Engineered Resilient Systems
David Foreman
foremand@leandesign.com
October 29, 2015
Since 1988, Munro has been a leader in delivering solutions to hundreds of customers around the world, helping them to achieve higher product quality with lower cost, resulting in better product value and higher company profits.

Munro understands the effects that design and other variables have on total life costs and has developed a unique suite of tools for managing cost and product complexity.

- DFM / DFX, VE, VSM
- Lean Design® (reduce complexity)
- DP Cost of Quality™ (ensure robustness by design)
- Workshops
  - Bringing people together – rapid results
- Benchmarking and Teardown (technology infusion)
- The Wall Process® (stakeholder collaboration)
- Design for Manufacturing®
- Cost Estimating
- MRL Software, Training, and Assessments (risk & readiness)

Design Profit® integrates these methodologies in a single integrated platform that provides a powerful collaborative AoA tradespace.
The majority of life cycle costs are fixed early in the concept stage.
OPTIMIZED “Should Cost” Analysis

Design Profit® Knowledge Repository

Vehicle Library
- A-Class
- B-Class
- C-Class
- D-Class
- E-Class
- F-Class
- Truck

System
- Body
- Interior
- Chassis
- Electrical
- Powertrain

Powertrain
- Transmission
- Engine

Engine
- Exhaust
- Manifold
- Shields
- Valves
- Seals

Costing Databases

Labor
- Burden Rates

Materials
- Exposed & Used

SOPK Profit
- Packaging
- Freight
- Logistics

Lean Design® Analysis

Quality Report Card® Analysis

Design Profit® Total Should Cost Analysis

Design Profit® Total Target Cost Analysis

Design Optimization

Financial Summary

Ideation

Manufacturing Analysis

Trade Studies

Down-select
Lean Design® provides rapid generation and quantification of alternatives.

**Lean Design® Baseline**

**Lean Design® Redesign 1**
- Concept 1 Asm

**Lean Design® Redesign 2**
- Concept 2 Asm

**Lean Design® Redesign 3**
- Concept 3

---

### Design Metrics

<table>
<thead>
<tr>
<th>Design Metrics</th>
<th>Baseline</th>
<th>Redesign 1</th>
<th>Redesign 2</th>
<th>Redesign 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts</td>
<td>876</td>
<td>532</td>
<td>467</td>
<td>455</td>
</tr>
<tr>
<td>Steps</td>
<td>1,289</td>
<td>1148</td>
<td>1004</td>
<td>988</td>
</tr>
<tr>
<td>Score</td>
<td>4,578</td>
<td>2879</td>
<td>2423</td>
<td>2279</td>
</tr>
<tr>
<td>Weight</td>
<td>35.78 lb</td>
<td>27.35 lb</td>
<td>22.55 lb</td>
<td>18.78 lb</td>
</tr>
<tr>
<td>Fasteners</td>
<td>523</td>
<td>326</td>
<td>310</td>
<td>306</td>
</tr>
<tr>
<td>Fastening Operations</td>
<td>672</td>
<td>572</td>
<td>555</td>
<td>522</td>
</tr>
<tr>
<td>Poke Yoko</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Right First Time</td>
<td>90.57%</td>
<td>93.5%</td>
<td>94.56%</td>
<td>95.68%</td>
</tr>
<tr>
<td>Sigma</td>
<td>5.03</td>
<td>5.12</td>
<td>5.22</td>
<td>5.42</td>
</tr>
<tr>
<td>Piece Cost</td>
<td>$390.10</td>
<td>$248.23</td>
<td>$228.23</td>
<td>$198.22</td>
</tr>
<tr>
<td>Supplier Labor Cost</td>
<td>$30.00</td>
<td>$2.00</td>
<td>$8.27</td>
<td>$7.97</td>
</tr>
<tr>
<td>Total Labor Cost</td>
<td>$14.12</td>
<td>$8.87</td>
<td>$8.27</td>
<td>$7.97</td>
</tr>
<tr>
<td>Q Burden</td>
<td>$3.67</td>
<td>$1.58</td>
<td>$1.28</td>
<td>$1.18</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$407.89</td>
<td>$351.68</td>
<td>$331.73</td>
<td>$291.18</td>
</tr>
<tr>
<td>Total Annual Savings</td>
<td>N/A</td>
<td>5.621,000</td>
<td>5.881,000</td>
<td>6.121,000</td>
</tr>
</tbody>
</table>
Lean Design® provides rapid generation and quantification of alternatives.

### Baseline

**Design Profit® EXECUTIVE SUMMARY**

**Analysis of Alternatives (AoA)**

<table>
<thead>
<tr>
<th></th>
<th>Pre-Concept</th>
<th>AoA - Design 1</th>
<th>AoA - Design 2</th>
<th>AoA - Design 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRL</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>MRL</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Parts</td>
<td>142</td>
<td>94</td>
<td>104</td>
<td>85</td>
</tr>
<tr>
<td>Steps</td>
<td>930</td>
<td>748</td>
<td>818</td>
<td>680</td>
</tr>
<tr>
<td>Actual Time (min)</td>
<td>397.87</td>
<td>339.96</td>
<td>361.08</td>
<td>231.60</td>
</tr>
<tr>
<td>No. of Operators</td>
<td>77.861</td>
<td>66.723</td>
<td>69.539</td>
<td>44.641</td>
</tr>
<tr>
<td>Fasteners</td>
<td>51</td>
<td>33</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>Ergo Dangers</td>
<td>77</td>
<td>63</td>
<td>57</td>
<td>62</td>
</tr>
<tr>
<td>Poka Yoke Issues</td>
<td>68</td>
<td>44</td>
<td>34</td>
<td>46</td>
</tr>
<tr>
<td>Total Weight</td>
<td>1.89 lb</td>
<td>1.77 lb</td>
<td>1.80 lb</td>
<td>0.90 lb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Pre-Concept</th>
<th>AoA - Design 1</th>
<th>AoA - Design 2</th>
<th>AoA - Design 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piece Cost</td>
<td>$5,098.22</td>
<td>$4,974.24</td>
<td>$4,781.98</td>
<td>$3,488.29</td>
</tr>
<tr>
<td>Total Labor Cost</td>
<td>$551.06</td>
<td>$479.00</td>
<td>$505.47</td>
<td>$329.38</td>
</tr>
<tr>
<td>Q Burden</td>
<td>$1,066.69</td>
<td>$1,066.69</td>
<td>$1,057.84</td>
<td>$883.15</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$6,715.97</td>
<td>$6,519.92</td>
<td>$6,345.29</td>
<td>$4,700.83</td>
</tr>
<tr>
<td>Investment Cost</td>
<td>$83,925</td>
<td>$56,000</td>
<td>$70,925</td>
<td>$120,500</td>
</tr>
<tr>
<td>Annual Savings</td>
<td>N/A</td>
<td>$4,705,054</td>
<td>$8,896,231</td>
<td>$48,363,432</td>
</tr>
</tbody>
</table>

### Redesign

**AoA and Decision Visualization**
Shift Product Realization for Maximum Flexibility

**New Model**

- **Concept** → **Use** → **Affordability** → **How to Build** → **Where to Buy** → **How to Design**

**Innovation Window**

- **Focus Efforts in this Region**

**Current Model**

- **Concept** → **Design** → **Buy** → **Build** → **Affordability** → **Redesign**

**Source:** DARPA Rapid Design Exploration and Optimization Project

**Life Cycle Cost Determination**

- 100% → 85% → 70% → 35% → 22% → 95%

**Cost Reduction Opportunities**

**Region of Focus**

- **Mission Assurance Forum 2010**

**The Sum of Our Commitment**
Design Profit® provides data and history needed to perform total life cycle trade studies to minimize risk before engineering.
Questions
Design Profit® provides a systematic approach to translate requirements into total life cycle costs through conceptual modeling.

This provides the platform for effective decision-making considering all relevant metrics.

The baseline model consolidates and allocates data at the symbol level.

- Unit $
- Program $
- Quality $
- Labor $
- Machine $
- Overhead $
- Investment $
- MRL
- Maintainability
- Producibility
- Sustainability
- Supplier
- Lead Time
- etc.

Model Integration and Knowledge Manager
Currently, the definition of a product requires a person to build the variant (Model X).

We propose to identify requirements and construct a model based on the requirements. The model will identify associated costs to the requirement. Putting costs against requirements can improve program definition.

Modeling is capturing knowledge, and this knowledge can be used to easily generate designs. Multiple options can be proposed based on factors such as cost, weight, and timing requirements.

Early intensive data mining is needed.
From either the Design Profit® process model or a BOM import, Design Profit will generate a topology that will visualize the data relationship.

The Phase 1 approach is to display the data relationship in a topology.

The next logical development will be utilizing advanced calculations to understand the relationship to specific design/performance characteristics.

For example, if we change the weight of a system how does it effect COG, MPH, etc., and what other systems does it effect.

Modeling is not limited to Design, but can be used for operations, service, energy requirement's, etc.