Reforming Project Management & Construction Education

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What has changed Manufacturing, and sharply pushed up productivity, are new concepts. Information and automation are less important than new theories of manufacturing, which are an advance comparable to the arrival of mass production 80 years ago. Indeed, some of these theories, such as Toyota’s “lean manufacturing”, do away with robots, computers and automation.

Results in words

- Workers hourly salaries are going up
- Job satisfaction is improved
  - Participation -> Motivation
  - Higher degree of self justice
- Less claims
- Shorter construction time
- Less errors and omissions
- Lower construction costs
- Improved competitive capacity
Results in numbers

5 test projects (PPB-programme):
- Reduced construction time by up to 20%
- Reduced construction costs by up to 10%
- Up to 35% higher hourly salaries
- 0-errors on several projects
Waste reduction in a design office

PRODUCT UNIT ERRORS

% OF WAITING TIME IN PROCESS

% NON VALUE ADDING ACTIVITIES

44% Decrease 53% Reduction 31% Decrease

PRODUCTIVITY INCREASE OF 31%
Evolution of PPC

CHANGES

weeks

PAC

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Productivity Evolution

<table>
<thead>
<tr>
<th>MONTHS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>0.60</td>
<td>0.70</td>
<td>0.80</td>
<td>0.90</td>
<td>1.00</td>
<td>1.10</td>
<td>1.20</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Changes:
- 65%
- 86%
Causes of no Completion

- Internal Causes: 62%
- External Causes
- Others

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The results show that we are on the right path...

- Budget profit: $6,200,000
- Actual profit: $9,200,000
Improvement in Throughput & Productivity

- Shear Walls
- Ts

- Old Output
- 1st Wk
- Now
Who else is exploring application?

Owners: Intel, Ford, Solutia, Rice University, BAA
Designers: IDC, Neenan, Burt Hill Kosar Rittelmann,
Constructors: Boldt, Kinetics, Southland Industries, EMCOR, Neenan, Linbeck, DPR, EMCOR, Fluor/Ames/Kramer, Walbridge Aldinger, GyM, Westbrook AC, Simpson Mechanical
Range of Projects & LCI

Stodgy

Understand the “Physics” of the Task

Design Systems to Support Lean Ideal

Conform Organization and Contracts

Dynamic
Objectives of LCI

• To develop theory and tools for understanding and managing the way work is done throughout the project delivery process, and

• To support implementation and dissemination.
What is this thing called “LEAN”?

- Not mass, not craft. A third form of production system design.
- The Lean Ideal
  - Meet requirements of a unique customer
  - Deliver it instantly
  - Maintain no inventory

- “Give customers what they want, deliver it instantly, with no waste.”
Lean Production Goals

Deliver the product, while...

maximizing value *(give the customer what they need when they need it)* and

minimizing waste *(eliminate anything not needed for delivering value)*, and

pursuing perfection *(never stop striving to better achieve the lean ideal)*
Business Objectives of Project-Based Producers

Minimize Waste

- Reduce defective products
  - Improve supplier quality & on-time delivery
  - Reduce the no. of suppliers & engage in lean
  - Actively learn with suppliers from project to project
  - Require evidence of product compliance from suppliers

- Structured work for flow
  - Improve the quality of intermediate products
  - Use in-process inspection
  - Pay after inspection / QA
  - Use commissioning

- Reduce
  - Work for flow
  - Inspection time
  - Work time

- Reduce inventory
  - Make materials & information flow/ reduce cycle times
  - Control work for flow
  - Reduce work for flow

- Decrease variability
  - Reduce transfer batch sizes
  - Reduce changeover times

- Reduce make:
  - Reduce set up times
  - Pull materials & info when possible

- Incorporate inspection into processing time
  - Make inspection unnecessary or automatic

- Use Last Planner
  - Type, size, & locate buffers to absorb variability

- Reduce negative iterations in design
  - Do in-process inspection

- Reduce unneeded work space

Deliver the Project

- Get more from less
  - Increase resource productivity
  - Reduce the cost of using materials & info

- Reduce time
  - Reduce time of on-site movement
  - Reduce cycle time

- Increase system control
  - Align stakeholder interests
  - Use a collaborative project definition

- Increase system transparency
  - Increase positive iteration

- Reduce cycle time
  - Reduce resource utilization
  - Reduce transaction costs

Maximize Value

- Deliver products that enable customers to better accomplish their purposes
  - Structure work for value generation
  - Understand, critique, & expand customer purposes
  - Increase system control (ability to realize purposes)

- Deliver products on time/ Reduce cycle time
  - Minimize production disruptions
  - Respond rapidly to production disruptions

- Increase system control
  - Use Last Planner

- Reduce variability
  - Use Last Planner

- Improve supplier quality & on-time delivery
  - Use in-process inspection
  - Pay after inspection / QA

- Use commissioning

- Type, size, & locate buffers to absorb variability

- Make materials & information flow/ reduce cycle times

- Reduce work for flow

- Decrease variability

- Reduce negative iterations in design

- Do in-process inspection

- Reduce unneeded work space

- Reduce 'emissions'
How do we manage projects now?

• Determine client requirements and design to meet them. Align design to quality, schedule and budget limits.
• Manage the project by breaking it into pieces, estimating duration and resource requirements for each piece, then put the pieces in a logical order with CPM.
• Assign or contract for each piece, give start notice and monitor each piece to assure it meets safety, quality, schedule and cost standards. Take action on negative variance from standards.
• Coordinate using the master schedule and weekly meetings.
• Cost may reduced by productivity improvement. Duration by speeding each piece or changing logic. Quality and safety get better with inspection and enforcement.
More Physics: Variability, Lead Time, & Capacity Utilization

![Graph showing capacity utilization vs. time with a point marked A]
PPC and Capacity Utilization

- PPC = 50%
- PPC = 70%
- PPC = 90%

Wait Time vs. Capacity Utilization

Target: 65% 80%
Essential Features of Current Practice

- **Activity** centered - Batch and Queue that **trades** efficiency for apparent security.
- **Inflexible** to changes in business case and owner requirements after concept design.
- **Control** begins with **Tracking** cost and schedule.
- **Improving** local productivity/speed leads to **Unreliable Work Flow** further reducing project performance.
- **Protecting** activities leads to **adversarial** relations.
- **Planning** system cannot **Coordinate** the work between crews.
The Opportunity in Projects

Change the way projects are managed!

– Current practice
  • Takes too long, costs too much, kills too many
  • Rests on a deficient theory; an incomplete understanding of work, its control and improvement
  • Confuses scheduling with production management.
  • Commercial contracting trades system efficiency for a fantasy of security. Bob Lane, BAA
  • Increases risk and uncertainty
  • Causes sub-optimal performance
Designing Project Based Production Systems

• Understand the physics of production (making - dependence and variation, and design - wicked problems).
• Assure design, planning and logistic systems all support reliable and speedy workflow.
• Provide organizations to support these systems.
• Draft contracts that create these organizations.
Dice Game

- Move a 100 units/tasks/requirements into the last bucket.
- Roll in sequence to the end of the line.
- Average roll of 5.
- How many times will the die have to be passed down the line?
- When will the red chip, #50 be at station 4?
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game
Sample Game

1

2

3

4

5
Sample Game
Sample Game
Sample Game
Sample Game
Flow Variation and Project Outcomes

# of Rolls To Move 100 Through 5 Steps

<table>
<thead>
<tr>
<th>Distribution</th>
<th>9 &amp; 1</th>
<th>8 &amp; 2</th>
<th>7 &amp; 3</th>
<th>6 &amp; 4</th>
<th>5s</th>
<th>10 &amp; 2</th>
<th>6s</th>
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<tbody>
<tr>
<td>Worst</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Best</td>
<td></td>
<td></td>
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<td></td>
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</table>

Distribution

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Key Points

• Reducing workflow variability
  – Improves total system performance,
  – Makes project outcomes more predictable,
  – Simplifies coordination,
  – Reveals new opportunities for improvement.

• Point speed and productivity don’t matter to the customer – throughput does.

• Strategy: Reduce variation then go for speed to increase throughput.
Key Terms

• Work Flow - The movement of work between interdependent specialists.
• Release of work - making work available to the next crew.
• Dependence - waiting on release of work.
• Variation - the range of work completed each day or week.
• Buffer - a verb: “to isolate one activity from the next.”
• WIP - Work in process.
• Point Speed - how fast each assignment or activity is completed.
• Throughput - the amount of the project completed each period.
• Capacity - amount of work that can be done by the crew, related to productivity.
• Push - Advancing work based on central schedule
• Pull - Signaling for components of work to arrive when they will be required.
What We Know for Sure about Last Planner Production Management

First - It Works!!!!!!
Master & Phase Schedules

Planning System Measurement

Lookahead Plan With Constraint Analysis

Weekly Work Planning
A Traditional (Push) Planning System

1. INFORMATION
2. PROJECT OBJECTIVES
3. PLANNING THE WORK
4. SHOULD
5. RESOURCES
6. EXECUTING THE PLAN
7. DID
## Traditional Management Increases Variability: Plan Reliability Data

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor 1</td>
<td>33 %</td>
</tr>
<tr>
<td>Contractor 2</td>
<td>52 %</td>
</tr>
<tr>
<td>Contractor 3</td>
<td>61 %</td>
</tr>
<tr>
<td>Contractor 4</td>
<td>70 %</td>
</tr>
<tr>
<td>Contractor 5</td>
<td>64 %</td>
</tr>
<tr>
<td>Contractor 6</td>
<td>57 %</td>
</tr>
<tr>
<td>Contractor 7</td>
<td>45 %</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>54 %</strong></td>
</tr>
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</table>
## 1 WEEK PLAN

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Est</th>
<th>Act</th>
<th>Mon</th>
<th>Tu</th>
<th>Wed</th>
<th>Thurs</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
<th>PPC</th>
<th>REASON FOR VARIANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas/F.O. hangers O/H &quot;K&quot; (48 hangers)</td>
<td>XXXX</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Owner stopped work (changing elevations)</td>
</tr>
<tr>
<td>Gas/F.O. risers to O/H &quot;K&quot; (3 risers)</td>
<td></td>
<td></td>
<td>xxxx</td>
<td>xxxx</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Same as above-worked on backlog &amp; boiler blowdown</td>
</tr>
<tr>
<td>36&quot; cond water &quot;K&quot; 42' 2-45 deg 1-90 deg</td>
<td>XXXX</td>
<td>xxxx</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Chiller risers (2 chillers wk.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Matl from shop rcvd late Thurs. Grooved couplings shipped late.</td>
</tr>
<tr>
<td>Hang H/W O/H &quot;J&quot; (240'-14&quot;)</td>
<td>XXXX</td>
<td>xxxx</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Cooling Tower 10&quot; tie-ins (steel) (2 towers per day)</td>
<td>XXXX</td>
<td>xxxx</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Weld out CHW pump headers &quot;J&quot; mezz. (18)</td>
<td>XXXX</td>
<td>xxxx</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Weld out cooling towers (12 towers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No</td>
<td>Eye injury. Lost 2 days welding time</td>
</tr>
<tr>
<td>F.R.P. tie-in to E.T. (9 towers) 50%</td>
<td>XXXX</td>
<td>xxxx</td>
<td>xxxx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

### WORKABLE BACKLOG
- Boiler blowdown-gas vents
- Rupture disks

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The Last Planner System

1. **Project Objectives**
   - Information
   - Planning the Work
     - SHOULD
   - Can
     - The Last Planner
       - Production
         - Resources
         - WILL
   - DID
Forming the Weekly Work Plan

- CAN
- POSSIBLE WORKABLE BACKLOG
- ELIGIBLE FOR WILL

SHOULD

- THESE TASKS NEED TO BE MADE READY
LAST PLANNER SYSTEM: WEEKLY WORK PLANNING

Design Criteria

Work Structuring ➔ Master/Phase Schedule

Selecting, sequencing, & sizing work we think can be done

Lookahead

Selecting, sequencing, & sizing work we know can be done

Weekly Work Plans

Actions to prevent repetitive errors

Chart PPC & Reasons

Resources ➔ Production ➔ Completed Work

Information ➔ Make work ready by screening & pulling ➔ Workable Backlog

Current status & forecasts

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Quality Characteristics of Weekly Work Plans

- Definition
- Soundness
- Sequence
- Size
- Learning
LAST PLANNER SYSTEM: SHIELDING

Design Criteria

Work Structuring

Master/Phase Schedule

Selecting, sequencing, & sizing work we think can be done

Lookahead

Selecting, sequencing, & sizing work we know can be done

Weekly Work Plans

Action to prevent repetitive errors

Chart PPC & Reasons

Completed Work

Resources

Production

Workable Backlog

Make work ready by screening & pulling

Information

Current status & forecasts

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# Weekly Planning

## Weekly Work Plan

**Project:** Same Day Surgery  
**Planner:** Dena Deibert  

### Make Ready Needs

<table>
<thead>
<tr>
<th>Week</th>
<th>Assignment Description</th>
<th>Responsible Party</th>
<th>Work that Must and Can Be Performed Prior to Release of this Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Issue vibration study</td>
<td>Brad/STS</td>
<td>M T W F S Y N Comments</td>
</tr>
<tr>
<td>1</td>
<td>Award Bid Pack 3</td>
<td>Dena/Brad</td>
<td>x X X X</td>
</tr>
<tr>
<td>1</td>
<td>Reissue construction documents</td>
<td>Jose</td>
<td>Coordinate with Ring &amp; DuChateau</td>
</tr>
<tr>
<td>2</td>
<td>Test Glycol Mains</td>
<td>Jarosz</td>
<td>x X X X</td>
</tr>
<tr>
<td>3</td>
<td>Pour Roof</td>
<td>Randy</td>
<td>X X X X</td>
</tr>
<tr>
<td>4</td>
<td>Confirm brick is ready</td>
<td>Roger Spahr</td>
<td>X X X X</td>
</tr>
<tr>
<td>4</td>
<td>Stone production</td>
<td>Rossi</td>
<td>X X X X</td>
</tr>
<tr>
<td>5</td>
<td>Complete roof framing</td>
<td>Bob Brue</td>
<td>X X X X</td>
</tr>
<tr>
<td>5</td>
<td>Begin roof detailing</td>
<td>Bob Brue</td>
<td>X X X X</td>
</tr>
<tr>
<td>5</td>
<td>Re-submit curtainwall support shops</td>
<td>Dick</td>
<td>X X X X</td>
</tr>
<tr>
<td>5</td>
<td>Issue penthouse curb ASK's</td>
<td>Jose</td>
<td>X X X X</td>
</tr>
<tr>
<td>6</td>
<td>Submit Phase 2 millwork shops</td>
<td>Precision</td>
<td>X X X X</td>
</tr>
<tr>
<td>6</td>
<td>Deliver mock-up millwork</td>
<td>Precision</td>
<td>X X X X</td>
</tr>
<tr>
<td>7</td>
<td>Submit additional roofing shops</td>
<td>Scott Harms</td>
<td>X X X X</td>
</tr>
<tr>
<td>8</td>
<td>Resubmit curtainwall shops</td>
<td>Jim L</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Submit curtainwall Struct. Calcs</td>
<td>Jim L</td>
<td>X</td>
</tr>
<tr>
<td>8</td>
<td>Order Glass</td>
<td>Jim L</td>
<td>ARC verbally confirm dimensions</td>
</tr>
<tr>
<td>10</td>
<td>Fab. Louvers</td>
<td>Air Flow</td>
<td>X X X X X Week 1 of 6</td>
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</table>

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# Measuring PPC

**Week of 10/16/00**

<table>
<thead>
<tr>
<th>Repeat</th>
<th>Assignment Description</th>
<th>Responsible Party</th>
<th>M</th>
<th>T</th>
<th>W</th>
<th>T</th>
<th>F</th>
<th>S</th>
<th>Y</th>
<th>N</th>
<th>Reasons For Variance / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Remember the Five Criteria for Release of Assignments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Defined - Sound - Proper Sequence - Right Size - Able to</em></td>
</tr>
<tr>
<td></td>
<td><strong>Learn</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>Learn</em></td>
</tr>
<tr>
<td></td>
<td><strong>Done?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>PPC Analysis</strong></td>
</tr>
<tr>
<td></td>
<td><strong>PPC = 69%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Reasons For Variance / Comments</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Review mock-up drywall dimensions</strong></td>
<td>Randy</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td>Wardrobe dimensions changed</td>
</tr>
<tr>
<td></td>
<td><strong>Review microscope vibration Study</strong></td>
<td>David</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Review bids - Bid Pack 3</strong></td>
<td>Dena/ Brad</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td>Will award next week.</td>
</tr>
<tr>
<td></td>
<td><strong>Review roofing shops</strong></td>
<td>Jose’</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td>Week 1 of 2</td>
</tr>
<tr>
<td></td>
<td><strong>Complete concrete haunches</strong></td>
<td>Randy</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Release order on limestone</strong></td>
<td>Dena</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Re-submit curtainwall support shops</strong></td>
<td>Dick</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>N</td>
<td>Waiting for curtainwall shop drwg.</td>
</tr>
<tr>
<td></td>
<td><strong>Roof framing: 75% complete</strong></td>
<td>Bob Brue</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Submit Phase 2 Millwork Shops</strong></td>
<td>Precision</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>N</td>
<td>Week 2 of 3</td>
</tr>
<tr>
<td></td>
<td><strong>Fabricate mock-up millwork</strong></td>
<td>Precision</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Re-submit curtainwall shops &amp; structural calcs</strong></td>
<td>Jim Leicht</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>N</td>
<td>Middle of next week.</td>
</tr>
<tr>
<td></td>
<td><strong>Finalize review of louver shops</strong></td>
<td>Tony/ David</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Review GL-1 and GL-2</strong></td>
<td>ARC/Jim Leicht</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>
Percent Plan Complete (PPC) Chart

Rasacaven: Electrical Power Distribution
The Impact of Last Planner

Began making quality assignments

We e k ly Pro d u c t iv it y

Cu m u la t iv e Pro d u c t ivity

Began making quality assignments
PPC and Capacity Utilization

Wait Time

Target

Capacity Utilization

PPC=50%  PPC=70%  PPC=90%

50%  65%  80%  100%
Uncertainty and Variability Can Be Managed

• Reduce variability then go for speed.
• The place to start is by shielding production from flow variability by making only ‘quality’ assignments.
• Managing the remaining variability involves thoughtful location and sizing of inventory and capacity buffers.
LAST PLANNER SYSTEM: LOOKAHEAD PROCESS

Design Criteria

Work Structuring

Master/Phase Schedule

Selecting, sequencing, & sizing work we think can be done

Lookahead

Selecting, sequencing, & sizing work we know can be done

Weekly Work Plans

Chart PPC & Reasons

Action to prevent repetitive errors

Workable Backlog

Information

Make work ready by screening & pulling

Current status & forecasts

Completed Work

Production

Resources

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Purposes of the Lookahead Process

- Shape work flow sequence and rate
- Match work flow and capacity
- Maintain a backlog of ready work
- Develop detailed plans for how work is to be done
  - Safety, environmental, quality issues
Lookahead Process

• **Explode** scheduled activities into assignment-level detail, using the Activity Definition Model and First Run Studies.

• **Screen** the constraints on each assigned task within the lookahead window.

• **Make** assigned tasks **ready** by removing constraints.

• **Balance** load and capacity by advancing/retarding scheduled work, increasing/decreasing capacity, or deciding how to invest excess capacity.

• **Adjust** phase or master schedules as needed.

• **Learn**: measure and improve performance.
Mapping Language: Activity Definition Model

Directives → Meets Criteria?

Prerequisite Work → Process

Process → Output

Resources
Using the Activity Definition Model

- Build Foundation
- Specifications & Schedule
- Completed Foundation
- Permits
- Materials
- Drawings
- Labor, Surveyor, Equipment

OK?
Task Explosion

1. Stakes Siteplan Benchmarks
2. Layout Practices, Drawings
   - Layout
   - Layout Complete
   - Excavate
   - Excavate
   - Noise rules, Spoil location
     - OK
     - OK
     - Yes
   - Represented as a logical process with decision points.
   - Form
   - Equipment & Operator
   - Hole ready
   - Yes
   - Yes
   - Equipment & Operator
   - Yes
   - Labor & Material
   - Drawings

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Screening and Constraints

• Activities are made ready to be assigned by removing constraints.
• Screening is the process of analyzing the activities for constraints and evaluating if they can be removed in time for the planned start.
# Constraints Analysis: Design

**Project:** Mega Bldg  
**Report Date:** 3 Nov

<table>
<thead>
<tr>
<th>Activity</th>
<th>Responsible Party</th>
<th>Scheduled Duration</th>
<th>Directives</th>
<th>Pre-requisites</th>
<th>Resources</th>
<th>Comments</th>
<th>Ready?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design slab</td>
<td>Structural Engineer</td>
<td>15 Nov to 27 Nov</td>
<td>Code 98 Finish? Levelness?</td>
<td>Soils report</td>
<td>10 hours labor, 1 hr plotter</td>
<td></td>
<td>No</td>
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<tr>
<td>Get info. from client re floor finish &amp; level</td>
<td>Structural Engineer's gofer</td>
<td>3 Nov to 9 Nov</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>Yes</td>
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<tr>
<td>Get soils report from Civil</td>
<td>Structural Engineer</td>
<td>By 9 Nov</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td></td>
<td>Yes</td>
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<tr>
<td>Layout for tool install</td>
<td>Mechanical Engineer</td>
<td>15 Nov to 27 Nov</td>
<td>OK</td>
<td>Tool configurations from mfrger</td>
<td>OK</td>
<td>May need to coord. w/ HVAC</td>
<td>No</td>
</tr>
<tr>
<td>Week</td>
<td>Activity</td>
<td>Responsible Party</td>
<td>Comments / Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>------</td>
<td>------------------------------------------------------------</td>
<td>-------------------</td>
<td>-----------------------------------------</td>
<td></td>
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<tr>
<td>1</td>
<td>Build mock-up of room 11</td>
<td>Boldt</td>
<td>Millwork &amp; mirror</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Microscope vibration study</td>
<td>Boldt</td>
<td>CD's will be issued prior to this info; Isolation system will come as addendum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Bid &amp; award bid pack 3</td>
<td>Boldt</td>
<td>Review with Brad</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Release updated construction documents</td>
<td>ARC</td>
<td>Additional submittals required</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1</td>
<td>Demolition</td>
<td>Boldt</td>
<td>Coordinate with Ring &amp; Du</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>Pour roof</td>
<td>Boldt</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Expedite stone production</td>
<td>BDI</td>
<td>Stone was ordered 10-19-00</td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>Steel Shops: Curtainwall Support</td>
<td>Duwe</td>
<td>Klein Dickert will coordinate with Mike D</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1</td>
<td>Roof detailing</td>
<td>Duwe</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>Phase 3 Millwork Shop Drwngs</td>
<td>Precision</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1</td>
<td>Fabricate louveres</td>
<td>Air Flow</td>
<td>5-6 week lead time - Ordered 10-19-00</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Fabricate auto entrance doors</td>
<td>Besam</td>
<td>Shipping 11-3; Besam header to Dickert</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Fabricate curtainwall</td>
<td>Klein Dickert</td>
<td>Waiting for framing materials-by October</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Mock-up review</td>
<td>SLMC</td>
<td>Millwork; Mirror</td>
<td></td>
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<tr>
<td>2</td>
<td>Masonry Work</td>
<td>BDI</td>
<td>Roger needs to confirm if brick is in</td>
<td></td>
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<td></td>
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<tr>
<td>2</td>
<td>Penthouse framing &amp; decking</td>
<td>Duwe</td>
<td>Boldt to confirm placement of AHU's</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Bid Pack 3 Submittals</td>
<td>TBD</td>
<td>Award contracts</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>Start work on patient rooms 3847-49</td>
<td>TBD</td>
<td>Need to coordinate with Jan Keepers</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

Workable Backlog

<table>
<thead>
<tr>
<th>Activity</th>
<th>Responsible Party</th>
<th>Comments / Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabricate AHU's / ACCU</td>
<td>Trane</td>
<td>Shipping: 11-13-00</td>
</tr>
<tr>
<td>Med Gas Equip. Lead-Time</td>
<td>Squires</td>
<td>Delivery: 11-6-00</td>
</tr>
<tr>
<td>Demo shades at main entrance</td>
<td>TBD</td>
<td></td>
</tr>
<tr>
<td>Review room numbering</td>
<td>ARC / Lukes</td>
<td></td>
</tr>
</tbody>
</table>
LAST PLANNER SYSTEM: MASTER & PHASE SCHEDULING

Design Criteria

Initial Work Structuring → Master/Phase Schedule

Selecting, sequencing, & sizing work we think can be done

Lookahead

Selecting, sequencing, & sizing work we know can be done

Weekly Work Plans

Chart PPC & Reasons

Action to prevent repetitive errors

Weekly Work Plans

Resources → Production → Completed Work

Workable Backlog

Make work ready by screening & pulling

Current status & forecasts

Information
Products of Work Structuring

- Global sequencing
- Project Organizational/Contractual Structure
- Supply Chain Configurations (how the project hooks to external production systems)
- Master Schedule & Phase Schedules
- Rough Cut Operations Designs; e.g., decision to cast-in-place vs precast, or use a tower crane vs rolling stock
- Detailed Operations Designs; e.g., how to form-rebar-pour basement walls
Purposes of Master Schedules

- Demonstrate the feasibility of completing the work within the available time.
- Develop and display execution strategies.
- Determine when long lead items will be needed.
- Identify milestones important to client or stakeholders.
Phase Scheduling: Purposes and Actions

• Produce the best possible plan by involving all with relevant expertise and by planning near action.

• Assure that everyone in a phase understands and supports the plan by developing the schedule as a team.

• Assure the selection of value adding tasks that release other work by working backwards from the target completion date to produce a pull schedule.

• Publicly determine the amount of time available for ‘contingency’ and decide as a group how to spend it.
QuickTime™ and a Photo - JPEG decompressor are needed to see this picture.
Entry Rules

• Rule 1: Allow activities to remain in the Master/Phase schedule unless positive knowledge exists that it should not or cannot be executed when scheduled.
• Rule 2: Allow activities to remain in the lookahead window only if the planner is confident that it can be made ready for execution when scheduled. (Screening)
• Rule 3: Allow activities into weekly work plans only if all constraints have been removed. (Shielding)
Summary Recommendations for Production Control

- Limit master schedules to milestones and long lead items.
- Produce phase schedules with the team that will do the work, using a backward pass, and making float explicit.
- Drop activities from the phase schedule into a 6 week lookahead, screen for constraints, and advance only if constraints can be removed in time.
- Try to make only quality assignments. Allow assignments to be rejected.
- Track PPC and act on reasons for plan failure.
Project control in the *Last Planner System* is principally the practice of securing reliable promises and declarations of completion of those activities that releases work to others. This allows the project work to stay in the desired sequence.  

*Hal Macomber, Good2Great*
Project and Production Controls

- Project Objectives
  - Work Structuring
    - Master or Phase Schedule
      - Lookahead Planning
        - SHOULD
          - Make Ready Process
            - CAN
              - Last Planning Process
                - WILL
                  - Production
                    - PPC
                      - DID

On Budget & Schedule?
## Current Practice vs Lean

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Lean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Knowing</td>
<td>Learning</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>External</td>
<td>Internal</td>
</tr>
<tr>
<td>Control</td>
<td>Tracking &amp; React</td>
<td>Steering &amp; ?</td>
</tr>
<tr>
<td>Coordination</td>
<td>Following Orders</td>
<td>Making and Keeping Commitments</td>
</tr>
<tr>
<td>The Goal of Supervision</td>
<td>Point Speed</td>
<td>Reduce Variation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase System Throughput</td>
</tr>
<tr>
<td>Commercial Contracts</td>
<td>Trades Production System</td>
<td>Aligns Production System</td>
</tr>
<tr>
<td></td>
<td>Efficiency</td>
<td>Objectives</td>
</tr>
<tr>
<td></td>
<td>for Apparent Security</td>
<td>with Interests</td>
</tr>
</tbody>
</table>

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What is happening now.

- Lean Project-based production systems are coming into construction.
- Specialty contractors make the most money soonest. Construction Users get better projects sooner.
- Leading edge of significant change in the industry flying under the radar of current thinking.
- Need to develop and extend theory & technique.
A Path forward for Construction Education

• Develop an Explicit Theory Base
• Teach it
• Do research to continuously refine and extend it.
March 14/15  Production Control Research Meeting - Chicago
March 27/28  LCI Academic Forum - Michigan State
April 18/19  Introduction to Lean Construction - Washington DC
May 16/17   Design Management Research Meeting - Denver
July 31-Aug Introduction to Lean Construction - Berkeley
Aug 2       4th Annual Lean Congress - Berkeley
Aug 5/9     10th Annual IGLC Meeting - Brazil

* Member/CLIENT Only Meetings
Questions?