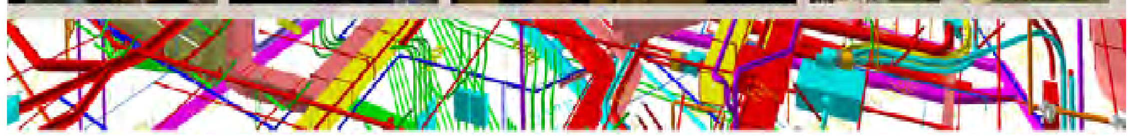
The team is working towards workflows that will facilitate direct digital exchange and design to fabrication without having to recreate the information generated in the design models during construction. There is no pre determined criteria for what should be included in the model and at what levels of detail. The team continuously evaluates the design and adds new systems to the model if the team determines that those systems are required to increase certainty.

Various software 3D tools are being used including: Revit, CAD Duct, CAD Pipe, Autocad Civil 3D, Autocad MEP, CAD Sprink, XSteel, among others.

The following facility systems/components are included in the model:

1. Building interior
2. Building exterior, curtain wall and pre-cast.
3. Stairs and elevators
4. Structural steel and concrete.
5. Slabs and slab openings.
6. All mechanical and plumbing systems
7. All electrical systems including conduit.
8. Fire protection.
9. IT and low voltage systems.
10. Nurse call systems.
11. Furniture.
12. Fixed medical equipment.
13. Rebar detailing
14. Foundations
15. All underground utilities
16. Civil site.
17. All seismic restraints.
18. Drywall





KEY SUCCESSES AND LESSONS LEARNED

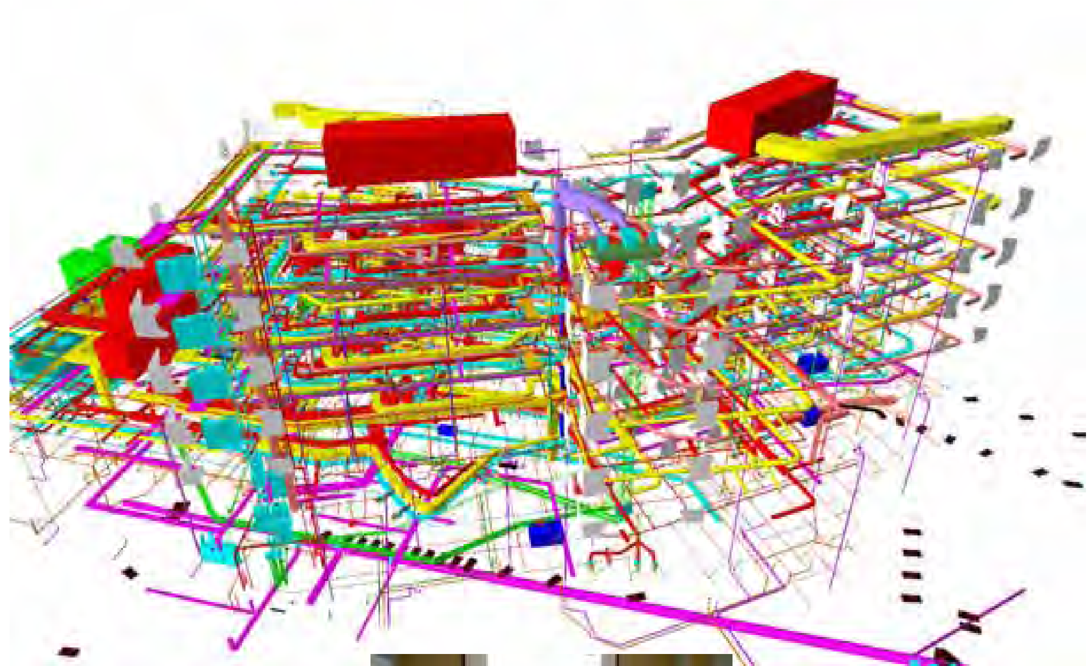
Direct Digital Exchange for M/P

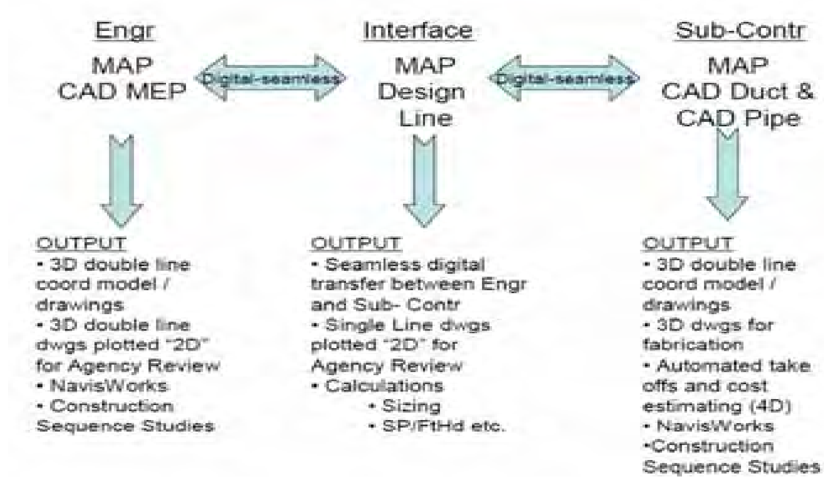
The Mechanical/Plumbing team set an aggressive goal for themselves to design, detail, estimate, coordinate, and fabricate their systems using the 3D model with as little use of 2D drawings as possible.

The design team and the trade partners used the same software from TSI to design and detail the M/P components. This software has two modules: one for use during design called Design Line and the other typically used by the detailers called CAD Duct for sheet metal & CAD Pipe for plumbing detailing and fabrication. This created an opportunity for using a complete digital and model based workflow from design to fabrication. However, there were no successful precedents to learn from.

Determined to get as close as possible to the ideal state for this model based workflow, key members of the design team and the detailing team collocated for almost an entire week at the offices of TSI, the software vendor, in Austin, Texas. The team collaborated with TSI's technical team to align the setups, software libraries, and configuration options so that the design models could be directly imported and edited by the detailers and then converted back to simplified design models. The goal was to use the best features of the design modules to do early routing and calculations, then have the detailers immediately apply fabrication logic to the route. After coordination is complete, the design team would then incorporate the same models into the final drawings without having to recreate models or drawings.

The next challenge for the M/P team is to implement automated quantity takeoffs and automated estimating to the extent possible as it is ironic that while the team is trusting the 3D model to drive automated fabrication, the quantity take off process continues to be done manually or in other systems. There are software limitations that the team is working to resolve with TSI in addition to changing the traditional mindset that this is how estimating is typically conducted.





KEY SUCCESSES AND LESSONS LEARNED

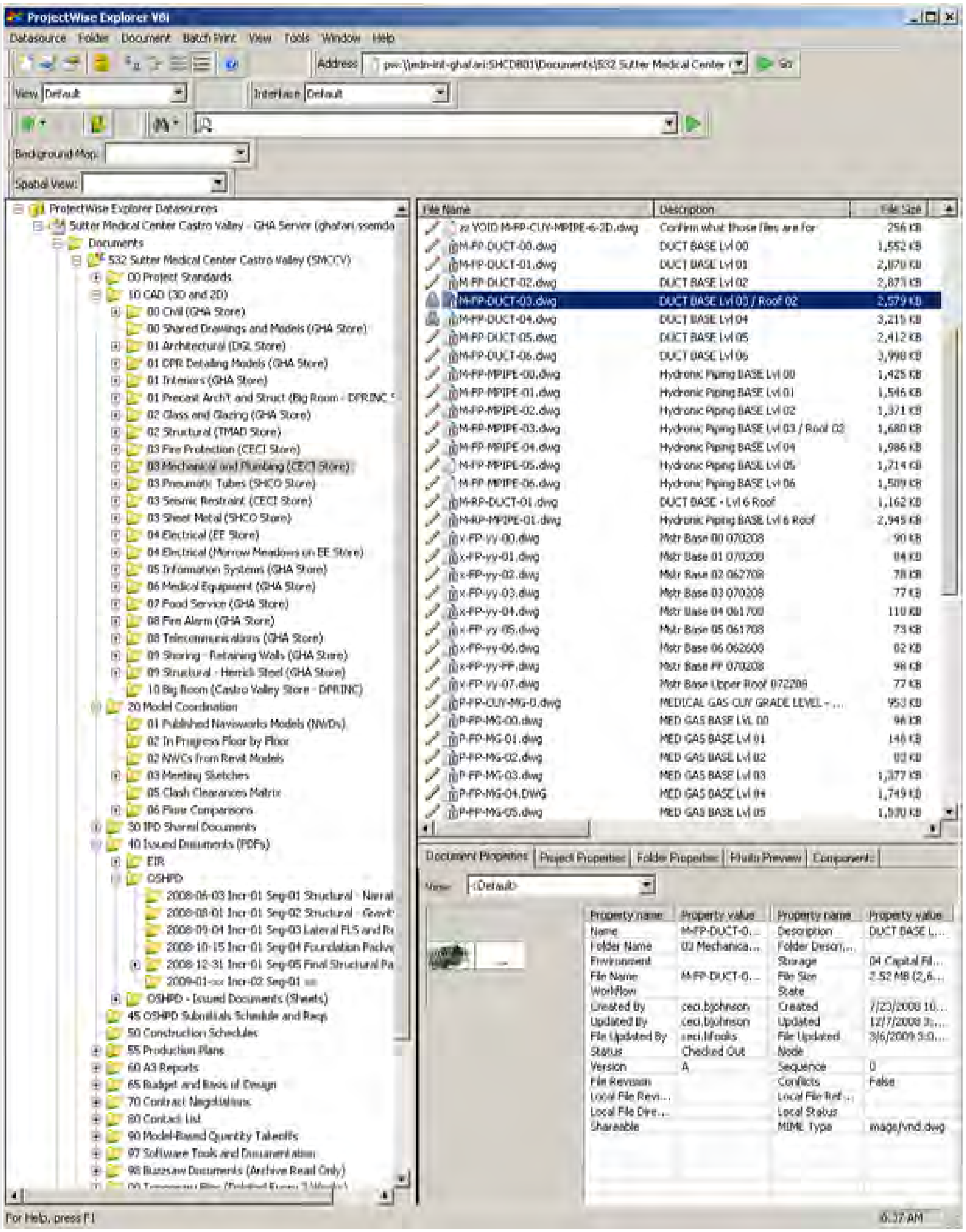
Immediate, Controlled, and Continuous access to all Project Information

Given that the key team members are working from various locations, it became very important from the beginning to make it possible for the team to have full and real time access to all project information and models regardless of location.

Portal solutions where models and files are worked on locally and then a copy is uploaded to a shared site so that other team members can download do not promote close collaboration. In addition, cross office VPN solutions are not practical. Therefore, the team is currently using ProjectWise from Bentley Systems which is a distributed client/server document control system that allows each team to keep their files stored locally on their server yet provide direct and controlled access to those same files to all other team members. By strategically locating ProjectWise Caching servers at the various offices, the system automatically synchronizes those files across the network so that any team member can have the exact same view of the project files regardless from the location they access those files.

For shared project documents (especially CAD files), each team member who needs to modify a file will check out the file to work on it then check it back in when work is complete so that it is immediately available to all other team members who need the changes. The system manages the references between files and insures that when a team member views or works on a file that they receive the most up to date copies of the file and its references regardless where those files are stored on the network, transferring only the changes made to those files to optimize download times.

Currently there are over 14,000 files and over 21GB of data that is distributed on the various servers and accessible from any location to all team members.



KEY SUCCESSES AND LESSONS LEARNED

BIM and Interoperability Challenges

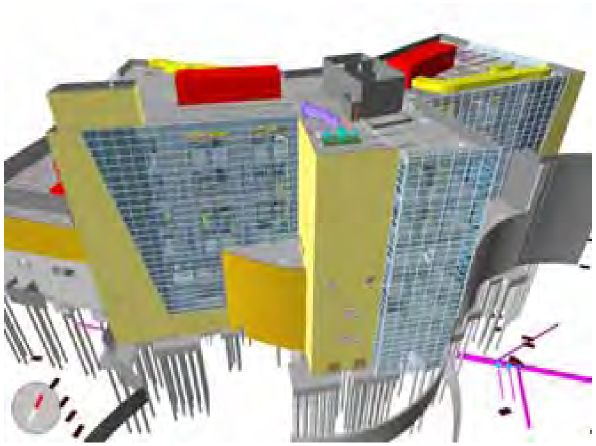
The goal for use of BIM on the project is to implement workflows that will allow seamless transition from design, to detailing, to fabrication. Unfortunately, many of the mainstream 3D BIM systems are not designed to support the level of detail required to for this workflow nor the complexity of the resulting cross discipline detailed design models.

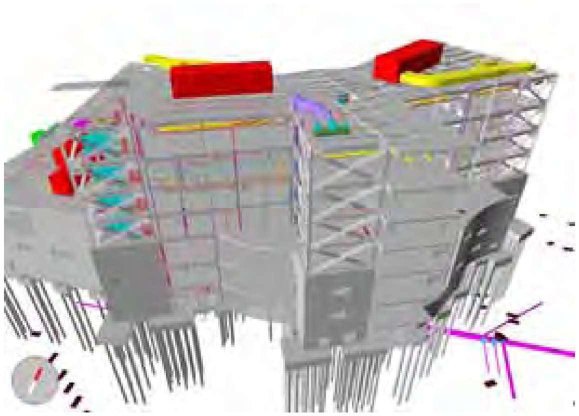
As the architectural model size continued to increase for example, the design team had to split their Revit model first into an exterior model and an interior model and then the interiors model had to be split into three other models. The team had to think hard about strategies for model creation and maintenance so that they can continue to add the detail required by other disciplines for accurate coordination.

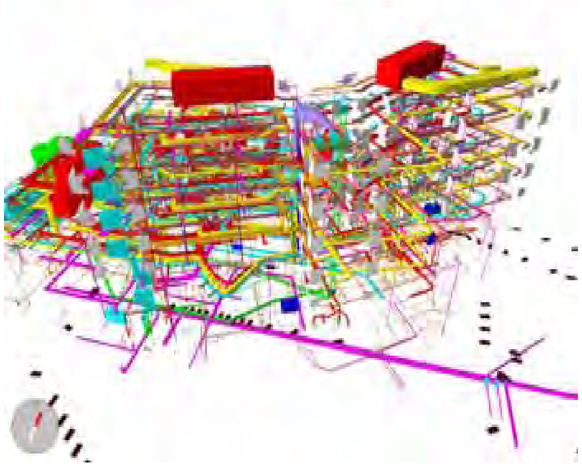
The GC and the architect are exploring workarounds so that the GC's detailing team can have direct access to the architect's model during design to add top of wall details and refine the elevations of walls in the model. Currently it is not possible, nor recommended, to share Revit files directly over the network.

The MEP team is AutoCAD based while the architectural and structural teams are Revit based. The lack of cross platform interoperability between AutoCAD 3D and Revit hinders the team's ability to do effective cross discipline coordination while they are designing. In addition to the use of Navisworks to review the resulting designs, workarounds continue to be explored to make it possible for the architectural team to see the MEP models while they are designing in their native platform.

Direct model based estimating remains to be a goal that the team strives to achieve. The problem is in part a cultural shift and in part limitations in the technology. For example, despite successes in pulling architectural and structural quantities from the model, the estimating team continues to also do manual takeoffs to validate model based quantities. The M/P team continues to work on changing workflows and resolving software limitations so that they can take full advantage of the detailed information they are building into their 3D models.







KEY SUCCESSES AND LESSONS LEARNED

Enhanced Constructability Reviews

The design for fabrication workflow and the ongoing model based constructability reviews is allowing the team to identify and solve hundreds of potential design coordination issues very early in the process, thus increasing the certainty of the design and reducing risk of downstream changes and schedule delays. Notable examples:

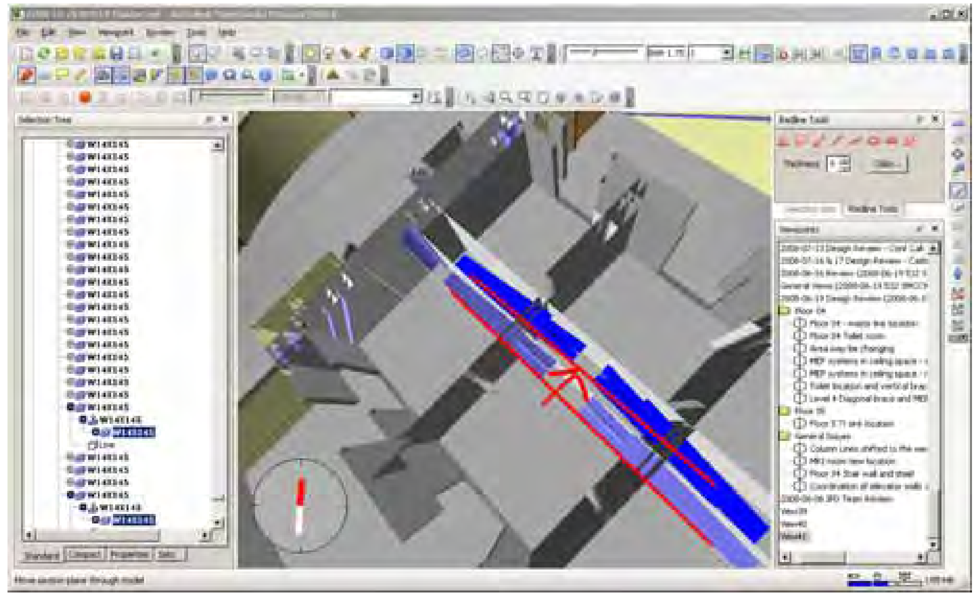
1. The implementation of selected elevator subcontractors shop drawings into the construction documents including the required clearances, opening sizes, and elevator support structures resulted in changes to the structural and architectural floor plans that would have been costly if discovered during construction.

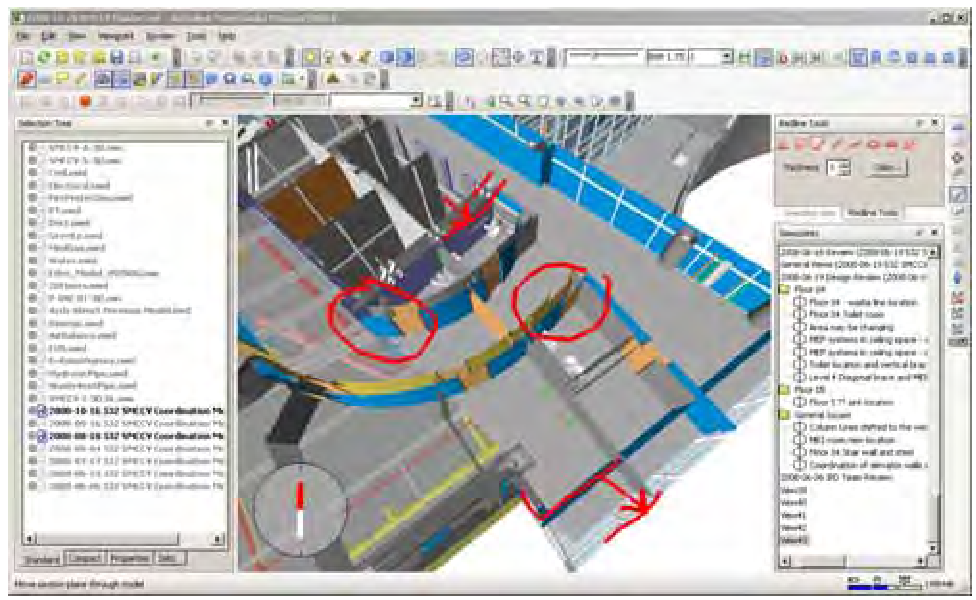
2. The detailed design of shop drawings of stairs identified minimum clearance and code issues that were incorporated in the in-progress architectural design and thus avoided downstream changes in wall locations, wall detailing, and avoided significant rework for the M/E/P disciplines.

3. The continuous constructability review of interior walls and the feedback from the detailed 3D modeling of those walls in the context of the MEP systems allowed the team to revise wall detailing and avoid installation conflicts with steel, fire proofing, and MEP systems.

4. The detailed review of shear wall design led the team to revise the construction details for those walls to maximize efficiency for forming systems and construction schedule sequencing with other trades.

5. The modeling of patient lifts and subsequent support structures allowed the team to reserve space for those systems and avoid rework of the installed MEP systems when those lifts are installed at a later date.





KEY SUCCESSES AND LESSONS LEARNED

Model-Based Estimating

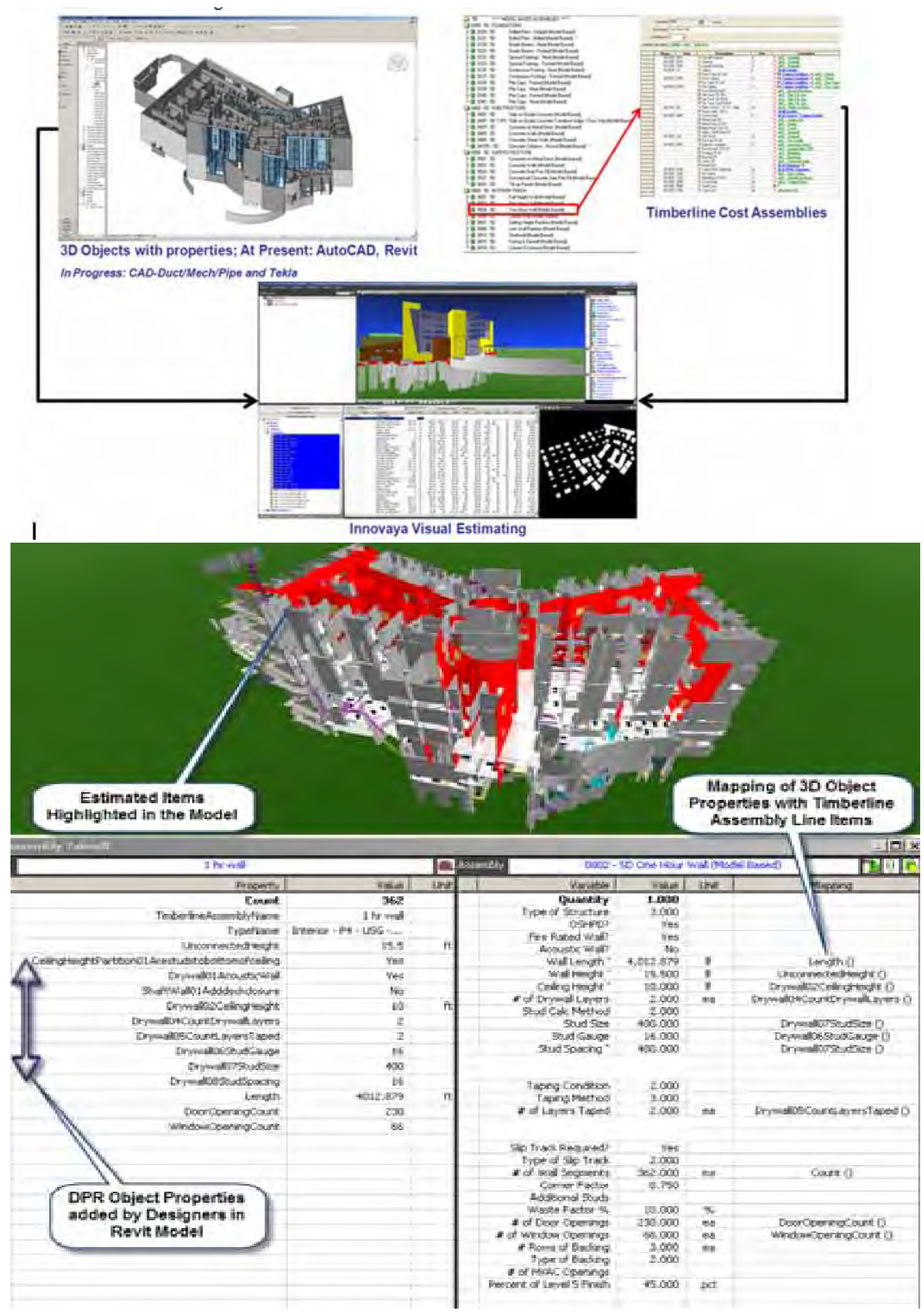
With speed and accuracy of real-time information being critical, the general contractor, needed to provide regular cost feedback as the design evolved. Automating cost estimating allowed the general contractor to generate cost estimates more frequently and in less time (weekly compared to once every month). DPR used Innovaya Visual Estimating to map the BIM objects with their respective cost assemblies in Sage Timberline Estimating (*see left*).

To automate the estimating process, a perfect mapping was required between the model objects and the cost assemblies. This was made possible by a collaborative effort between the Architects, Structural Engineers and DPR Estimators, where the estimators modified their cost assemblies in Sage Timberline and designers added object properties specific to these cost assemblies changes. The designers created the model in accordance with the DPR's "Modeling Guidelines for Cost Estimating" document (*see left/bottom*).

Once this mapping between the objects and cost assemblies was established, it became possible for both the Estimator and BIM engineer to estimate the cost associated with the model elements weekly and share the quantity and cost variation with the project team.

Benefits

Generating estimates from the model at shorter intervals helped bring all team members quickly up to speed on the status of the design and quantity output from the model. The time and labor it traditionally takes to do manual takeoffs and estimates from a set of drawings was reduced from one month to one week, giving the team more time to focus on other areas, such as productivity rates, crew sizes and escalation factors. Less paper was used, as it was no longer necessary to print out a full size set of drawings for manual takeoffs.



KEY SUCCESSES AND LESSONS LEARNED

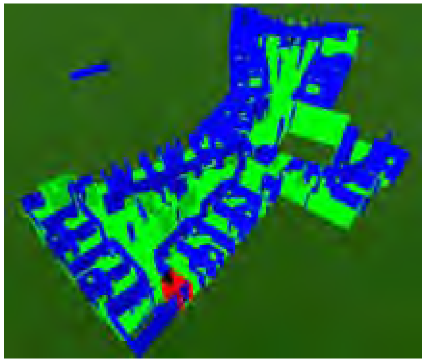
Model-Based Estimating

The process allowed for rapid decision-making based on actual, real-time data. The project team, including the owner, had timely access to cost information on design changes and was able to evaluate which design options were most cost effective. The following example shows a cost comparison provided to the owner that helped determine whether interior walls, excluding fire and smoke rated, should be built at full height or ceiling height (upper left).

This cost comparison was done using the variance report functionality in Sage Timberline. This study helped the team conclude that any wall that is not fire or smoke rated should be made ceiling height and not full height as it was more cost effective. Even though diagonal braces were an added cost for ceiling height walls, the reduction in metal stud material, framing and drywall labor, and the reduced need for scissor lift equipment outweighed the diagonal bracing cost. Ceiling height walls could be built at 11 feet, where full height walls would have varied from 16 to 19 feet.

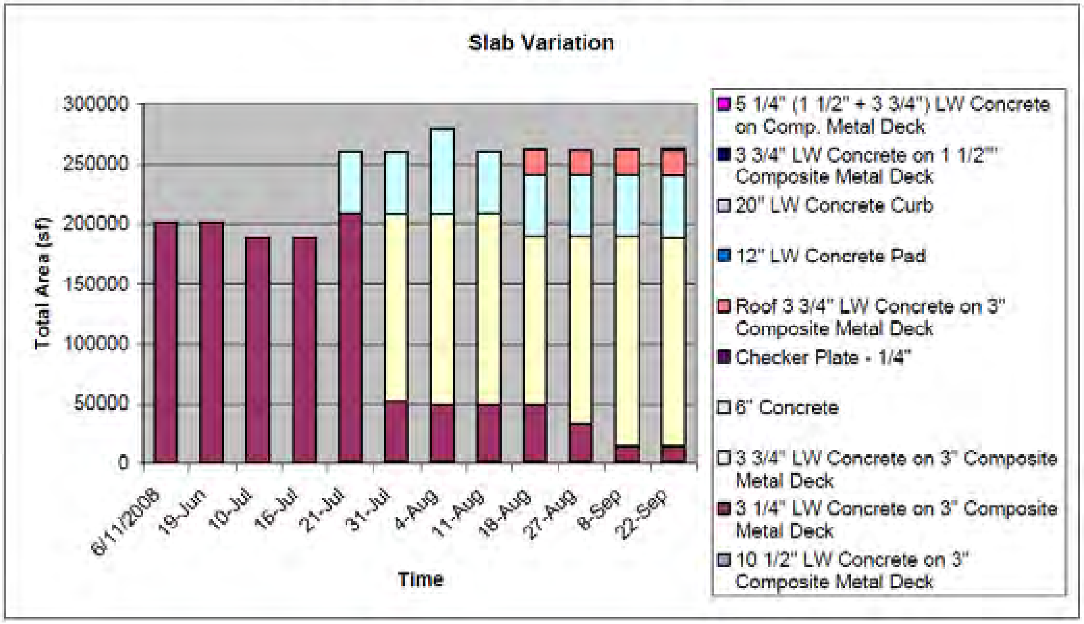
Variance Report

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Estimate Totals					
Labor	94,581.196hrs	99,113.543hrs	-4,532.347hrs	7,324,519	7,672,694	(348,175)
Material				2,526,753	2,575,697	(48,944)
Subcontract				135,481	135,481	0
Equipment	515.920hrs	816.560hrs	-300.640hrs	155,588	176,231	(20,643)
Other				19,106	18,496	610
				10,161,447	10,578,599	(417,152)
Total				***10,161,447***	***10,578,599***	***(417,152)***



This feature helped the team visualize the differences between model updates for what was deleted, modified, added from the previous weeks model.

SMCCV STRUCTURAL QUANTITY TRENDING



KEY SUCCESSES AND LESSONS LEARNED

Key Points to Remember

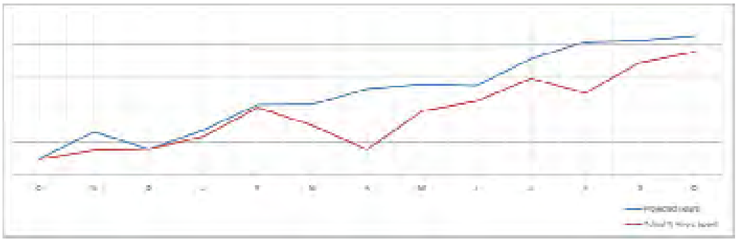
PLANNING AND REPLANNING: both are fundamental skills for any IPD project team. Both require investment in time and resources but are critical to insure proper alignment of work expectations. Careful planning of the design tasks and the team's ability to identify the last responsible moment to release work for production allowed the design to evolve with as little rework as possible. This allowed the team to produce a highly coordinated design using less time and resources than they would have been able to produce otherwise.

MODEL BASED COORDINATION: the team using the collaborative 3D model design review process was able to identify and resolve hundreds of cross discipline design issues much earlier than can be achieved in 2D processes.

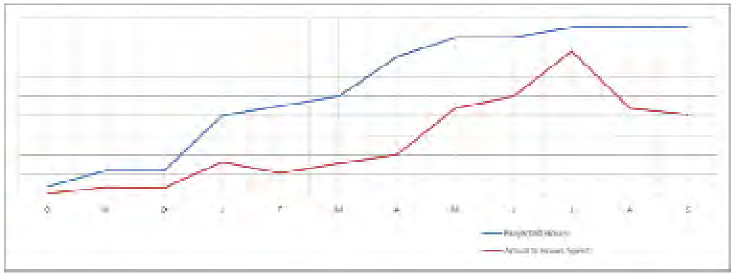
TARGET COSTING: as the team aligns their assumptions and gain confidence in the coordinated design the overall project budget continues to trend down towards the target cost without compromising any of the owners goals.

THERE ARE NO MINOR DESIGN CHANGES: the team is learning that small design changes that one team might consider minor, might cause significant problems for other disciplines. The team is learning to break away from the traditional design-then-check workflow to a more proactive approach where potential changes are communicated to the cross discipline team, options are explored early, and solutions with the least cross discipline impact are selected for further refinement.

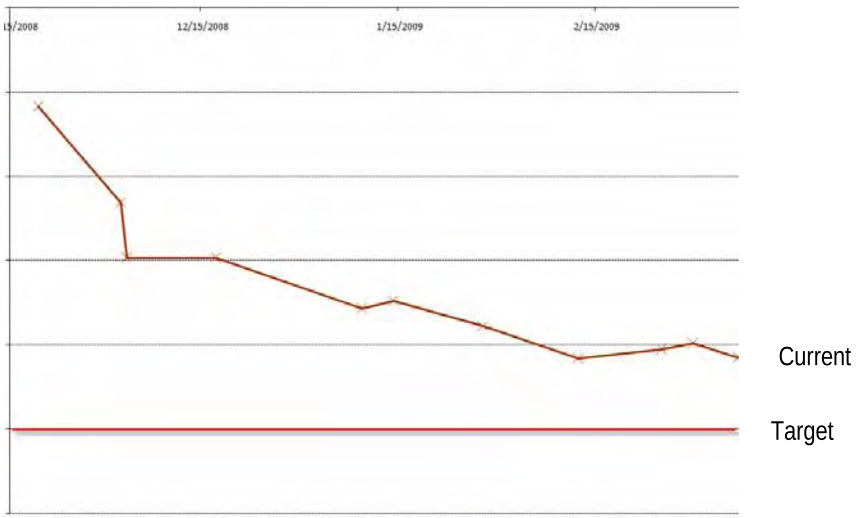
SHARING INCOMPLETE SOLUTIONS: the team is also learning that it is acceptable and actually better to share an incomplete solution than to wait until they are done with the design. By sharing incomplete solutions, they are able to get more frequent feedback from the assembled IPD team and to incorporate that input into their thinking early rather than having to go back and rework a design after it is completed.



Monthly trending of architectural design hours against baseline



Monthly trending of mechanical design hours against baseline



Monthly trending of overall project budget towards the target budget.