LEAN CONCEPTS ACROSS DELIVERY METHODS:
MORTENSON’S LEAN JOURNEY
Agenda

- Mortenson’s Lean Journey
  - What does Lean mean to Mortenson?
  - Review of Mortenson’s Lean Timeline
  - Lean in Construction – 9 Tools
  - 8 Types of Waste - DOWNTIME
  - Q & A
LEAN is not a tool but a philosophy and a culture.

LEAN is a journey in which we strive to maximize value for our customers through the elimination of waste.
History of the Mortenson Production System (MPS)

- May 1996: CCI Identifies Lean Opportunities
- 1997: Started work with Lean Construction Institute
- 2001: Walt Disney Concert Hall Modularization and Prefabrication
- April 2004: General Dynamics Electric Boat Tour Modularization Culture of Continuous Improvement
- 2005: Kaizen Events Deck Pour Process Reduce Man Power by 50%
- January 2005: Boeing Tour Kaizen Process
History of the Mortenson Production System (MPS)

2005 2006 2007 2008 2009 2010 2011 2012 2013

May 2005
Shingijsut Co.
Commitment Discipline

2006
Integrated Work Plans (IWPs)

June 2009
Shingijsutu
Gemba Kaizen

2009

2006
Renewal Energy Group
Standard Work

2012
Benchmarking with Linbeck
Last Planner System

2013
Exempla St. Joe’s
Multi Trade Prefabrication

April 2006
Virginia Mason
Value Steam Mapping

2006

Educational
Tactical
Chicago’s Journey

- **2006**: Projects Utilize IWP
- **2010**: Use of Prefabricated Assemblies
- **2011**: Prefabrication Plans Developed for Each Project
- **2012**: Rapid Process Improvement Events
- **2013**: Advocate Good Shepherd, Valparaiso University Residence Hall
Lean in Construction: Tools

- Value Stream Mapping
- Target Value Budgeting
- Process Mapping
- Pull Planning
- Gemba Kaizen
- Standard Work
- Five S’s
- Kitting
- Modularization / Prefabrication
Value Stream Mapping – Vision Alignment
Target Value Budgeting

Residence

Dining

Target Values
Forecast Values

Path to Target Choices

Structural
Enclosure
MEP
Equipment
Interiors
Pull Planning

- Specifies handoffs and communicates quality, safety and efficiency performance
- Promotes a team approach to efficiently sequence work
- Optimizes team productivity
Gemba Kaizen – CIP Concrete

- Event Results
  - Safety – 7 Hazards
  - Quality – 3 Issues
  - Efficiency – 14 Opportunities
## Gemba Kaizen – Solar Panel Supports

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>ISSUE</th>
<th>ACTIONS TAKEN</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pile driving to the specified height.</td>
<td>Laser receivers on Orteco machines are not working. Pile heights are out of spec approximately 5.3 times per tracker.</td>
<td>Adjustable elevation rod with receiver attached was built. Ground person now holds rod for a visual reading on the design height of the pile.</td>
<td>QC issues dropped from 5.3 height issues per tracker to .75 height issues per tracker. Potential Savings of: $2.7 Mill. in Potential Re-Work Costs 40,000 Re-Work MHs</td>
</tr>
</tbody>
</table>

### Before

- Using Orteca mounted laser receiver to stop driving hammer when design height is reached.
- 5.3 height failures per tracker
- 5 man hours per tracker to fix out-of-spec piles.

### After

![Image of construction site]
Preventing Water Damage on a Mortenson Jobsite (BP-01600-0001-1)

**Brief Description and Purpose**
This Best Practice details methods, temporary measures, facilities, and controls that should be put in place to prevent water damage during all phases of construction. This is intended to prevent costly repairs, damage to stored materials, mold, and other water infiltration damage.

**Before You Start**
- Determine prevailing weather conditions for all seasons for the job site including precipitation, temperature, wind, severe weather, etc.
- Determine unique site conditions that will be impacted by weather conditions such as ground water levels, surface run-off and drainage, potential for flooding and proximity to flood plains, wind exposure, etc.
- Consider the Project Strategy for building enclosure.
- Review the Contract Documents for required provisions for weather related events.
- Review the Contract Documents for required water control requirements.
- Follow the requirements of the Quality Section of the Operations Manual, including those for water damage and mold prevention (i.e. Mold Policy).
- Conduct an existing facility survey as required by the Mold Policy prior to start of work. (See link below)
- Conduct a third party engineering review of the building enclosure systems as required by the Mold Policy (See link below).
- Determine all potential sources of water infiltration including surface run-off, wind driven rain or snow, leaks in the building envelope, pipe leaks, equipment leaks,

**Available Actions**
- Print
- Edit
- Email
- Suggest Modification

**High Risk Items**
- Mechanical Systems (Hydronic, water carrying, and/or HVAC)
- De-watering pumps
- Floor Squeegees
- Wet/Dry shop vacs
- Tarps/Ducts to protect material, equipment, & openings
- Moisture monitoring equipment (if necessary for critical areas)
- Maps and buckets
- Means to divert water flow across concrete floors

**Personal Protective Equipment**

**Division Of Work:** 01 - General Requirements
**Master Format:** 01500 - Temporary Facilities and Controls
**Operating Group:** Quality
**Steward:** Scott West
**Author:** Scott West
**Created Date:** 5/9/2006
**Status:** Current
**Revision #:** 1
**Effective Date:** 5/24/2010
**Effective For:** Project

Mortenson Construction
LEAN & 5S

- Sort
- Straighten
- Standardize
- Shine
- Sustain
5S - Sort

- Sort through everything in each work area
- Keep what is necessary
- Move materials, tools, equipment, etc. that are not frequently used to a separate storage area
- Discard Items that are not used
5 S- Straighten

- A place for everything and everything in its place…with everything properly identified and labeled

- Organize, arrange, and identify everything in a work area for the most efficient and **effective retrieval** and return to its proper place
5S - Shine

- Regular cleaning and inspection makes one’s work easier...
  - To identify and correct problems early
  - To maintain equipment in order to minimize equipment failure
  - To monitor levels of tool, parts, and equipment to minimize downtime while waiting for new supplies to be delivered.
5 S- Standardize

- Establishment of a work structure that will support the new practice(s) and avoid slipping back into old work habits
- Educate fellow workers on “what right looks like”
- Use labels, signs, posters and banners as visual aids
5 S- Sustain

- Implement a formal system for monitoring the results
- Continue to educate people about maintaining standards
- Make any needed changes in the standards and provide training that addresses those changes
Kitting – Tool Kits

- Reduced inventory levels
- Operator effectiveness
  - Decreased unpacking, walking, searching
  - Reduced overall deliveries
  - Less space required for material storage
  - Quality and part shortage issues caught upstream
Prefabrication / Modularization

- Significant Time savings
- Higher Quality Reduced Punch List
- Better Safety
- Clean project site – less waste
Prefabrication – Multi-Trade Racks at Shop

- Quality - controlled environment
  - Temperature, moisture, lighting
- Safety - no fall hazards
- Assembly line efficiencies
  - Easy access to materials and tools

Mortenson construction
Prefabrication of Multi-Trade Racks on Site

Multi Trade Racks (MTR’s) – Lessons Learned

- Zone Planning - Decide early what a typical cross section of a rack looks like
- Early Coordination of recessed objects in ceilings
- Every rack is different
- Keep zones of the racks open for “pass thru” systems
Prefabrication – Wall Panels

- Allowed the team to develop the interface details between panels
  - Critical side and vertical interfaces
  - Penetrations thru barrier system
- Allowed for coordination process to be simplified
  - Panel location, overall dimensions, and opening RO’s, only
Prefabication - Headwalls

Assembly line for head wall construction
Prefabrication – Headwalls

Using the plywood template to locate all of the in-wall boxes
Prefabrication – Headwalls

Finished head walls stacked by type
Prefabrication - Headwalls

Clamping the head wall frame to the patient room wall

Prefabrication allowed 18% efficiency gains
<table>
<thead>
<tr>
<th></th>
<th>Driving Waste (Muda) Out of the Process</th>
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<tbody>
<tr>
<td><strong>D</strong></td>
<td>Defects</td>
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<tr>
<td><strong>O</strong></td>
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<td><strong>N</strong></td>
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<tr>
<td>Defects</td>
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<tr>
<td>Overproduction</td>
<td>Producing something either before it is needed or in too great a quantity.</td>
</tr>
<tr>
<td>Waiting</td>
<td>Waiting for parts, machines, people.</td>
</tr>
<tr>
<td>Non-utilized resources</td>
<td>Failing to use the people or resources effectively.</td>
</tr>
<tr>
<td>Transportation</td>
<td>Unnecessary movement of a product between processes.</td>
</tr>
<tr>
<td>Inventory</td>
<td>Storing product as a result of overproduction.</td>
</tr>
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<td>Motion</td>
<td>Any movement of man and/or equipment that does not add value to the process.</td>
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<tr>
<td>Excess processing</td>
<td>Work that is not specifically asked for by the customer.</td>
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Virtual Mock-Ups ≠ NO Effects

NOTE: Bed CL located incorrectly on Architectural Elevations

Coord Location—To be verified at imaging meeting

Why is this a GFI?

Locate DO on opposite side of EO

GFI

quad outlet

Bed CL

Elapsed

Time Clock

Standard Clock

Lead Lined Borrowed Lite
(3F204D)

Cath Lab Control Entry Door
(3F204A)

Mortenson construction
Cost Modeling + QTO = NO

**CW-02 - L05 Office**
Unitized Curtain Wall Assembly with projected glass screen protecting automated external louver/roller shades. Glass screen is pressure equalized to enable venting of cavity. Manually operated internal vents provide natural ventilation to office spaces as well as access to shades for cleaning and maintenance.

**CW-01 - Typ. Office**
Unitized Curtain Wall Assembly with projected glass screen protecting automated external louver shades. Glass screen is pressure equalized to enable venting of cavity. Manually operated internal vents provide natural ventilation to office spaces as well as access to shades for cleaning and maintenance. (Glass screen follows syncopated pattern around L03 / L04 wrap).

**CW-05 - Clairesorey**
Insulated channel glass assembly follows sinuous wrap of L06 Penthouse.

**CW-06a - Light Court**
Single glazed, 4-sided SSG on aluminum frame.

**CW-06b - Light Court**
Single glazed on aluminum frame. Larger operable (sliding) doors to accommodate flex meeting space.

Mortenson Construction
DWF Exports (from Revit Models)

Primavera P6 Schedule

4D Modeling = NO Waiting

Building Information

Schedule Information

Sycho Visual Schedule

University of Iowa Hancher Auditorium
Architecture: Pelli Clark Pelli
Structure: Thorton Tomesetti

Mortenson Construction
Collaboration Tools ✔ NON-utilized resources

MotNet
CITRIX

salesforce chatter

JIVE SOFTWARE
What’s Next in Collaboration

SINGLE BIGGEST ASSET

Idea Innovation

People innovate
Through Collaboration
not access to information
Just In Time Delivery  NO EXTRA Transportation

- 9,400 tons of steel erected in 9 months
- Just in Time delivery – no laydown
- No truck staging outside of fence
- Picked from truck hung in place
Model Based Estimates \(=\) NO Inventory
BIM in Field  ✺  NO EXTRA M

The Last 100 Feet
Open Discussion

Q & A
A Case Study of The University of Chicago Administration Building

Patrick Wilson
Nathan Cool
Don Semple
Benjamin Rubach
Larry Arndt
Peter Rumpf
Project Overview – U of C Portal Project

- Renovation of a prominent building on campus that houses executive officers of the University
- Construction Budget - $5.5 million CMAR
- Overall Project Schedule – 9 months
- Primary work on two floors (7,500 SF/floor)
  - Lower Level (Mechanical Rooms)
  - 1st Floor Lobby and South Offices
Project Overview – U of C Portal Project
What is the Process?

- **Design Intent Modeling** (Revit Architecture, Revit MEP)
- **Design Phase Coordination** (Navisworks)
- **Existing Conditions Modeling** (Laser scan of existing conditions incorporated into design model)
- **Design Assist Review** (Harmon Glass, Hill Mechanical, Titan Electric)
- **Design Intent Deliverables** (Contract Documents, Revit Models, Navisworks Models)
- **Construction / Fabrication Modeling** (3D CAD, Revit MEP)
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Construction / Fabrication Modeling (3D CAD, Revit MEP)
Design Intent Modeling
Design Phase Coordination
Design Phase Coordination

Clearance @ underside of beam along 31 "B" is insufficient for FF Piping. Recommend a reducer.
Existing Conditions Documentation – Laser Scan
Existing Conditions Documentation – Laser Scan
Construction / Fabrication Modeling
Design Assist Review
Level of Development (LOD)

**LOD 100:** The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200.

**LOD 200:** The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation.

**LOD 300:** The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation.

**LOD 350:** The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems.

Schematic Design

Design Development

Construction Documents

Coordinated Construction Documents
Design Intent Model
Construction / Fabrication Model
Curtain Wall Design Intent Model (LOD 350)
Curtain Wall Installation
Curtain Wall Installation
Lessons Learned

- Undocumented existing conditions conflicted with MEP intent
- Design phase coordination issues had to be dealt with by the construction coordination team
- Need to develop Model Progression Specification to align LOD of design intent with construction schedule and final model use
Open Discussion

Q & A
Panel Discussion Questions

- How do contracting arrangements engender the collaboration needed for virtual design and construction?

- How do we provide more value through the design assist delivery model?

- What design deliverables are required? Model only? Paper only? Performance specification?