Lean Design: Mock-ups, Simulation, and Design for Prefabrication

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Project Overview and Challenges
Project Overview

- 1.5 Million SF
- 17 stories
- 6 Years

- 47 Operating Rooms
- 500 Private Patient Rooms
- 60 Emergency Department Rooms
- 690 Parking Spaces
Site Logistics

- Curb-to-curb construction
- Active medical campus
- Limited Laydown Area
- Heavy Traffic and Limited Parking
Site Logistics

New Patient Pavilion Project
Target Budgets vs Design

Target Cost Reductions:
- Below Grade: 5%
- Structure (A/G): 5%
- MEP Infrastructure (A/G): 5%
- Envelope: 5%
- Erection Fit-Out: 5%
- Interventional Fit-Out: 5%
- Medical Equipment: 0%

I. Proj. Target Costs

- SHE:M: $253.9M
- Site: $994.0M
- CC: $3.7M
- Connections: $15.3M
- Construction Cost: $638.3M
- PennFIRST: $51.1M
- Project Target Cost: $689.2M
- BIM Cost: $45.3M
- TOTAL LPT.C.: $734.4M

Owner Costs

- MEP: $141.3M
- HVAC: $12.0M
- Low Voltage: $86.1M
- Misc/Other Fixed Cost*: $85.1M
- TOTAL OWNER COSTS: $276.9M

GRAND TOTAL**: $1011M

INCREMENT COSTS

- Contract Closeout: $625.4M
- Impact to Project Cost: $276.9M

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Projected Project Manpower

- Peak Manpower (Traditional): 1,200
- Peak Manpower (w/ Prefabrication): 1000
Design for Prefabrication
Design for Prefabrication
Prefabrication Maps

- Conceptualize prefabricated elements before design is completed.
- Mechanical layout supports prefabrication on day 1
- Effective communication tool to show architectural team construction constraints
- Visual guide to % of off site manufacturing (OSM)
Prefabrication Maps

- Maintained Digitally and posted in the big room
- Not limited to mechanical and plumbing elements. Includes multi-trade, electrical, and drywall elements too
- No one loses sight of the installation plan
Early Install Duct Headers

- Large ductwork for mechanical rooms injected into steel erection sequence
- Multi-party Collaborative Effort
  - Structural Designer – added supplemental steel
  - Structural Erector – sequenced installation
  - Design Engineer – Early validation of duct sizing
  - Mechanical Installer – Duct construction and reinforcing for bulk hoisting
- Reduced mechanical room install hours by 1/3
Patient Level Rack

- Who’s in the Room?
  - Owner
  - Engineering
  - Architect
  - Const. Manager
  - Key Subcontractors
    - Sprinkler
    - Mechanical
    - Plumbing
    - Electrical
    - Low Voltage
Patient Level Rack

- Early Concept
  - During Programming
  - Structure respected
- Rack to achieve desired ceiling height
- 1 Room : 1 Rack
- Sized to minimize material handling
Patient Level Rack

**NOTES:**
- Racks will be stacked 3 high with 4" x 4" wood dunnage between banded straps to secure racks to dunnage. Whole shipping assembly will be set on caster wheels for movement.
Bathroom PODS

• Utilized in all 500 patient beds
• Complete bathroom module
• Constructed at PennFAB
  • 50,000 sqft multi-trade facility
  • Project dedicated space
• Single point connections
  • Plumbing, electrical, HVAC
Bathroom Pods

• Functional Mock-up
  • Showerhead placement
  • Finish material resiliency

• Full Mock-up
  • Validates cost and time estimates
  • More precise scheduling
  • Expedited learning curve
  • Construction quality check
  • Design finishes validation
Precast Foundation Walls

- 120 precast wall and buttress panels 5’x30’x1’
- Reduced Schedule – 500 lf of foundation wall installed in 8 days
- Reduced Cost
- Reduced truck traffic to site – rebar deliveries/formwork/concrete trucks
- Reduced Man-Power on site
Precast Parking Garage

- 700 parking space below grade parking garage
- Reduced Schedule – 3 month savings vs cast in place
- Reduced Cost – 30% reduction vs cast in place
- Reduced truck traffic to site – rebar deliveries/formwork/concrete trucks
- Reduced Man-Power on site
Mock-Ups and Simulations
Individual Room Mock-Ups

- Operating Rooms (various sizes)
- Initial focus: Table and Booms
- Styrofoam – to – Finishes
- Room specific simulations
Individual Room Mock-Ups

- Hospital users and patient/family feedback
- Ongoing adaptation based upon input
- Styrofoam – to – Finishes

- Equipment placement
- Room specific simulations
Individual Room Mock-Ups
Original Building Design: Inpatient Floor
Design Confirmation

Full-Scale Prototype

• Objectives:
  • Test functional performance
  • Feedback and data

• Steps:
  • Facilitated Tours
  • Designed Simulations
  • General Tours
  • Surveys
  • Data Analysis
Simulation Overview

Meet Objectives

- Focus on Patient Care Unit
- Collect and provide tangible, detailed qualitative and quantitative data to the design team
- Extensive use of internal resources
- Engage executive leaders in these activities in order to initiate change management process
Simulation Overview

Process

• Utilized PDCA cycle
• Applied to Inpatient and Interventional Floors
• Modified Design based on feedback from simulation
• Revisited simulations for confirmation of new design
Full Scale Prototypes
Tour Data

- 22 Tours completed, 546 Tour participants, 291 Surveys submitted
- Faculty, nursing, services
- Employee experience ranging from 1-45 years
Simulation Data

7 Sessions on initial mock-up
• 138 Participants, 108 Hours of video reviewed

3 Sessions on revised mock-up
• 57 Participants, 40 Hours of video reviewed
Original Building Design: Inpatient Floor
New Building Design: Inpatient Floor
Full Scale Prototypes: Interventional Floor Mock-up Plan
Simulation Video
Simulation Outcome

Enabled evaluation of the physical layout of the entire patient care unit.

94%
Strongly Agree or Agree

The modified design will provide a positive patient experience.

98%
Strongly Agree or Agree

The modified design will provide a positive employee experience.

90%
Strongly Agree or Agree

The modified design will provide a positive visitor experience.

96%
Strongly Agree or Agree
In the spirit of continuous improvement, we would like to remind you to complete this session’s survey in the Congress app! We look forward to receiving your feedback. Highest rated presenters will be recognized.