**Objectives**
- VDC Background at DPR Construction
- Case study of 3D Model Based Integrated Concurrent Detailing on the Camino Medical Office Building Project
  - Project background and context
  - How the detailing and coordination was done
  - Lessons Learned and Benefits
- Observations, Intuition and Research Questions

**Virtual Building at DPR Construction**

**Camino Medical Office Building**
- 27 Departments
- Over 130 Physician Offices
- Nearly 260 Exam Rooms
- 34 Procedure Rooms
- A Major Radiology Department
- Ambulatory Surgery Center
- OSHPD 3
- Urgent Care
- Conference Center
- 2 levels of structured parking

**Camino MOB Capacities**
- 250,000 sq.ft. Medical Office Building (MOB)
- Parking structure for 1100 cars
- $94.5 M construction cost
- 80% Work completed
- Project Completion March 2007
3D Model Based Integrated Concurrent Detailing at DPR

Camino Project Timeline

- Demolition
- Mass Excavation
- Foundation & Steel
- DA Coordination
- Skin & Roofing
- Tenant Improvements
- Commissioning

Camino MOB Virtual Building - Context

- Sutter Health adopted Lean construction as their project delivery system
- Lean construction is the application of Toyota Production System (TPS) or Lean manufacturing principles to the construction project delivery system
- Lean = eliminating waste, creating value
- DPR presented Collaborative Virtual Building process as an enabler of Lean for the Camino MOB project

Camino Lean Project Delivery

Big Idea
- Lean Approach
  - Builders brought in early to participate in design
  - Target costing
  - Applying the Last Planner System™
    - Weekly work planning
    - Work streams
  - Build virtually in 3-D before constructing

Collaborative Virtual Building.....Beyond BIM

Product (BIM)  Process  Organization

3D Coordination and Detailing

- Organizing the Team
- Defining the Purpose of the Modeling Effort
- The Collaborative Virtual Building Process
- Handoffs between Team Members
- Technical Logistics, Software and Data Exchange
- Setting up the “BIG ROOM”
- The Daily Grind

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Organizing the Team

- All MEP / FP subs were engaged in early Design Development
- Guaranteed Maximum Price Contracts were used for all MEP / FP subs
- The whole team participating in a shared incentive sharing plan setup for the whole project

Defining the Purpose of the Modeling Effort

- To be able to accomplish a clash free, 100% coordinated MEP / FP system virtually
- To be able to pre-fabricate “major assemblies”
- To insert the deck rather than drill supports
- To accomplish the Lean ideals of reducing waste during the design & construction process

The Collaborative Virtual Building Process

- To produce a clash free, 100% coordinated MEP / FP system virtually
- To pre-fabricate “major assemblies”
- To insert the deck rather than drill supports
- To accomplish the Lean ideals of reducing waste during the design & construction process

Defining the Handoffs

- Contractor Input to Design
- Alternatives
- Engineer
- Engineering
- Design in 2D
- SD
- 100%
- SD
- 50%
- Engineer
- Design Review
- RFIs
- Documentation in 2D
- Bldg
- Dept
- Permits
- Engr
- Stamps
- Drwgs
- CD
- 100%
- Collaboration
- Collaboration
- Collaboration

3D Coordination Pulled from Construction Schedule

- A screenshot of the Quadrant Assist Design Schedule Template
- Modeling and coordination driven by dates for inserting elevated decks

Construction Drrove Fabrication, which Determined Coordination Sign-offs

- A screenshot of the Design Assist Team Sign-off Schedule for Fabrication showing “Release for Fab” dates by system
Technical Logistics
- File naming conventions
- Reference point for 3D models
- Protocol for sharing files using FTP site
- Protocol for updating the drawing files
- CAD backgrounds, colors and layer management for the drawings/models
- Protocol for combining drawings in a single NavisWorks model for coordination

Color Assignments
Color Assignments for Coordination

Picture shows the agreement on color assignments for creating the super plot

File Naming Conventions, Work Breakdown
Picture shows the breakdown of a Floor into smaller areas for modeling and coordination

Above Ceiling Space Allocation
Picture shows the allocation of above ceiling space for various systems

Software Tools and Data Exchange

Setting up The BIG ROOM
All detailers co-located in a single "BIG ROOM" onsite

The team used shared resources like servers, plotters etc. in this single BIG ROOM

Atul Khanzode, DPR Construction, Inc. 2006
The Daily Grind - 3D Modeling & Coordination

- Parametric objects assembled from libraries.
- Picture shows steel framing for one of the quadrants on Camino MOB

The Daily Grind - 3D Modeling & Coordination

- Picture shows the model with steel structure, interior walls and fire sprinkler model for one of the quadrants of Camino MOB

The Daily Grind - 3D Modeling & Coordination

- Picture shows the model with steel structure, interior walls, fire sprinkler, the HVAC sheetmetal and plumbing models for one of the quadrants of Camino MOB
The Daily Grind - 3D Modeling & Coordination

Parametric models from different trades combined into a single "Super-plot" into the NavisWorks Clash Detective program which acts as a 3D light table. Clashes are identified automatically between two different systems.

Camino MOB MEP/FP Clash Detection
Specific Examples – 1st Floor SE Quad

Screenshot from 1st Clash Detection session on 7/19/05 shows multiple clashes between the Sprinkler main and supply ducts on south side. It was decided to move the main to correct the issue.

Specific Examples – 1st Floor SE Quad

Screenshot from 2nd Clash Detection session on 7/26/05 shows that the sprinkler main was moved and clashes with supply ducts on south side have been resolved.

Final Sign-off of 100% Coordination

One (or two) final meetings with all detailers present to sign-off on a coordinated set of models to agree on the last remaining clashes.

The Daily Grind – Coordinating Installation using 4D Models

- Use of models to identify Priority wall installation
- Foremen marked up fabrication drawing to show sequence and installation times
- 4D simulation created
- Foremen planned material staging using 4D model

Priority Walls Being Built in 2nd Floor NE Quadrant

Screenshot of 4D model showing priority wall construction in 2nd floor NE quadrant.
WE EXIST TO BUILD GREAT THINGS

3D Model Based Integrated Concurrent Detailing at DPR

Priority Walls Construction Complete
Medium Pressure Duct Being Built

Screenshot of the 4D model showing construction of medium pressure duct in 2nd floor NE quadrant

Medium Pressure Duct Complete
Low Pressure Duct & Sprinklers Installed

Screenshot of the 4D model showing construction of low pressure duct in 2nd floor NE quadrant

Benefits of 3D model based integrated concurrent detailing at Camino MOB

Potential Savings on Investment of Collaborative Virtual Building on Camino MOB

Camino MOB is expecting an ROI of 2-3 times the investment in CVB

Cost Savings from…

- More pre-fabrication
- Just-in-Time delivery
- Fewer RFI’s and Change Orders
- Smaller crew sizes
- Higher field productivity
- Less rework

Sheet Metal Prefabrication
Larger Sections

Sealed for delivery
Ready for job delivery
3D Model Based Integrated Concurrent Detailing at DPR

Atul Khanzode, DPR Construction, Inc. 2006

**Just-in-Time (J-I-T) Delivery**
- Deliveries twice a week to meet weekly work schedule
- Items bundled to reference the fab sheets
- Very few field cuts

**Pre-fab from Coordinated 3-D Model**
- 1. 3D Model of Plumbing System
- 2. Bill of Materials from 3D Model
- 3. System assembled on site
- More confidence in pre-fab due to accurate 3D modeling
- Right material at the right time
- 50% more plumbing pre-fab than conventional

**Fabrication drawings produced from 3D Model**
- Components are selected for each spool sheet.
- Spool sheets are produced in a signal batch process.
- Additional details and information are extracted from the model.
- Fabrication drawings are printed and distributed.

**J-I-T Delivery to the Field**
- The Lean process is incorporated into the delivery schedule.
- Fabrication is marked and bundled for a specific fabrication sheet.
- All material required to install the fabrication sheet is included in the bundle.
- Fabrication bundles are palletized for areas.

**Fewer RFI’s and Change Orders**
- 95% of MEP Rough in place
- Zero RFI’s for conflicts between systems modeled in 3D
- Only 6 Mech & Elec conflict RFI’s related to MEP/FP systems conflicting with other systems

**Southland Delivered HVAC Duct Twice Daily**
- Larger sections on longer trucks
- Everything on wheels
- Pieces bundled into kits

**Camino Medical Group MOB**
- Coordinated installation of complex MEP systems

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Contingency Used

To date 80% work put in place on the $94.5 M Camino MOB project

Contingency Used on Camino MOB

- Design Contingency
- Construction Contingency
- Owner Contingency

Higher Mechanical Productivity
Smaller Crew Sizes

- 30% fewer sheetmetal workers than estimated
- 55% fewer pipe fitters than estimated
- 20-37% higher productivity

Electrical Labor Savings

- NECA 1 represents the Highest Productivity in Electrical Estimating
- Camino MOB is 15% better productivity than NECA 1

Less Rework / Savings

- Re-work based on original design only 43 hours out of 25,000 hours (owner changes not included)
- HVAC Contractor projecting over $400K of labor savings on $9.04 Million GMP contract

Beating Escalation
With 3D model based Collaborative Virtual Building Process

- Camino MOB saved $9M and 6 months by using the Collaborative Virtual Building process as compared to traditional Design-Bid-Build process

Observations

- Creating a structure of handoffs for a 3D model based MEP design and coordination process with an objective towards eliminating waste is hard
- Decisions made by system detailers on routing, sizing, locations etc. has significant impact on the productivity of field crew. Some detailers do it well, some don’t
Intuition

- A new design coordination process using VDC and lean methods can help reduce the waste (uncertainty, risk) in MEP coordination process.
- A formal, computer interpretable framework for MEP coordination process based on the use of VDC and lean methods can help create a best in class MEP design.

Research Questions

- How can the new tools (3D/VDC) help structure the (support a new) design coordination process (who works with whom when and how on what) to eliminate waste (uncertainty, risk)?
- How can we create a formal, computer interpretable framework for MEP coordination process based on the use of virtual building and lean methods?