WHY MORE PUBLIC SECTOR OWNERS ARE CONSIDERING LEAN PROJECT DELIVERY BASED ON DATA-DRIVEN METRICS

Presented to LCI San Diego CoP
January 15, 2015
Current State

Future State

Source: www.kent.ac.uk/lbs/applied-research/vcr
What’s Going On Elsewhere in the World?
The Tunnel of Rantaväylä
Tampere, Finland

Courtesy: Mauri Mäkiaho
Tunnel allows built new housing to the city center
Target costs 180,3 M€ (May 2013)

Development period (in Alliance) July 2012 – autumn 2013

Implementation period (in Alliance) has been started October 2013

Ready to use in 2017

Finishing 2018

2 one-way 2,3 km road tunnels

Interchange in both ends

Provision for one in the middle

Daily traffic volume Over 40 000

In the future 54 000

Courtesy: Mauri Mäkiaho
# Finnish Project Key Performance Indicators

<table>
<thead>
<tr>
<th>Key result area</th>
<th>Key performance indicator (KPI)</th>
<th>KPI values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule</td>
<td>On schedule</td>
<td>240 days late</td>
</tr>
<tr>
<td>Safety</td>
<td>No. of accidents</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>No. of days of absence due accidents</td>
<td>1000</td>
</tr>
<tr>
<td>Usability</td>
<td>Traffic disturbances caused after the construction phase completion</td>
<td>Set at 3 months before the construction phase completion</td>
</tr>
<tr>
<td>Public image</td>
<td>Tone of public image</td>
<td>40</td>
</tr>
</tbody>
</table>

Courtesy: Mauri Mäkiaho
## Finnish Project Key Performance Indicators

**Table 6.3. Positive modifiers**

<table>
<thead>
<tr>
<th>Positive modifier</th>
<th>Indicator</th>
<th>Indicator values</th>
<th>Points</th>
</tr>
</thead>
</table>
| Traffic disturbances during construction | Amount of traffic during construction | KVL same as before the project  
KVL less than a maximum of 7% compared to before the project | + 10 points  
+ 5 points |
| Damages                          | Amount of damages                | Total damages below 0.75% of the target outcome cost, 180 million euros         | + 5 points  |
| Significant accolade            | Reward for accolade             | See description of the measurement                                               | + 5 points  |
| Life cycle cost                 | Reduction in operation costs     | 100,000 euros/year                                                              | + 5 points  |

Courtesy: Mauri Mäkiaho
### Finnish Project Key Performance Indicators

#### Table 6.4. Negative modifiers

<table>
<thead>
<tr>
<th>Negative modifier</th>
<th>Indicator</th>
<th>Indicator value</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway 12 traffic disturbances</td>
<td>Hours</td>
<td>Traffic stopped for 12-24 h Traffic stopped for 24 h</td>
<td>-2 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-5 points</td>
</tr>
<tr>
<td>Train traffic disturbances</td>
<td>Hours</td>
<td>Traffic stopped for 6-24 h Traffic stopped for 24-48 h</td>
<td>-3 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-6 points</td>
</tr>
<tr>
<td>Grey economy</td>
<td>Observations</td>
<td>Observed once Observed twice</td>
<td>-2 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-5 points</td>
</tr>
</tbody>
</table>

#### Table 6.5. Major event modifiers (major negative factors)

<table>
<thead>
<tr>
<th>Major event modifier</th>
<th>Indicator</th>
<th>Indicator values</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train traffic disturbance</td>
<td>Hours</td>
<td>Train traffic stopped for &gt; 48 h</td>
<td>-50 points</td>
</tr>
<tr>
<td>Major accident</td>
<td>Observation</td>
<td>Alliance activities found to have caused the accident according to the Accident Research Board</td>
<td>-50 points</td>
</tr>
</tbody>
</table>

 Courtesy: Mauri Mäkiaho
What’s Going On Elsewhere in the World?
UK Construction 2025 Goals

UK Construction 2025 Goals

Lower costs
33%
reduction in the initial cost of construction and the whole life cost of built assets

Faster delivery
50%
reduction in the overall time, from inception to completion, for newbuild and refurbished assets

Lower emissions
50%
reduction in greenhouse gas emissions in the built environment

Improvement in exports
50%
reduction in the trade gap between total exports and total imports for construction products and materials
UK BIM Goals

2.32 Government will require **fully collaborative 3D BIM** (with all project and asset information, documentation and data being electronic) as a minimum by 2016. A staged plan will be published with mandated milestones showing measurable progress at the end of each year.
HOUSE BILL 07-1342 [Digest]

BY REPRESENTATIVE(S): John, Buschur, Carroll, Caso, Gadea, Labuda, Rice, Todd, Benefield, Looper, and Ross; also SENATOR(S): Tapia.

AN ACT

CONCERNING AUTHORIZATION FOR PUBLIC ENTITIES TO USE INTEGRATED PROJECT DELIVERY METHODS IN CONNECTION WITH CONTRACTS FOR PUBLIC PROJECTS.
What is UCSF Doing?
UCSF Use of Available UC Delivery Methods

1. Private (P3) – MB Neurosciences
2. Best Value DBB – many small projects
3. Best Value Lean CM@Risk (w/ DB Prime Subs)
4. Best Value Lean Design / Build (Performance-Based)
5. Modified Design / Build (not used)
6. Design Consultants & Joint Ventures (not used, open to appropriate use)
7. Multiple Prime (not used)
8. IPD (incorporated into Lean approach)
9. Best Value Lean JOC – (developing for small projects)

Source: UCSF (2014)
Measuring Value

PROJECT GOALS

A Quality Work & Learning Environment
- Design the identity and urban presence of the building to reinforce UCSF’s mission of caring, healing, teaching and discovering.
- Develop passionate, innovative, contemporary yet timeless architecture through the composition of architectural elements and arrangement of materials.
- Imaginatively reinterpret the context of the UCSF campus and city through architectural design.
- Employ high performance design and innovative sustainability strategies to enhance the experience and productivity of the building users.
- Create meaningful spatial interactions between indoors and outdoors to enrich the experience of the building occupants, members of UCSF, and the public.

A Model of Architectural & Urban Design

A High Performing Building

Environmentally Sustainable

Durable & Long-lasting

Efficiently Serviced & Maintained

BUILDING EXTERIOR

- Support UCSF’s mission of excellence in academics, health care research and clinical care by developing a gathering place that facilitates a rich professional and community life.
- Foster an interactive, collegial, and collaborative environment that fuses the clinical programs with basic and translational research.
- Set a model for the future of UCSF workplace through an Activity-Based Workplace tailored to the function, activities, and tools of UCSF faculty, staff and students.
- Achieve optimal efficiencies in the use and organization of space, circulation and core functions.
- Integrate building functions, technology and systems for high performance, maximizing function, serviceability and durability.
- Connect the exterior, interior, office and learning program elements to create a rich and full experience for the building users.
- Design the building interior to be imaginative, contemporary yet timelessly elegant, cohesive and meaningfully transparent.

Source: UCSF (2014)
Measuring Value

PROJECT GOALS

A Quality Work & Learning Environment
A Model of Architectural & Urban Design
A High Performing Building
Environmentally Sustainable
Durable & Long-lasting
Efficiently Serviced & Maintained

01 Energy & Resource Efficiency
Design a project that integrates all systems to provide a high-performing building that is appropriately controlled and monitored to minimize energy and resource consumption.

02 Structurally Sound
Develop a code-compliant, safe building that can withstand major seismic events. Provide an efficient structural system that is integrated with the proposed spatial and building systems and that can efficiently adapt to changing office use requirements and infrastructure improvements, while fulfilling or exceeding required performance standards.

03 Climate Responsive
Provide a building that is weather-tight while making maximum use of day lighting and natural ventilation. Design site utilities, plantings, and site drainage to respond to the specific climatic and soil conditions of the Mission Bay environs.

Source: UCSF (2014)
## Structurally Sound | 02

### BUILDING UTILITIES

**REQUIRED**
- Flexible connections to be provided for all utilities connecting to the site.
- Underslab piping to be supported per 02/A4.6 “Slabs at Grade, Supplementary Components.” CR Tech 07/D1.1

### VERIFICATION

1. **PROPOSAL:** Narrative for the system design. Preliminary calculations and schematic drawings.
2. **DOCUMENTATION (CD):** Final design calculations and drawings. Cut sheets of the equipment selected.

### FIRE SUPPRESSION (D4010)

**REQUIRED**
- The building shall be protected by hydraulically calculated automatic wet sprinkler system.
  - Each building floor shall be an individual zone.
  - Appropriate drainage of the system shall be provided.

**TIER 2**

Source: UCSF (2014)
LEAN Processes Successes Caused UCSF to Modify its Contracts: Practical Changes

- Acknowledgment of fostering collaboration and openness
- Require LEAN Processes Training and Contract Training among *all* team members prior to commencement of Work
- “Big Room” Requirement
- Information Center Meetings
- Principals Meetings
- Performance Incentive Program, based upon achieving schedule/cost milestones, quality metrics, safety, achieving measurable LEAN “best practices” successes. All Project Team members share in the PIP.
- Duty to first negotiate directly prior to initiating mediation, arbitration or litigation
- Second step: Claims Review Board, to avoid expense and delays attendant to claims resolution and intended to foster collaborative approach

Source: UCSF (2014)
LEAN Processes Successes Caused UCSF to Modify its Contracts: “Best Value” Evaluation Questionnaire

- Experience with LEAN Construction methods and processes (15 pages maximum)
- Provide (2) copies of construction contracts containing Lean Construction methods and processes performed by you in the past five (5) years (confidential terms and conditions to be redacted). Provide full copies in electronic format (pdf compatible) only as an attachment in Appendix.
- Provide a listing of all LEAN project teams in which you have been a participant, the other team members with whom you have participated, and in what capacity(ies) for the past five (5) years.
- Provide examples of your implementation of the following Lean construction methods and processes, as applicable:
  - Built in Quality;
  - Eliminating waste while continually improving the project;
  - Set-Based Design;
  - Target Value Design;
  - 5S and Visual Management;
  - Continuous Cost Modeling;
  - Pull Planning;
  - Information Center Meetings;
  - Standardized Work;
  - Total Station Layout;
  - Just in Time;
  - Last Planner™ System construction management;
  - Takt-Time; and
  - Building Information Modeling (BIM) and computer-aided design.

Source: UCSF (2014)
LEAN Processes Successes Caused UCSF to Modify its Contracts; LEAN Construction Key Provisions

• Contractor, in accordance with input from the University and its representatives, shall be responsible for developing and implementing the “best in class” standard for each of the LEAN Construction criteria, and will implement those subject to, and as finally approved by, the University Representative.

• Contractor shall be responsible for preparing the necessary documents relating to deployment of each of the below-referenced criteria as well as the bases for measuring the progress of each of the below, including the preparation of any and all measures and counter-measures so that each of the below-referenced criteria are performing as “best in class” throughout the duration of the Program and for its individual Projects, including ongoing measurable, and measured, improvement increases.

Source: UCSF (2014)
UCSF’s 5s and Visual Management Metrics

What processes does the program use for implementing 5S and Visual Management?

- Contractor’s and Subcontractors’ 5S and Visual Management processes add to the safety, quality and productivity of the Program and each Project.
- Contractor, Subcontractors’ leadership and behaviors support 5S implementation throughout the Program.
- CI opportunities are made clearer by Contractor and Subcontractors’ 5S and Visual Management.

What does evidence look like?

- Contractor and Subcontractors personnel implement 5S changes regularly as CI ideas.
- Contractor and all Subcontractors personnel put new standards in place as improvements are made and Contractor constantly improves ideas for Visual Management techniques.

Source: UCSF (2014)
UCSF’s Standardized Work Metrics

What processes does the program use for implementing Standardized Work?

- **All Contractor and Subcontractor personnel write and use Standardized Work.**
- **Contractor’s and Subcontractors’ training and knowledge of the relevant Standardized Work is understood before a task is begun.**
- **The Contractor and Subcontractors use Standardized Work continually for Continuous Improvement and Waste Elimination on the Program.**

What does the evidence look like?

- **Savings and efficiencies are obvious from the use of Standardized Work by Contractor and Subcontractors for the Program and its individual Projects.**
- **All key tasks for the Program have Standardized Work.**

Source: UCSF (2014)
UCSF’s Quality Assurance/Quality Control Criteria Document
Waste Elimination and Continuous Improvement Metrics

What processes does the Program use for eliminating waste?

• All Contractor and Subcontractor participants practice waste elimination and prevention in Program activities.

• Contractor and Subcontractors do not accept the status quo; rather, reflects and learn from past unsuccessful practices.

What does evidence look like?

• Program and individual Project savings and efficiencies obvious from ongoing and integrated work to eliminate waste.

• Visitors regularly remark on exceptionally clean and orderly sites in Program.

Source: UCSF (2014)
Quality: Built-in Quality

**UCSF 25A**

**INSPECTION TRACKING METRICS**

**UPDATED - 7/28/2014**

**THRU CONFIRMED, RETURN INSPECTION NUMBER 813 (SOME INSPECTIONS STILL OPEN IN THIS RANGE); INSPECTIONS OVERALL UP TO 966**

**SUMMARY (OVERALL TOTALS)**

**TOTAL INSPECTIONS: 734 PASSED INSPECTIONS: 720 FAILED INSPECTIONS: 14**

**PASS RATE:**

**98.09%**

Source: UCSF (2014)
Quality: Built-in Quality

**Structural Total Inspections:** 211  **Passed Inspections:** 203  **Failed Inspections:** 8  
**Pass Rate:** 96.21%

**Exterior Skin**
**Total Inspections:** 42  **Passed Inspections:** 40  **Failed Inspections:** 2  
**Pass Rate:** 95.24%

**MEP / Fire Sprinkler**
**Total Inspections:** 243  **Passed Inspections:** 236  **Failed Inspections:** 7  
**Pass Rate:** 97.12%

**Site**
**Total Inspections:** 10  **Passed Inspections:** 10  **Failed Inspections:** 0  
**Pass Rate:** 100.00%

Source: UCSF (2014)
UCSF’s Last Planner System Metrics

How does the program use the Last Planner System?

- Contractor and subcontractors actively plan to improve PPC – their goal is 100%.
- Contractor and subcontractors require new members to learn and participate in LPS.
- Contractor and subcontractors prepare and submit their WWP in a timely fashion.
- Contractor and subcontractors are evaluated based on their LPS performance.
- Contractor and subcontractors effectively remove Program constraints “Tasks Made Ready (TMR) and properly comprehends the Tasks Anticipated (TA), breakdown and operations and design process.

What does evidence look like?

- Steadily, increasing PPC.
- Contractor and subcontractors take steps to learn from, and minimize, variances.
- PPC and variances are part of program and individual project evaluation.

Source: UCSF (2014)
UCSF’s Pull Planning Metrics

**How is Pull Planning used on the program?**

- **Pull Planning** is used for planning all activities, not just design and construction.
- All Contractor team members including Subcontractors require planning and commitments to be based on a Pull Plan session.
- Contractor and Subcontractor Management require Pull Planning to be performed prior to making commitments.

**What does evidence look like?**

- All Contractor and Subcontractors’ trade foremen and project managers conduct Pull Planning without assistance from specialist or coach.
- Cost savings and production efficiencies from Pull Planning are substantial.

Source: UCSF (2014)
What Other Public Agencies are Requesting Lean Approaches to Projects?
What Is Important to Public Owners?
What is of Value?

• Total Cost of Ownership?
• Energy Efficiency?
• Speed to Market?
• No disruption to ongoing business operations?
• Iconic design?
• Improved productivity and occupant satisfaction?
• Sustainable buildings?
Total Cost of Ownership

- 50-year design life
- 100,000 square foot classroom building
- Design and construction cost - $30 million
- Capital Renewal: 2% of current replacement value (APPA benchmark)
- O&M Budget $5.69/square foot
- Inflation: 3%
Total Cost of Ownership

- Save 5% in Cap. Renewal
- Save 10% in O&M

### Savings

<table>
<thead>
<tr>
<th></th>
<th>D&amp;C</th>
<th>Cap. R.</th>
<th>O&amp;M</th>
<th>Total</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$30M</td>
<td>$101M</td>
<td>$149M</td>
<td>$280M</td>
<td>$4.4M</td>
</tr>
<tr>
<td></td>
<td>$20M</td>
<td>$5M</td>
<td>$15M</td>
<td>$20M</td>
<td>$4.4M</td>
</tr>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>
Defining Values for SDCCD

- Enhance the student experience
- Flexibility in design to accommodate future changes in pedagogy
- Lower total cost of ownership
- Highly energy efficient buildings
- Reduce maintenance and operations costs
- Meet or exceed sustainability objectives
Value-Waste Nexus

• How to create value within fixed monetary constraints?
• Eliminate waste
• Enhance value with the savings from waste reduction
Public Owner Benefits

- Reduced Waste in Project Delivery
- Sustainable Buildings
- Reduced Total Cost of Ownership

= Enhanced Value
Use of Lean Tools in Capital Project Delivery

1. Target Costing
2. A3 Problem Solving and Reporting
3. Set-Based Design
4. Value Stream Mapping
5. Building Information Modeling (BIM)
6. The Last Planner™ System
Target Costing - Project Budget Development

- Space Programming
- Space Efficiency
- Targeted Cost Per Sq. Ft.
A3 Problem Solving – HVAC Design

<table>
<thead>
<tr>
<th>Title</th>
<th>Section 1: Background, Relevance of the topic to CEM Objectives &amp; Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comparisons of HVAC system options to determine which option has lowest life cycle cost and provides greatest benefit to the facility. Responding to the challenge to improve efficiency, access reliability, reduce maintenance and help achieve LEED Silver. A facility of this size is typically served by a chilled water (CW) system with central plant, underground distribution piping and 6-pipe CHW/AC air handling units. This analysis will compare the CHW system to systems based on package direct expansion (DX) rooftop air conditioning units and ground source heat pumps (GSHP).</td>
</tr>
<tr>
<td></td>
<td>- For the CW system, heating hot water (SHW) is supplied by boilers and pumps in the central plant via underground distribution piping.</td>
</tr>
<tr>
<td></td>
<td>- Heating for the package DX system is provided by gas furnaces within the rooftop package units.</td>
</tr>
<tr>
<td></td>
<td>- In the GSHP system, heating is provided by the heat pump cycle of the GSHP unit. The GSHP system uses a closed loop system of plastic pipe buried in the ground (ground coupled) to allow heat transfer between the earth and fluid flowing through the pipes. This closed-loop system transfers thermal energy within the building(s) where it is connected to the condenser/evaporator heat exchangers in each GSHP unit.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 2: Current Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two 15,000 SF facilities located in San Diego CA. Life cycle cost analysis is for a period of 25 years using a 7.5% discount rate, a 2% escalation rate and a 3% inflation rate. Average energy rates of $0.09/Kwh and $0.61/Gal are used.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 3: Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHOULD CRITERIA</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mechanical System Options</td>
</tr>
<tr>
<td></td>
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<tr>
<td>CHW System</td>
</tr>
<tr>
<td>Package System</td>
</tr>
<tr>
<td>Base Multizone System</td>
</tr>
<tr>
<td>Ground Source Heat Pump</td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 4: Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide existing CUP capacity. - Don Harrisberger</td>
</tr>
<tr>
<td>2. Analyze existing CUP capacities, - Don Harrisberger</td>
</tr>
<tr>
<td>3. Review weighting of advantages with Don and entire team - Don Harrisberger</td>
</tr>
<tr>
<td>4. Conduct CEM (or final HVAC design) users budget - Don Harrisberger</td>
</tr>
<tr>
<td>5. Proceed with implement CEM (or final HVAC design) - Don Harrisberger</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section 5: Follow-up</th>
</tr>
</thead>
</table>
| Based on the current information at hand the option of chilled and hot water air handlers served by central plant is recommended.
A3 Problem Solving – Structural System Design
Is Critical Path Method Scheduling Obsolete?
Schedule Performance

• SDCCD Experience:
  34 Major Projects with CPM Scheduling
  4 (12%) finished on time
• UC System Experience in past 10 years: More than 30% of projects delayed by more than 90 days
• Research by Glenn Ballard and Greg Howell indicated only 54% of planned weekly activities get completed on average.
• Last Planner® pull system – a better way (typically 80-90% percent promises kept)
Last Planner® System Principles

1. All plans are forecasts and all forecasts are wrong. The longer the forecast the more wrong it is. The more detailed the forecast, the more wrong it is.
2. Plan in greater detail as you get closer to doing the work.
3. Produce plans collaboratively with those who will do the work.
4. Reveal and remove constraints on planned tasks as a team.
5. Make reliable promises.
6. Learn from breakdowns.
San Diego Ccd
Metrics discussion
Wouldn't It Be Nice If You Could…

- Average Savings of $900,000 on each of 15 projects
- Reduce Average Schedule Delay by 56 days
- Enhance Sustainability Objectives by 44%
- Reduce Facilities Maintenance Costs by 53%
The Compelling Need for A Different Model

- Built Environment (+1.6M square feet)
- Operating Budgets (-US$46M)

+ 80 percent
- 16 percent
By the Numbers – The Database

- 35 Completed Projects
- US$584M Contract Value
- 8000 Change Orders
## Selected Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition of Metric</th>
<th>Lean Principle(s) Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Project Change Order Rates</td>
<td>% of change order costs of total project construction costs</td>
<td>Waste reduction</td>
</tr>
<tr>
<td>Change Orders caused by errors and omissions (as % of project construction costs)</td>
<td>% of change order costs due to errors and omissions of total project construction costs</td>
<td>Waste reduction, collaboration</td>
</tr>
<tr>
<td>Project Schedule Performance</td>
<td>Number and % of projects meeting the original contract completion date</td>
<td>Waste reduction, flow, enhanced communication and collaboration</td>
</tr>
</tbody>
</table>
## Selected Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition of Metric</th>
<th>Lean Principle(s) Evaluated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Target Value Design</td>
<td>Number and % of projects meeting the published target budget</td>
<td>Value generation, waste reduction</td>
</tr>
<tr>
<td>Sustainability Value Generation</td>
<td>Number and % of projects that exceeded LEED Silver certification</td>
<td>Owner-defined value generation</td>
</tr>
<tr>
<td>Annual Maintenance Costs</td>
<td>Annual total maintenance costs divided by the square footage in the portfolio</td>
<td>Waste reduction, process improvement; value generation</td>
</tr>
</tbody>
</table>
Methodology

• Evaluated 35 completed projects (20 without BIM and lean; 15 with BIM and lean)
• Construction value of these projects: $584,731,760
• 11 projects using target costing; 6 have reached GMP
Change Order Rates with/without BIM and Lean

<table>
<thead>
<tr>
<th></th>
<th>Number of Projects (n)</th>
<th>Total CO Rate (%)</th>
<th>Errors &amp; Omissions CO Rate (%)</th>
<th>Ratio of Errors &amp; Omissions Rate/Total CO Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without BIM or Lean</td>
<td>20</td>
<td>7.73</td>
<td>2.99</td>
<td>0.33</td>
</tr>
<tr>
<td>With BIM and Lean</td>
<td>15</td>
<td>4.43</td>
<td>1.88</td>
<td>0.36</td>
</tr>
</tbody>
</table>

©2014 Umstot Project & Facilities Solutions, LLC
Change Order Analysis

Pre-Lean
- 7.73% Total COs
- 2.99% E&O COs

Post-Lean
- 4.43% Total COs
- 1.88% E&O COs
Interesting Finding

Without Lean:
E&O 33% of COs

With Lean:
E&O 36% of COs
## Change Order Rates – New Construction vs. Renovation

<table>
<thead>
<tr>
<th></th>
<th>Number of Projects (n)</th>
<th>Total CO Rate</th>
<th>Errors &amp; Omissions CO Rate</th>
<th>Ratio of Errors &amp; Omissions Rate /Total CO Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New Construction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without BIM or Lean</td>
<td>13</td>
<td>7.54%</td>
<td>3.04%</td>
<td>0.305</td>
</tr>
<tr>
<td>With BIM and Lean</td>
<td>13</td>
<td>4.38%</td>
<td>1.90%</td>
<td>0.355</td>
</tr>
<tr>
<td><strong>Renovation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without BIM and Lean</td>
<td>7</td>
<td>8.00%</td>
<td>2.90%</td>
<td>0.367</td>
</tr>
<tr>
<td>With BIM and Lean</td>
<td>2</td>
<td>4.80%</td>
<td>1.79%</td>
<td>0.388</td>
</tr>
</tbody>
</table>

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Who is on Time?

Pre-Lean

- 1/19 (5%)

Post-Lean

- 3/15 (20%)
San Diego CCD Schedule Impacts – Lean (with BIM) vs. No Lean or BIM (20 projects)

Average Delay (All Contract Types)
Lean w/ BIM: 25 days (n=8)
Pre-Lean w/o BIM: 80 days (n=12)
Target Costing

11 Projects

Avg. Value:
US$21.8M

83% Met Target Cost; Avg. 7% Below Target Cost
Target Value Design

- Six projects evaluated
- Range of GMP: $4,707,408 to $50,423,353
- Average: $21,768,648
- 5/6 (83%) met target budget
- Averaged 7% under target budget
Target Value Design – Root Cause Analysis

• Lack of contemporaneous estimating and exclusion of specialty trades from early participation in project resulted in project exceeding target budget
• Counter measure: All subsequent projects required presentation of budget first
SDCCD Values

• Enhance the student experience
• Flexibility in design to accommodate future changes in pedagogy
• Lower total cost of ownership
• Highly energy efficient buildings
• Reduce maintenance and operations costs
• Meet or exceed sustainability objectives
Potential Sustainability Features

• Higher building energy efficiency
• Extensive use of daylighting
• Use of natural ventilation tied to EMS
• Reduced water consumption
• Use of reclaimed water for irrigation, flushing
• Solid flooring without need for stripping and waxing
Sustainability as a Core Value
LEED Gold Projects

- 20% Direct Contract with Architect
- 26% Post-Lean
- 44% Target Value Design
## Value Generation – LEED Certification Level

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of Projects</th>
<th>Number of Projects Exceeding LEED Silver Goal</th>
<th>% of Projects Exceeding LEED Silver Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without BIM or Lean</td>
<td>9</td>
<td>5</td>
<td>55</td>
</tr>
<tr>
<td>With BIM and Lean</td>
<td>25</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Direct Contracts with Architect</td>
<td>22</td>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td>Target value design with Design-Builder</td>
<td>12</td>
<td>4</td>
<td>33</td>
</tr>
</tbody>
</table>
## Value Generation – LEED Certification Level

<table>
<thead>
<tr>
<th></th>
<th>Number of Projects (LEED v2)</th>
<th>Number of Projects (LEED v3)</th>
<th>Number of Projects Exceeding LEED Silver Goal (LEED v2)</th>
<th>Number of Projects Exceeding LEED Silver Goal (LEED v3)</th>
<th>% of Projects Exceeding LEED Silver Goal (LEED v2)</th>
<th>% of Projects Exceeding LEED Silver Goal (LEED v3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without BIM or Lean</td>
<td>9</td>
<td>0</td>
<td>5</td>
<td>NA</td>
<td>56%</td>
<td>NA</td>
</tr>
<tr>
<td>With BIM and Lean</td>
<td>14</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>29%</td>
<td>29%</td>
</tr>
<tr>
<td>Direct Contract with Architect</td>
<td>21</td>
<td>5</td>
<td>9</td>
<td>1</td>
<td>42%</td>
<td>20%</td>
</tr>
<tr>
<td>Target value design with design-builder</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>4</td>
<td>0%</td>
<td>44%</td>
</tr>
</tbody>
</table>
San Diego Community College District (SDCCD)

Potential Cumulative Savings - $25,863,512

<table>
<thead>
<tr>
<th></th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>Avg. Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Custodial Forecast H/C</td>
<td>104</td>
<td>113</td>
<td>132</td>
<td>149</td>
<td>162</td>
<td>173</td>
<td>189</td>
<td>191</td>
<td>$58,643</td>
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<tr>
<td>Cust Forecast Salary</td>
<td>$6,098,855</td>
<td>$6,650,098</td>
<td>$7,769,004</td>
<td>$8,731,333</td>
<td>$9,504,832</td>
<td>$10,169,255</td>
<td>$11,098,158</td>
<td>$12,277,172</td>
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</tr>
<tr>
<td>Custodial Adj H/C</td>
<td>77</td>
<td>82</td>
<td>88</td>
<td>100</td>
<td>122</td>
<td>130</td>
<td>140</td>
<td>147</td>
<td>45</td>
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<tr>
<td>Custodial Adj Budget</td>
<td>$4,497,197</td>
<td>$4,782,522</td>
<td>$5,187,077</td>
<td>$6,788,320</td>
<td>$7,150,669</td>
<td>$7,622,296</td>
<td>$8,208,826</td>
<td>$8,597,611</td>
<td></td>
</tr>
<tr>
<td>Delta</td>
<td>$1,601,658</td>
<td>$867,576</td>
<td>$2,581,927</td>
<td>$2,853,013</td>
<td>$3,545,162</td>
<td>$2,546,959</td>
<td>$889,331</td>
<td>$2,629,561</td>
<td>$19,324,187</td>
</tr>
</tbody>
</table>

Hold HC Flat until projection exceeds current HC $13,273,027

<table>
<thead>
<tr>
<th></th>
<th>FY09</th>
<th>FY10</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>Avg. Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maint Forecast H/C</td>
<td>45</td>
<td>50</td>
<td>57</td>
<td>64</td>
<td>69</td>
<td>73</td>
<td>79</td>
<td>80</td>
<td>$76,457</td>
</tr>
<tr>
<td>Maint Forecast Salary</td>
<td>$3,440,546</td>
<td>$3,793,010</td>
<td>$4,344,262</td>
<td>$4,857,286</td>
<td>$5,245,685</td>
<td>$5,579,036</td>
<td>$6,044,656</td>
<td>$6,108,880</td>
<td></td>
</tr>
<tr>
<td>Maintenance Adj H/C</td>
<td>29</td>
<td>32</td>
<td>37</td>
<td>41</td>
<td>45</td>
<td>47</td>
<td>51</td>
<td>52</td>
<td>28</td>
</tr>
<tr>
<td>Maint Adj Salary</td>
<td>$2,236,355</td>
<td>$2,465,457</td>
<td>$2,823,770</td>
<td>$3,157,236</td>
<td>$3,409,695</td>
<td>$3,626,373</td>
<td>$3,929,027</td>
<td>$3,970,772</td>
<td></td>
</tr>
<tr>
<td>Delta</td>
<td>$1,204,191</td>
<td>$1,327,554</td>
<td>$520,492</td>
<td>$1,700,050</td>
<td>$1,835,990</td>
<td>$1,952,663</td>
<td>$2,115,630</td>
<td>$2,138,108</td>
<td>$13,794,676</td>
</tr>
</tbody>
</table>

Hold HC Flat until projection exceeds current HC $12,590,485

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Maintenance Costs (2009-2013)

Goal of $2.55 in 2013
Value as Reduced Maintenance Costs

Over 3 Years

$3.93/sq.ft.
$1.91
$1.73
$1.46
## Benefits to SDCCD Using Lean

<table>
<thead>
<tr>
<th>Benefit</th>
<th>SDCCD Metric</th>
<th>SDCCD Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced waste associated with change orders</td>
<td>Total and error &amp; omission change orders as % of total construction cost</td>
<td>Total change orders reduced from 7.73 to 4.46% on average; $13.6M estimated savings; average cost savings of $900,000 per project</td>
</tr>
<tr>
<td>Improved schedule performance</td>
<td>% of projects that completed within contractual completion date</td>
<td>Project schedule performance improved using BIM and Lean, but using critical path method scheduling only 20% of projects completed on time; this prompted abandonment of CPM scheduling and requirement to use the Last Planner® System</td>
</tr>
<tr>
<td>Meeting programmatic requirements and enhancing value with a constrained budget</td>
<td># of projects that met target value design budget</td>
<td>Used target value design to enhance value and meet the target budget in 83% of the projects included in this study</td>
</tr>
</tbody>
</table>
## Benefits to SDCCD Using Lean

<table>
<thead>
<tr>
<th>Benefit</th>
<th>SDCCD Metric</th>
<th>SDCCD Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhanced value generation through more sustainable buildings</td>
<td># of buildings that exceeded LEED Silver certification</td>
<td>Using BIM and Lean improved this by a factor of 45% and using target value design improved this by a factor of 100% from projects where none of these tools were used.</td>
</tr>
<tr>
<td>Enhanced value generation through lower operational and maintenance costs</td>
<td>Maintenance cost per square foot</td>
<td>Major factor in helping reduce annual square footage maintenance costs from $3.73 to $1.46 over a 3-year period</td>
</tr>
</tbody>
</table>
US$34.6 Million of Waste Eliminated

- US$13.6M Total Savings in Reduced COs
- US$7.7M Total Savings To Date with TVD
- US$13.3M Total Savings over 3 Years in Maintenance Costs
Questions?

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