Synergy: Building Information Modeling and Lean Construction

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Introduction

- Both Lean and BIM are deep **process changes**, in thinking and in practices. Both require concerted **long-term efforts**, within **stable business and work environments**

“Insanity”: Doing the same thing over and over and expecting a different result” (Albert Einstein)
What is Lean Construction?

The Lean Construction Vision:

- *new principles and methods for product development and production management specifically tailored to the AEC industry, but akin to those defining lean production* that proved to be so successful in manufacturing.

  (from [www.iglc.net](http://www.iglc.net))

- **Value** - to better meet *customer demands*
- **Flow** - *AEC process* as well as *AEC product*
- **Remove** *Waste*
- *applies to design, detailing, supply and construction*

AEC = Architecture, Engineering, Construction
** Toyota Production System **

- **Goal:** Highest Quality, Lowest Cost, Shortest Lead Time
- **Just-in-Time:**
  - Continuous Flow
  - Takt Time
  - Pull System
- **Jidoka:**
  - Stop and notify of abnormalities
  - Separate man's work & machine's work
- **Heijunka:**
- **Standardized Work:**
- **Kaizen:**
- **Stability:**
- **Value:**
- **Continuous Flow:**
- **Pull system:**
- **Remove Waste (Muda):**
- **Error-free work:**
- **Kaizen - continuous improvement:**
- **Standardised work:**
Project managers on high-end projects reported spending up to 60% of their time managing client changes and the resulting complexity of instructions to specialty contractors.

LEAPCON Cash Flows

**F**: Lean

**F'**: Lean, no customization

**A**: Conventional

**A'**: Conventional, no customization

LEAPCON Simulation

[www.technion.ac.il/~cvsacks/tech-leap.htm](http://www.technion.ac.il/~cvsacks/tech-leap.htm)
Building Information Modeling

**Building Information Modeling (BIM)**

- Tools, processes and technologies that are facilitated by digital, machine-readable documentation about a building, its performance, its planning, its construction and later its operation.

Therefore BIM describes an activity, not an object. To describe the result of the modeling activity, we use the term ‘Building Information Model’, or more simply ‘Building Model’ in full.

**Building Model**

- A digital, machine-readable record of a building, its performance, its planning, its construction and later its operation.

A Revit® model or a Digital Project™ model of a building are examples of Building Models. ‘Building Model’ can be considered the next-generation replacement for ‘construction drawings’, or ‘architectural drawings’.
One Island East, Swire, Hong Kong
### BIM Benefits

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Reduce design and engineering labor</td>
</tr>
<tr>
<td>Quality</td>
<td>Prevent design and coordination errors</td>
</tr>
<tr>
<td>Duration</td>
<td>Shorten design duration</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Heighten accuracy for all analyses</td>
</tr>
<tr>
<td>Industrialization</td>
<td>Produce detailed fabrication data, increase preassembly and prefabrication</td>
</tr>
<tr>
<td>Management</td>
<td>Improve information flow</td>
</tr>
</tbody>
</table>
Lean and BIM Synergies

- **Reduce design development cycle time**
- **Manage information flows**
- **Standardized work methods**
- **Error free construction**
- **Pull flow of information**
- **Pull flow of labor**
- **Increased prefabrication and pull of parts**
- **Maintain information value**

**Design**

**Detailing**

**Construction**

**Operate and Maintain**
## Maintain Information Value

<table>
<thead>
<tr>
<th>Lean construction need</th>
<th>BIM facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximize <strong>Value</strong> to Client</td>
<td>Re-use of model information</td>
</tr>
</tbody>
</table>

**Diagram:**

- **Value of design documentation**
  - Loss of value due to handover recreation of information
  - BIM model – collaborative process
  - Traditional single, stage, paper drawings
  - Retrofit utilizing ‘as-built’ and existing facility documentation

**Introduction**

*Lean Construction*

*Lean-BIM Synergy*

**Conclusions**

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### Reduce Design Cycle Time

<table>
<thead>
<tr>
<th>Office Building Façade</th>
<th>Engineering Phase</th>
<th>Assembly</th>
<th>Coordination</th>
<th>Engineering</th>
<th>Drafting</th>
<th>Eng Checking</th>
<th>Drafting</th>
<th>Submittal Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1,046 hrs</td>
<td>755 hrs</td>
<td>45 hrs</td>
<td>284 hrs</td>
<td>392 hrs</td>
<td>23 hrs</td>
<td>31 hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Lean construction need**

**BIM facility**

**Reduce Cycle Time**

- Review model instead of drawings, automatic drawing production

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Manage Design Information Flow

- Design Group meeting
- Number of data transfers
- Average number of data transfers

Continuous Flow
Using project extranets with building models:

Information Development Velocity

Continuous Flow
### Probability of Bottleneck

**Using project extranets:**

<table>
<thead>
<tr>
<th>Lean construction need</th>
<th>IT and BIM facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visualization</strong> of flow – design</td>
<td>Monitoring of design information flow using BIM and model servers or project intranets</td>
</tr>
</tbody>
</table>

![Graph showing probability of bottleneck](image)

**Continuous Flow**
Pulling Detailing Information

4D Simulation; Set sequence priority (e.g. walls for medium pressure duct); pull detailing work only when construction approaches
### Pulling Detailing Information

#### Lean construction need

| Pull detailing and fabrication/assembly of building system components according to short term plans |

#### BIM facility

- **Collaborative detailing** with integration across disciplines, automated clash checking

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**Clash checking**
Standardized Work

Lean construction need | BIM facility
--- | ---
**Standardised work** | Automated assembly instructions and bills of material

1. Drawings for each work package generated automatically from the model;
2. Parts fabricated and packaged off-site;
3. Installed on site as a package
4D Modeling, Temporary Facilities

<table>
<thead>
<tr>
<th>Lean construction need</th>
<th>BIM facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stable work</strong> - effective project planning, predicting problems, avoiding problems</td>
<td>4D animation and modeling of temporary process facilities, error-free design and detailing</td>
</tr>
</tbody>
</table>
Increased Prefabrication

Campbell, Architecture Week 2006
Increased Prefabrication
Increased Prefabrication
Introduction

Lean Construction

Lean-BIM Synergy

Conclusions

Increased Prefabrication

Remove Waste
Increased Prefabrication

The maximum member stress is 20.0 ksi

Cases: 2 (WIND1)

Cases: 3 (COMB1)
### Increased Prefabrication

#### Lean construction need

| Prefabrication – remove waste of unnecessary or inefficient activities |

#### BIM facility

| Accurate error-free detailing for prefabrication |

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**Performance Mock-Up Configurations**

![Mock-Up Diagram]

**Example Table:**

<table>
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<tr>
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<tbody>
<tr>
<td>Prefabrication – remove waste of unnecessary or inefficient activities</td>
<td>Accurate error-free detailing for prefabrication</td>
</tr>
</tbody>
</table>
Pulling prefabricated parts

<table>
<thead>
<tr>
<th>Lean construction need</th>
<th>IT and BIM facility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pull</strong> of materials and Kanban signals for fabrication</td>
<td>On-line pull of materials and signals through management information linked through a BIM server</td>
</tr>
</tbody>
</table>

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The diagram shows a pull flow system involving prefabricated parts, with Kanban signals facilitating the pull of materials and information management linked through a BIM server.
### Introduction

Lean Construction

Lean-BIM Synergy

Conclusions

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### Pulling Labor and Visualizing Status

#### Pull Flow

<table>
<thead>
<tr>
<th>Specialty Contractor</th>
<th>Activity</th>
<th>Apt #</th>
<th>Cycle Time</th>
<th>Status Date</th>
<th>Status activity duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>Partitions</td>
<td>#5</td>
<td>14</td>
<td>3/2/2005</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#7</td>
<td>11</td>
<td>6/2/2005</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#3</td>
<td>7</td>
<td>10/2/2005</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>#11</td>
<td>4</td>
<td>10/2/2005</td>
<td>4</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Window support frames</td>
<td>#2</td>
<td>7</td>
<td>8/2/2005</td>
<td>14/2/2005</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11/2/2005</td>
<td>13/2/2005</td>
</tr>
<tr>
<td>Steel</td>
<td>Entrance door-frame</td>
<td></td>
<td></td>
<td>12/2/2005</td>
<td>14/2/2005</td>
</tr>
<tr>
<td></td>
<td>Electric Ducts</td>
<td></td>
<td></td>
<td>11/2/2005</td>
<td>14/2/2005</td>
</tr>
</tbody>
</table>

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Civil and Environmental Engineering, Technion - Israel Institute of Technology
**Pulling Labor and Visualizing Status**

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<tr>
<td><strong>Pull flow signals</strong> are not visible, like in manufacturing, so directives to teams pull work</td>
<td>On-line pull flow signals can be communicated to teams online</td>
</tr>
<tr>
<td>Project status changes rapidly and sometimes unexpectedly. Information is complex, diverse, plentiful and difficult to integrate</td>
<td>Good visualization is needed for construction process and work readiness information</td>
</tr>
</tbody>
</table>

*Civil and Environmental Engineering Technion - Israel Institute of Technology*
Safety – Risk forecast for work planning
## Safety – Risk forecast for work planning

<table>
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<tbody>
<tr>
<td>Safe processes – <strong>no waste</strong></td>
<td>BIM supports dynamic <strong>safety conscious planning</strong></td>
</tr>
</tbody>
</table>

- **Lean construction need**
  - Safe processes – *no waste*

- **BIM facility**
  - BIM supports dynamic **safety conscious planning**

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### Lean construction need

<table>
<thead>
<tr>
<th>Location</th>
<th>Source Activity</th>
<th>Exposed Trade</th>
<th>Scenario</th>
<th>Severity</th>
<th>R.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facade 1</td>
<td>L4 1-6 slabs</td>
<td>CurtainWalls worker</td>
<td>Falling object</td>
<td>51.4</td>
<td>4,397</td>
</tr>
<tr>
<td>Facade 1</td>
<td>Curtain Walls</td>
<td>CurtainWalls worker</td>
<td>Hit by a tool</td>
<td>24.4</td>
<td>2,925</td>
</tr>
<tr>
<td>Facade 1</td>
<td>Curtain Walls</td>
<td>CurtainWalls worker</td>
<td>Fall from height</td>
<td>63.2</td>
<td>1,752</td>
</tr>
<tr>
<td>Facade 1</td>
<td>L4 7-12 slabs</td>
<td>CurtainWalls worker</td>
<td>Falling object</td>
<td>73.1</td>
<td>312</td>
</tr>
<tr>
<td>Facade 1</td>
<td>Curtain Walls</td>
<td>CurtainWalls worker</td>
<td>Sprayed materials</td>
<td>17.5</td>
<td>31</td>
</tr>
</tbody>
</table>

### Risk forecast for work planning

- **Filtered Risk Level:** 9.329

- **Date:** December 3, 2007

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**Risk Levels:**
- 3000
- 1000
- 100
- 1

**Risk Levels of Events:**
- Load unload upper bc: 413
- L1 1-6 precast: 2,201
- L3 1-6 slabs: 2,200
- L1 7-12 precast: 2,201
- L3 7-12 slabs: 2,201
- L4 1-6 precast: 8
- L4 7-12 precast: 12
- L4 7-12 slabs: 10,663
- L5 1-6 precast: 14,779
- L5 1-6 slabs: 74
- L5 7-12 slabs: 500

**Scenario Summary:**
- Load unload upper bc: 413
- L1 1-6 precast: 2,201
- L3 1-6 slabs: 2,200
- L1 7-12 precast: 2,201
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**Animation speed:** 0.05 sec = 1 day

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**Animation speed:** 0.05 sec = 1 day
Conclusions

- BIM makes construction leaner;
  - Lean thinking focuses BIM implementation
- Owners have a unique role to play as leaders of Lean and BIM initiatives
- Lean and BIM can improve an owner’s bottom line, but also have a ripple effect across the construction industry

The challenge to all owners, designers, contractors and fabricators:

To perform lean, BIM-enabled projects ..... 

.....worthy of inclusion as best practice case studies in the 2nd edition of the BIM Handbook !!!