DFMA Back To Its Roots

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Global Competitive Advantage
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The Robot Revolution

“Integrate, Automate, or Evaporate”.

Manufacturers needed peripheral equipment feeders and grippers to present parts so that a robot could place them appropriately in the product assembly.

With funding from the NSF, Boothroyd and Dewhurst did pioneering work in assembly automation which included the analysis of parts for automated feeding. (Boothroyd, 1991)
The Robot Revolution

Figure 4: The Six Stable Block Orientations: Flat Lengthwise (FL), On-Edge Lengthwise (OEL), Erect Lengthwise (EL), Flat Crosswise (FC), On-Edge Crosswise (OEC), and Erect Crosswise (EC)
DFMA Back To Its Roots

• The robotic revolution faded in the United States, mainly because inserting a robot to replace a worker to automate traditional hand assembled products was more difficult than initially believed.

• The area of design for manufacturing and assembly (DFMA) shifted focus as a result to the analysis of whole products and their constituent parts and subassemblies.

• Boothroyd and Dewhurst incorporated in 1983
What was happening in 1983?

What was happening 35 years ago?

http://www.worldometers.info/world-population/

- World population was at 4.84 billion
- Gasoline in U.S. was $1.21 a gallon
What was happening 35 years Ago?

• First Dot.COM company name was registered Symbolic’s Corporation
• Block Buster video opened its first store
• New Coke was introduced
What has Happening 35 years ago

• Nintendo sells its First entertainment System in U.S.

• Dave Letterman's first top ten list appeared “what rhythms with peas”

• Titanic resting place was discovered
What was happening 35 Years Ago?

• Microsoft Windows 1.0 was released

• Back to the Future was block buster movie that summer

• Boothroyd and Dewhurst was incorporated held their first DFMA conference
DFMA Back To Its Roots
Origins, History and Evolution of DFMA methodology & software

• 1977 – 1980 Boothroyd starts DFA research, first NSF funding, Dewhurst joins UMass. Faculty

• 1980 -1983 Boothroyd and Dewhurst begin partnership, Development of DFA software for Apple II, conversion of software for IBM PC, DFA handbook published


• 1986- 1989 Work begins on DFM, publication of DFA handbook, machine parts and injection molding software release.

Funding was provided by NSF (9 years) & Xerox, GE, DEC, AMP Inc., IBM, Gillette, Westinghouse,
DFMA Back To ITS Roots

Origins, History and Evolution (cont.)

• 1988 Committee for the Advancement of Competitive Manufacturing formed, Members included GM, Ford, Loctite, DEC, Navistar, Allied Signal

• 1989–1991 DFA 5.0 released with PCB analysis, Sheet metal DFM released, DFA 5.1 released supporting Macintosh and VMS, Die casting and Powder metal DFM software released.

• 1991 – 1994 Newer versions of DFA, Large parts DFA, and Design for the Environment, and additional DFM modules released

• 1991 National Medal of Technology Recipients
DFMA Back To Its Roots

Origins, History and Evolution (cont.)


- 1997 - 2015  versions 7, 8, 9, 10 of DFA released as well DFM concurrent costing 2.0, 2.3, Major software rewrites to keep up with ever changing Microsoft operating systems

- 2015 – 2018 Improvements made to software to keep up with the 26 different windows versions that have come and gone, partial CAD data capture added, quick estimation feature.

- 2018 and beyond Extrusion Metal DFM module and more extensive CAD model input data capability
DFMA Back to Its Roots

I. DFA
   SIMPLE DFA, STAND ALONE

II. Capabilities expand.
   Libraries, operations, parts, machines.
   Quick estimates added.
   Beginning to pass data back and forth.

III. DFMA

IV. Integrated
   - Data
   - Libraries
   - Screens
   - Full CAD
DFMA Back To Its Roots

The resulted was a methodology and modular software tool that is customizable, easy to use, and capable of being used during the entire Product Development process.
The application of the methodology and software tool can be applied:

- Anytime during product development process
- Bottoms up
- Top down
- Subassemblies
- Single Parts
- Labor
- Quality Prediction
- Cost Estimates
- Almost anything you can think of …….
DFMA Back To Its Roots
A couple of prerequires:
Product Development Design Process

- A high quality new product development process
- A clear well communicated new product development strategy
- Adequate resources
- Senior management committed to new products
- An entrepreneurial climate
- Senior management accountability
- Strategic focus and synergy
- High quality development teams
- Cross functional teams

Source: Benchmarking the firm’s Critical Success Factors in New Product Development
Product Development

DFMA can be used throughout the entire Product Development Process

- Early Product Costing
- Competitive product benchmarking
- Concept selection
- Creation of time standards
- Assembly Instructions
- Design Simplification
- Cost reduction
- Quality
- Vendor quote verification
- Estimate hard tooling
Typical Product Cost Breakdown

- Part Costs: 72%
- Overhead: 24%
- Labor: 4%

Source: The True Cost of Oversea Manufacturing June 2004 N. Dewhurst & D. Meeker
Define Levels of Cost Analysis

**Level 1** - A first impression by knowledgeable engineers of what a part, assembly or system would cost based on prior experience. (analogy)

**Level 2** - An estimation based on prior experience with similar products, budgetary estimates, vendor quotes and expert opinion and experience. (parametric)

**Level 3** - Detailed costing of every part accomplished by using material cost estimation data bases, and time/motion studies. A high degree of accuracy is achieved by comparisons to industry standards and vendor quotes. (analytical)
Trend Line Analysis

Tractor example

$/HP 42 & 48 inch cut lawn tractors

\[ y = 2.4787x + 43.107 \]
\[ R^2 = 0.9997 \]

\[ y = 2.78x + 29.84 \]
\[ R^2 = 0.9876 \]

18 23 28
horsepower

$/Hp.
$/HP
$/HP(48)
Linear ($/HP(48))
Linear ($/HP)
Trend Line Analysis

Next steps:

Break lawn tractor into major subassemblies

Project trend lines for each major subassembly

Next level is to break down material content of each major subassembly, to incorporate material trends.

Best paper on topic is “Controlling New Product Cost Through Trend Analysis” by Terry Ayer Teradyne, Inc. May 2004 B&D conference
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Product Benchmarking

Only the Paranoid Survive”

Andy Grove 1936-2016

Building better products requires a good comparative perspective about other companies to gain insight into other sources of outstanding performance

Product Development Performance
Kim Clark & Takahiro Fujimoto
Definitions

**Benchmarking**
- Is the continuous process of measuring products, services and practices against the toughest competitors or those recognized as industry leaders.

**Competitive Intelligence**
- Is the process of gleaming and combining disparate information about a competitor in order to deduce its objectives.

**Reverse Engineering**
- Is the systematic dismantling of a product to understand its technology with the purpose of replication.
A Comparison of 1U Servers

Sun Netra - System Front View

Slate - DS10L - Front View

MicroMachine

IBM NetInfinity 4000R - Front View
Whats inside

Sun Netra - Internal Front View

- IO Section
- CPU Section
- Power Supply
- Disk Bay #1
- Disk Bay #2
- CD-ROM Bay

- Fan #1
- Fan #2
- Fan #3

SNetra-E15a.jpg

Slate - Internal View

- CPU & Blower
- Memory
- Primary SCSI Disk
- CD/Floppy or 2nd Disk
- PCI Option

Slate-E511a.jpg

Micromachine - Internal Overview

- CPU 1
- CPU 2
- PCI Slot 1
- PCI Slot 2
- Memory DIMMs
- Main System Blower
- SCSI Backplane
- Power Supply
- Disk 1
- Disk 2
- CD/Floppy

Micromachine-E2040a.jpg

IBM Netfinity 4000R - Internal Overview

- CD-ROM
- Disk Slot 2
- Power Supply
- IDE Disk 1
- PCI Riser 1
- PCI Riser 2
- DIMM Slot 1-4

IBM-Netfinity.jpg
# Function Cost Comparison

<table>
<thead>
<tr>
<th>Sun Netra t1</th>
<th>IBM NetInfinity 4000R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooling</strong></td>
<td><strong>Cost</strong></td>
</tr>
<tr>
<td>$14</td>
<td>0.9%</td>
</tr>
<tr>
<td><strong>CPU</strong></td>
<td>$675</td>
</tr>
<tr>
<td><strong>Disk</strong></td>
<td>$215</td>
</tr>
<tr>
<td><strong>Enclosure</strong></td>
<td>$50</td>
</tr>
<tr>
<td><strong>I/O</strong></td>
<td>$235</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>$274</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>$86</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td>$17</td>
</tr>
<tr>
<td><strong>Pkg/Doc/SW</strong></td>
<td>$19</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1,585</strong></td>
</tr>
</tbody>
</table>
Product development

DFMA can be used throughout the entire Product Development Process

• Early Product Costing
• Competitive product benchmarking

• Concept selection
• Creation of time standards
• Assembly Instructions
• Design Simplification
• Cost reduction
• Quality
• Vendor quote verification
• Estimate hard tooling
Traditional Concept Selection of Design Alternatives

GUIDELINE | WRONG | RIGHT
---|---|---
Avoid complex bent parts (material waste); rather split and join

(a) Misleading producibility guideline for the design of sheet metal parts

Set-up | 0.015 | 0.023
Process | 0.535 | 0.683
Material | 0.036 | 0.025
Piece part | 0.586 | 0.731
Tooling | 0.092 | 0.119
Total manufacture | 0.678 | 0.850
Assembly | 0.000 | 0.200
Total | 0.678 | 1.050

(b) Estimated costs in dollars for the two examples if 100,000 are made

Source: B & D example
**Locomotive fab to cast example**

- **6 Parts**
  - ‘cost estimate’
    - DFMA estimate $84
    - Assembly time 1384 sec (23 min)
    - Current price $209

- **1 Part**
  - ‘could cost’
    - DFMA estimate $25
    - Assembly time 0 sec
    - Expected Price $35

Annual Savings = $261k

Source: B&D Inc. example
Cost Estimating Example

- Machining estimate
- Machining estimate with recommendations
- Alternative manufacturing methods
Machining issues

Highlighted areas represent holes that require side operations.

Undercut Area

Highlighted areas represent deep counterbores.

Highlighted areas represent small fillets or chamfers.

This area represents an undercut which sits underneath the first undercut as shown in the other highlighted area.
Machining Estimate

Current:

Time = 12 - 15 hrs
Cost = $780 - 975

With Recommendations:

Time = 7 - 10 hrs
Cost = $455 - 650

Total Savings = $325/part
Alternative Methods Estimates (investment cast)

Investment Casting

Re-designed for Investment Casting:

Investment Cast Part:

- Initial Tooling Investment of $22,000 - $25,000
- Cast parts will cost: $16.00 - $22.00 / part (in lots of 100)
- CNC Machine side features with 4th axis machine center < 2 hours = $110.00

Total Part Cost: < $135.00 each
Alternative Methods Estimates (Metal Injection Molded)

Metal Injection Molding

Some Re-design Required:

Metal Injection Molded Part:

- Initial Tooling Investment of $45,000 - $50,000
- Molded parts will cost: $45.00 - $50.00 / part (in lots of 100)
- CNC Machine side features with 4th axis machine center < 2 hours = $110.00

Total Part Cost:

< $160.00 each
Product development

DFMA can be used throughout the entire Product Development Process

- Early Product Costing
- Competitive product benchmarking
- Concept selection

**Creation of time standards**
- Assembly Instructions
- Design Simplification
- Cost reduction
- Quality
- Vendor quote verification
- Estimate hard tooling
**Total Cost of Ownership (TCO)**


Outsourcing to China: A Case Study Revisited Seven Years Later, D. Meeker & J. Mortensen 2011

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### Total Cost of Ownership (TCO) Estimation Table

<table>
<thead>
<tr>
<th>COST FACTOR</th>
<th>VAR</th>
<th>DIFFERENT</th>
<th>CALCULATION FORMULA</th>
<th>ADDITIONAL COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost (Gross of Grade Tax)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit price</td>
<td>2.500</td>
<td>2.500</td>
<td>2.500</td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Duty</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Tariff</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Freight insurance</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Handling</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Base Motor</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Base Motor accessories</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Parts &amp; Accessory</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Employee salary</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Rent</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>20.00</td>
<td>2.00</td>
<td>22.00</td>
<td></td>
</tr>
<tr>
<td>New row</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

http://www.reshorenow.org
Time Standard Project

The Challenge

• Needed six time standards completed in under two weeks

• Update legacy time standards.

• Create new product time standards.

• Low cost and quick creation time
Compaq Time Standard Project

Alternative methods

• MTM, MOST, Lucas, Westinghouse method, Assembly View, SEER, LASer, XPI….  
• When evaluated against time, $$, training, software investment.

Chose B&D

• Established tool for assembly operations  
• Some flexibility to capture non assembly operations
DFA Customized Operation Libraries

DFMA Libraries are a storage mechanism for customized-operations.

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Category</td>
<td>Example:CORE Operation library</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Misc Op</td>
<td>MTM: Place approximate &lt;= 8 in</td>
<td>MTM:PA1</td>
</tr>
<tr>
<td>3</td>
<td>Assembly Op</td>
<td>AA1 g&amp;p_2lbs_easy_app_code1</td>
<td>MTM-AA1 &lt;8 in get and place command</td>
</tr>
<tr>
<td>4</td>
<td>Category</td>
<td>Ex: Standard Macro library</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Assembly Op</td>
<td>Typing process function</td>
<td>Macro: Key strokes, looks, reads combined</td>
</tr>
<tr>
<td>6</td>
<td>Assembly Op</td>
<td>Detrash operations</td>
<td>Macro: Various detrash operations</td>
</tr>
<tr>
<td>7</td>
<td>Category</td>
<td>Ex: Specific Macro library</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Assembly Op</td>
<td>Desk side pick to light process</td>
<td>Macro: time to pick-to-light all necessary objects</td>
</tr>
<tr>
<td>9</td>
<td>Assembly Op</td>
<td>Wrapping machine</td>
<td>Macro: Time to wrap 1 cab using machine</td>
</tr>
<tr>
<td>10</td>
<td>Category</td>
<td>Ex: Standard Process Library</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Assembly Op</td>
<td>Deskside Final test time</td>
<td>B&amp;D:sidefinl.dfa Deskside final test time</td>
</tr>
<tr>
<td>12</td>
<td>Assembly Op</td>
<td>Deskside Packing process</td>
<td>B&amp;D:sidepack.dfa Deskside drawer packing p</td>
</tr>
</tbody>
</table>
Note work done on old version of DFMA software. Operations Libraries do not look like this anymore but function in similar way.
## Calculator Build

<table>
<thead>
<tr>
<th></th>
<th>Standard creation time</th>
<th>Calculator build standard time</th>
<th>Complete assembly Kit, build, test, pack</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(minutes)</td>
<td>(minutes)</td>
<td>(minutes)</td>
</tr>
<tr>
<td><strong>B&amp;D Standard tool</strong></td>
<td>19.94</td>
<td>1.40</td>
<td>3.93</td>
</tr>
<tr>
<td><strong>MTM</strong></td>
<td>48.15</td>
<td>1.31</td>
<td>3.54</td>
</tr>
<tr>
<td><strong>Time study AVG.</strong></td>
<td>-</td>
<td>1.78</td>
<td>4.42</td>
</tr>
<tr>
<td><strong>Time study A</strong></td>
<td>-</td>
<td>1.80</td>
<td>4.58</td>
</tr>
<tr>
<td><strong>Time study B</strong></td>
<td>-</td>
<td>1.85</td>
<td>4.34</td>
</tr>
<tr>
<td><strong>Time study C</strong></td>
<td>-</td>
<td>1.70</td>
<td>4.33</td>
</tr>
</tbody>
</table>
Historical Statistics

Creation Time Historical Results

<table>
<thead>
<tr>
<th>Tool</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>B&amp;D tool Historical</td>
<td>3 - 1*</td>
</tr>
<tr>
<td>MTM-UAS</td>
<td>10 - 1</td>
</tr>
<tr>
<td>Most</td>
<td>10 - 1**</td>
</tr>
<tr>
<td>MTM-1</td>
<td>40 - 1**</td>
</tr>
</tbody>
</table>

* Historical data based on total number of systems analyzed over 8 months.
** Historical data: Zjell B. Zandin Most work measurement Systems Book, Marcel Decker Inc. Copyright 1990 pg.14

Process Time Historical Results

B&D standard tool accuracy with generic macros to within 5-15% of MTM-UAS times.
Product development

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DFMA Example-Comparing Estimates Against Vendor Quotes

Load Port for Standard Mechanical Interface SMIF enclosures
DFMA Example-Comparing Estimates Against Vendor Quotes

B&D Estimates Against Actual Quotes

<table>
<thead>
<tr>
<th>Item Description</th>
<th>QTY</th>
<th>Cost</th>
<th>B&amp;D Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOOR,</td>
<td>1</td>
<td>$22.34</td>
<td>$9.40</td>
</tr>
</tbody>
</table>

[Diagram of product]
DFMA Example-Vendor Quote

<table>
<thead>
<tr>
<th>Item Description</th>
<th>QTY</th>
<th>Cost</th>
<th>B&amp;D Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOOR,</td>
<td>1</td>
<td>$22.34</td>
<td>$9.40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Delivery: (8) weeks ARO</th>
<th>Resin: LNP DB 1004 EMMR, BK115</th>
</tr>
</thead>
</table>

Tooling Description: Single cavity self-contained *pre-hardened steel mold*, tri-plate gating with (4) pin-point gates, pin ejection, flat parting line, and bead blast cavity finish.

Notes:

- The molding material is a suggestion by our contact at LNP Corporation, based upon the need for optimum flatness. *(20% glass bead filled polycarbonate)*
- The flatness is difficult to predict. We are proposing a “tri-plate” gating design with (4) pin-point gates for help in improving flatness. A flatness specification of .010 cannot be guaranteed. We feel reasonably confident that we could mold between .012” and .020” flatness.
- “Sink” marks may be evident because of the intersecting wall section ratios. Any “sink” mark would not be part of the measured flatness.
Questions were asked to gather further information

- Material parameters and material cost from vendor, tonnage machine, and process information.
  PTA $7.35/lb  GE $7.65/lb  PTA is passing their material cost saving.

- New Plastic Material database created

- The cost estimate was revised using the above information.

- New B&D estimate is $23.30 VS. Vendor Quote $22.34
Regression Analysis
Total Weight to Metal Only Material Charge

Vendor Material Cost vs Total Metal Weight

Regression Coefficient
\( r^2 = 86.9\% \)

Zero Crossing Slope
$1.026/kg

Standard Error
$0.228/kg

- Indicates Strong Correlation
- Based on believed market rates = a material adder of 30-40%
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• Estimate hard tooling
Quality Tool

Design for Assembly

Product Quality/Assembly Efficiency Correlation

Every one second of assembly penalty time causes an average of 100 DPM
Quality Assessment Conclusions

- For many corporations part variability is no longer the quality issue; quality problems arise mainly in assembly.
- Assembly quality problems seem to correlate strongly with assembly difficulties.
- The key to quality improvement is to reduce both the number of assembly steps, and the average time per operation.

Source: Dr. Peter Dehewhurst URI.
Mistake-proofing achieves superior results, faster, and with less efforts.

Source: Make NO Mistake – A Mistake – Proofing Methodology C. Martin Hinckley B&D conference June 2003
A Big Secret
Biggest bang for the buck
Theoretical Minimum Part Count (TMPC)
How to get rid of parts

Theoretical Minimum Part Count

Test for Unnecessary Parts

Are all parts of the assembly REQUIRED to meet the function of the design?

- Yes - this part may be required
- No

Are these parts required to MOVE relative to each other?

- Yes - this part may be required
- No

Must this part be made of DIFFERENT MATERIAL than other parts in the assembly?

- Yes - this part may be required
- No

Is this part NECESSARY for disassembly or service of this assembly?

- Yes - this part may be required
- No

Part is a candidate for elimination
What is the best part in your design?
What is the best part in your design?

Answer: NO PART !!!!! You don’t have to do anything --- design it, prototype it, document it, source it, inspect it, replace it .........
Some of the Intangible Cost of No Parts

Table 1 summarizes these average costs by program activity. While it is possible that in some cases the added costs of adopting a unique part design could be offset by lower manufacturing or purchasing costs, such choices should be justified and carefully documented.

**Table 1. Average Costs for Adding a Part into a System**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering and design</td>
<td>$12,600</td>
</tr>
<tr>
<td>Testing</td>
<td>1,000</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2,400</td>
</tr>
<tr>
<td>Purchasing</td>
<td>5,200</td>
</tr>
<tr>
<td>Inventory</td>
<td>1,200</td>
</tr>
<tr>
<td>Logistics support</td>
<td>5,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$27,500</strong></td>
</tr>
</tbody>
</table>

*The testing cost was reduced significantly because not every part added to inventory requires testing. However, every part needs to be evaluated, either by similarity, bench test, or analysis.*

This document can be found at http://www.convergencedata.net/Docs/PartsMgt.pdf.
### Epson MX 80
- **Total Assm. time sec.**: 1866
- **Total Number of operations**: 185.
- **Total parts/subs.**: 152
- **Theoretical part count**: 41.

### IBM PRO Printer
- **Total Assm. Time**: 170.
- **Total number of operations**: 32.
- **Total parts/subs.**: 32.
- **Theoretical part count**: 29

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https://www.youtube.com/watch?v=spDYSKl3kmo
# Digital Corporate Mouse

<table>
<thead>
<tr>
<th></th>
<th>Old</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part count</td>
<td>61</td>
<td>44</td>
</tr>
<tr>
<td>Mechanical</td>
<td>31</td>
<td>16</td>
</tr>
<tr>
<td>Electrical</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Assm. Time</td>
<td>17 min</td>
<td>6</td>
</tr>
<tr>
<td>Assm. Oprs.</td>
<td>83</td>
<td>56</td>
</tr>
<tr>
<td>Adjustments</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Fasteners (3 types)</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Material Cost Reduction</td>
<td>&gt;40%</td>
<td></td>
</tr>
</tbody>
</table>
Case Study

Respironics BagEasy III

- 84% reduction in assembly time
- 65% reduction in the number of unique parts
- 81% reduction in assembly operations
- 6 patent applications
The DFM team reduced the Color Spin’s parts count by 49%, while increasing the toy’s quality and performance. Creative plastic molding, ultrasonic welding, and combining moving parts aided the effort.
Case Study – Hypertherm HPR130 Plasma Cutter

Results:

• Over 50% part count reduction
• Over 75% assembly time reduction
• Factory output quadrupled without additional floor space
• Better design allows for:
  • Tighter tolerance cutting
  • Unit cuts as fast as some 200 amp units
  • 2/3rds less operating cost per unit
  • 1/10th warranty costs of predecessor
• Doubled annual sales
• More reliable unit

$5 million savings in first 24 months alone

Source: Mike Shipulski  Hypertherm Inc.
SWATCH

Day-month ring
Bridge
Date ring
Motor stator
Motor coil
CMOS chip
Stem wheel
Battery
Battery hatch
SISTEM51 is 100 percent Swiss made and features an exceptional 90 hour power reserve. Hermetically sealed within its case, the 3 Hz movement delivers precise, long-lasting, maintenance-free performance.

There is much to explore in this intriguing new world. Unprecedented technological innovation (17 pending patents) enabled the development, in less than two years, of a self-winding mechanical movement with only 51 parts in five modules.

Design has only one screw!
NCR 2670 Point of Sales Terminal

85 % Part count reduction
75 % Assembly time reduction
44 % Reduction in labor cost
65 % Fewer suppliers
No assembly tooling
No fasteners
$1.1 Mil. dollars lifetime labor savings
1/3 Mfg. floor space saved
Questions that Should Be Asked but Aren’t  Cris Tsai & David Meeker  31 DFMA forum June 2016
DFMA Back To Its Roots

“Perfection is reached not when there is no more to add but when there is no more to take away.”

Antoine de St. Exupery
1900 -1944
Cautionary Note - Pitfalls

• DFMA is oversold and early results do not materialize

• Poor selection of projects to implement the process on

• The champion gets promoted and things die

• Didn’t renew the software

• Doesn’t become part of the culture