LEAN DESIGN
Target Value Design
Set Based Design
Choosing By Advantages

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University of California, Berkeley

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Goals

• Lend perspective on lean design
• Introduce a framework for lean design based on
  • Target Value Design
  • Set Based Design
  • Choosing by Advantages
What is this thing called LEAN?

Not mass, not craft, but a third form of production system design.

The Lean Ideal

1. Meet requirements of a unique customer
2. Deliver it instantly
3. Maintain no inventory

Give customers what they want, deliver it instantly, with no waste.

*Doe wat the klant wil, zo vlug mogelijk, zonder verspilling.*

Source: Lean Construction Institute (LCI)
Lean Triangle

- Organization
- Commercial
- Operating System
Topics

Designing to Targets:
Delivering value within customer conditions of satisfaction

Set Based Design:
Generating, Evaluating & Selecting Design Alternatives
by means of Choosing by Advantages
"JUST GO DOWN TO THE VANISHING POINT AND TAKE A LEFT."
Project Phases and Target Costing

1. Preproject Planning
   - Project Definition
     * Business Planning
     * Plan Validation
   - Go/No Go

2. Design
   - * Develop Design
   - * Detailed Engineering
   - Design to Targets
   - Go/No Go

3. Permit
   - Go/No Go

4. Construct
   - Build to Targets

5. Commission/Turnover
   - Conform
Design Development

- Set the target cost—typically lower than the budget that assumed current best practice
- Form Target Value Design teams by system and allocate the target cost to each team
- Hold a kickoff workshop
- Use a set-based approach, evaluating alternatives against target values
- Provide cost and constructability guidelines for design; e.g., product/process standardization
- Promote collaboration: have designers get cost input before developing design options
- Do rapid estimating; hold frequent budget alignment sessions
- Use value engineering proactively
- Hold design reviews with permitting agencies
The Validation Study

Establishing a Shared Understanding,
Basis of Design, Budget and Schedule.

The Starting Point for Target Value Design
Setting the target cost and project schedule

Nine-project marketplace average

Target set 14% ‘below’ marketplace
Innovation
The cardinal rule: The Project’s Target Cost shall never be exceeded without express approval of Owner.

The budget becomes an influence on design and decision-making rather than an outcome of design.
Point Based Design vs Set-Based Design

Design Space

Marketing

Maintenance Planning

Styling

System Design

Component Design

Manufacturing Engineering

Marketing Concept

Styling

Product Design

Component 1

Component 2

Manufacturing System Design

Set-Narrowing Phase

Problem Correction Phase

Note: Based on a sketch by Toyota’s general manager of body engineering in 1993.

Figures from Ward et al. 1995
Set-Based Design

Concept:
Avoid rework and iteration by considering a set of design alternatives

Criterion: A decision-rule or a guideline; a standard on which a judgment is based; any decision that guides further decisionmaking
What HEALTHCARE customers really need

(ANNUAL COSTS)

Operation and Maintenance
Construction
Design 0.1
Business Costs

Healthcare outcomes
Clinical outcomes
Hospital-acquired infection rates
Safety outcomes
Medication error rates
Medication rates
Re-hospitalisation rates
Length of stays
Patient transfers
Costs per unit of service
Patient satisfaction
Visitor satisfaction
Staff morale
Staff turnover

From Evans, et al. 1998
JUST A MINUTE... WHY YES!! APPARENTLY I AM THE DECISION MAKER FOR THE COMPANY!!
Methods → Decisions → Actions → Outcomes

If outcomes matter, then methods matter.
The Fundamental Rule of the CBA System:

Decisions must be based on the IMPORTANCE of ADVANTAGES
Relation to ‘Lean’

- All decisions are subjective = VALUE
- Consider multiple views using a set-based approach
  - Explore alternatives
  - Defer selection until Last Responsible Moment
  - Reconsider = positive iteration
- Build agreement in group decision making, work in the ‘oba’
- Document the context in which decision is made (factors, criteria, attributes, advantages, and importances of advantages)
- Articulate value (a personal matter) separately from money (a market issue)
Example Situation

- removed an interior chimney from our house
  → opened up a lot of closet space
- water heater in basement vented through that chimney
  → need to provide new vent
Alternatives

1. Keep 7-year old 40-gallon gas water heater and build new flue from basement through roof through opening left after chimney removal
2. Replace water heater by newer model that vents sideways using a ventilation pump (does not fit in space next to exterior basement wall)
3. Replace 40-gallon water heater by a 75-gallon model that vents sideways using a ventilation pump (does not fit in space next to exterior basement wall)
4. Replace 40-gallon water heater by an on-demand water heater that vents sideways, and no pump needed if adjacent to exterior basement wall (requires upgrading of gas supply line)
## Alternatives

<table>
<thead>
<tr>
<th></th>
<th>Keep 40 gallon, build flue</th>
<th>New 40 gallon with side vent</th>
<th>New 75 gallon with side vent</th>
<th>On-demand system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy use to heat water</strong></td>
<td><strong>less is better</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34,000 BTU/hour</td>
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<td>70,000 BTU/hour</td>
<td></td>
</tr>
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</tr>
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<td>Hot air rises by itself</td>
<td>Power assist uses electricity</td>
<td>Power assist uses electricity</td>
<td>No energy needed</td>
<td></td>
</tr>
<tr>
<td>through flue</td>
<td></td>
<td></td>
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</tbody>
</table>

...
## Factors

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# Criteria

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### Attributes

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...
## CBA Table – part 1 of 2

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</tr>
<tr>
<td></td>
<td></td>
<td>10 KWatt</td>
<td>11.8 KWatt</td>
<td>15.8 KWatt</td>
</tr>
<tr>
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</thead>
<tbody>
<tr>
<td>Hot water available at points of use – <em>less time to get warm water is better</em></td>
<td>Pipe is long, system uses circulation pump on timer</td>
<td>Pipe is long, system uses circulation pump on timer</td>
<td>Pipe is long, system uses circulation pump on timer</td>
<td>Pipe is long, circulation pump defeats ‘flash benefits’</td>
</tr>
<tr>
<td>– <em>water is available for 3 consecutive 5 minute showers</em></td>
<td>May run out (~ 33 gallon/hour output)</td>
<td>May run out</td>
<td>OK</td>
<td>OK</td>
</tr>
</tbody>
</table>
Premises of Sound Decision Making with CBA

- Alternative must exist
  - concrete details
  - it must be real and available to you
- Select based on favorable differences between advantages of alternatives
  - advantages are relative to one another
  - there is no absolute ‘best’
In each row, select **least desirable attribute** (underline) and then assess **advantage of each alternative’s attribute** relative to that least desirable attribute.

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<td>40,000 BTU/hour 11.8 KWatt</td>
<td>54,000 BTU/hour 15.8 KWatt</td>
<td>70,000 BTU/hour 20.5 KWatt</td>
</tr>
<tr>
<td></td>
<td>36,000 BTU/h 10.5 KW less</td>
<td>30,000 BTU/h 8.7 KW less</td>
<td>16,000 BTU/h 4.7 KW less</td>
<td></td>
</tr>
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<td>Hot air rises by itself through flue</td>
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<td>Power assist uses electricity</td>
<td>No energy needed</td>
</tr>
<tr>
<td></td>
<td>Less energy</td>
<td></td>
<td></td>
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<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
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<td>Pipe is long, system uses circulation pump on timer</td>
<td>Long pipe defeats ‘flash’ benefits</td>
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<td>– <em>less time to get warm water is better</em></td>
<td>Less time</td>
<td>Less time</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less likely to run out</td>
</tr>
</tbody>
</table>
Importance of Advantages

- 16,000 BTU/hour less (4.7 KW less)
- 30,000 BTU/hour less (8.7 KW less)
- 36,000 BTU/hour less (10.5 KW less)

Less likely to run out of hot water
Less time to get warm water
Less energy used to vent

Paramount advantage

Items that are underlined define baseline from which advantages are measured
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<td></td>
<td>36,000 BTU/h 10.5 KW less [52]</td>
<td>30,000 BTU/h 8.7 KW less [45]</td>
<td>16,000 BTU/h 4.7 KW less [38]</td>
<td></td>
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<tr>
<td></td>
<td>Less energy [50]</td>
<td>Less energy [50]</td>
<td></td>
<td></td>
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<tr>
<td></td>
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## Terminology

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</tr>
<tr>
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<td>Less time [100]</td>
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<td>Less time [100]</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less likely to run out [90]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Less likely to run out [90]</td>
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## Price product + install

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<tr>
<td>TOTAL IMPORTANCE OF ADVANTAGES</td>
<td>202</td>
<td>145</td>
<td>228</td>
<td>140</td>
</tr>
</tbody>
</table>

### Keep old ~ $1,300
- 3” flue is OK, but use 4” to allow upgrade to larger tank later

### New 40 gallon with power assist ~ $2,000

### New 75 gallon with power assist ~ $2,775

### On-demand system ~ $3,325
- Upgrade gas supply
California Pacific Medical Center
Sutter Health
HerreroBoldt
SmithGroup
Degenkolb Engineers
Pankow Builders
Malcolm General Engineering
Ferma Corporation
Ryan Engineering
Rosendin Electric
Silverman and Light
Southland Industries
Ted Jacob Engineering Group
Bagatlos Architectural Glass
Herrick Steel
Olson Steel
KHS&S Contractors
ISEC
Otis
Pacific Erectors
RLH Fire Protection
Treadwell and Rollo
DIS
Fuel Oil System
Advanced Pneumatic Tube
Rescue Air
Ad-In Inc
Capital Engineering
Orange Blade Consulting
The Lawson Roofing
Tractel Inc.
Build Pods
MRI Corporation
<table>
<thead>
<tr>
<th>A3# and Status</th>
<th>Proposal No.</th>
<th>Appears in LEE (still verified?)</th>
<th>Affects LEE (still verified?)</th>
<th>Description of Non-Exclusive Proposals</th>
<th>Net Summary of Advantages for “with vs without alternatives” within the proposal</th>
<th>Net Import $ of Alternatives on 062309 PK</th>
<th>Construction Cost</th>
<th>Running Total Construction Cost</th>
<th>Annual Costs 5% Discount, 10 years</th>
<th>Zero Inflation Constant Dollars</th>
<th>Priority (1-100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>117-canceled O</td>
<td>78</td>
<td>NO</td>
<td>YES</td>
<td>Exit Well - Response to Planning Department Comments - Current Premium Over Validation</td>
<td>Very large difference in Planner's acceptance of this proposal compared to prior exterior designs (primarily reacting to glass and panel layout and characteristics) was received. Without this design, the project is delayed further.</td>
<td>400</td>
<td>$93,930,831</td>
<td>$10,439,831</td>
<td>NC</td>
<td>$10,439,831</td>
<td>3.685</td>
</tr>
<tr>
<td>24</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>Tier 4 Generator - New EPA Requirements</td>
<td>Large difference in compliance with anticipated air quality regulations</td>
<td>299</td>
<td>$1,806,123</td>
<td>$12,326,936</td>
<td>Cost ↑</td>
<td>$12,326,936</td>
<td>166</td>
</tr>
<tr>
<td>57.1</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>Wind Study Requirements - Change Generator Vent Stacks</td>
<td>Large difference in meeting dilution requirements of generator exhaust and separation from air intakes. Required by code. Contributes to LEED points.</td>
<td>299</td>
<td>$900,320</td>
<td>$13,136,264</td>
<td>NC</td>
<td>$13,136,264</td>
<td>360</td>
</tr>
<tr>
<td>79</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>Improve Protection of Duct Penetrations through Corridor Wells per new code requirement</td>
<td>Some difference in life safety by improving penetrations of rated walls according to new code requirements.</td>
<td>297</td>
<td>$3,652,718</td>
<td>$18,938,892</td>
<td>NC</td>
<td>$18,938,892</td>
<td>77</td>
</tr>
<tr>
<td>78 R&amp;R 071098, 96, 101-110, 143</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>LEED Silver with living roof priority</td>
<td>Suspected large difference in acceptability of project through sustainable design. Also enhances clinical quality, visitor and patient healing.</td>
<td>298</td>
<td>$1,741,732</td>
<td>$15,370,714</td>
<td>Cost ↓</td>
<td>$15,370,714</td>
<td>22</td>
</tr>
<tr>
<td>15.1</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>Displacement Vent at Med/Surg Patient Rooms</td>
<td>More control of thermal comfort, air cleanliness, contaminant concentration and infection potential for a large quantity of sensitive people in Patient Rooms. Reduces cooling load and could reduce chiller equipment size.</td>
<td>280</td>
<td>$1,649,002</td>
<td>$32,387,716</td>
<td>Cost ↓</td>
<td>$32,387,716</td>
<td>170</td>
</tr>
<tr>
<td>15.5</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>Displacement Ventilation in lieu of OH Delivery at ICU Rooms</td>
<td>More control of thermal comfort, air cleanliness, contaminant concentration and infection potential for a large quantity of sensitive people in ICU Rooms. Reduces cooling load and could reduce chiller equipment size.</td>
<td>279</td>
<td>$544,679</td>
<td>$32,283,856</td>
<td>Cost ↓</td>
<td>$32,283,856</td>
<td>512</td>
</tr>
</tbody>
</table>
Lean ideal:
give customers internal and external exactly what they need to accomplish their purposes with no waste.
But let’s not forget the basics
to design for value delivery…

• understand how the facility will be used, at occupancy and after, before designing = WHOLE LIFE DESIGN
• understand owner conditions of satisfaction for delivery of the facility; typically cost and time.
• link what’s wanted and owner conditions of satisfaction and keep them linked when either changes—don’t let scope and cost drift apart.
• set stretch goals in scope, cost, or time to spur innovation.
• align commercial interests with delivery of value to the owner.
• design to target values and conditions of satisfaction—do not design, then cost.
Why does the expected cost fall as design develops?

Scope control
  – steering design to targets

Proactive value engineering

Reduced contingencies
Target Value Design:

...rests on a production management foundation and treats **cost as an outcome** of production system design, operation and improvement.

For those who only buy and do not produce (design or make), cost is driven by market pricing and deal making. But buying for less is not the only available strategy. Actual cost is a function not only of what you pay but also of what you buy and how you use what you buy. Design of product and process can change the type of materials required and their quantities, and can improve the productivity of design and construction professionals.

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Questions?