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)

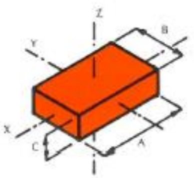
The Robot Revolution

**AUTOMATIC HANDLING—
DATA FOR NON-ROTATIONAL PARTS
(first digit 6, 7 or 8)**

Key:

First digit	OE	FC
6	0.7	1
7	0.45	1.5
8	0.5	2

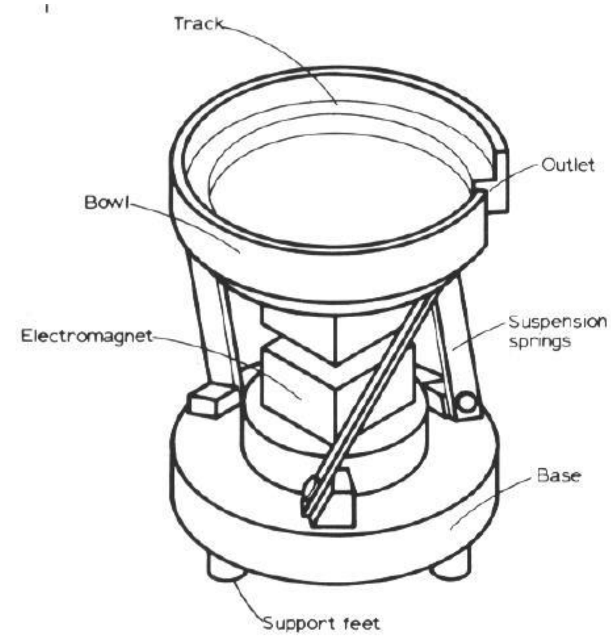
		A > 1.1B and B > 1.1C	A ≤ 1.1B or B ≤ 1.1C (code the main feature or features which distinguish the adjacent surfaces having similar dimensions)							
			steps or chamfers (2) parallel to —			through grooves (2) parallel to —			holes or recesses > 0.1B (cannot be seen in silhouette)	other - including slight asymmetry (3), features too small etc.
			X axis and > 0.1C	Y axis and > 0.1C	Z axis and > 0.1B	X axis and > 0.1C	Y axis and > 0.1C	Z axis and > 0.1B		
		0	1	2	3	4	5	6	7	8
part has 180° symmetry about all three axes (1)	0	0.8 1 0.9 1 0.6 1	0.8 1 0.9 1 0.5 1	0.2 1 0.5 2 0.15 2	0.5 1 0.5 1.5 0.15 1.5	0.75 1 0.5 1 0.5 1	0.25 1 0.5 1.5 0.15 1	0.5 1.5 0.6 1 0.15 1.5	0.25 2 0.5 1 0.15 2	MANUAL HANDLING REQUIRED



			code the main feature, or if orientation is defined by more than one feature, then code the feature that gives the largest third digit							
			steps or chamfers (2) parallel to -			through grooves (2) parallel to -			holes or recesses > 0.1B (cannot be seen in silhouette)	other - including slight asymmetry (3), features too small etc.
			X axis and > 0.1C	Y axis and > 0.1C	Z axis and > 0.1B	X axis and > 0.1C	Y axis and > 0.1C	Z axis and > 0.1B		
			0	1	2	3	4	5	6	7
part has 180° symmetry about one axis only (1)	about X axis	1	0.4 1 0.5 1 0.4 1	0.6 1 0.15 1 0.6 1	0.4 1.5 0.25 2 0.4 2	0.4 1 0.5 1 0.2 1	0.3 1 0.25 1 0.3 1	0.7 1 0.25 1.5 0.15 1	0.4 2 0.25 3 0.1 2	MANUAL HANDLING REQUIRED
	about Y axis	2	0.4 1 0.4 1 0.5 1	0.3 1 0.2 1 0.15 1	0.4 1.5 0.25 2 0.5 2	0.5 1 0.4 1 0.2 1	0.3 1 0.25 1 0.15 1	0.4 1 0.25 1 0.15 2	0.4 2 0.25 2 0.15 2	
	about Z axis	3	0.4 1 0.3 1 0.4 1	0.3 1 0.2 1 0.2 1	0.4 1.5 0.25 2 0.4 2	0.4 1 0.3 1 0.2 1	0.3 1 0.25 1 0.15 1	0.4 1.5 0.25 2 0.15 2	0.4 2 0.25 2 0.15 2	
part has no symmetry (code the main feature(s) that define the orientation) (4)	orientation defined by one main feature	4	0.25 1 0.25 1 0.15 1	0.15 1 0.1 1.5 0.14 1	0.15 1.5 0.24 2 0.15 1	0.1 1 0.2 1 0.1 1	0.15 1 0.1 1.5 0.05 1	0.1 1.5 0.15 2 0.1 1.5	0.1 2 0.15 3 0.08 2	
	orientation defined by two main features and one is a step, chamfer or groove	6	0.2 2 0.1 3 0.05 2	0.15 2 0.1 1.5 0.05 2	0.1 2.5 0.1 4 0.05 2.5	0.1 2 0.1 3 0.05 2	0.15 2 0.1 1.5 0.05 2	0.1 2.5 0.1 4 0.05 2.5	0.1 3 0.1 5 0.05 3	
	other - including slight asymmetry (3) etc.	9	MANUAL HANDLING REQUIRED							

© 1982 Boothroyd & Dewhurst

CHART 6



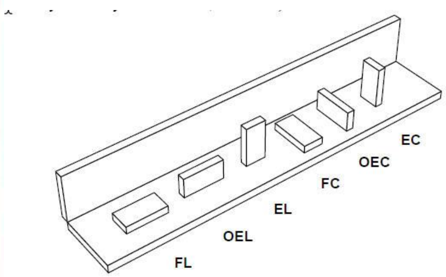


Figure 4: The Six Stable Block Orientations: Flat Lengthwise (FL), On-Edge Lengthwise (OEL), Erect Lengthwise (EL), Flat Crosswise (FC), On-Edge Crosswise (OEC), and Erect Crosswise (FC)

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

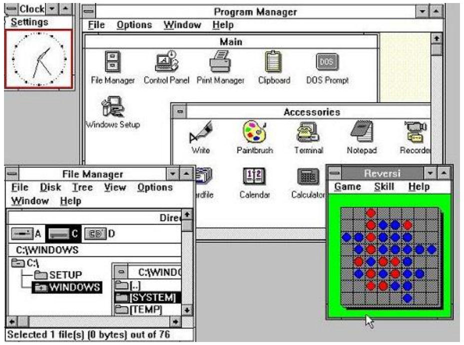
What has Happening 35 years ago

- 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

- 1983 – 1986 DFA PCB research begins, B&D move to Uni. Of R.I. ,W.A. Knight moves to URI, release of robotic assembly software, first DFMA conference held.

- 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.)

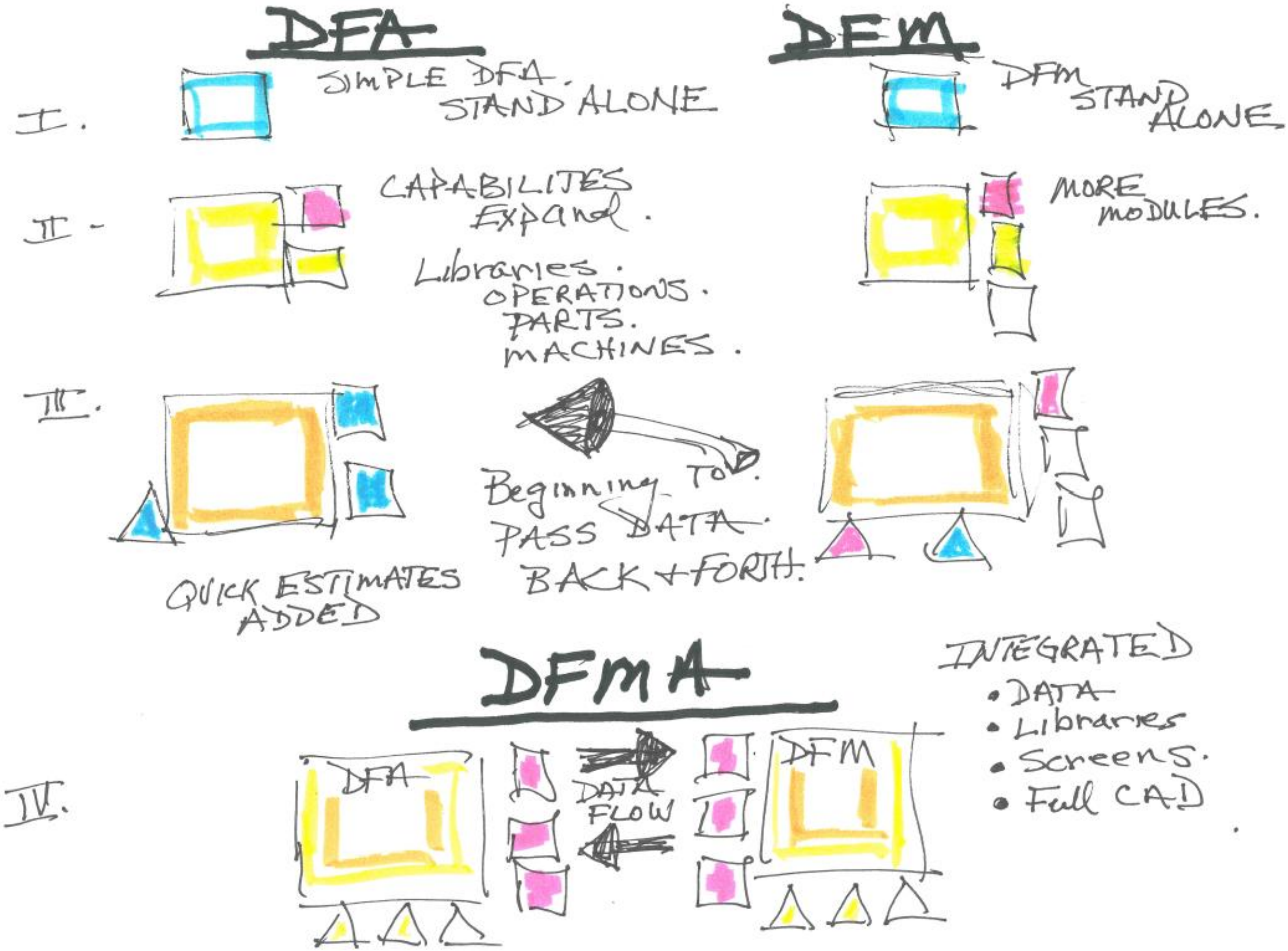
- 1994 -1997 Updated versions of DFA and DFM, and Design for Service software release.

- 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.

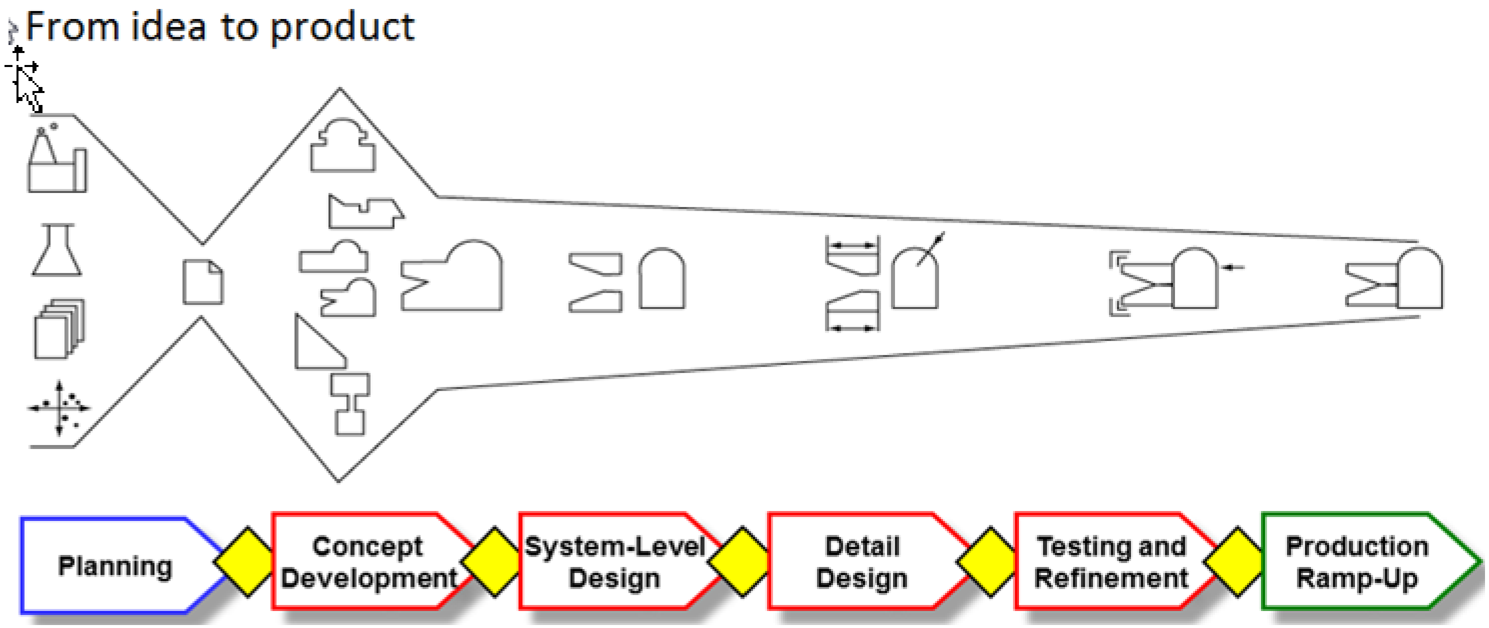
- 2018 and beyond Extrusion Metal DFM module and more extensive CAD model input data capability

DFMA Back to Its Roots



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



Product Design and Development Eppinger & Ulrich 5th edition

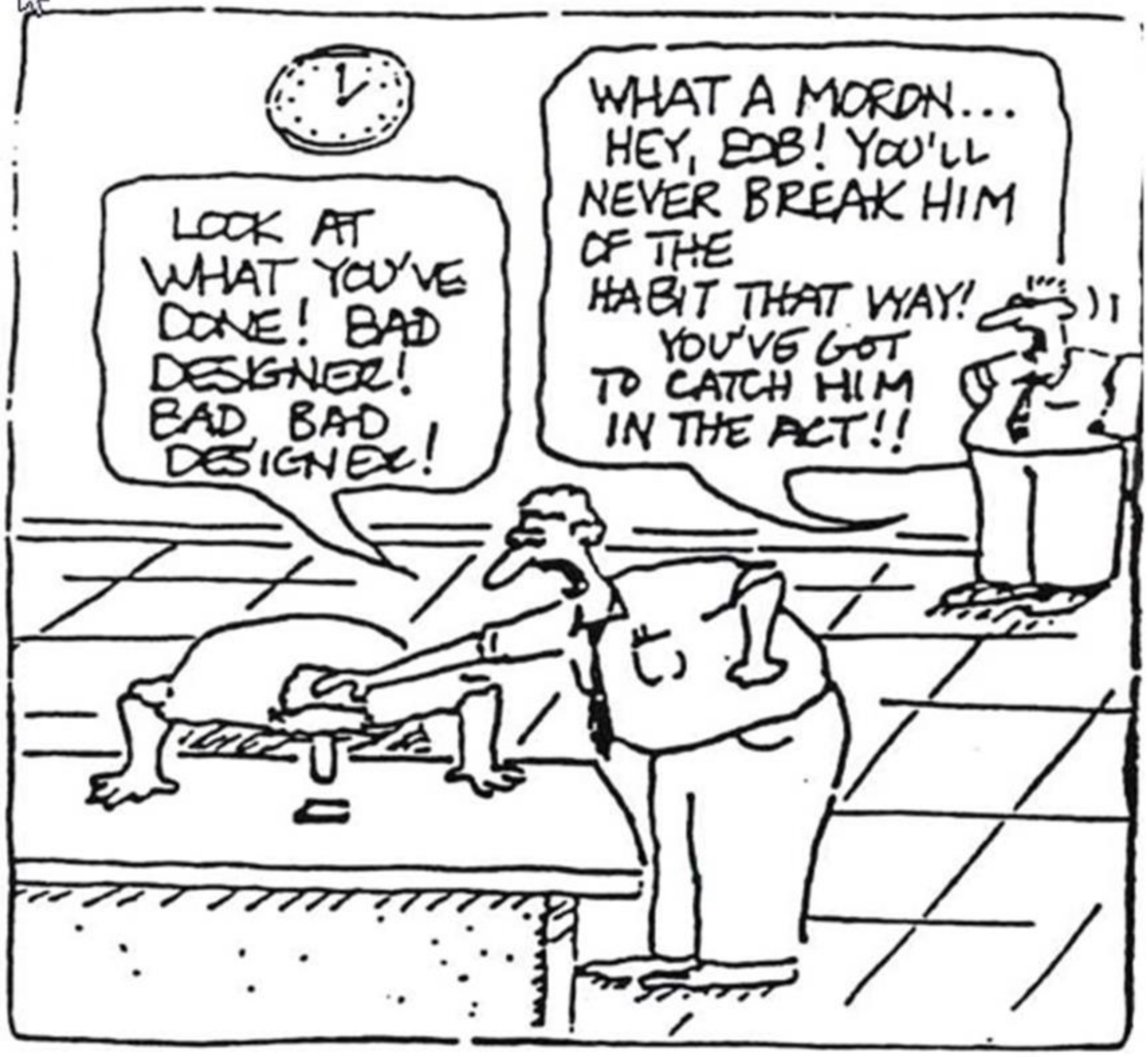
Designing Differently

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

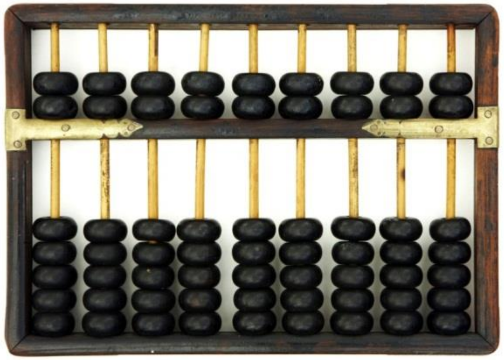
- A high quality new product development process
- A clear well communicated new product development strategy
- Adequate resources
- Senior management committed to new products
- An entrepreneurial climate
- Senior management accountability
- Strategic focus and synergy
- High quality development teams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

Source: Benchmarking the firm's Critical Success Factors in New Product Development Robert G. Cooper and Elko Kleinschmidt, Journal of Innovation Management, 1995 12: 374-391

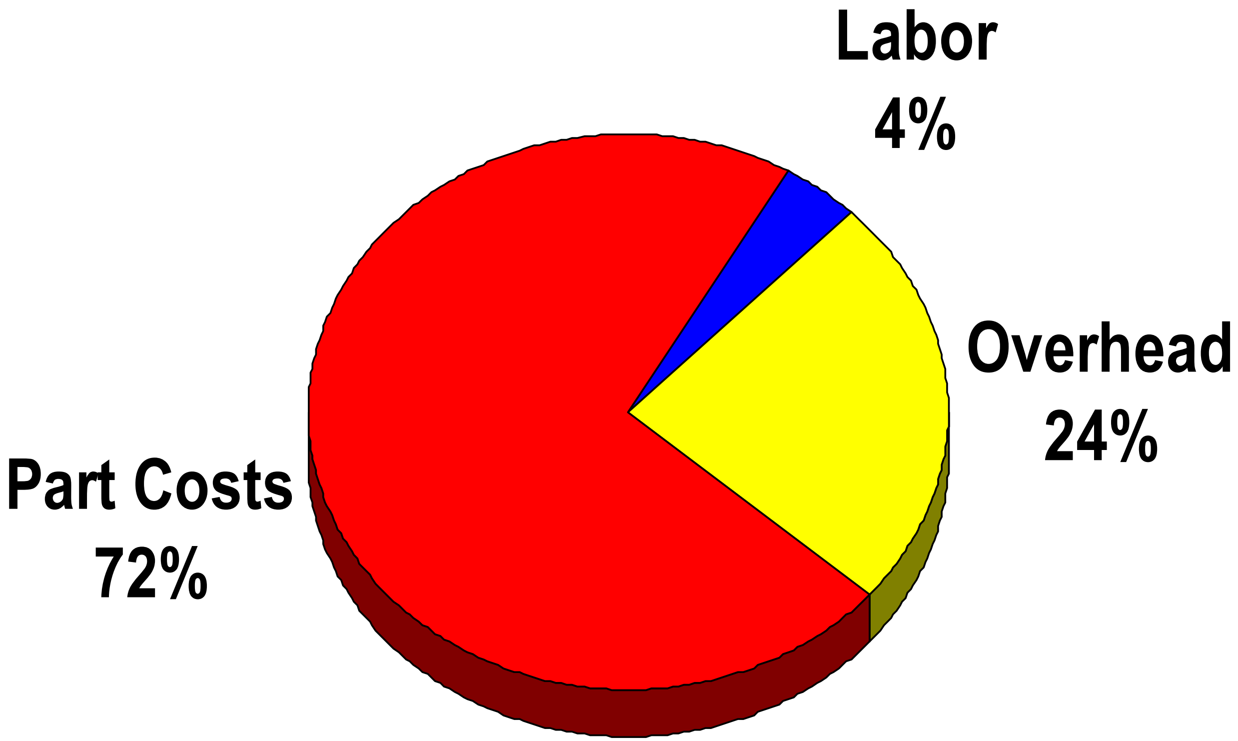
Product Development

DFMA can be used throughout the entire Product Development Process

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



Typical Product Cost Breakdown



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

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Define Levels of Cost Analysis

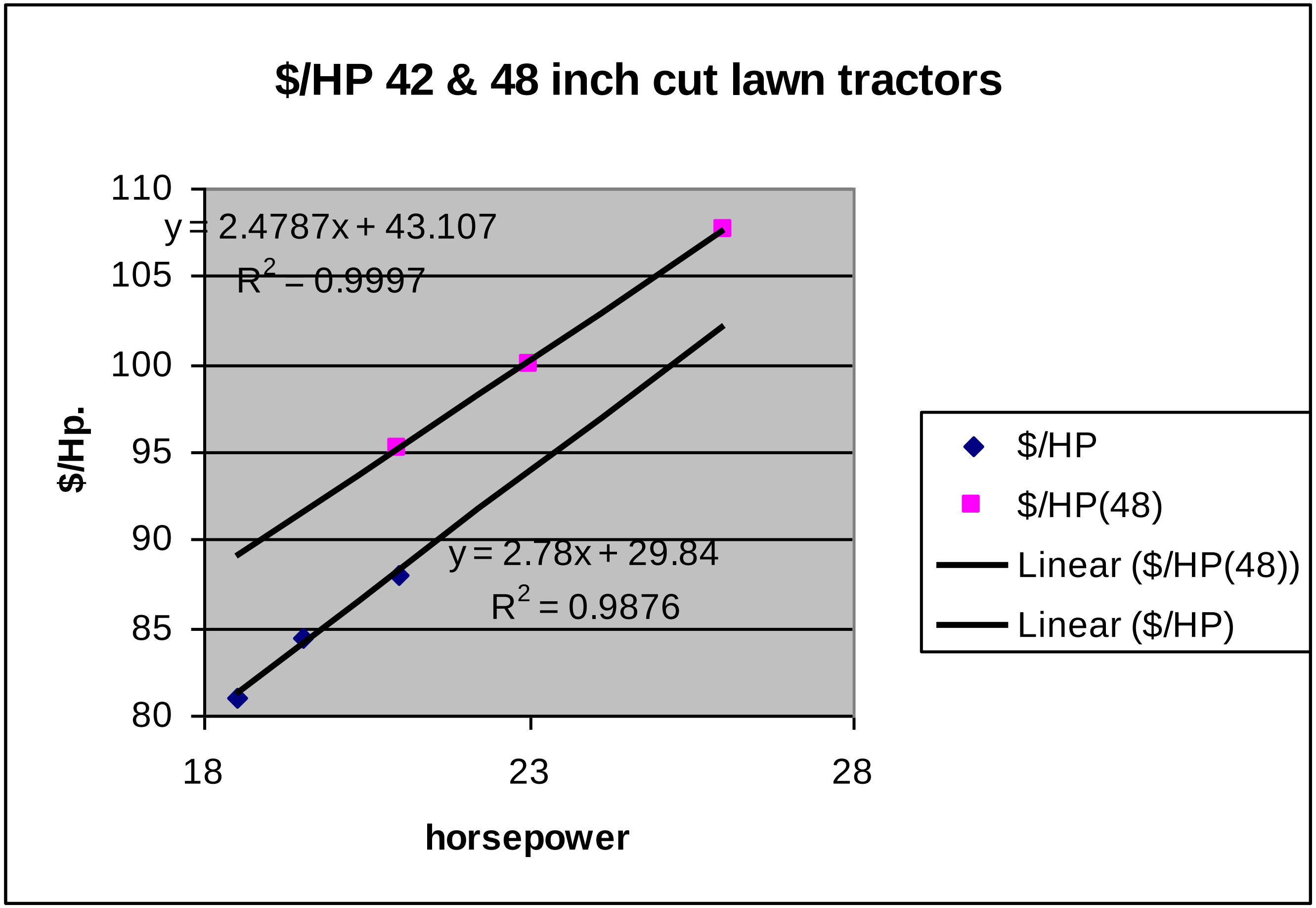
Level 1 **- A first impression by knowledgeable engineers of what a part , assembly or system would cost based on prior experience. (analogy)**

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



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

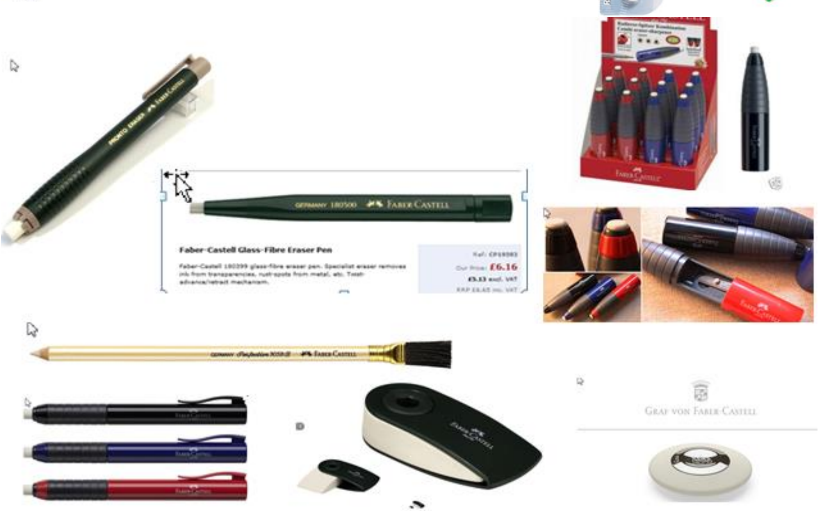
- Is the systematic dismantling of a product to understand its technology with the purpose of replication.


TUFF STUFF
ERASER STICK
SANFORD
Clic Eraser
Pentel
Scripto


mignon
MONO zero
SEED
SLENDY+


Retractable Erasers
MERCUR
WESTCOTT
NEW


STAEDTLER

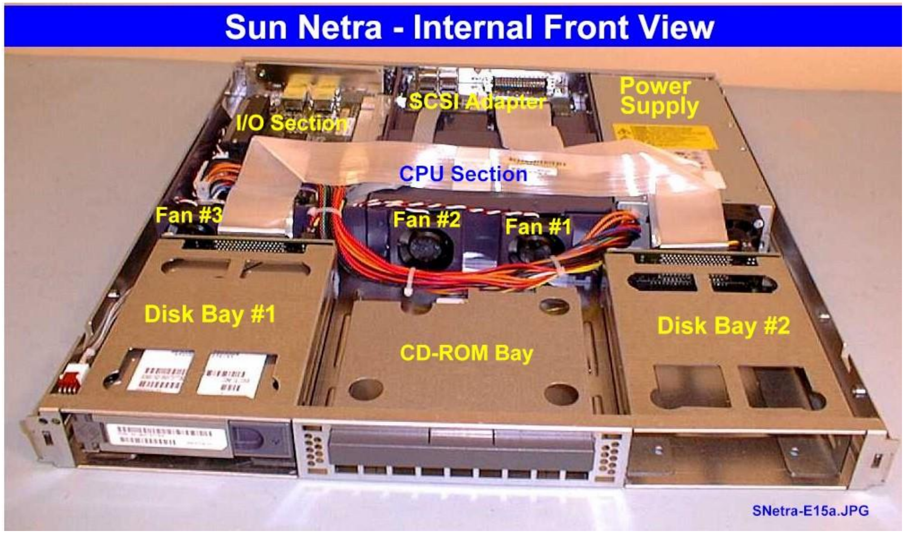

FABER-CASTELL
Faber-Castell Glass-Fibre Eraser Pen
Our Price: £6.16
GRAF VON FABER-CASTELL

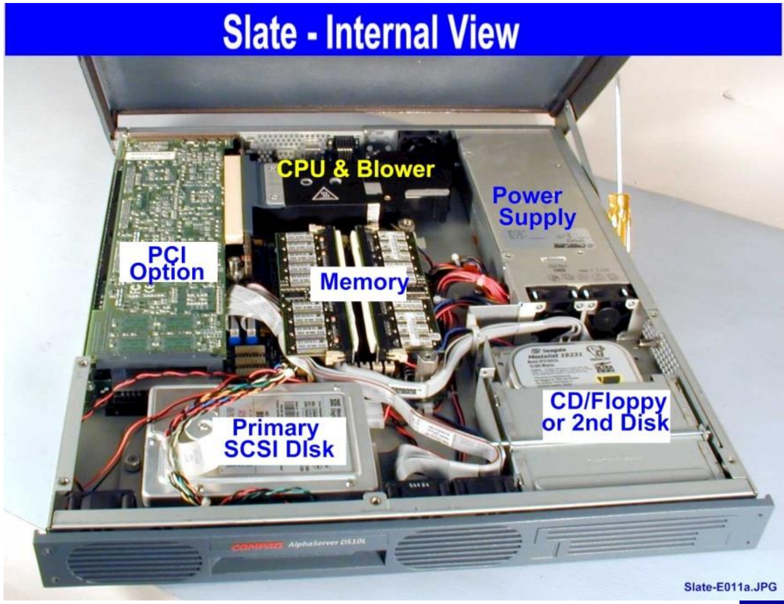

Maped
Erasers

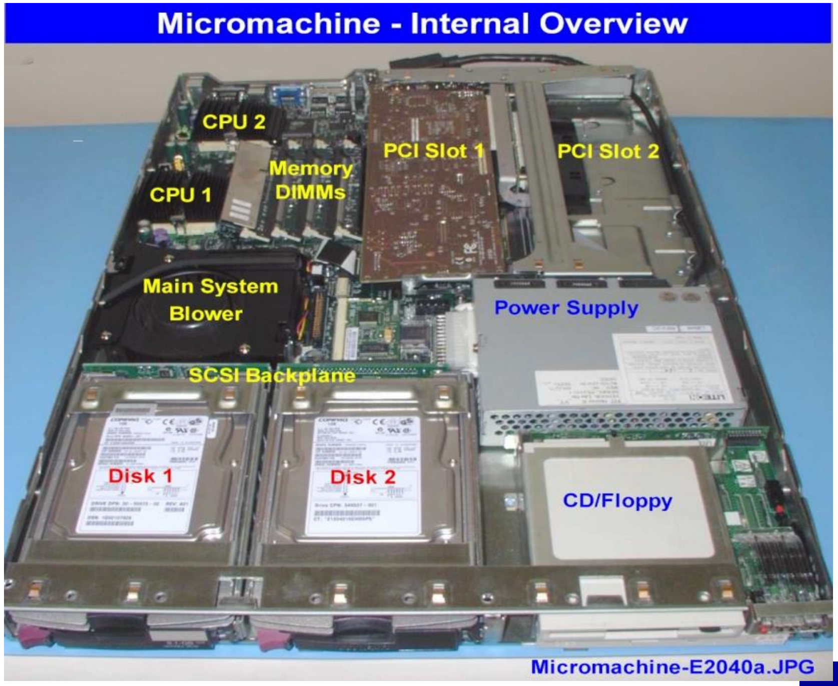
DPV

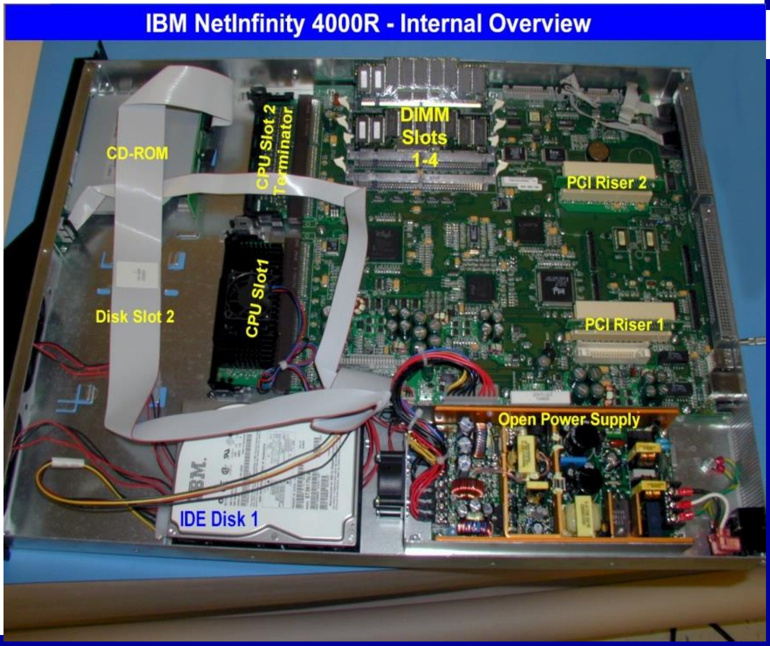
A Comparison of 1U Servers

Whats inside

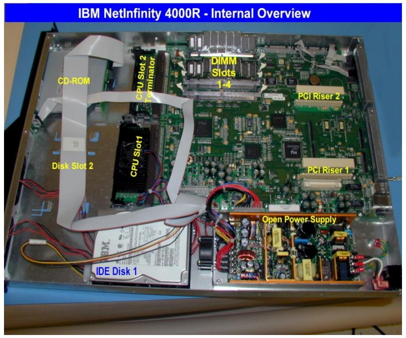


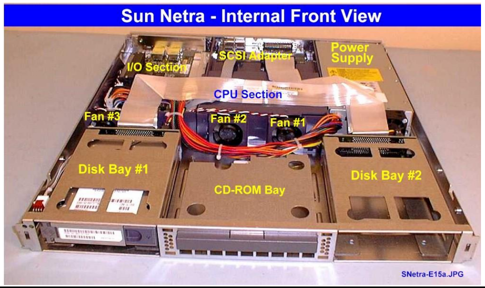






Function Cost Comparison





	Sun Netra t1		IBM NetInfinity 4000R	
	Cost	% of Total	Cost	% of Total
Cooling	$14	0.9%	$9	0.5%
CPU	$675	42.6%	$189	11.2%
Disk	$215	13.6%	$281	16.6%
Enclosure	$50	3.2%	$93	5.5%
I/O	$235	14.8%	$187	11.0%
Memory	$274	17.3%	$410	24.2%
Power	$86	5.4%	$52	3.1%
System	$17	1.0%	$428	25.3%
Pkg/Doc/SW	$19	1.2%	$42	2.5%
Total	$1,585		$1,691	

Product development

DFMA can be used throughout the entire Product Development Process

- Early Product Costing
- Competitive product benchmarking
- **Concept selection**
- Creation of time standards
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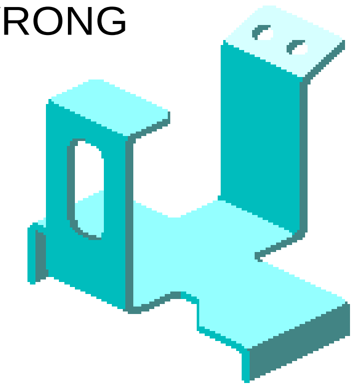
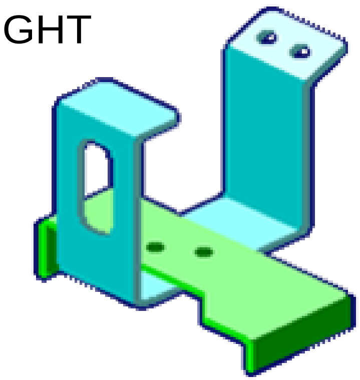
- Estimate hard tooling

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

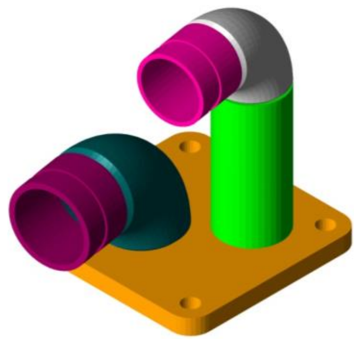
Set-up	0.015	0.023
Process	0.535	0.683
Material	0.036	0.025
Piece part	0.586	0.731
Tooling	0.092	0.119
Total manufacture	0.678	0.850
Assembly	0.000	0.200
Total	0.678	1.050

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

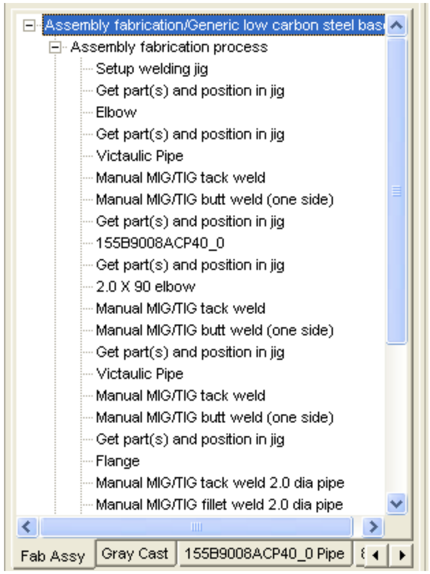
Source: B & D example

Concept Selection

Locomotive fab to cast example



6 Parts
' cost estimate'



1 Part
'could cost'

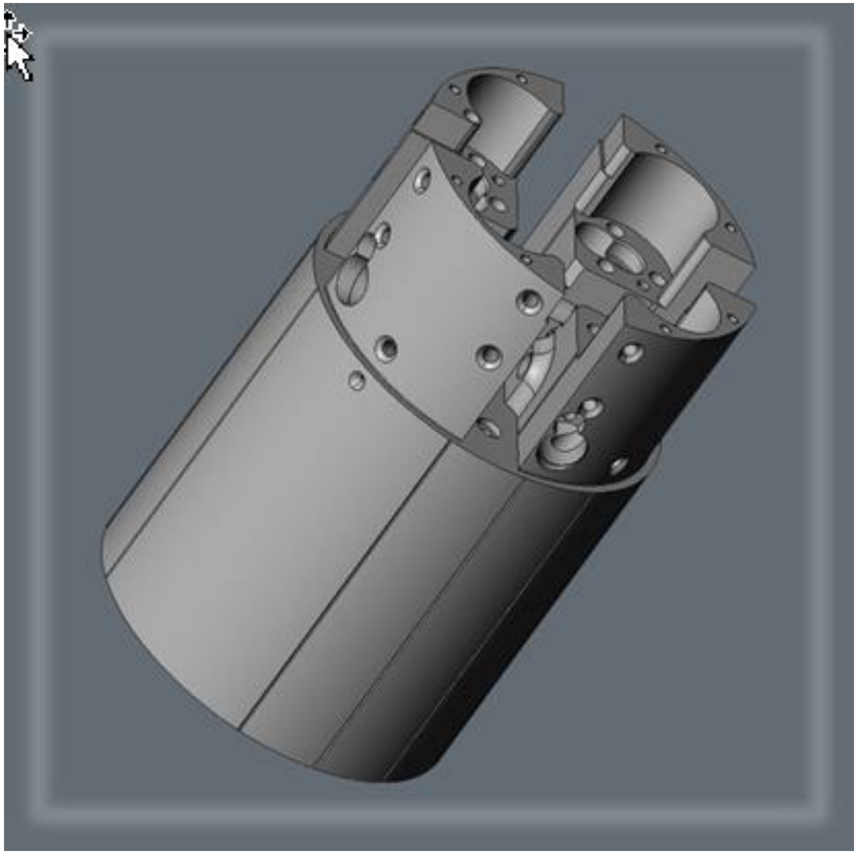
- DFMA estimate $84
- Assembly time 1384 sec (23 min)
- Current price $209

Annual Savings = $261k

- DFMA estimate $25
- Assembly time 0 sec
- Expected Price $35

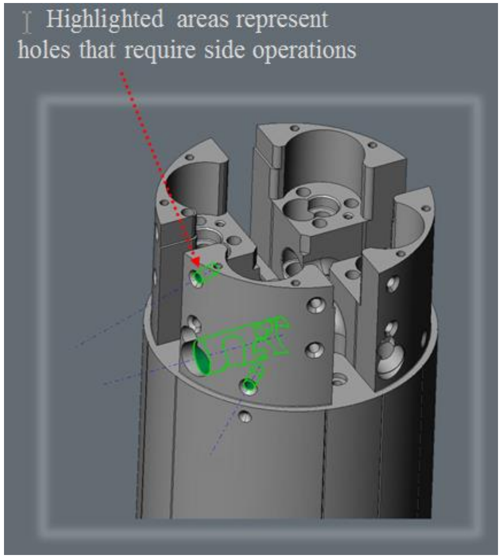
Source: B&D Inc. example

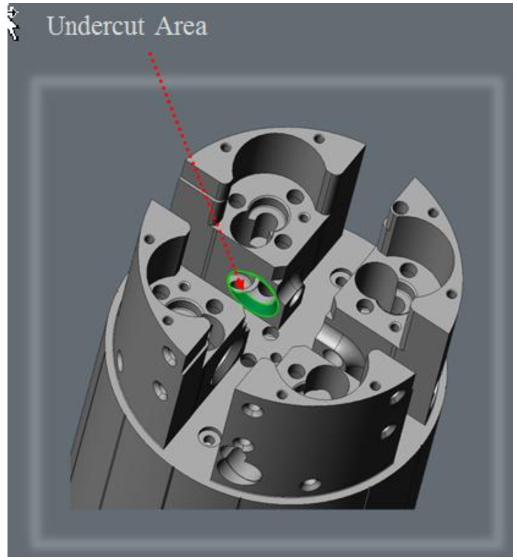
Cost Estimating Example

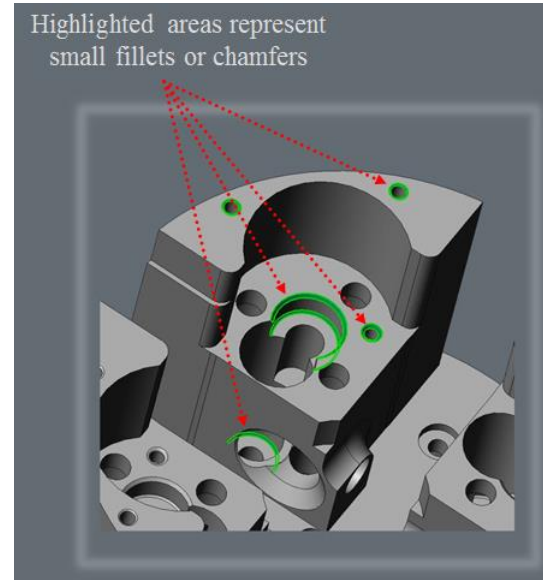


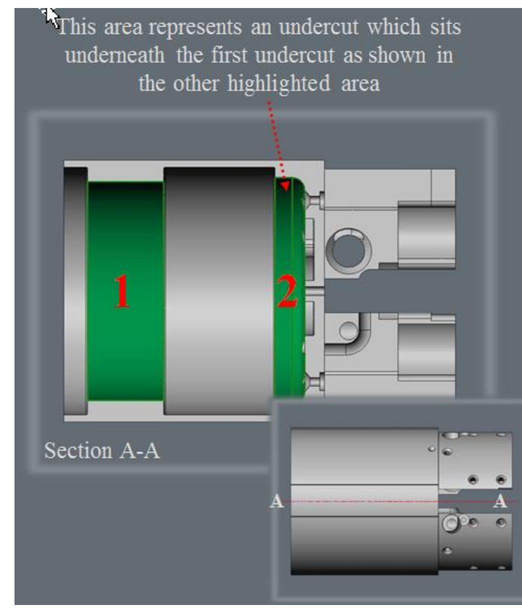
- Machining estimate
- Machining estimate with recommendations
- Alternative manufacturing methods

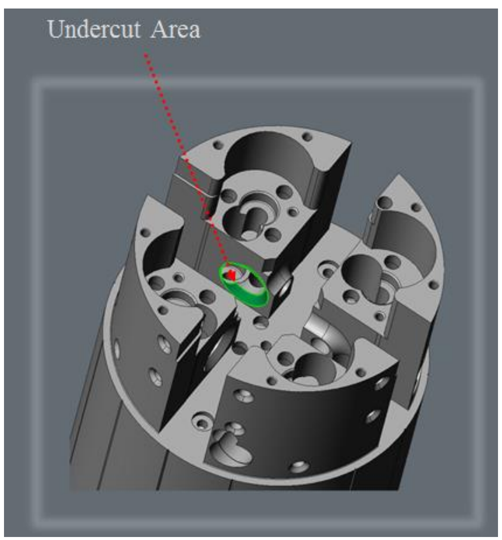
Machining issues

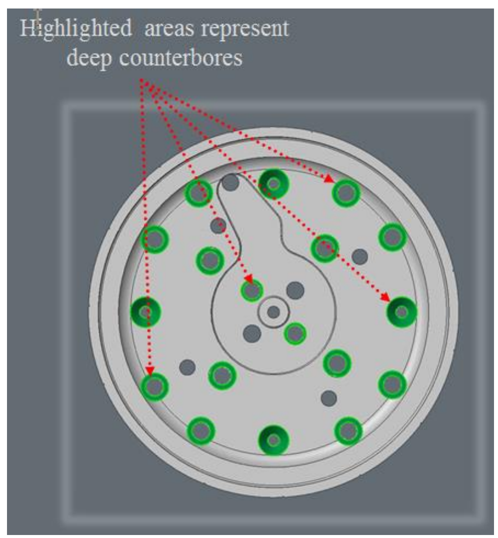






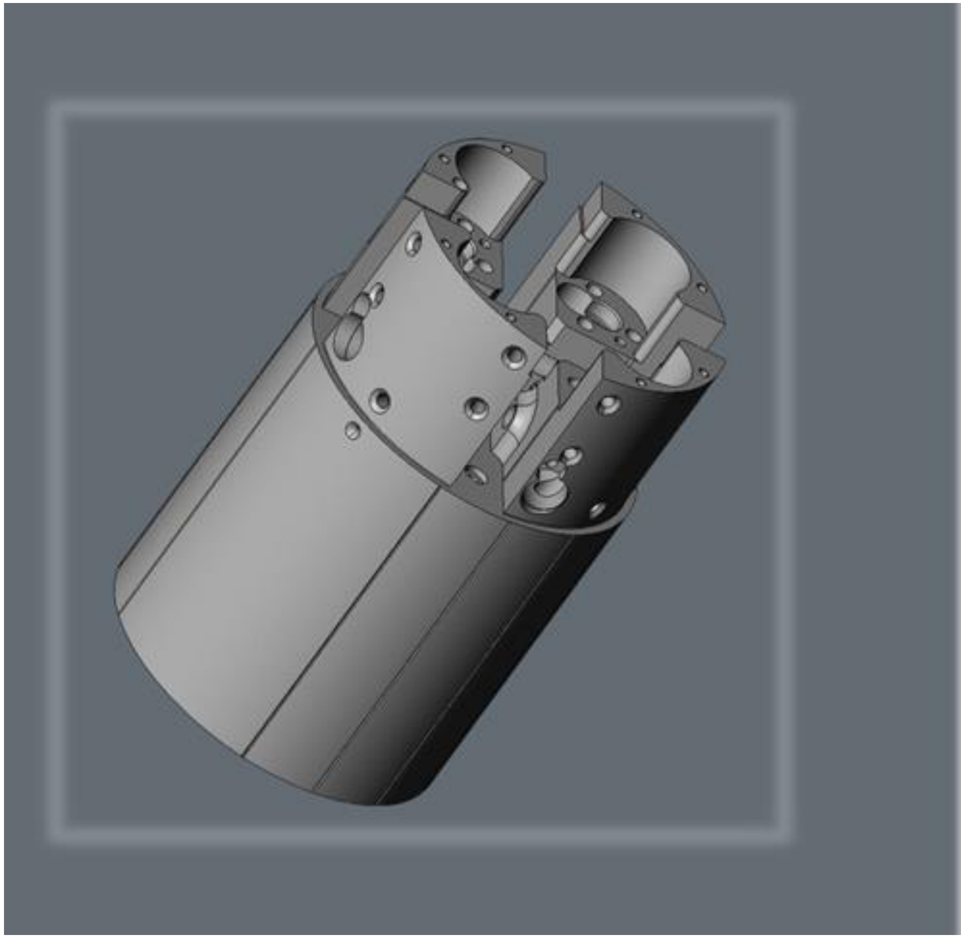






DaTuM 3D
Design To Manufacture

Machining Estimate



Current:

Time = 12 - 15 hrs

Cost = $ 780 - 975

With Recommendations:

Time = 7 - 10 hrs

Cost = $ 455 - 650

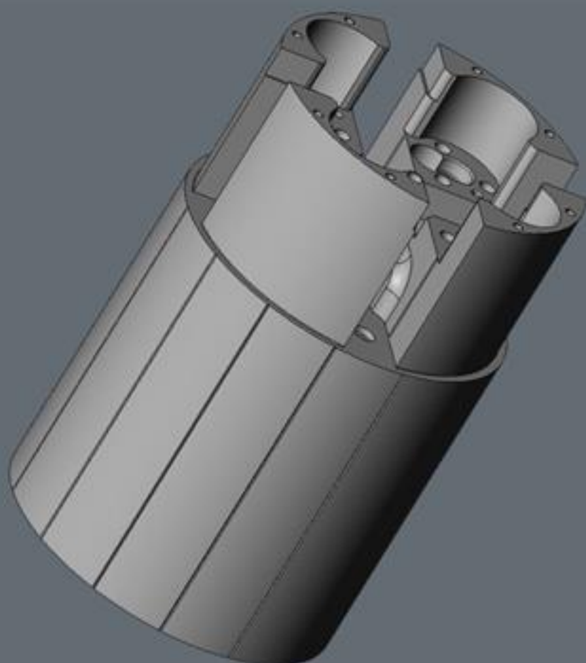
Total Savings = $ 325 / part

Alternative Methods Estimates (investment cast)

Investment Casting

DaTuM 3D
Design To Manufacture

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:

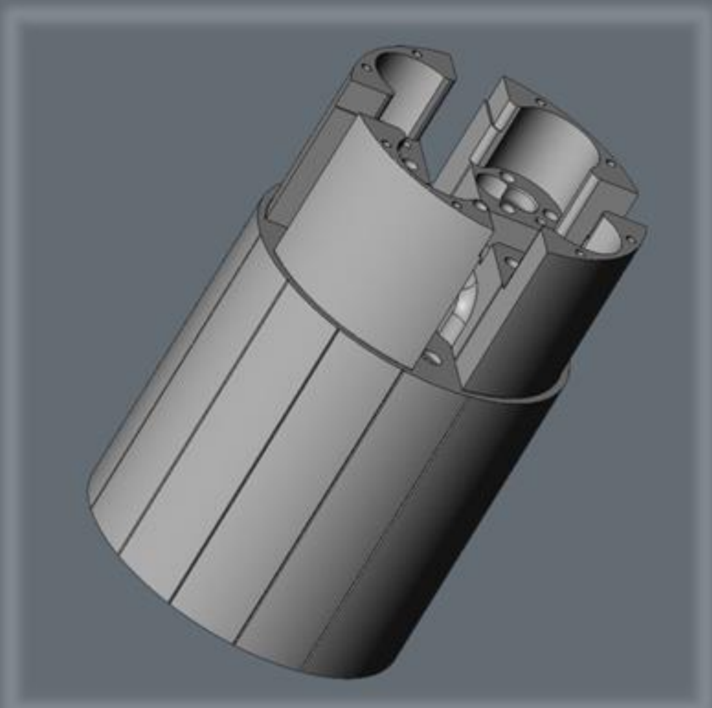
< $135.00 each

Alternative Methods Estimates (Metal Injection Molded)

Metal Injection Molding

DaTuM 3D

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 4^{th} 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
- Deign Simplification
- Cost reduction
- Quality
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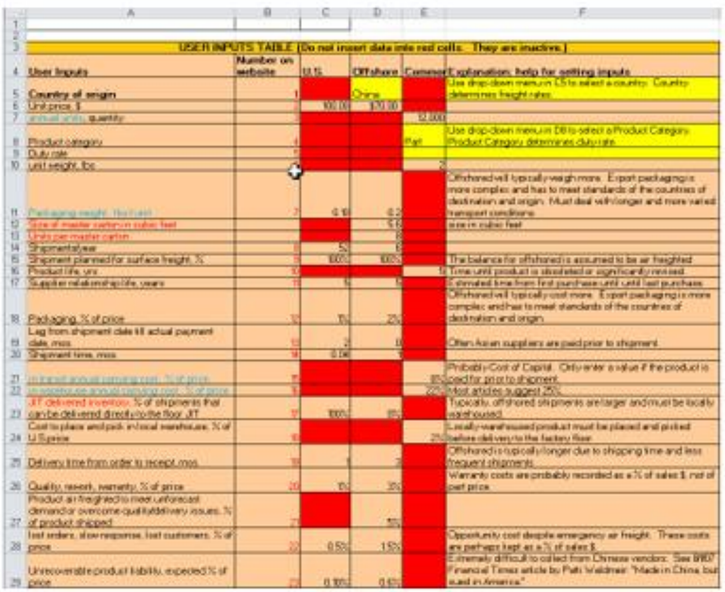
Total Cost of Ownership TCO

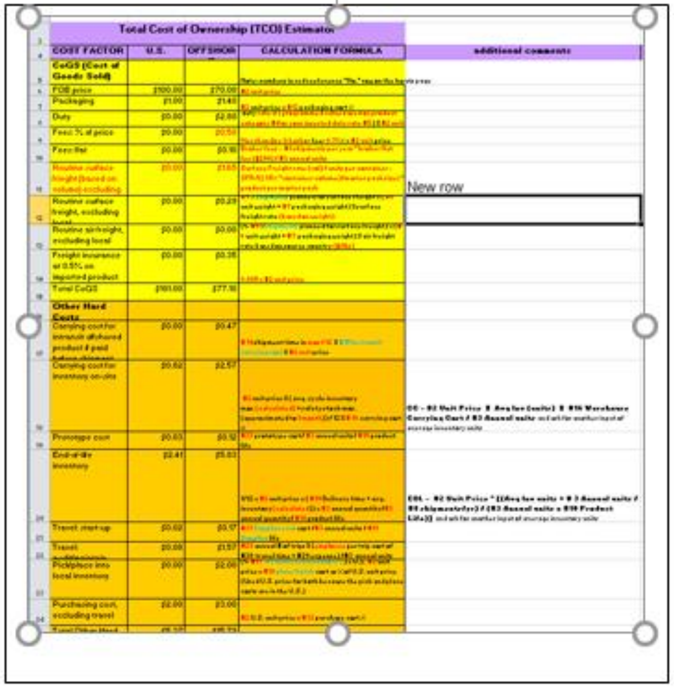
Improved Product Design Practices
Would Make U.S. Manufacturing More Cost Effective: *A Case to Consider Before Outsourcing to China. N. Dewhurst & D. Meeker 2004*

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

User input screen



Output screen



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.

Category ▾ | Add

No.	Type	Name	Comment
1	**Category**	**Example:CORE Operation library**	
2	Misc Op	MTM: Place approximate <= 8 in	MTM:PA1
3	Assembly Op	AA1 g&p_2lbs_easy_app_code1	MTM-AA1 <8 in get and place command
4	**Category**	**Ex: Standard Macro library**	
5	Assembly Op	Typing process function	Macro: Key strokes, looks, reads combined
6	Assembly Op	Detrash operations	Macro: Various detrash operations
7	**Category**	**Ex: Specific Macro library**	
8	Assembly Op	Desk side pick to light procss	Macro: time to pick-to-light all necessary objects
9	Assembly Op	Wrapping machine	Macro: Time to wrap 1 cab using machine
10	**Category**	**Ex: Standard Process Library**	
11	Assembly Op	Deskside Final test time	B&D:sidefinl.dfa Deskside final test time
12	Assembly Op	Deskside Packing process	B&D:sidepack.dfa Deskside drawer packing p

B&D Design Analysis

(1) B&D Design Analysis	111.30	
1.1 (2) Assembly	1	
2.1 (3) Photo Cell assembly	1	
3.1 Install plastic cover: PN 1	1	4.60
3.2 Install rubber protector; PN 2	1	4.60
3.3 Install Photo Cell: PN 3	1	6.10
3.4 Inst. Back rubber protect PN 4	1	4.60
2.2 Install LCD: PN 5	1	4.60
2.3 Install PCA board: PN 6	1	14.40
2.4 Install Key pad: PN 7	1	4.60
2.5 Install flex cable: PN 8	1	6.10
2.6 Install flex cable support:PN9	1	4.60
2.7 (4) Install Back of unit	1	
4.1 Place back on unit PN 10	1	6.80
4.2 Screw down back PN 11-17	6	50.30

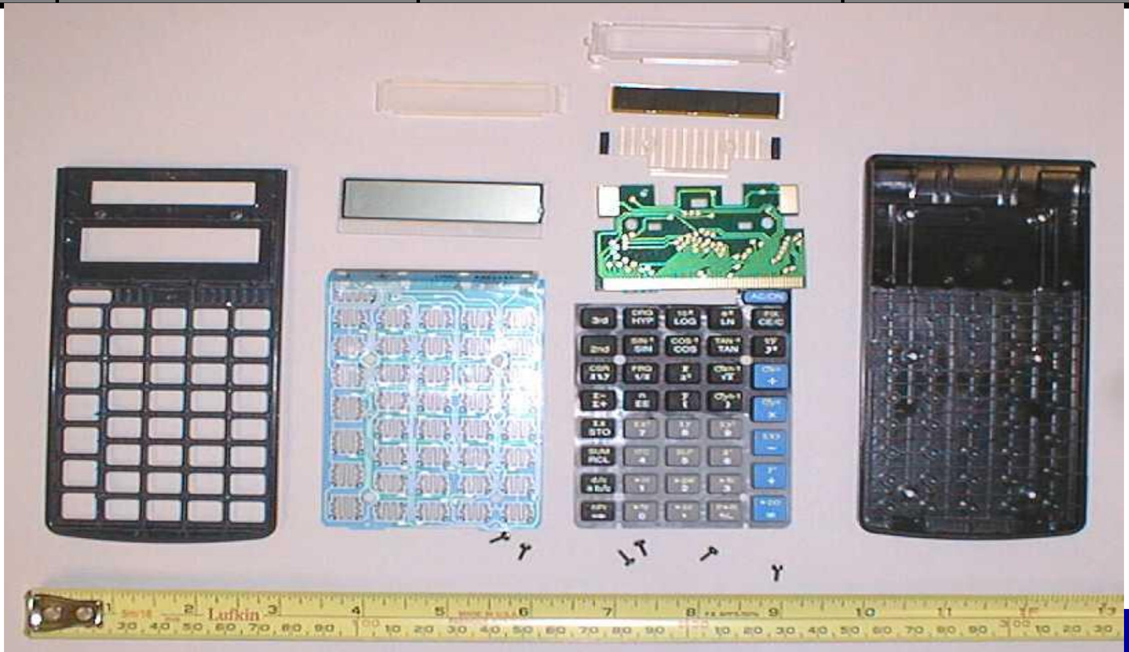
Note work done on old version of DFMA software Operations Libraries do not look like this anymore but function in similar way

B&D Time Standard Tool

(1) Calculator Assembly	235.52	
1.1 (2) Kitting Operation	1	
2.1 Get tote	1	1.80
2.2 Walk to pick face	1	2.88
2.3 Pick part & place in tote	17	21.42
2.4 Check off on paperwork	11	17.82
1.2 (3) Deliver units to assembly area	1	
3.1 Walk to assembly bench	1	3.78
1.3 (4) Assembly	1	
4.1 (5) Photo Cell assembly	1	
5.1 Install plastic cover: PN 1	1	3.4
5.2 Install rubber protector; PN 2	1	3.4
5.3 Install Photo Cell: PN 3	1	4.9
5.4 Inst. Back rubber protect PN 4	1	3.4
4.2 Install LCD: PN 5	1	3.45
4.3 Install PCA board: PN 6	1	7.45
4.4 Install Key pad: PN 7	1	3.45
4.5 Install flex cable: PN 8	1	4.95
4.6 Install flex cable support:PN9	1	3.45
4.7 (6) Install Back of unit	1	
1.4 (7) Close out paperwork process	1	
7.1 Scan serial number	1	5.40
2.1 Get paperwork	1	1.80
7.3 Sign complete name	1	7.92
7.4 Turn page	1	1.51
7.5 Initial paperwork	1	3.96
1.5 (8) Test	1	
8.1 Check Add button	1	3.37
8.2 Check off on paperwork	1	2.52
8.3 Check Subtract button	1	3.37
8.4 Check off on paperwork	1	2.52
8.5 Check Divide button	1	3.37
8.6 Check off on paperwork	1	2.52
8.7 Check Multiply button	1	3.37
8.8 Check off on paperwork	1	2.52
8.9 Sign off on test	1	7.92
1.6 (9) Pack	1	
9.1 Place calculator in bag	1	9.72
9.2 Tape the end of the bag	1	5.40
9.3 Place syrophon sides	2	9.90
9.4 Open box	1	3.96
9.5 Place unit in box	1	2.70
9.6 Close box	1	7.92
9.7 Staple box using foot stapler	1	10.08
1.7 Place paperwork in bin	1	1.80

Calculator Build

	Standard creation time (minutes)	Calculator build standard time (minutes)	Complete assembly Kit, build, test, pack (minutes)
B&D Standard tool	19.94	1.40	3.93
MTM	48.15	1.31	3.54
Time study AVG.	-	1.78	4.42
Time study A	-	1.80	4.58
Time study B	-	1.85	4.34
Time study C	-	1.70	4.33



Historical Statistics

Creation Time Historical Results

B&D tool Historical	3 - 1*
MTM-UAS	10 - 1
Most	10 - 1**
MTM-1	40 - 1**

* 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

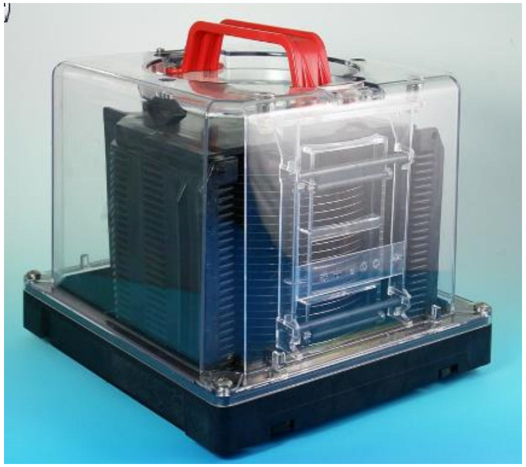
B&D standard tool accuracy with generic macros to within 5-15% of MTM-UAS times.

Product development

DFMA can be used throughout the entire Product Development Process

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

DFMA Example-Comparing Estimates Against Vendor Quotes

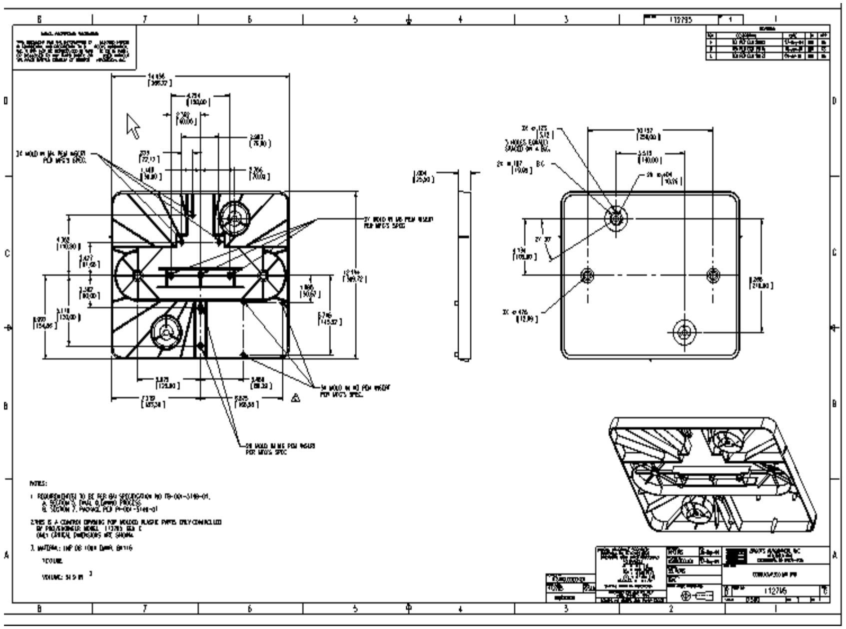


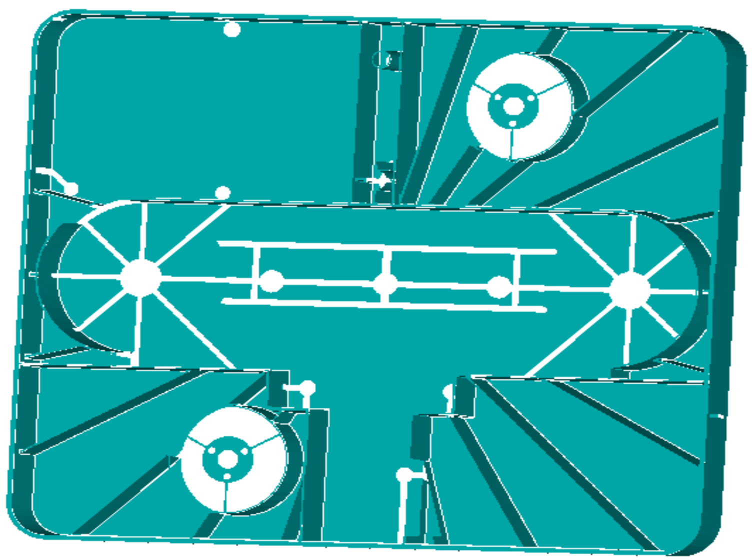
Load Port for **S**tandard **M**echanical **I**nter**F**ace SMIF enclosures

DFMA Example-Comparing Estimates Against Vendor Quotes

B&D Estimates Against Actual Quotes

•Item Description	QTY	Cost	B&D Estimate
• DOOR,	1	$22.34	$9.40





DFMA Example-Vendor Quote

Item Description	QTY	Cost	B&D Estimate
DOOR,	1	$22.34	$9.40

112795

		2,500	1,500	1,000	500	250
FOUP Door	**$55,000.00**	**$14.17/ea.**	**$15.59/ea.**	**$17.30/ea.**	**$18.74/ea.**	**$22.34/ea.**
Delivery: (8) weeks ARO		Resin: LNP DB 1004 EMMR, BK115				

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.

148 Christian Street
Oxford, CT 06478
203-888-0585

PTA CORP
www.ptacorp.com

7350 Dry Creek Parkway
Longmont, CO 80503
303-652-2500

DFMA Example-Data Collection for estimate refinement

Questions were asked to gather further information

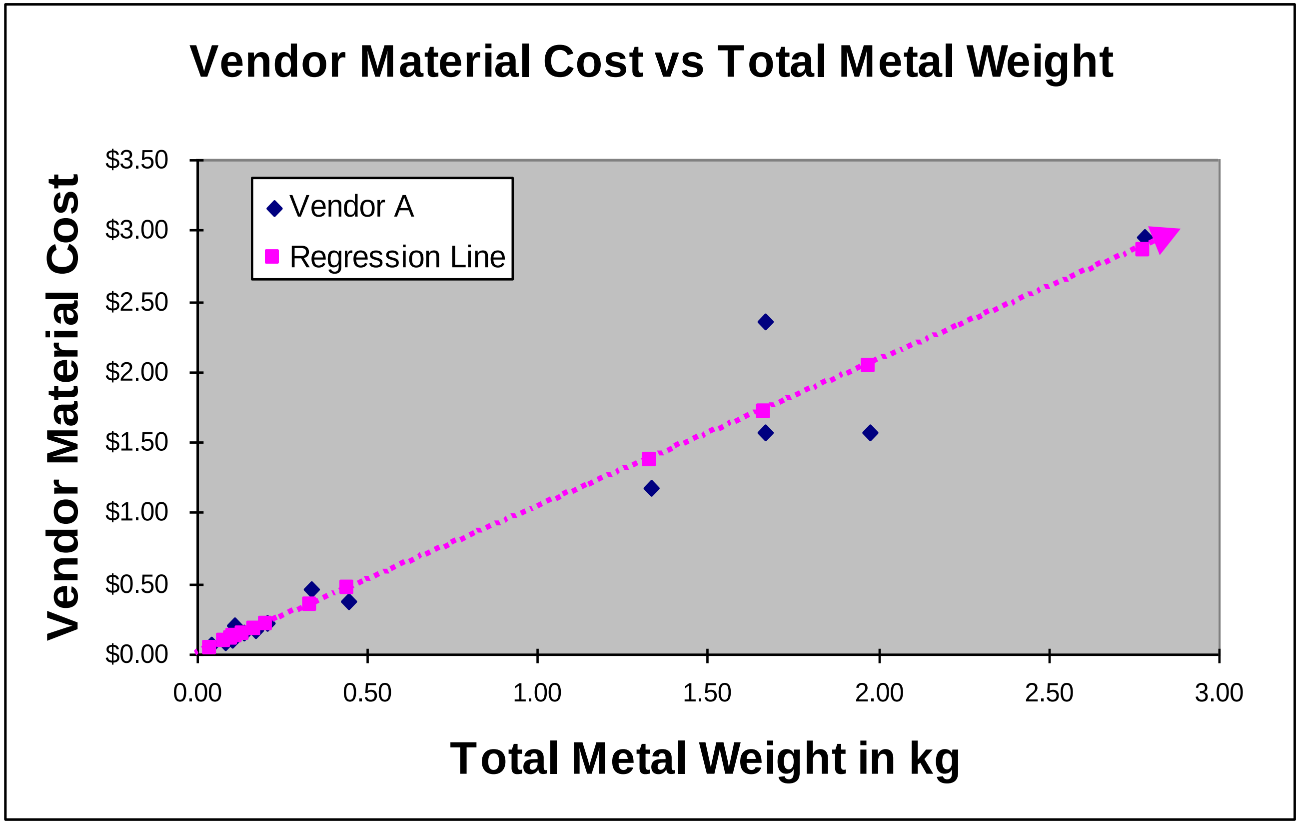
- Material parameters and material cost from vendor, tonnage machine, and process information.
PTA $7.35/lb GE $7.65/lb PTA is passing their material cost saving.

- 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



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%

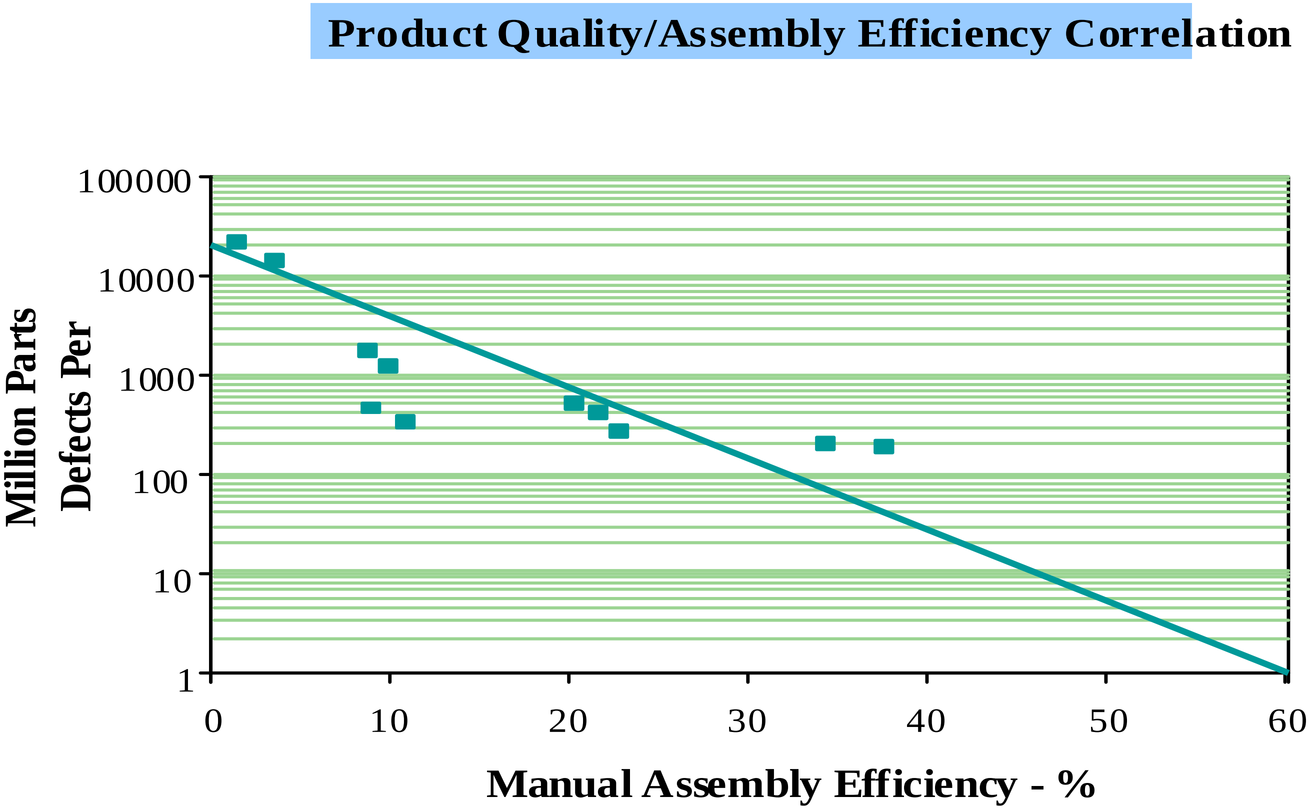
Product development

DFMA can be used throughout the entire Product Development Process

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

Quality Tool

Design for Assembly



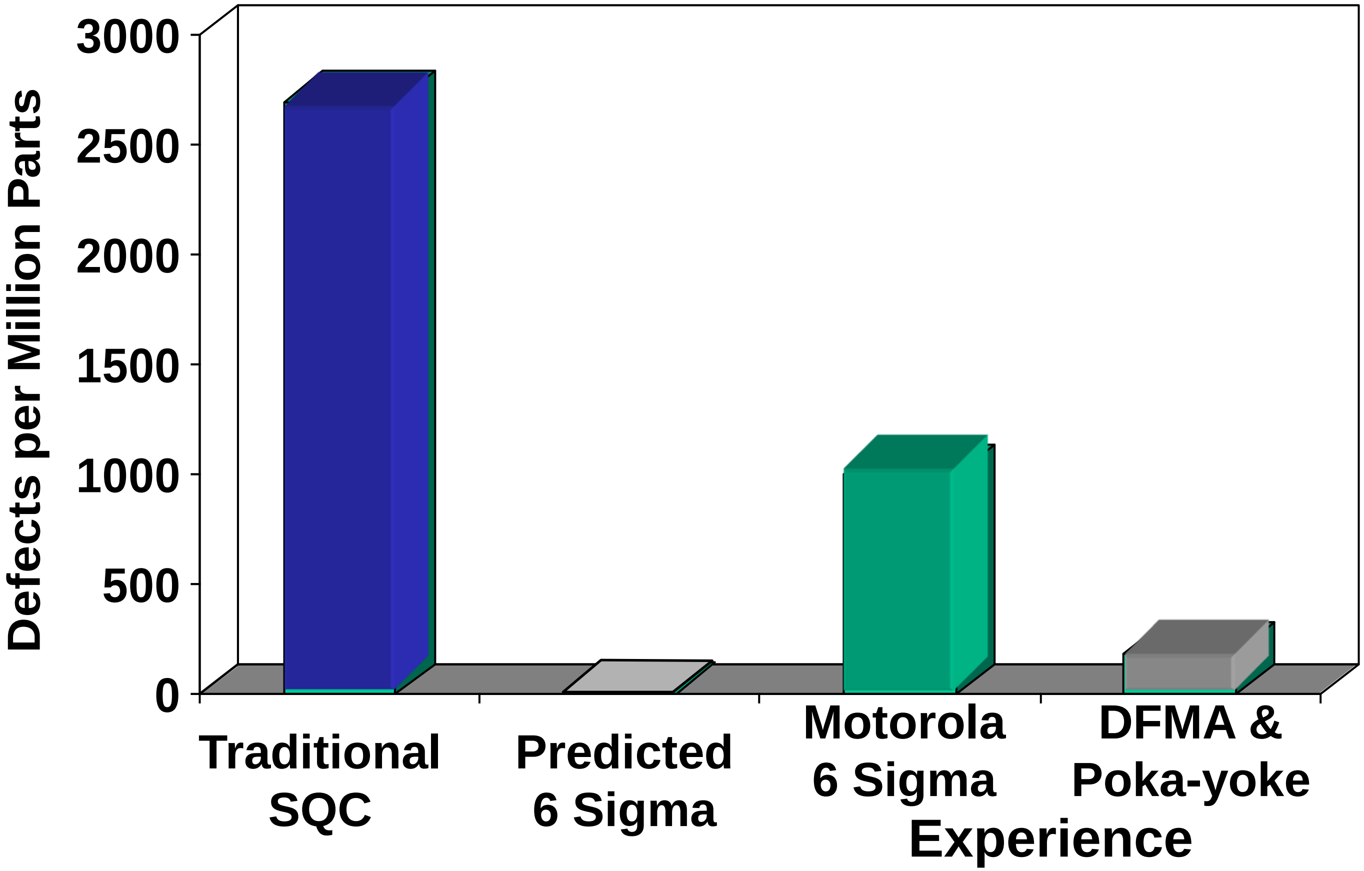
Every one second of assembly penalty time causes an average of 100 DPM

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

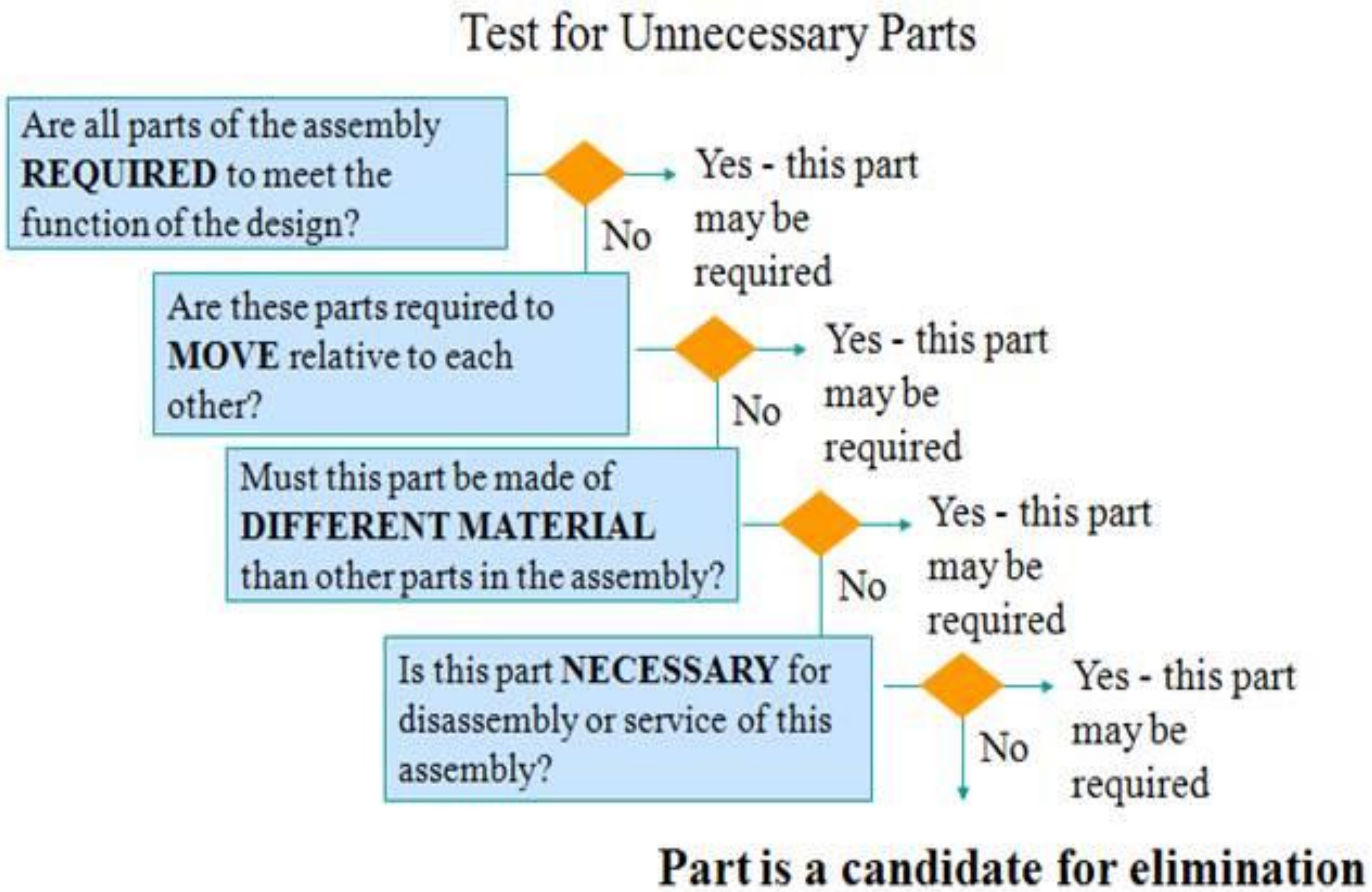
Big

Secret

Biggest bang for the buck
Theoretical Minimum Part Count (TMPC)

How to get rid of parts

Theoretical Minimum Part Count



Theoretical Minimum Part Count TMPC

What is the best part in your design ?

Theoretical Minimum Part Count TMPC

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

Activity	Cost
Engineering and design	$12,600
Testing[a]	1,000
Manufacturing	2,400
Purchasing	5,200
Inventory	1,200
Logistics support	5,100
Total	$27,500

[a]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.

IBM ProPrinter vs. Epson

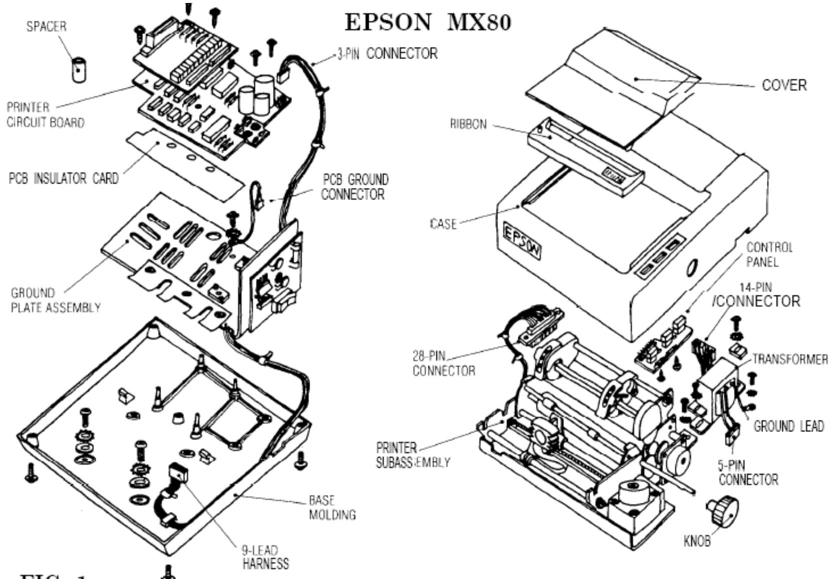


FIG. 1
The EPSON MX80 dot matrix printer final assembly consists of 49 parts or subassemblies as shown in this exploded view.

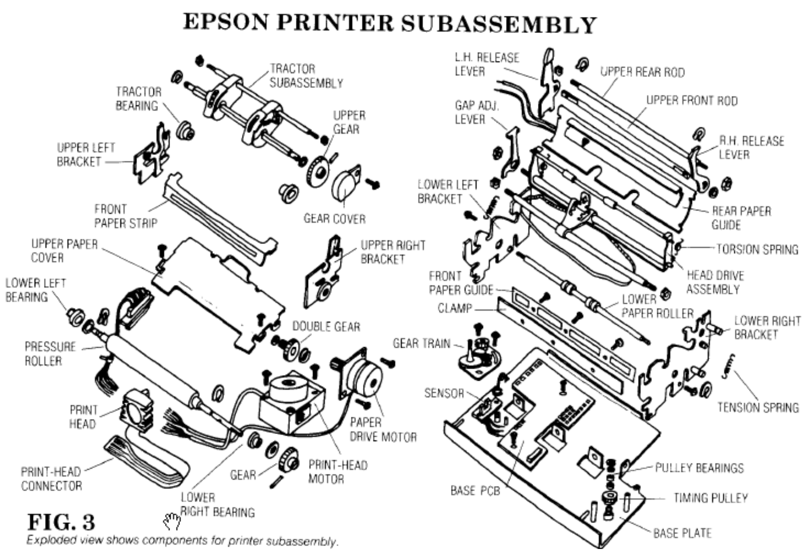


FIG. 3
Exploded view shows components for printer subassembly.

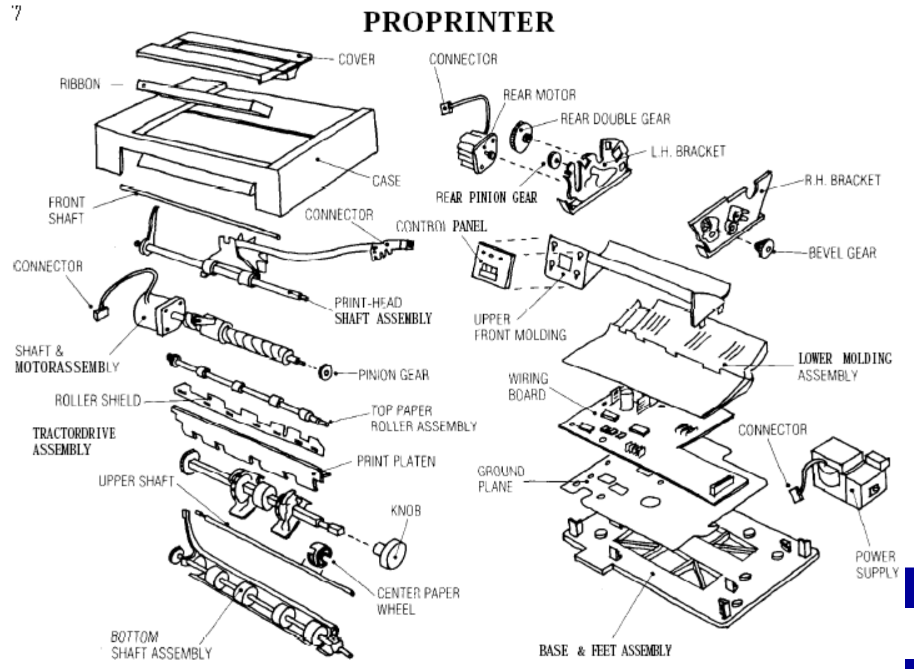
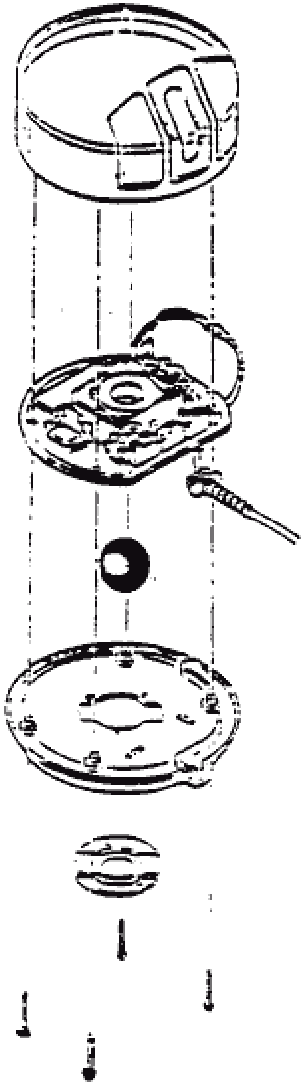


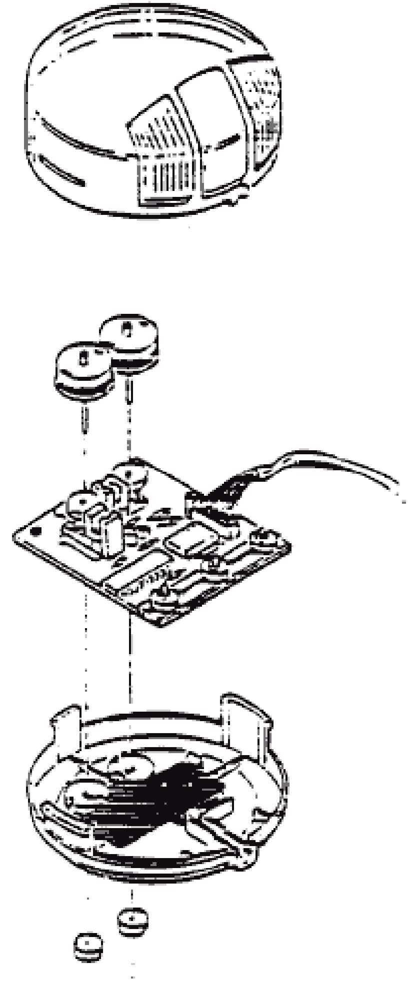
FIG. 5
Exploded view of IBM Proprinter highlights design simplification in this product.

Epson MX 80	IBM PRO Printer
Total Assm. time sec. 1866	Total Assm. Time 170.
Total Number of operations 185.	Total number of operations 32.
Total parts/subs. 152	Total parts/subs. 32.
Theoretical part count 41.	Theoretical part count 29

https://www.youtube.com/watch?v=spDYSKl3kmo

Digital Corporate Mouse





	Old	New
Part count	61	44
Mechanical	31	16
Electrical	28	30
Assm. Time	17 min.	6
Assm. Oprs.	83	56
Adjustments	11	0
Fasteners (3 types)	10	0
Material Cost Reduction		>40%

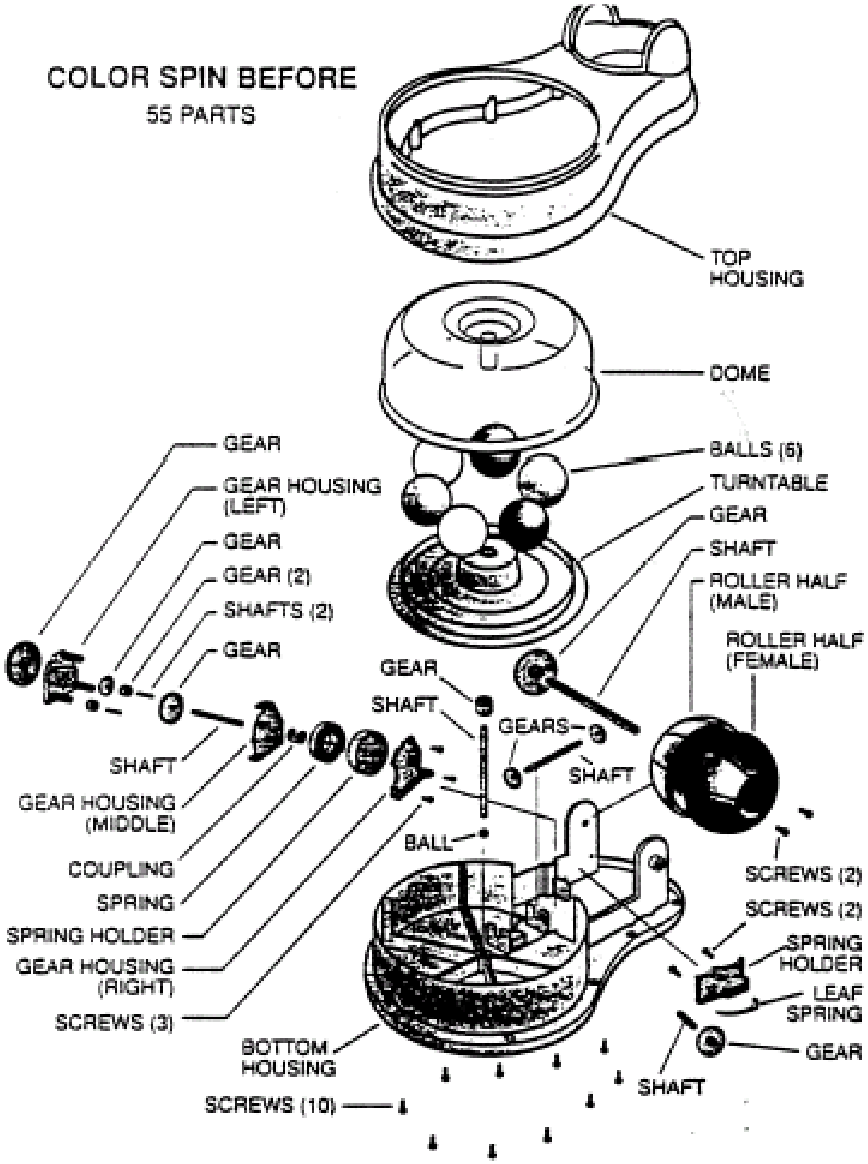
Case Study

Respironics BagEasy III

- 84% reduction in assembly time
- 65% reduction in the number unique parts
- 81% reduction in assembly operations
- 6 patent applications

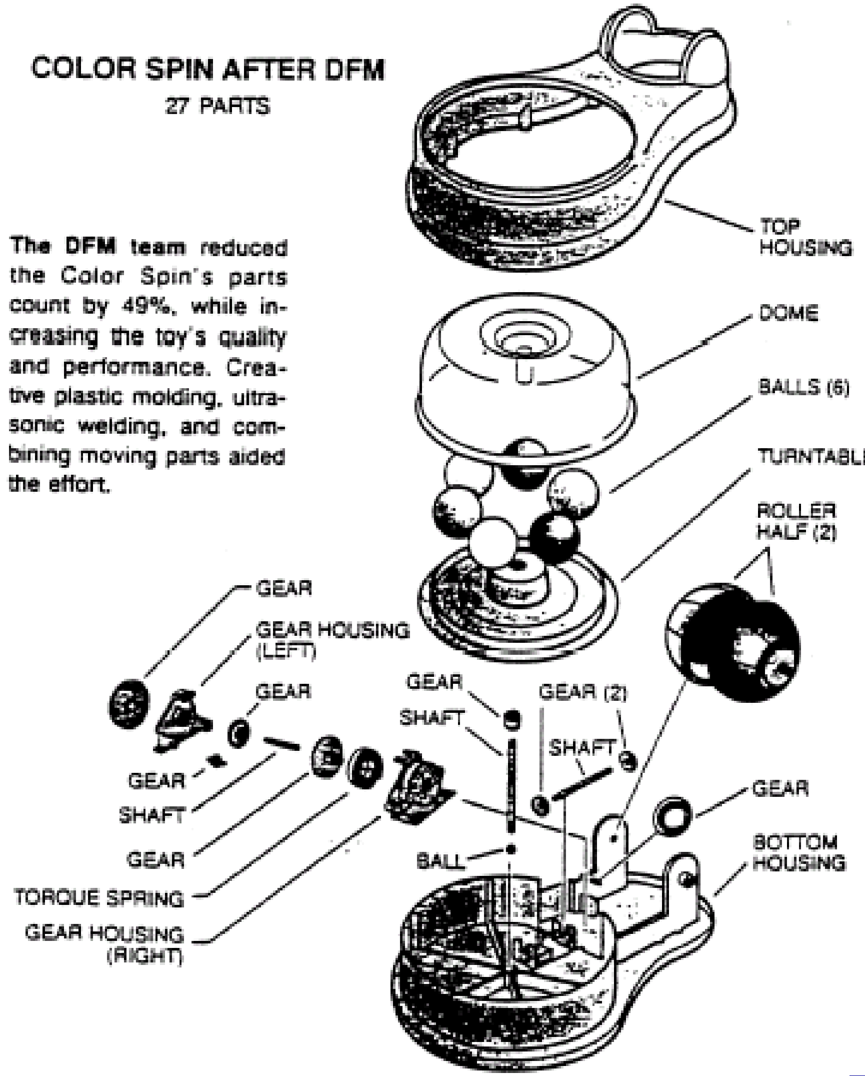
Mattel Color Spin

COLOR SPIN BEFORE
55 PARTS



COLOR SPIN AFTER DFM
27 PARTS

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

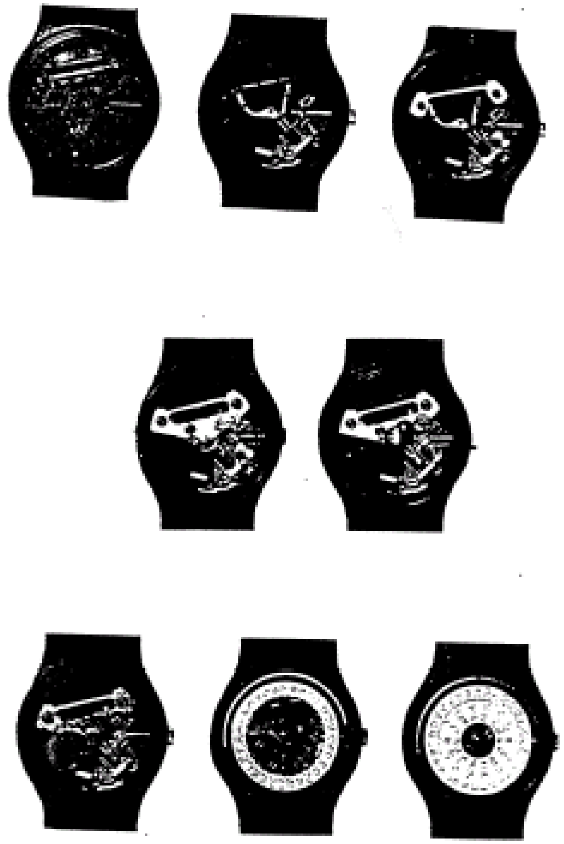
Results:

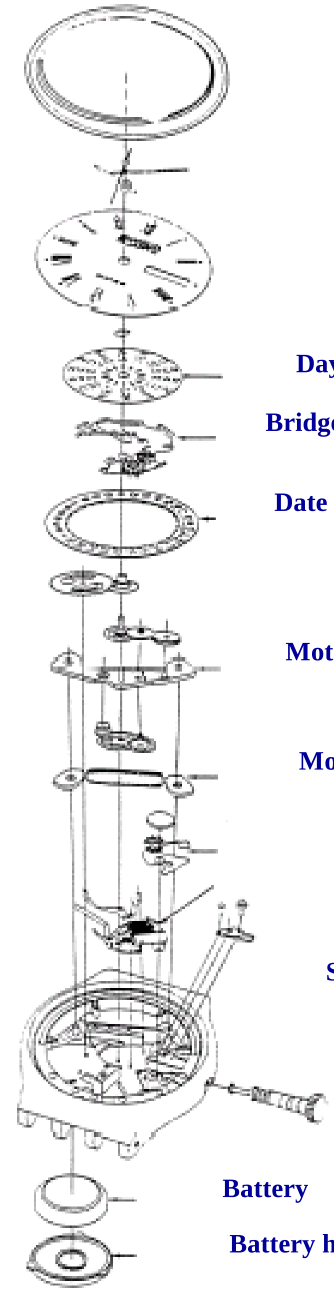
- Over 50% part count reduction
- Over 75% assembly time reduction
- Factory output *quadrupled* without additional floor space
- Better design allows for:
  - Tighter tolerance cutting
  - Unit cuts as fast as some 200 amp units
  - 2/3rds less operating cost per unit
  - 1/10th warranty costs of predecessor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

Mechanical Chronograph

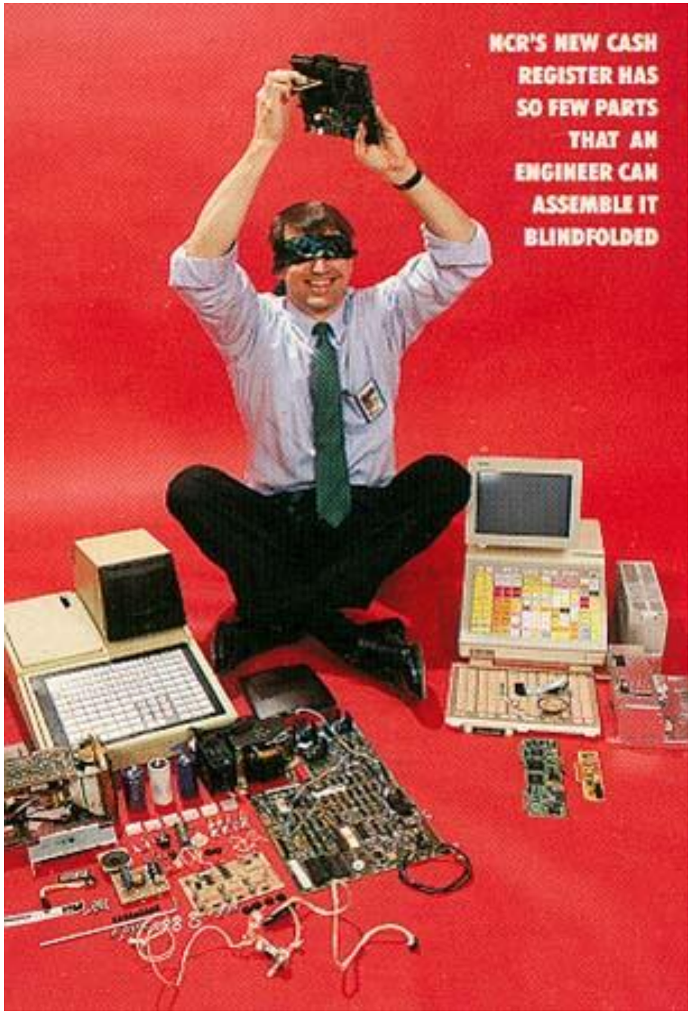
SISTEM51 is 100 percent Swiss made and features an exceptional 90 hour power reserve. Hermetically sealed within its case, the 3 Hz movement delivers precise, long-lasting, maintenance-free performance.

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



DFMA Back To Its Roots

Harbor Freight Flashlight

	Name	Quantity	Min. Part Criteria	Min. Part Count
1	Chassis	1	*Base*	1
2	Battery Terminal - dual	2		
3	Battery Terminal - single pos	1		
4	Battery Terminal - single neg	1		
5	3 LED Lens	1		
6	3 LED Board & wires	1		
7	3 LED Reflector	1		
8	Battery Wire	2		
9	24 LED Board	1		
10	Screws - small	6		
11	24 LED Reflector	1		
12	Cover - Lens	1		
13	24 LED Lens	1		
14	Button	1		
15	Batteries - AAA	3		
16	Cover - Hook/Mag	1		
17	Magnet	1		
18	Hook	1		
19	Hook retainer	1		
20	Screws - retainer	2		
21	Screws	3		
22	Labels	3		

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


LOONEY TUNES
"That's all Folks!"
A WARNER BROS. CARTOON

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**