30 Years of Innovation:

The Evolution and Application of DFMA

David Meeker
Neoteric Product Development
Meeker@mit.edu

30 Years of Innovation

What was happening 30 years ago ?

- World population was at 4.84 billion http://www.worldometers.info/world-population/
- Gasoline in U.S. was $1.21 a gallon

30 Years of Innovation

What was happening 30 years ago ?

- World population was at 4.84 billion
- Gasoline in U.S. was $1.21 a gallon
- First Dot.COM company name was registered Symbolic's Corporation
- Block Buster video opened its first store
- New Coke was introduced

30 Years of Innovation

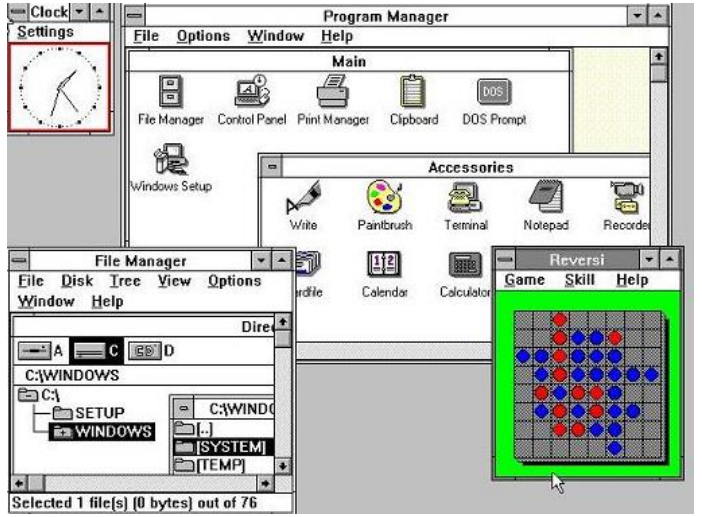

What was happening 30 years ago ?

- World population was at 4.84 billion
- Gasoline in U.S. was $1.21 a gallon
- First Dot.COM company name was registered Symbolic's Corporation
- Block Buster video opened its first store
- New Coke was introduced
- Nintendo sells its First entertainment System in U.S.
- Dave Letterman's first top ten list appeared "what rhythms with peas"
- Titanic was discovered

30 Years of Innovation

What was happening 30 years ago ?

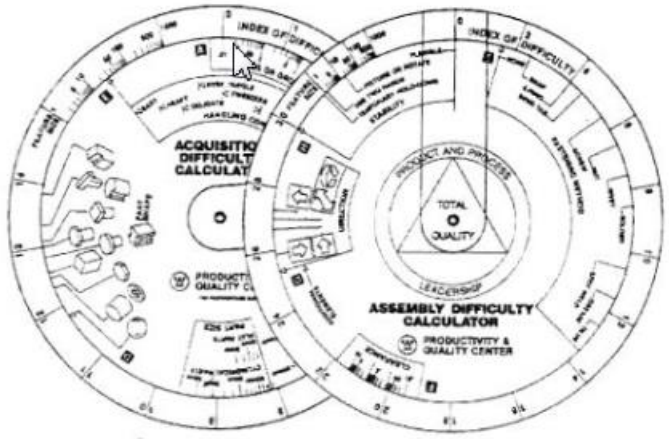
- World population was at 4.84 billion
- Gasoline in U.S. was $1.21 a gallon
- First Dot.COM company name was registered Symbolic's Corporation
- Block Buster video opened its first store
- New Coke was introduced
- Nintendo sells its First entertainment System in U.S.
- Dave Letterman's first top ten list appeared "what rhythms with peas"
- Titanic was discovered
- Microsoft Windows 1.0 was released
- Back to the Future was block buster movie that summer
- **Boothroyd and Dewhurst held their first DFMA conference**



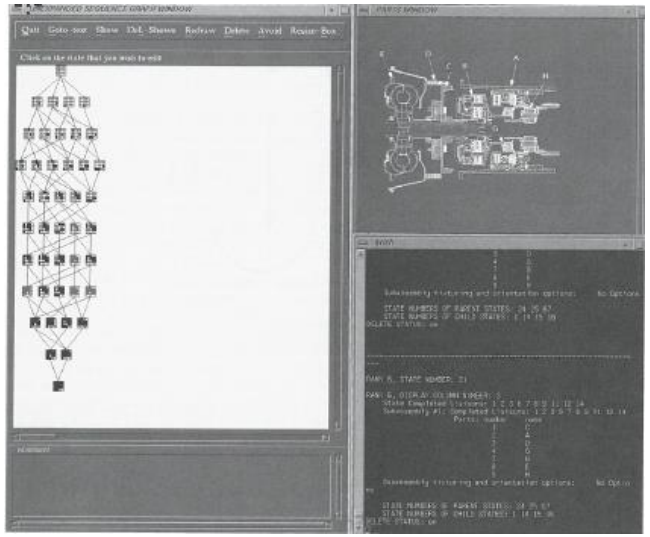
30 Years of Innovation

DFA/ DFM methodologies and software that have come and gone:

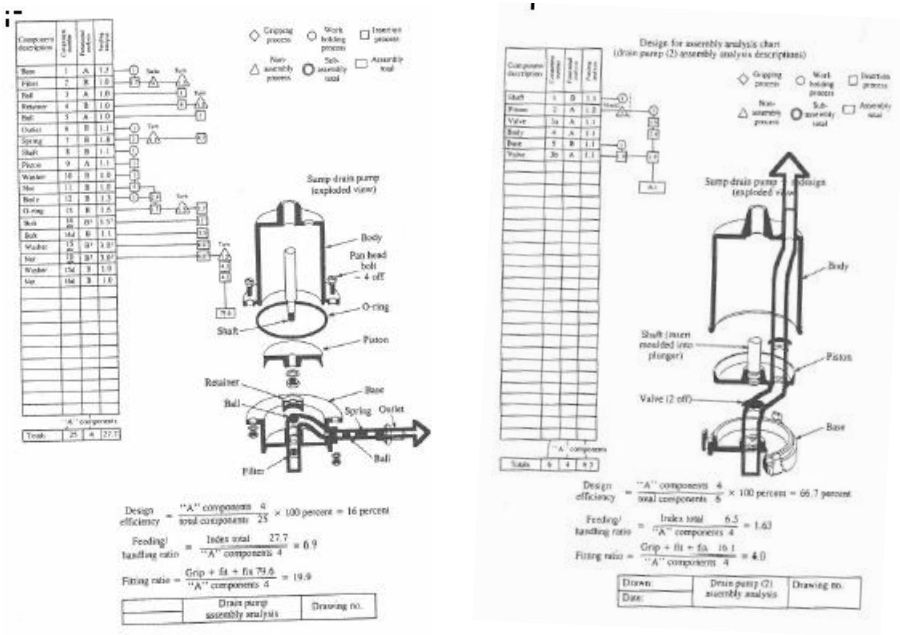
- Hitachi AEM
- Sony DAC
- Fujitsu Productivity Evaluation Method
- Xerox Producibility Index & Pumpkin books
- Lucas Engineering
- Westinghouse Calculator
- Sapphire Design
- Draper Labs



Westinghouse Calculator



Draper Labs



Lucas Engineering

30 Years of Innovation

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,

30 Years of Innovation

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

  "For their concept, development and commercialization of DFMA, which has dramatically reduced costs, improved product quality and enhanced the competitiveness of major U.S. manufacturers."

30 Years of Innovation

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

30 Years of Innovation

There are lots of tools to use during product development:

- House of Quality Quality Function Deployment QFD
- Value Engineering / Value Analysis VE/VA
- Six Sigma
- DTC / CAIV
- Lean
- Lean Six Sigma
- CAD / CAM
- 3D Printing

At the end of the day if you had to choice only one tool to use

It would be DFMA WHY?

30 Years of Innovation

DFMA is the one tool that impacts the entire Product Development cycle.

The **INNOVATION** is all that DFMA can be used for throughout the entire Product Development Process

- Design Simplification
- Early Product Costing
- Competitive product benchmarking
- Concept / Process selection
- Creation of time standards
- Assembly Instructions
- Cost reduction
- Quality
- Vendor quote verification
- Lots of other possibilities ……..

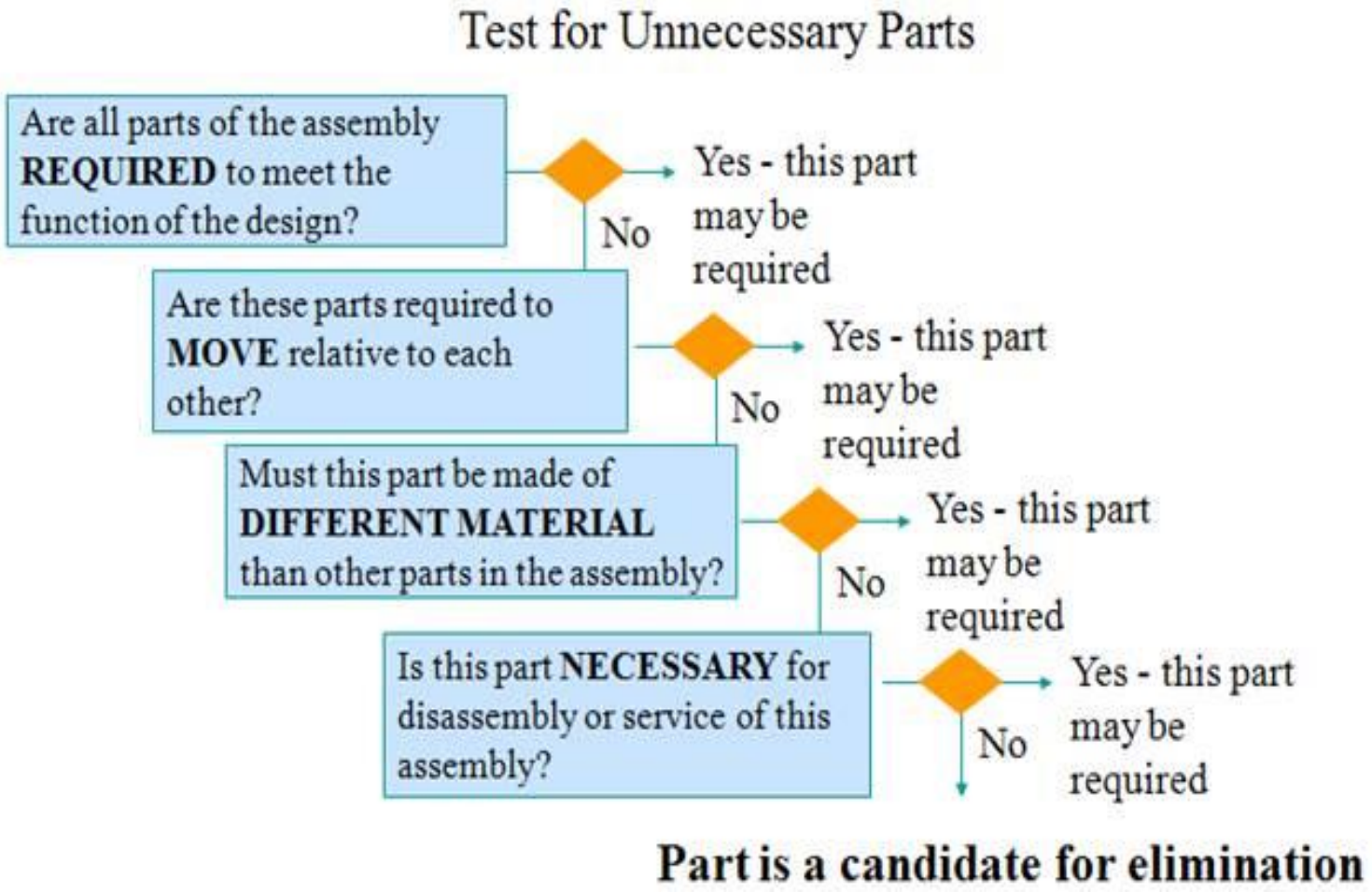
A

Big

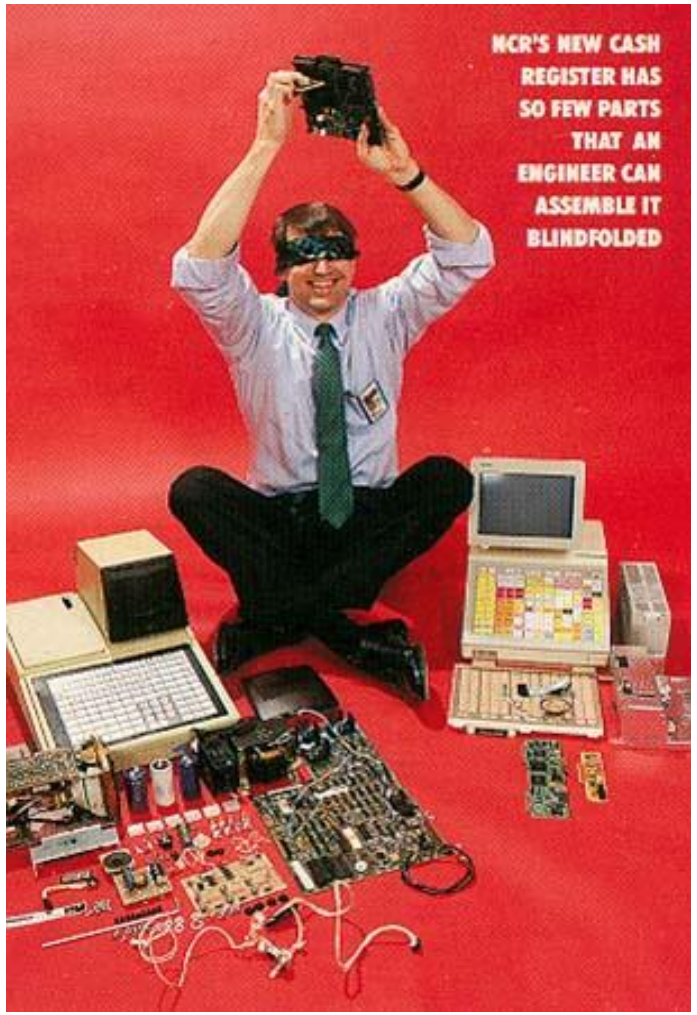
Secret

How to get rid of parts

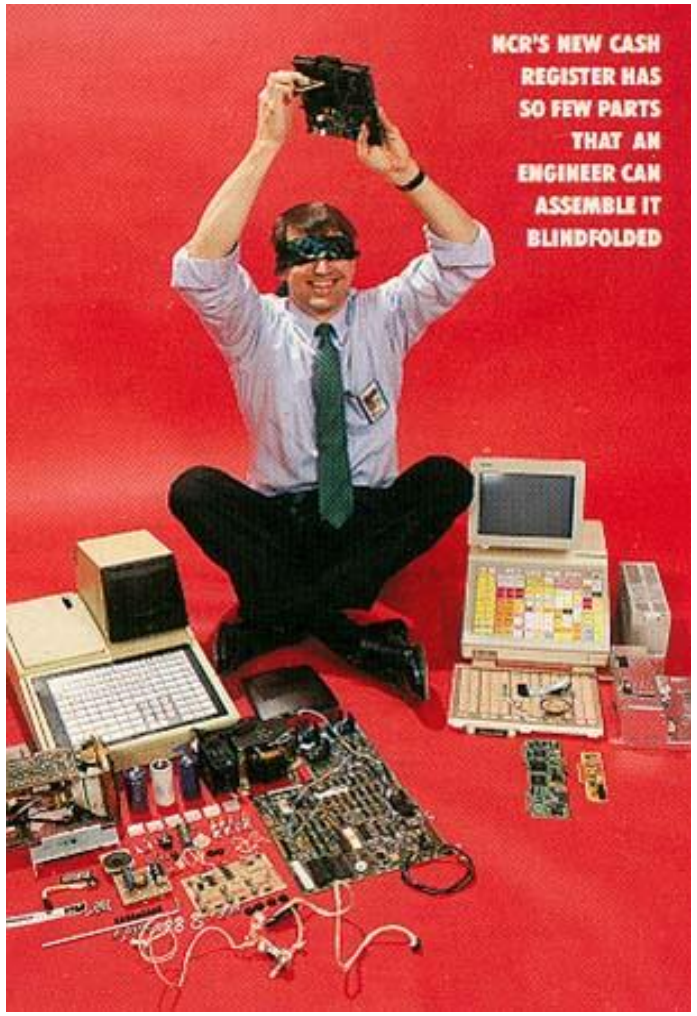
Theoretical Minimum Part Count



What is the best part of all ?



The one that is not THERE !



85 % Part count reduction
75 % Assembly time reduction
44 % Reduction in labor cost
65 % Fewer suppliers
No assembly tooling
No fasteners

30 years of Innovation

Theoretical Minimum Part Count (TMPC)

30 years of Innovation

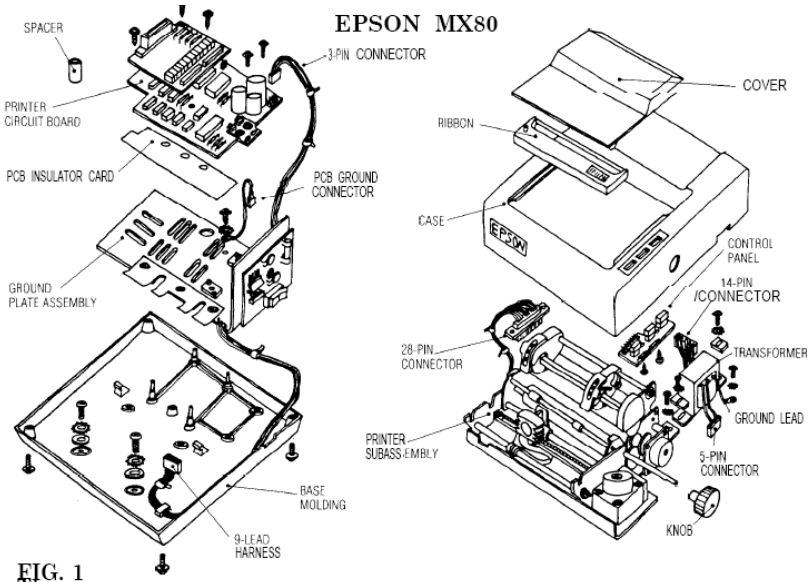


FIG. 1
The EPSON MX80 *dot matrix printer final assembly consists of 49 parts or subassemblies as shown in this exploded view.*

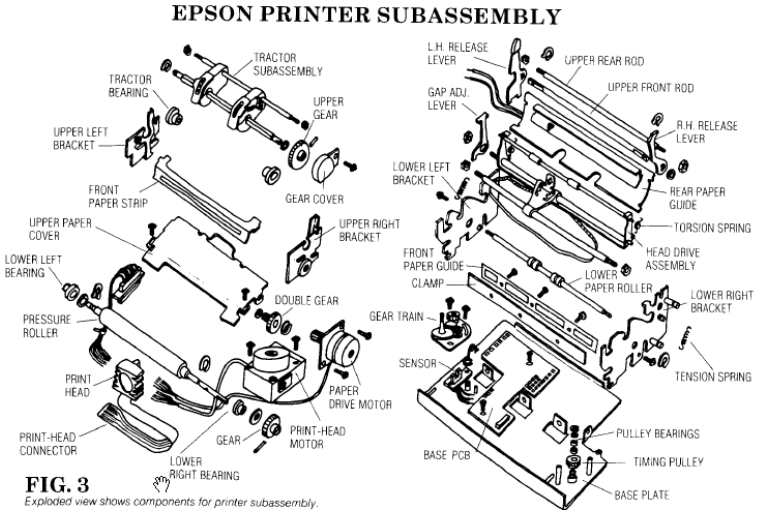


FIG. 3
Exploded view shows components for printer subassembly.

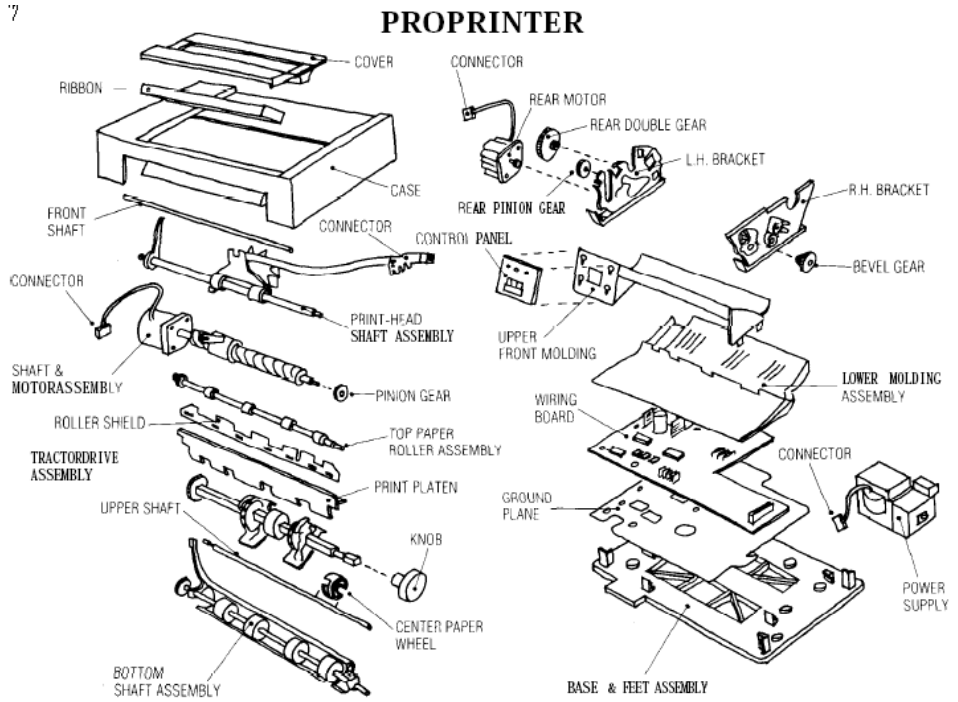


FIG. 5
Exploded view of IBM Proprinter highlights design simplification in this product.

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

Early Product Costing

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. (parametric)**

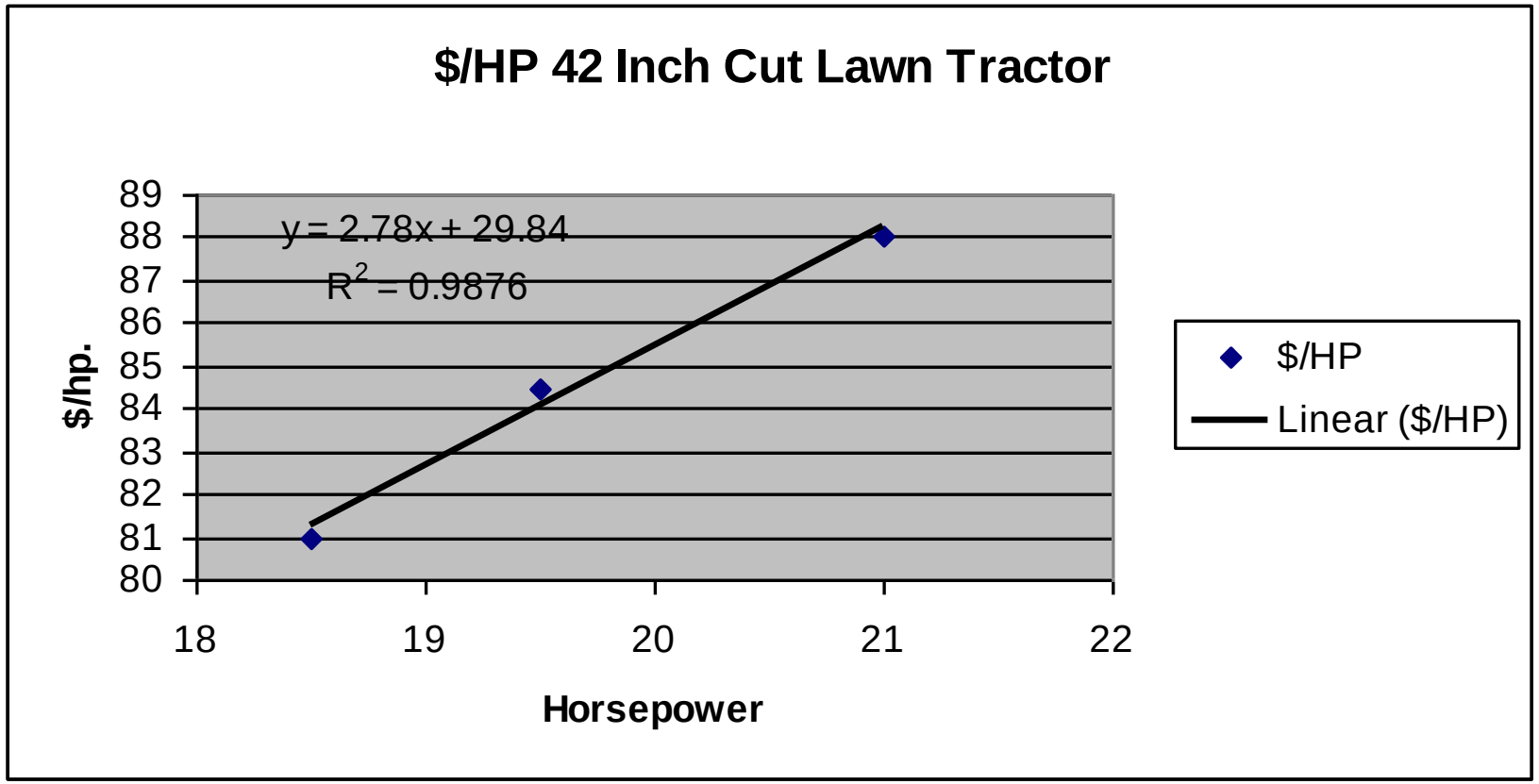
- ***Level 2*** **- An estimation based on prior experience with similar products, budgetary estimates, vendor quotes and expert opinion and experience. (analogy)**

- ***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)**

Early Product Costing

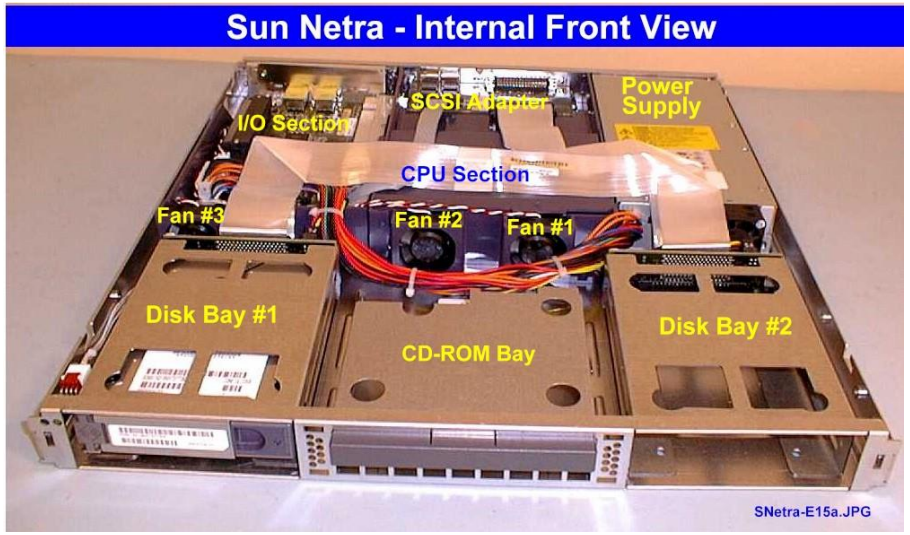
Trend Line Analysis

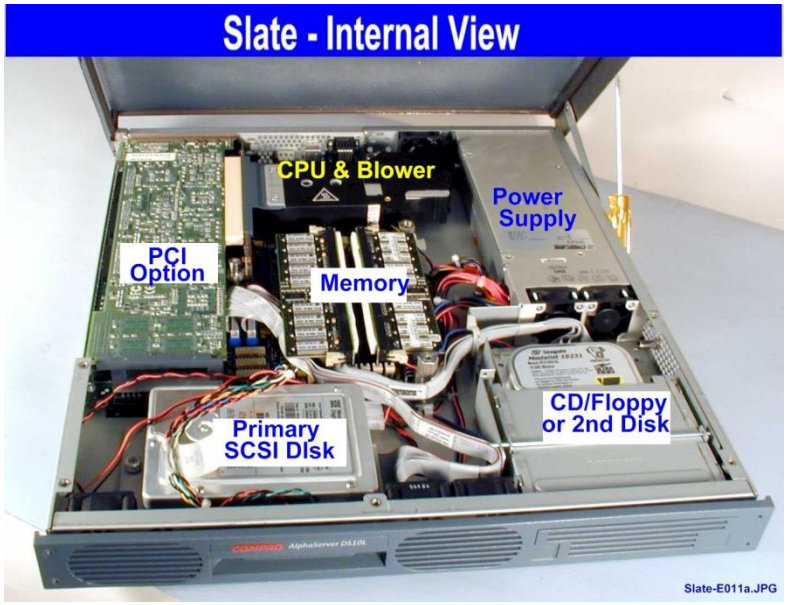
- **Tractor example**

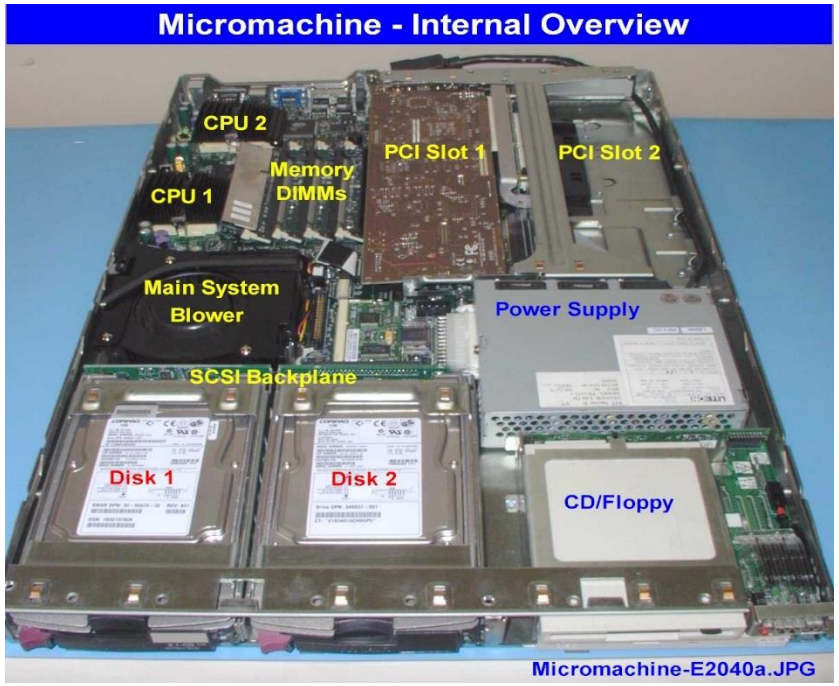


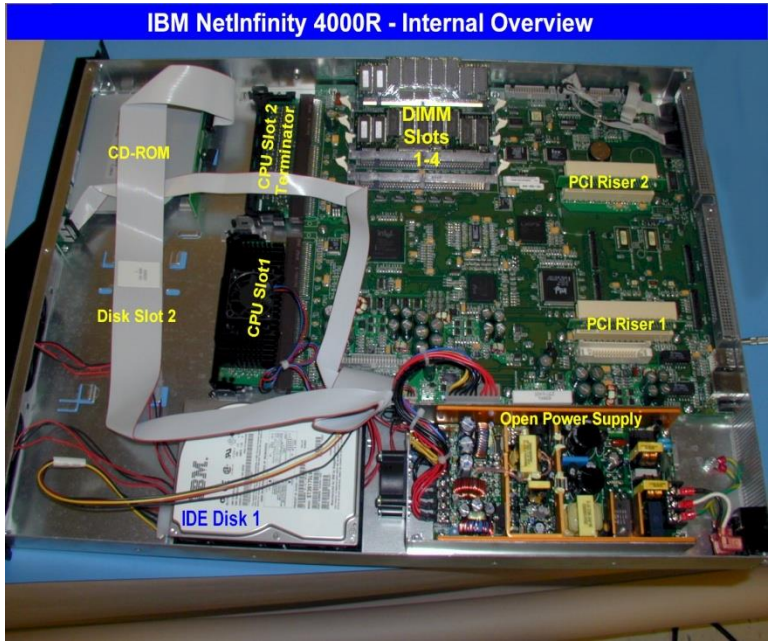
A Comparison of 1U Servers

Whats inside



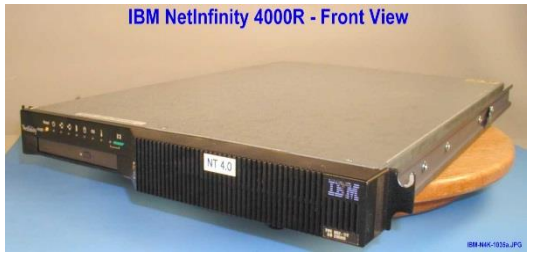


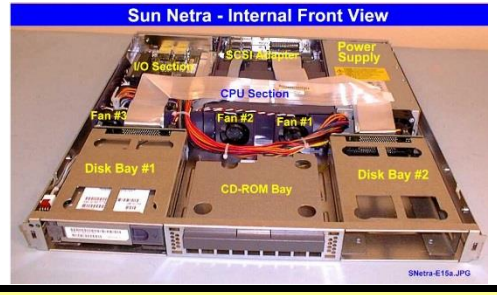


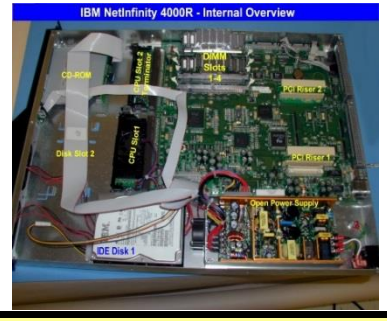


Benchmarking

Function Cost Comparison



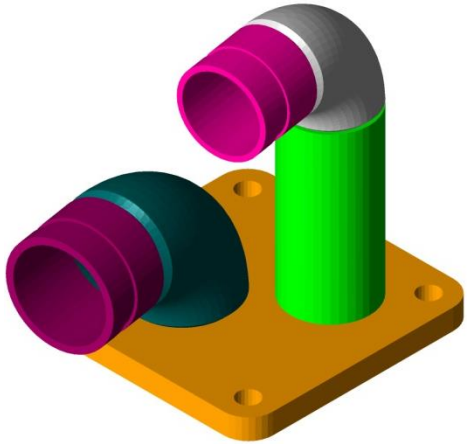




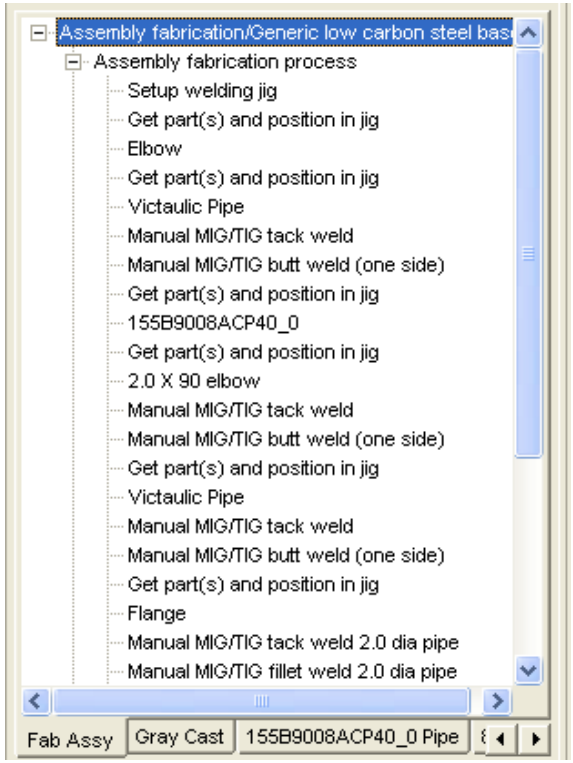
	Sun Netra t1		IBM NetInfinity 4000R	
	Cost	**% of Total**	**Cost**	**% of Total**
Cooling	$14	0.9%	$9	0.5%
CPU	$675	42.6%	$189	11.2%
Disk	$215	13.6%	$281	16.6%
Enclosure	$50	3.2%	$93	5.5%
I/O	$235	14.8%	$187	11.0%
Memory	$274	17.3%	$410	24.2%
Power	$86	5.4%	$52	3.1%
System	$17	1.0%	$428	25.3%
Pkg/Doc/SW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

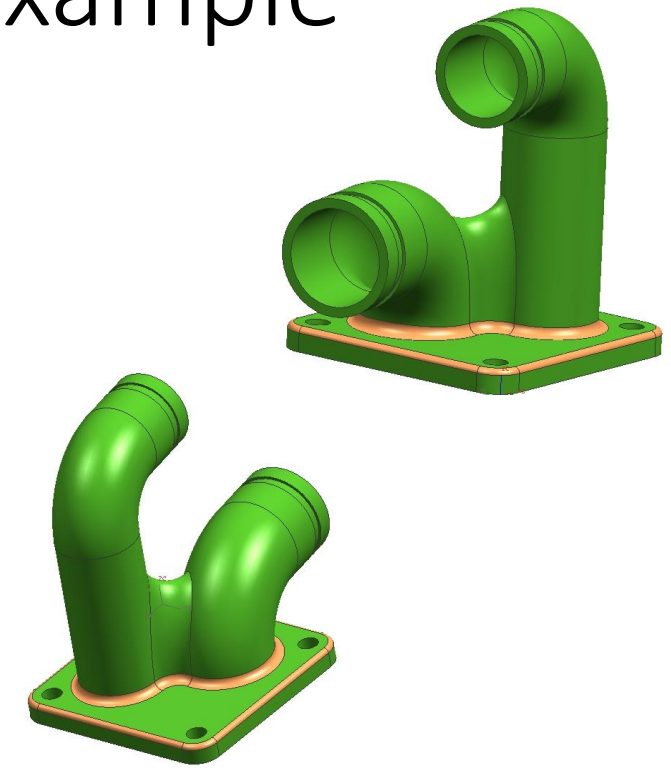
Concept Selection

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

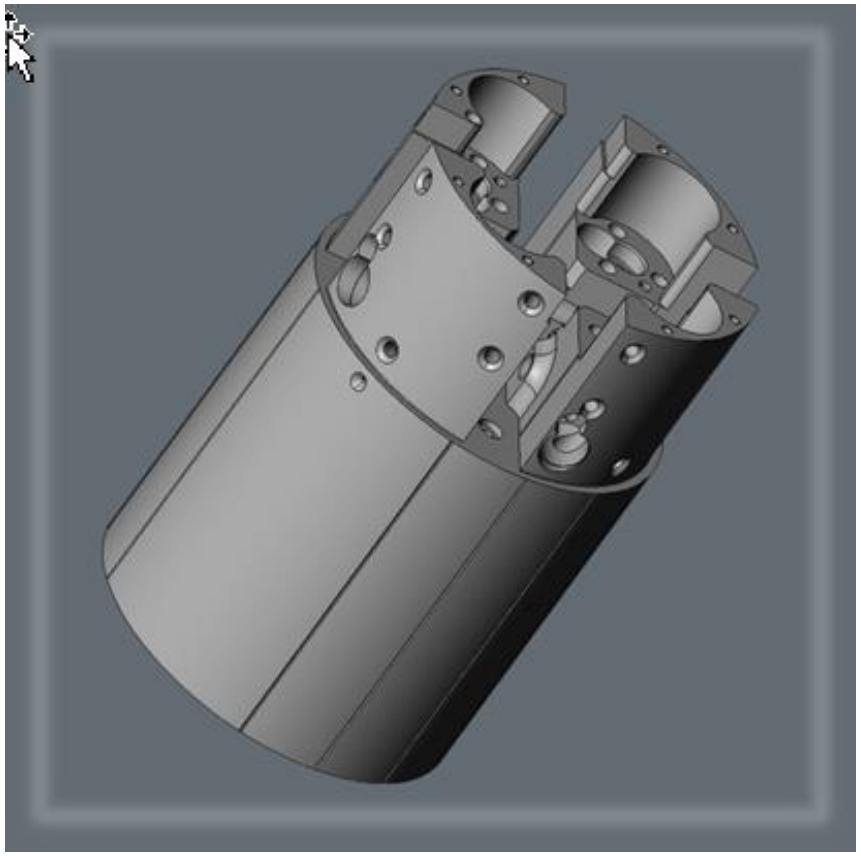
Annual Savings = $261k

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

Source: B&D Inc. example

Concept Selection

Concept / Process selection



Machined as designed each	**$780- 975**
Machined Design changes each	**$455-650**
Investment cast/ CNC	**$135 each**
Metal Injection Molded / CNC	**$160 each**

Time Std.'s

DFA Customized Operation Libraries

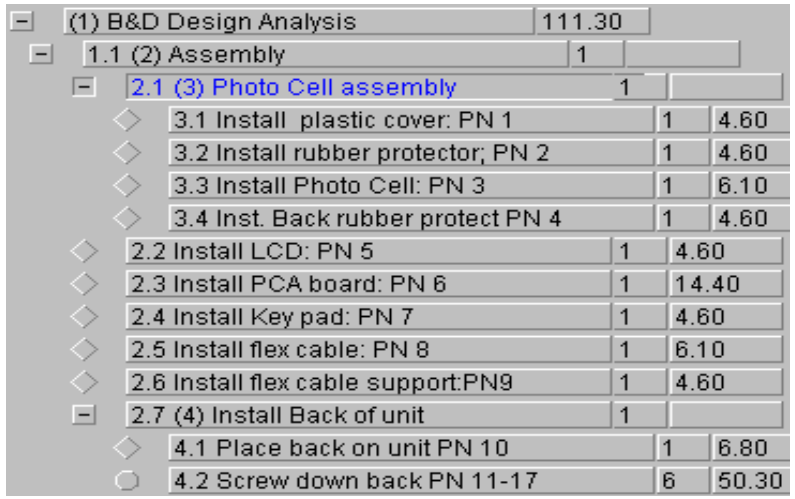
DFMA Libraries are a storage mechanism for customized-operations.

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

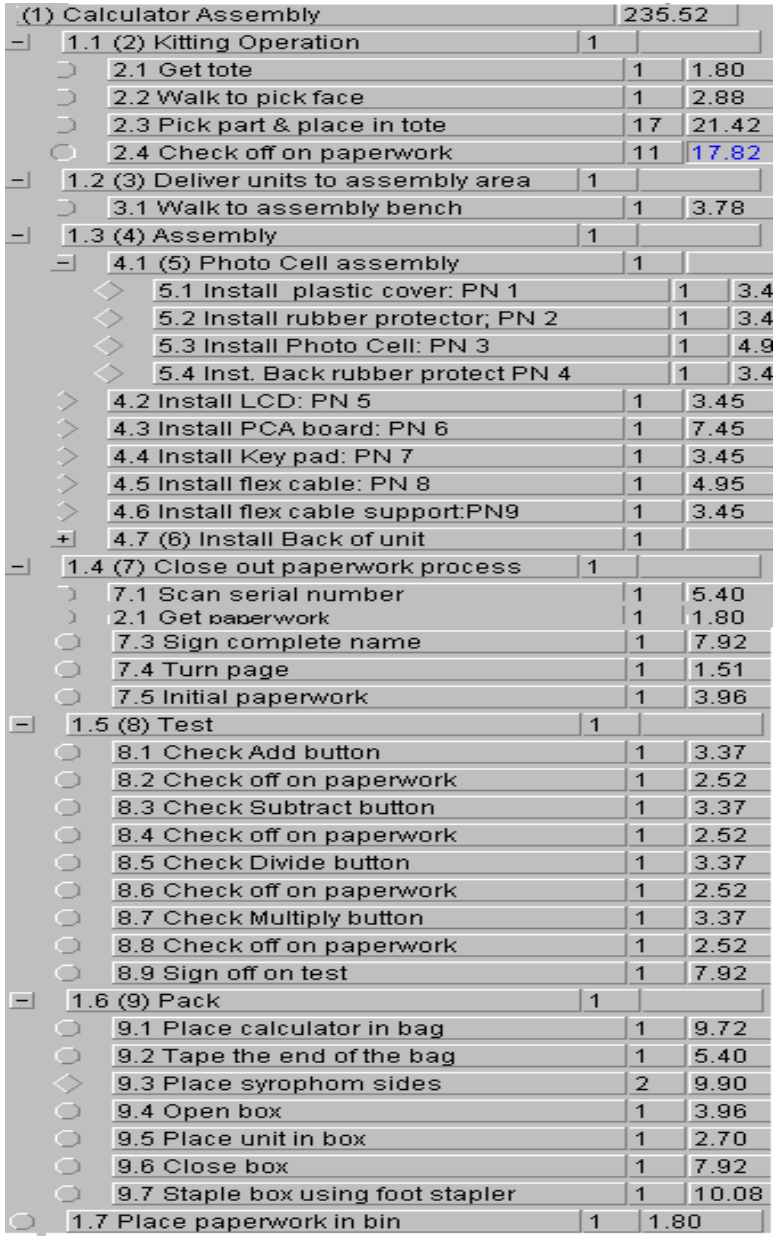
Time Std.'s

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	

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 syrophom 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

Historical Statistics

Creation Time Historical Results

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

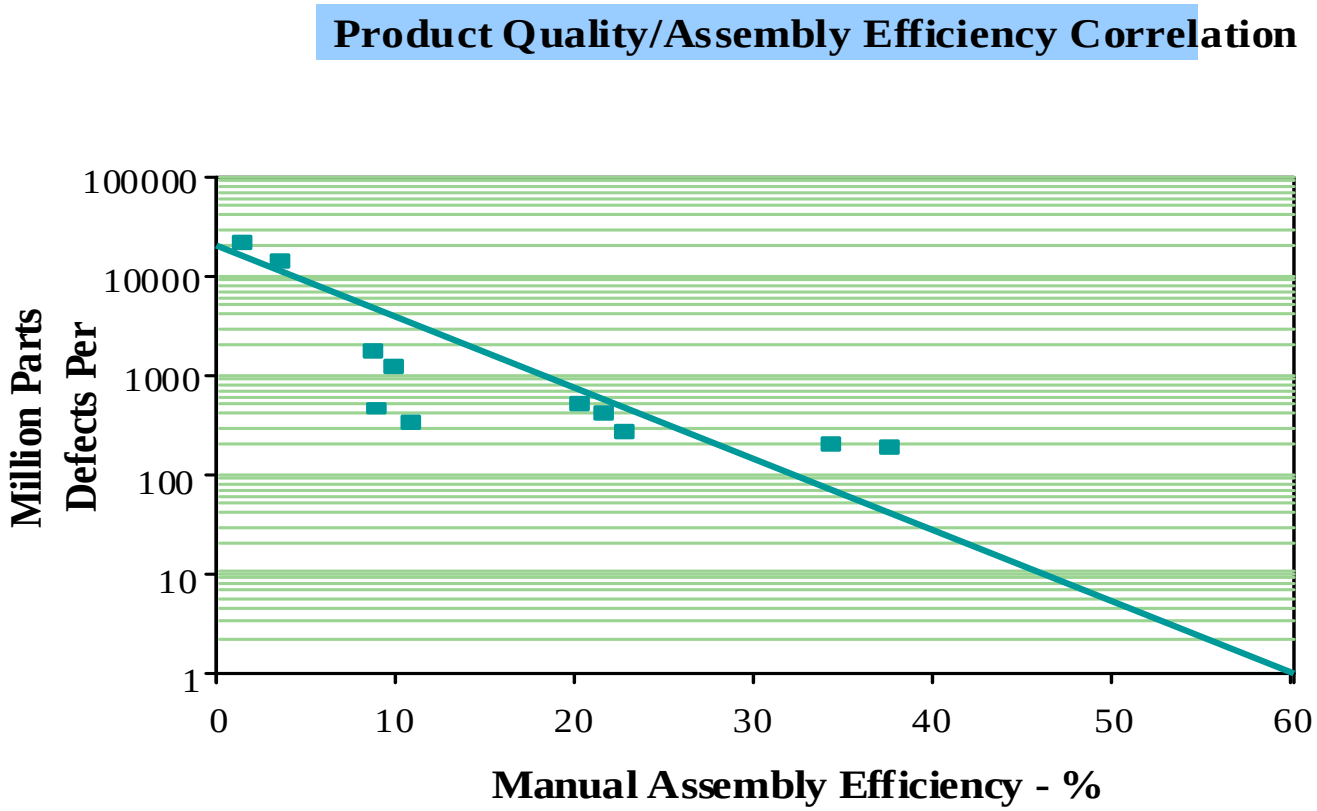
* Historical data based on total number of systems analyzed over 8 months.

** 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.

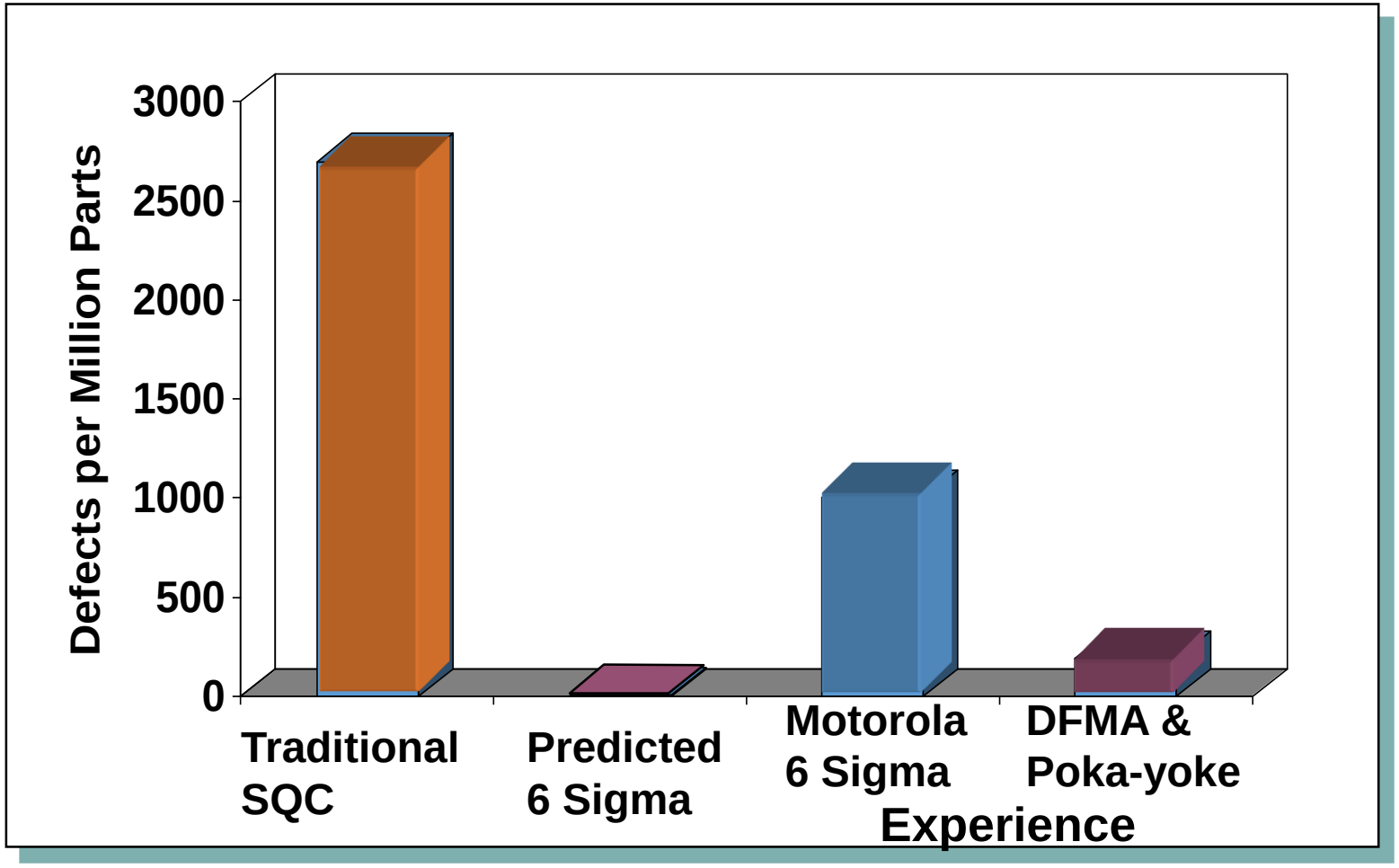
Design for Assembly



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

Quality

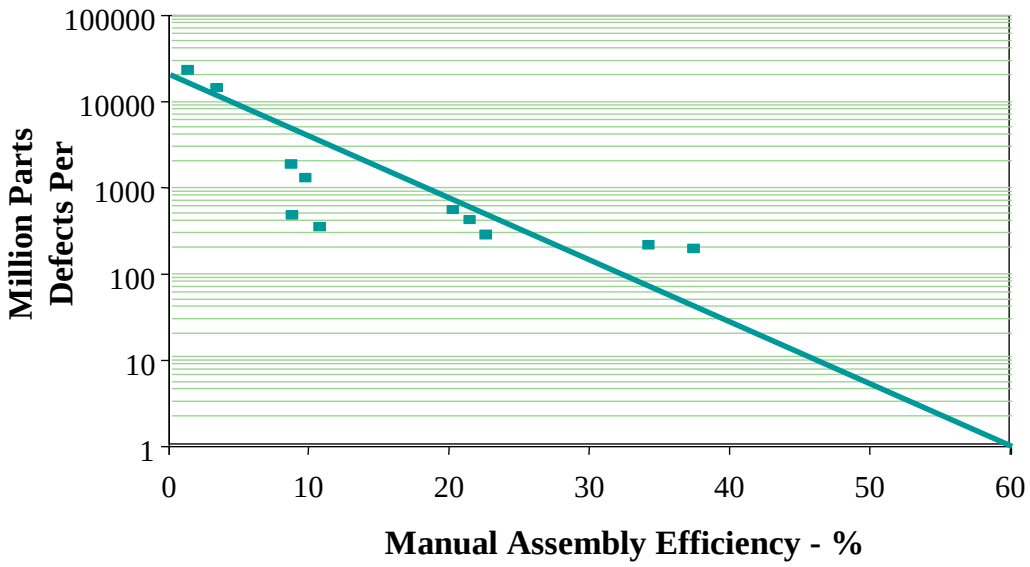
Mistake-proofing achieves superior results, faster, and with less efforts.

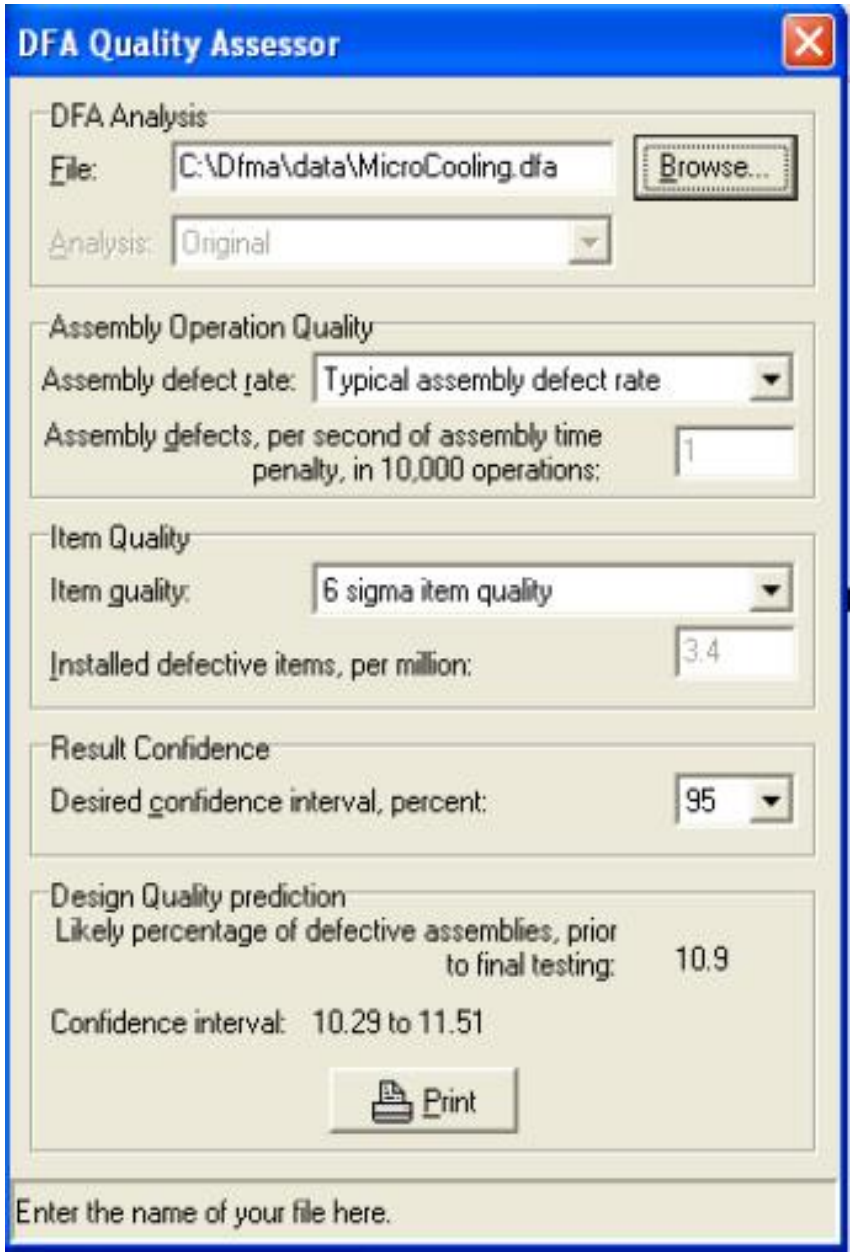


Source: Make NO Mistake – A Mistake – Proofing Methodology C. Martin Hinckley B&D conference June 2003

Quality Prediction

Design for Assembly






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

30 Years of Innovation

Questions

質問

Fragen

Bonpoci

Spørgsmålet

Perguntas