Cost Estimating

What is it ?

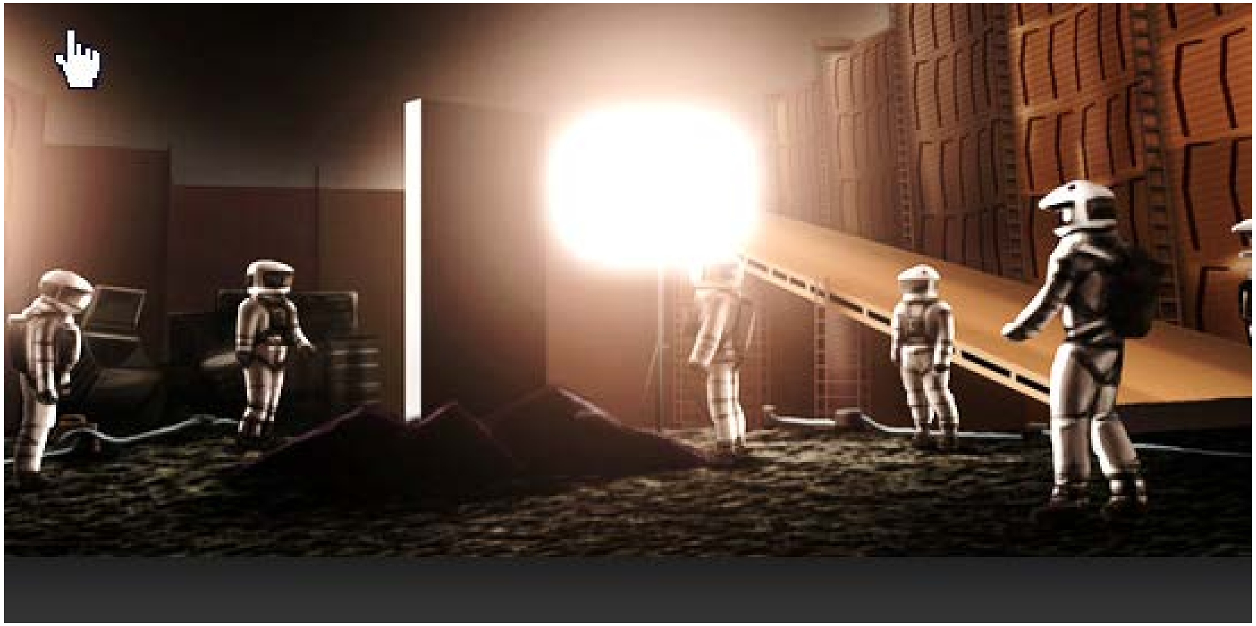
How do you do it ?

What can it do for you ?

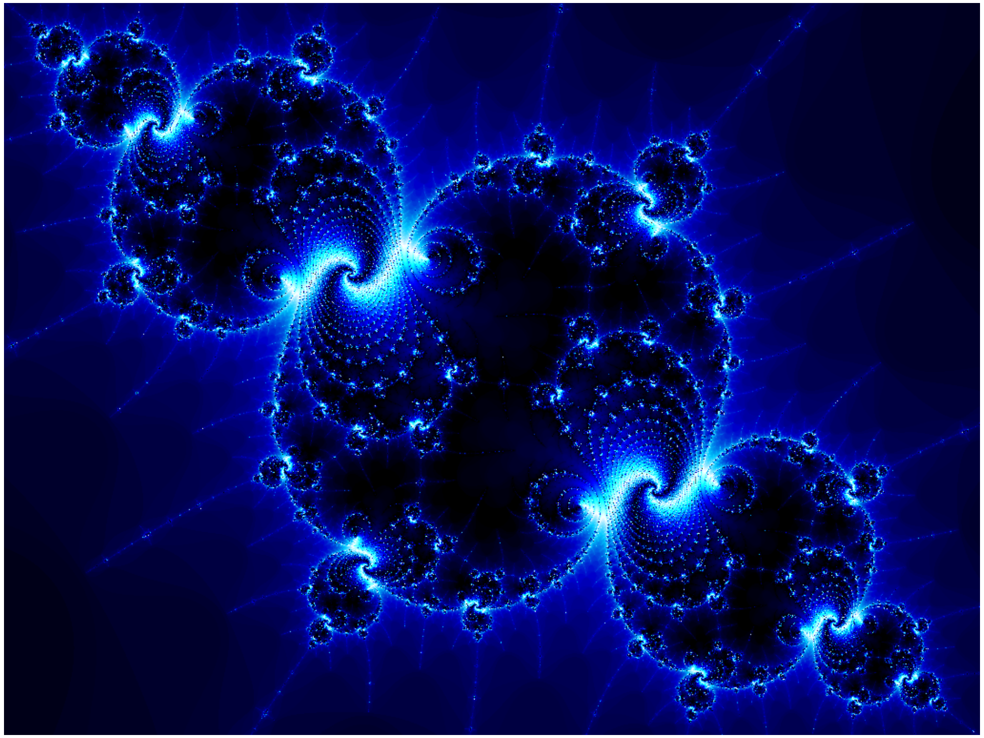
Neoteric Product Development
David Meeker
Meeker@mit.edu

Cost Estimating:

What is it ?

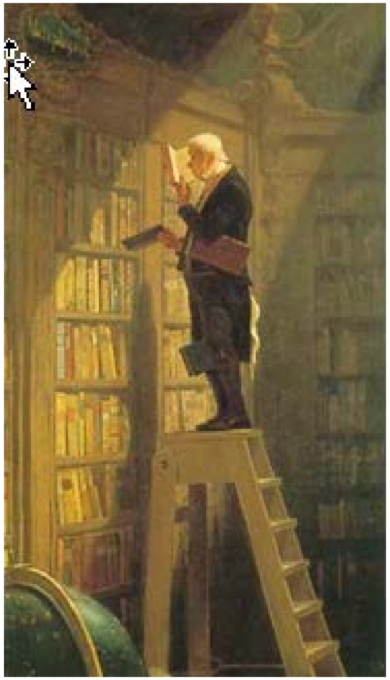


- Cost estimating is an art as well as a science



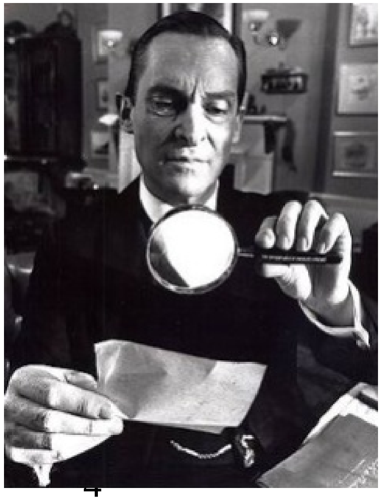
Cost Estimating requires the skills of:

Librarian



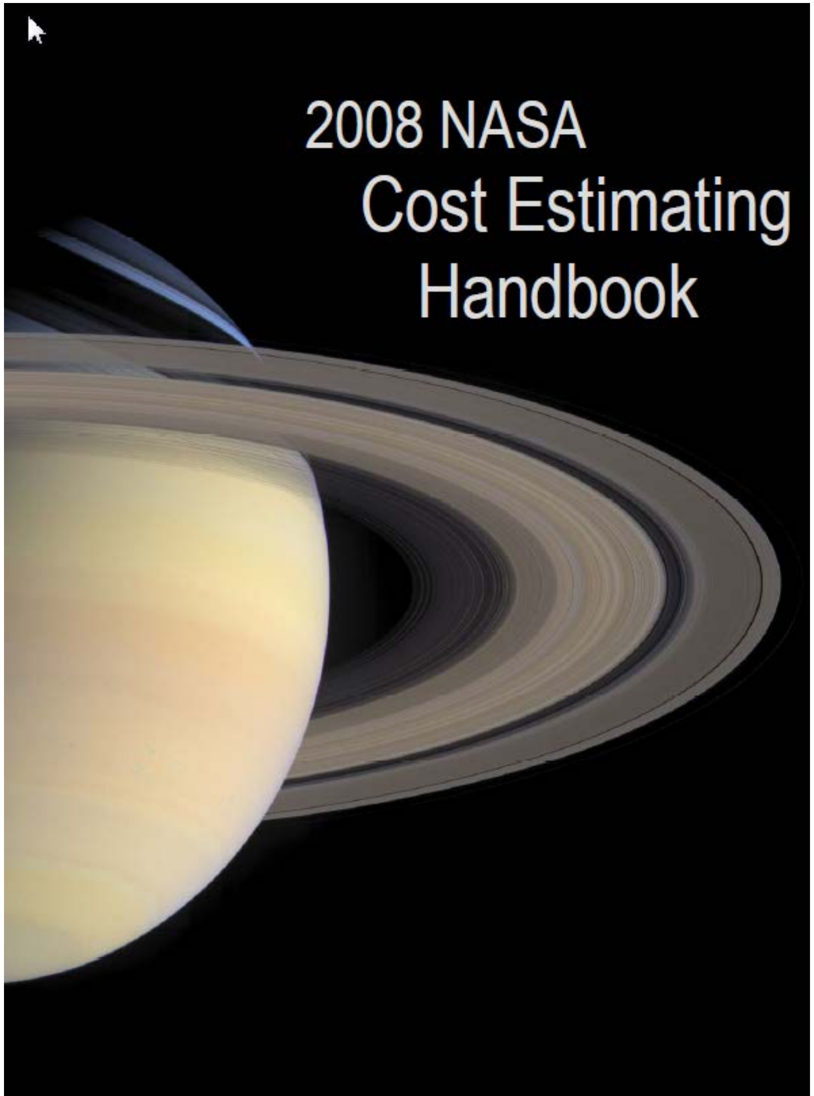
Design Engineer

Detective



Manufacturer

Very useful

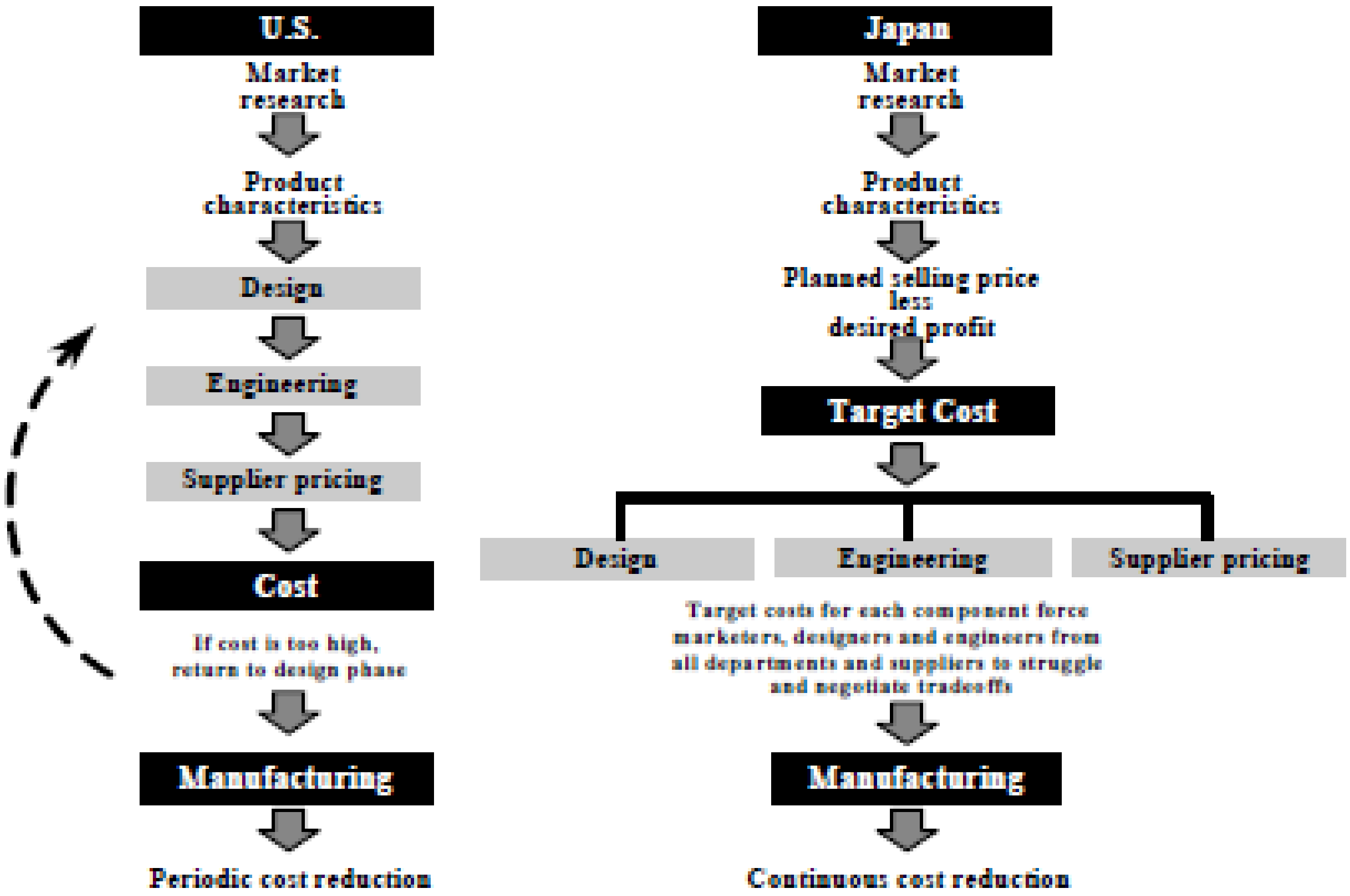


International Society of Parametric Analysts

Parametric
Estimating
Handbook©

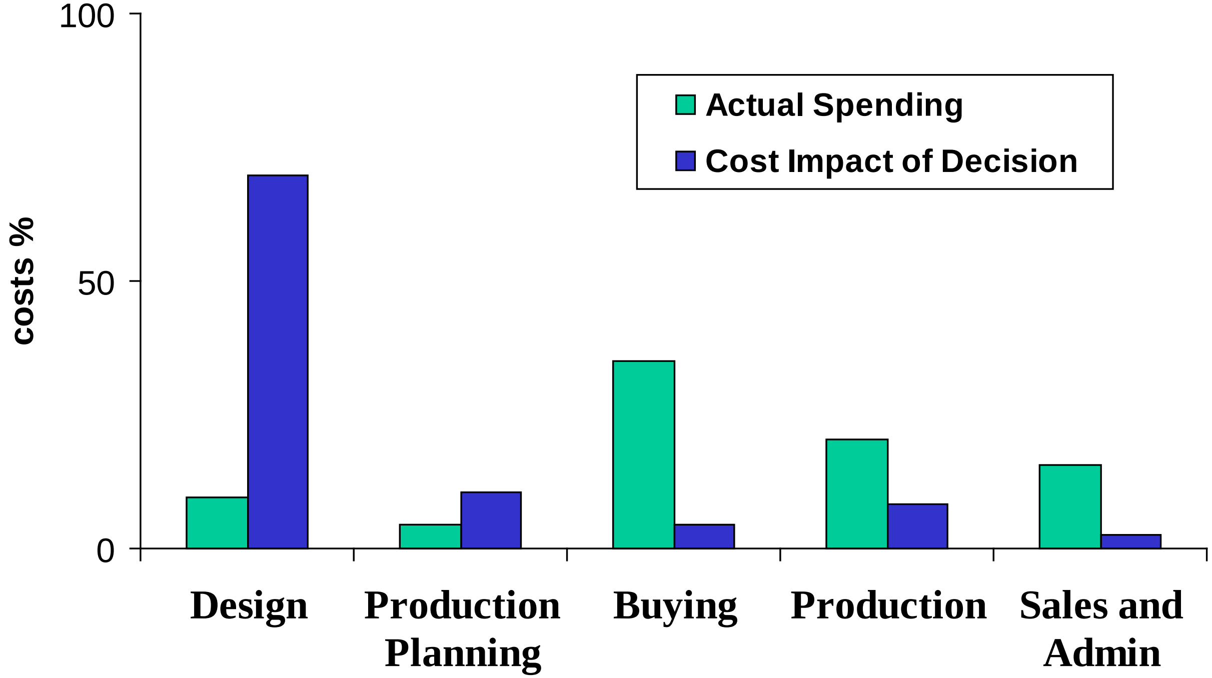
Fourth Edition – April 2008

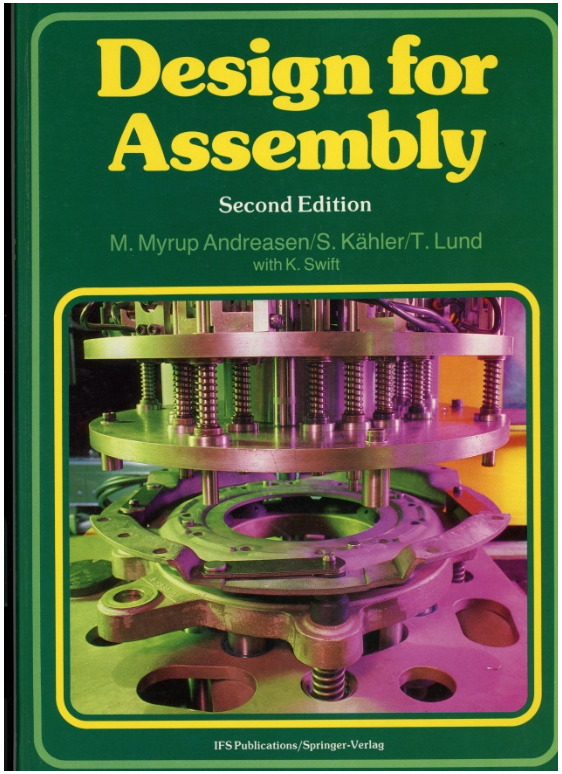
Japan vs. U.S.



Source: Worthy, F. (1991), Japan's smart secret weapon, *Fortune* 124, 1991, 4, pp. 72-75.

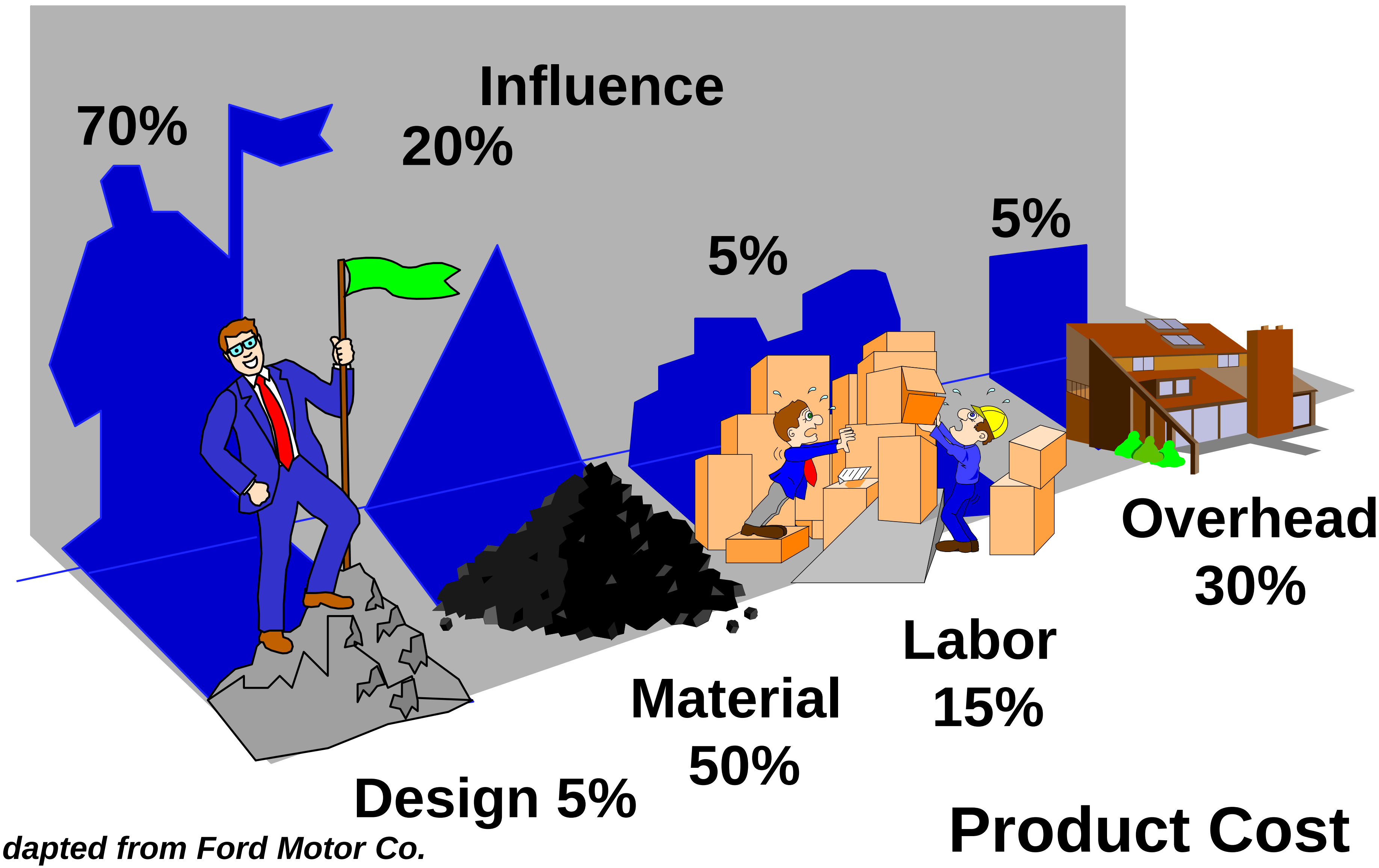
Some facts about cost





Design for Assembly, Andreasen, Hahler, Lund IFS Publications, Ltd. U.K.

Who Casts the Biggest Shadow?



Adapted from Ford Motor Co.

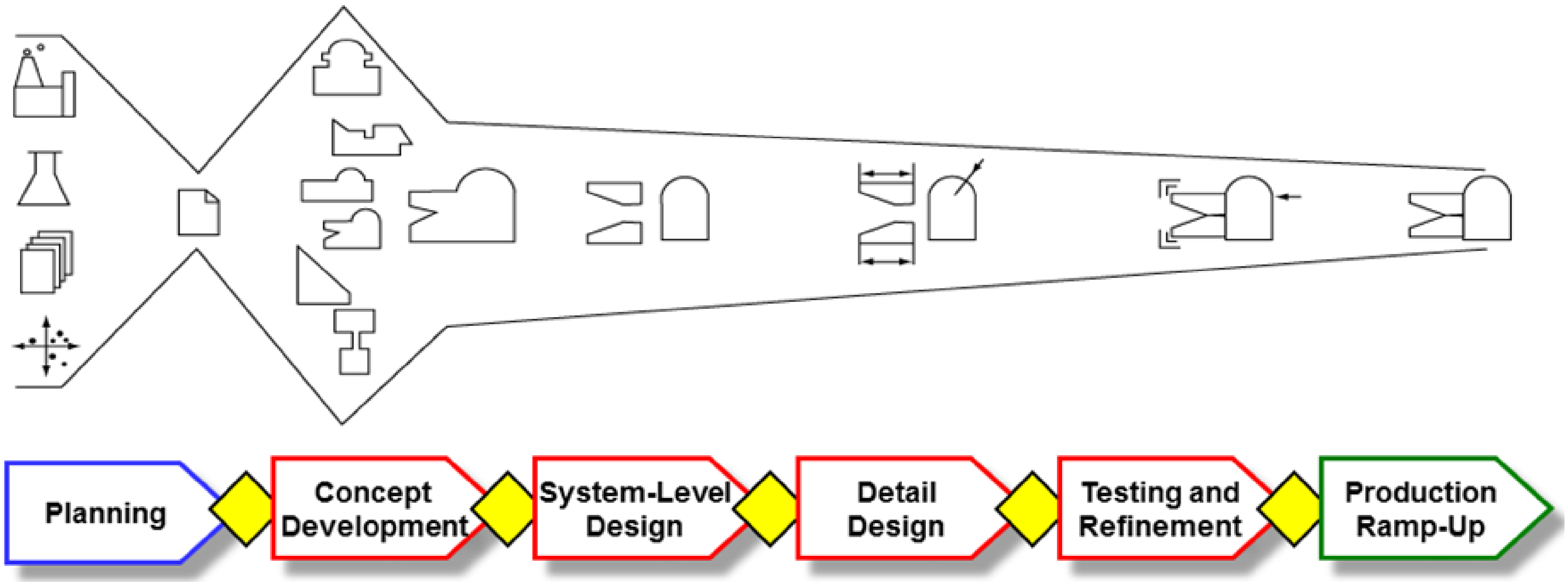
Cost estimating -- what is it?

At its simplest level it is:

“ the approximation of probable cost of a program, project or product computed on the basis of available information. “

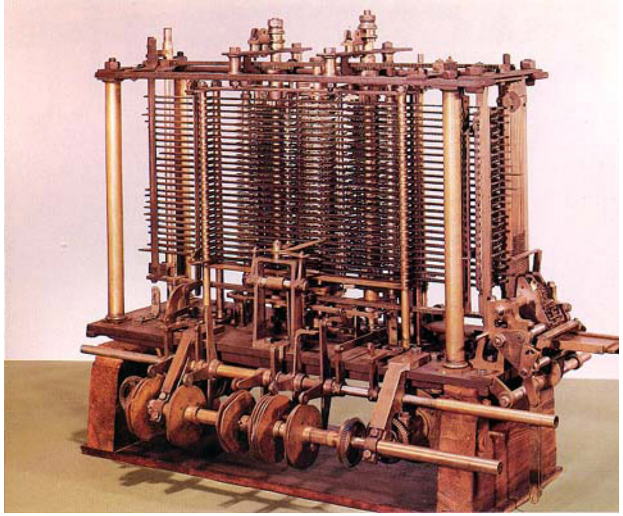
Cost Estimating can be used through the entire Product Development Cycle

- From idea to product

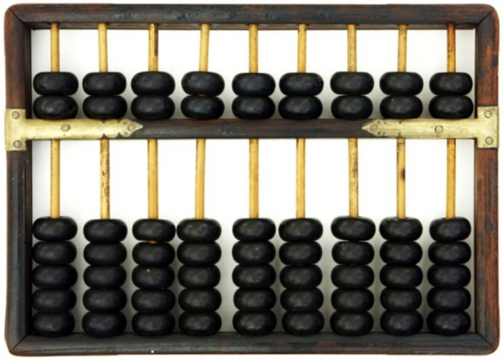


Cost Estimating Cost Estimating Cost Estimating

Cost Estimating:



How do you do it ?



Three Basic Modeling Methodologies

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

- ***Level 2*- An estimation based on prior experience with similar products, budgetary estimates, vendor quotes, expert opinion, and some analysis** ***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/Engineering***

Analogy Method

A first impression by knowledgeable engineers (EXPERT) of what a part , assembly or system would cost based on prior experience and history. ***Analogy***

To test this concept --- you are now all experts

Analogy Method

Write down:

what you think this cost to buy ________________

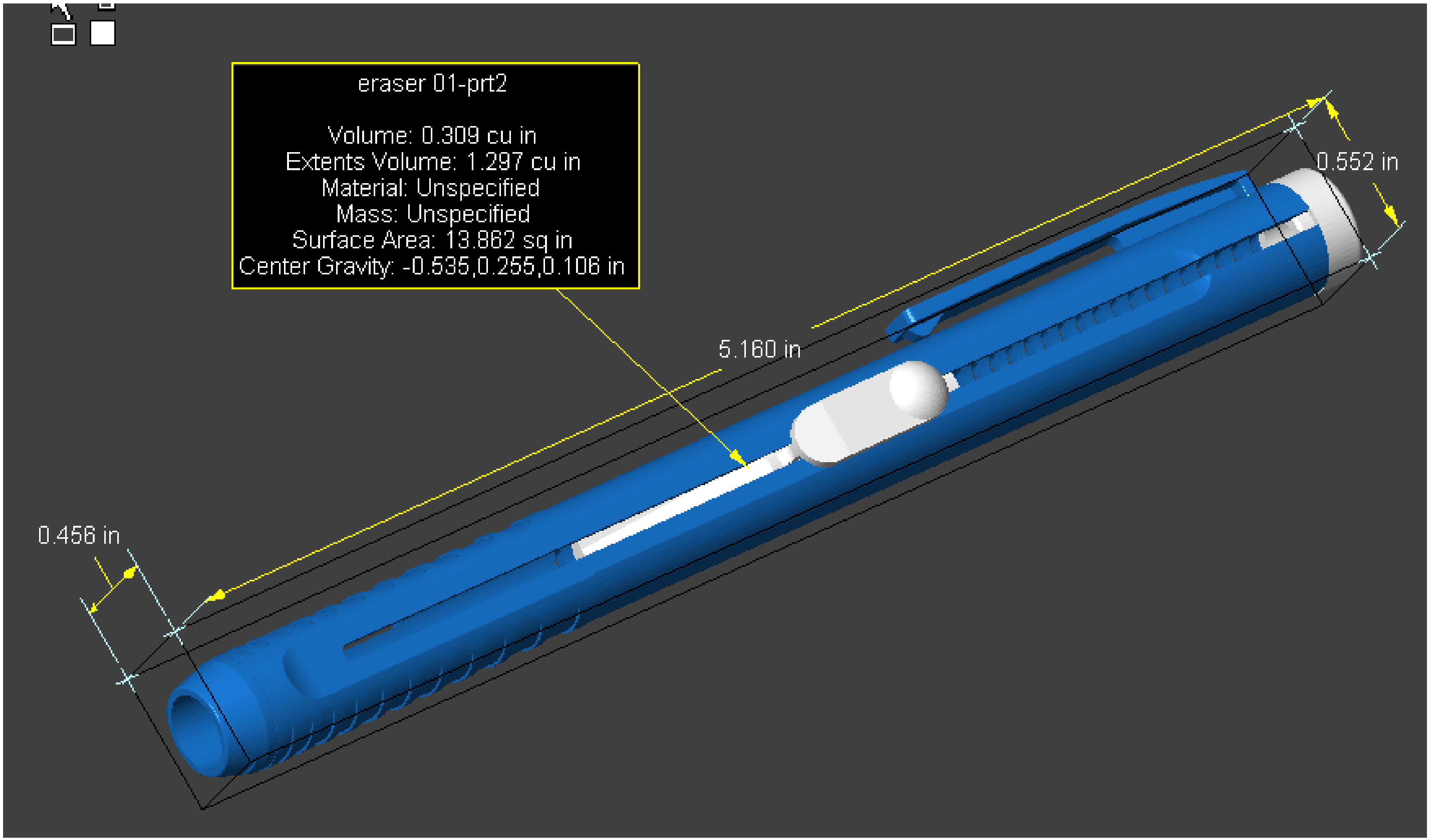
What you think it cost to make _______________

Analogy Method

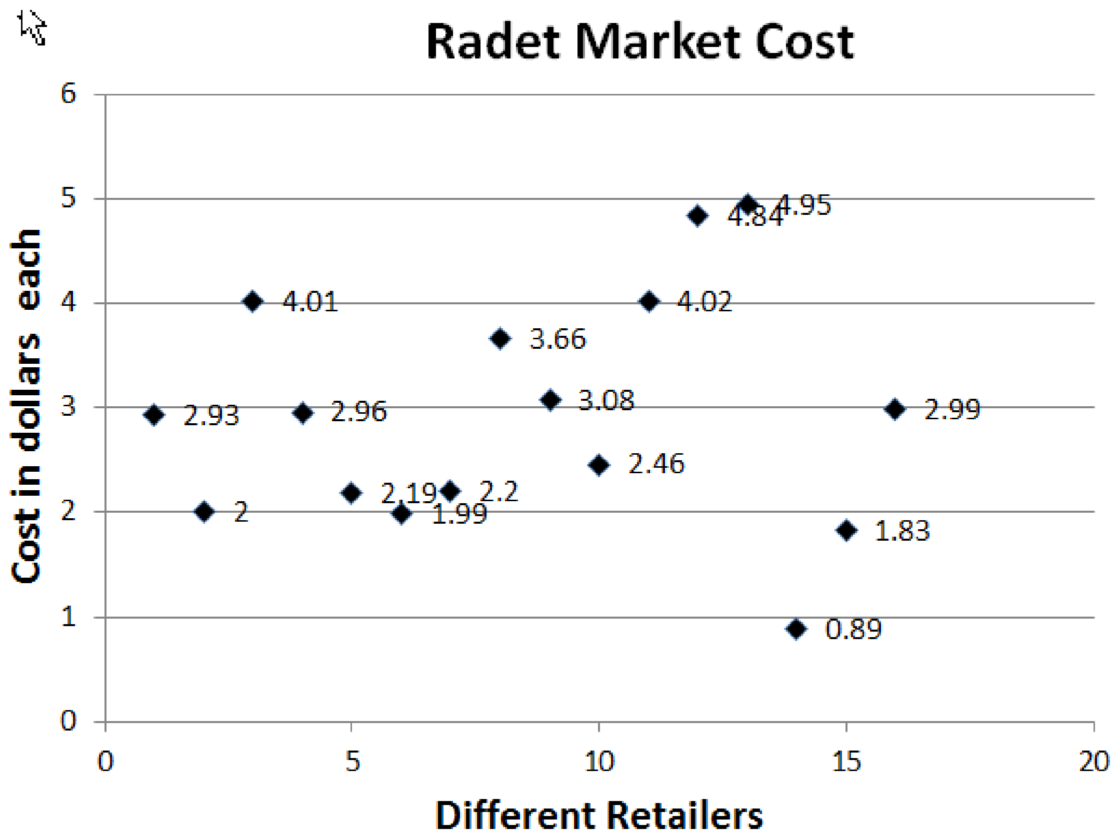
Additional information:

- Made in Germany
- Total weight 0.6 ounces --
- Eraser is latex & phthalate free
- Quantity in millions

Analogy Method



Analogy Method



PRICE

- Highest $4.95
- Average $2.93
- Lowest $0.89

- MSRP $2.19

COST

50% STORE MARKET UP

Times 4 Staedtler Cost $0.1113

Table 1-7. Strengths and Weaknesses of Analogy Method of Cost Estimating

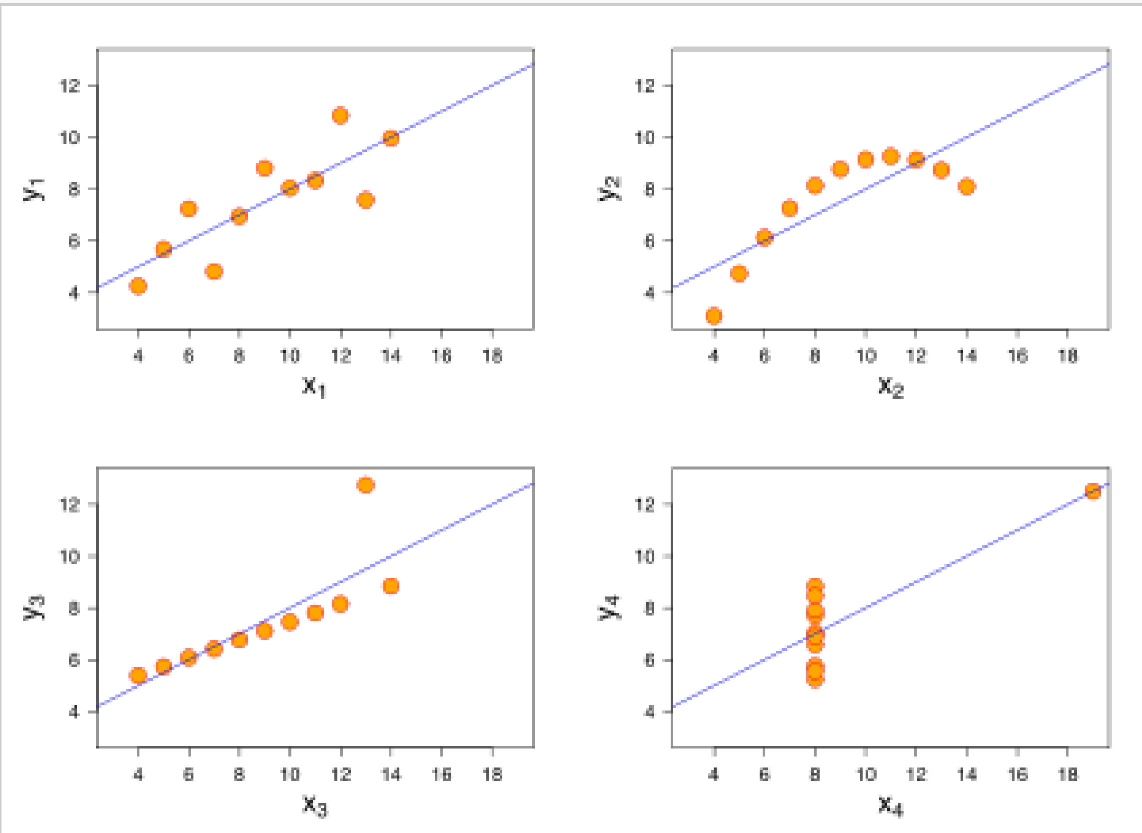
Strengths	Weaknesses
Based on actual historical data	Relies on single data point
Quick	Can be difficult to identify appropriate analog
Readily understood	Requires "normalization" to ensure accuracy
Accurate for minor deviations from the analog	Relies on extrapolation and/or expert judgment for "adjustment factors"

Parametric Methodology

- Parametric modeling requires a lot of data, both cost and attribute data about the part in question. Attributes like weight, volume, total linear feet, or color may be a major cost driver.
- These attributes are plotted in a scatter plot data in order to see a trend or grouping. Not every part can be modeled parametrically. Also not every plot is a linear relationship; non -linear parametric relationships are possible. It is about what mathematical expression best fits the data.

Parametric Methodology

It is about plotting the data !



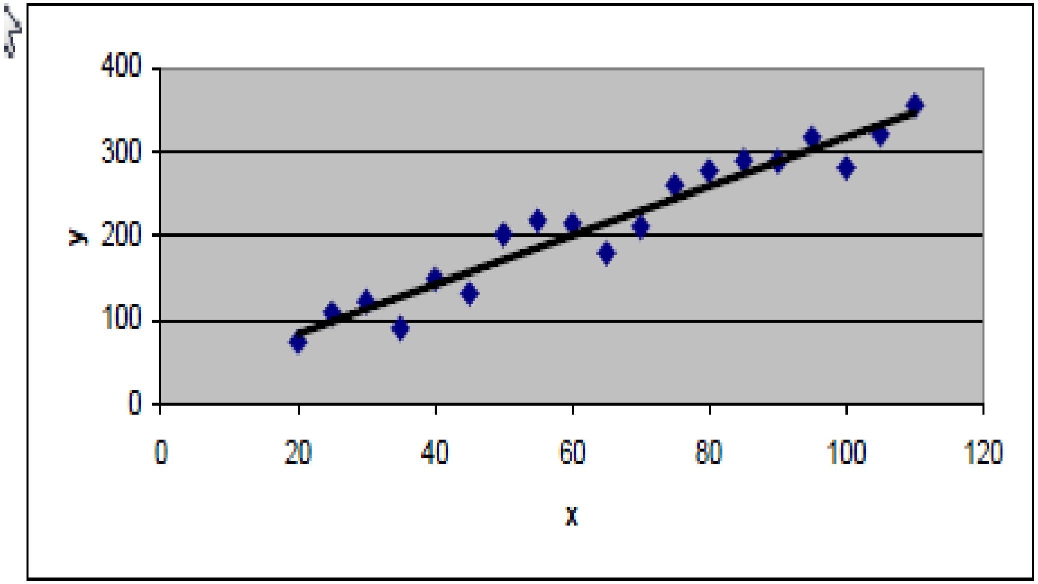
The sets in the Anscombe's quartet have the same linear regression line but are themselves very different.

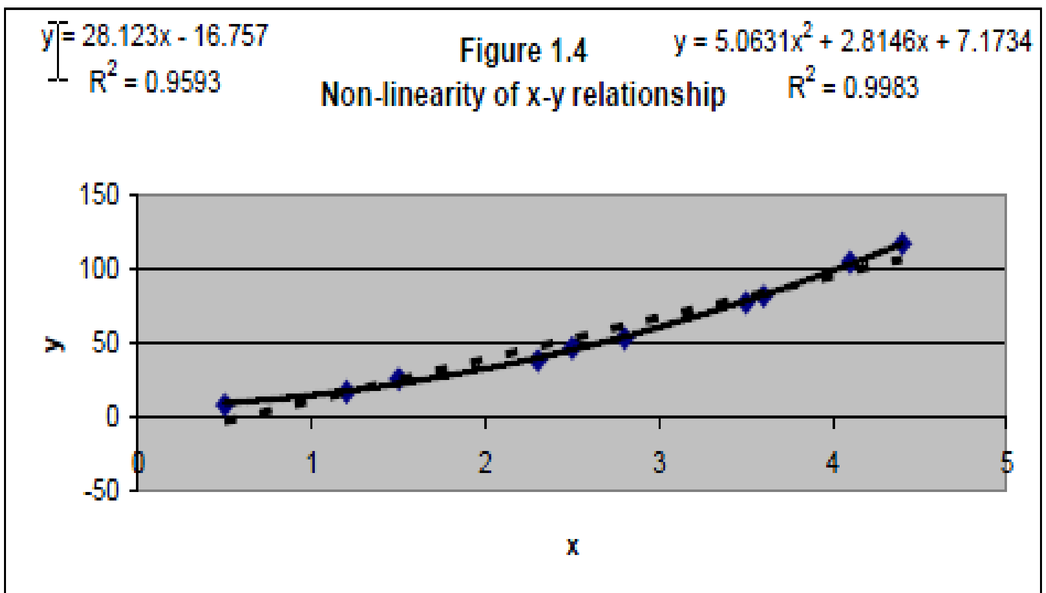
http://en.wikipedia.org/wiki/Anscombe%27s_quartet

Each one of these graphs has same:

- mean of x&y
- variance of x&y
- correlation of x&y
- linear regression equation

Examples of linear and non-linear regression





Parametric Estimating Handbook, International Society of Parametric Analysts. Fourth edition April 2008, www.ispa-cost.org. ISBN 0-9720204-7-0

Trend Line Analysi

- **Tractor example**

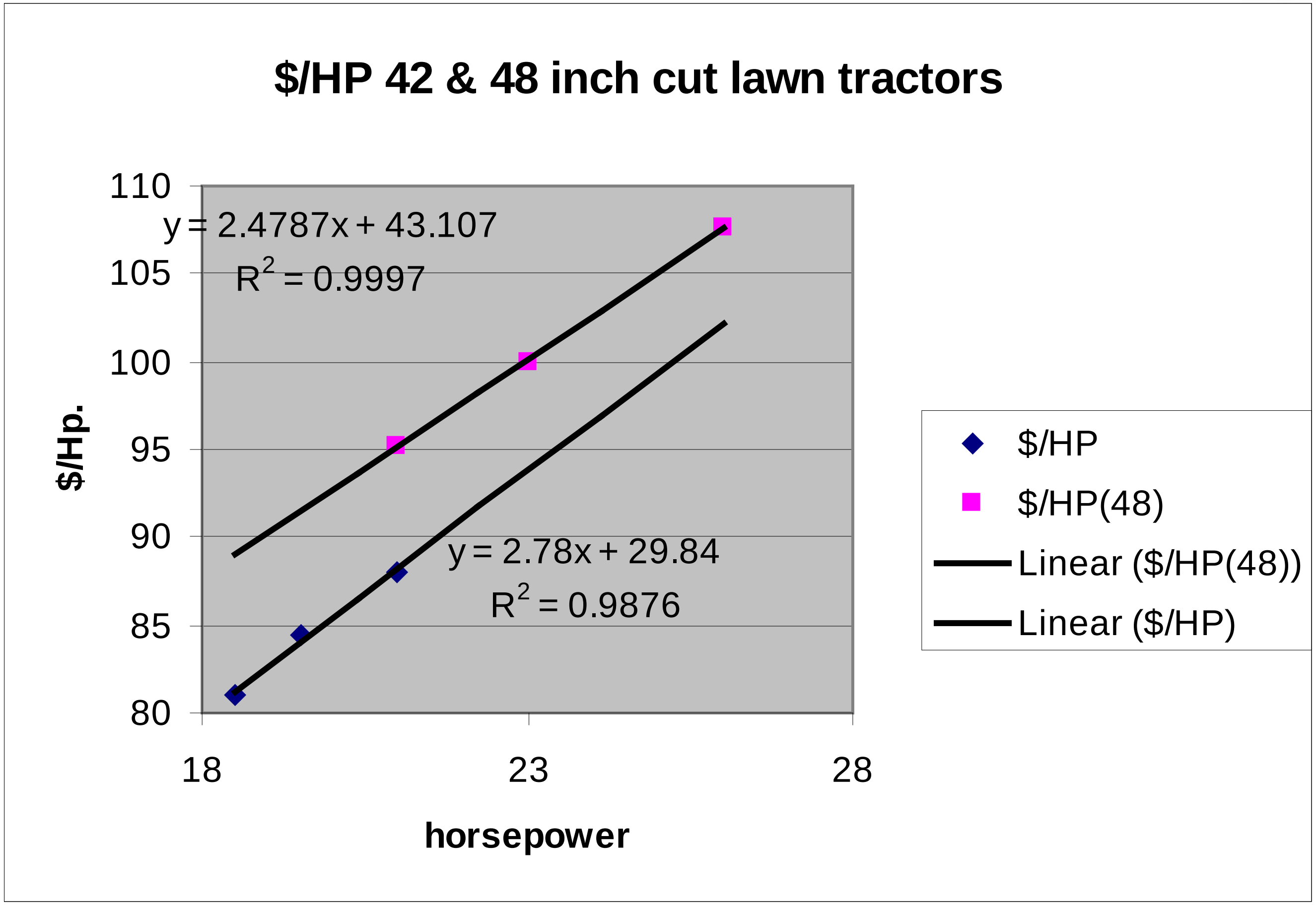


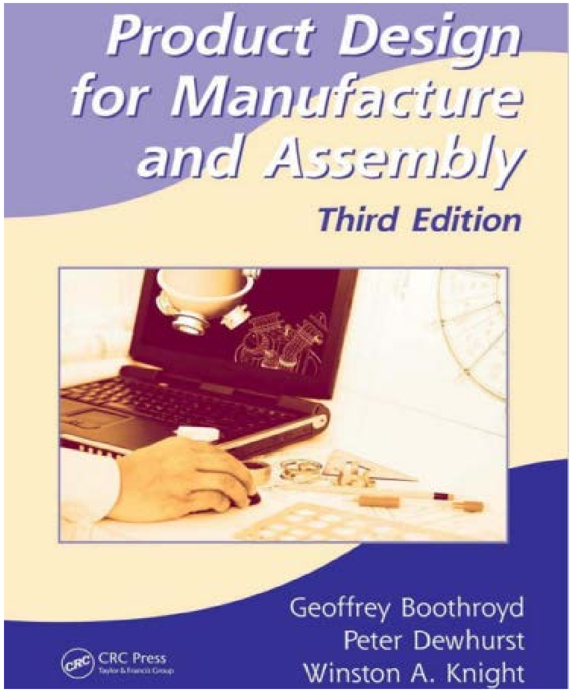
Table 1-6. Strengths and Weaknesses of Parametric/CER Cost Methodology

Strengths	Weaknesses
Once developed, CERs are an excellent tool to answer many "what if" questions rapidly	Often difficult for others to understand the relationships
Statistically sound predictors that provide information about the estimator's confidence of their predictive ability	Must fully describe and document selection of raw data, adjustments to data, development of equations, statistical findings and conclusions for validation and acceptance
Eliminates reliance on opinion through the use of actual observations	Collecting appropriate data and generating statistically correct CERs is typically difficult, time consuming, and expensive
Defensibility rests on logical correlation, thorough and disciplined research, defensible data, and scientific method	Loses predictive ability/credibility outside its relevant data range

Engineering Methodology

- A detailed bottoms up analysis of all the material, process time, labor, and other cost that go into creating a part.

An excellent example, I will point you to Chapter 8 of *Design for Injection Molding*, the classic text for Product Design for Manufacture and Assembly, by G. Boothroyd, P. Dewhurst, and W. Knight



Engineering Methodology

- Materials (they are commodities)
- Process labor
- Process Cycle time
- Additional Tooling (hard & soft) ie Plastic molds
- Scrap, expendables
- Other
  - Secondary operations
  - Overhead, SG&A, ……
  - etc……. Packaging, inspection, …..

Table 1-8. Strengths and Weaknesses of Engineering Build Up Method of Cost Estimating

Strengths	Weaknesses
Intuitive	Costly; significant effort (time and money) required to create a build-up estimate
Defensible	Not readily responsive to "what if" requirements
Credibility provided by visibility into the BOE for each cost element	New estimates must be "built-up" for each alternative scenario
Severable; the entire estimate is not compromised by the miscalculation of an individual cost element	Cannot provide "statistical" confidence level
Provides excellent insight into major cost contributors	Does not provide good insight into cost drivers
Reuse; easily transferable for use and insight into individual project budgets and individual performer schedules	Relationships/links among cost elements must be "programmed" by the analyst

Product Cost Reduction

Cost Reduction Methodologies

- Value Engineering (VE)
- Design for Manufacturing and Assembly (DFMA)
- Design to Cost (DTC)
- Cost as An Independent Variable (CAIV)
- Should Cost
- Benchmarking

Product Cost Reduction

Value Engineering (VE)

Origins

The concept evolved from the work of Lawrence Miles who, in the 1940's was a purchase engineer with the General Electric Company Because of WWII there were shortages in steel, copper, bronze, nickel, bearings electrical resistors, and many other materials. G. E. wished to expand its production of turbo supercharger for B24 bombers from 50 to 1000 per week. Miles he was unable to obtain the specific material or component specified by the designer, so he reasoned, "if I can not obtain the product, I must obtain an alternative which performs the same function".

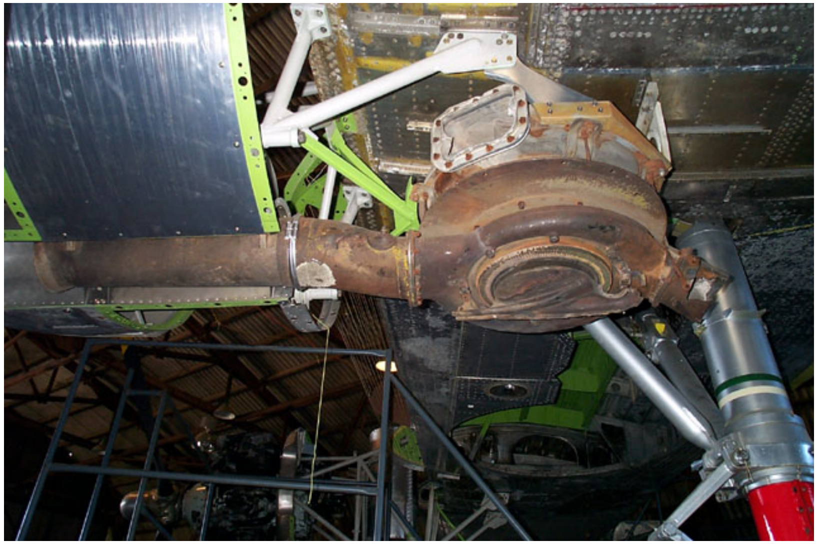
Definition

Miles observed that many of the substitutes were providing equal or better performance at a lower cost and from this evolved the first definition of value engineering. Increasing value by lowering cost or increasing value or both.

Application

Typically used in product redesign

B-24 Super charger



Product Cost Reduction

Design for Manufacturing and Assembly (DFMA)

<u>Origins</u>

Boothroyd and Dewhurst originally did research in feeding and handling of parts for the robot revolution. The revolution never came they adapted their methodology to parts, subassemblies and whole products.

<u>Definition</u>

DFMA is a process used to analyze a product for the possibility of simplification of the product structure. It also enables a more detailed view into product cost through the use of early costing techniques.

<u>Application</u>

Can be used for both new design and redesign

Product Cost Reduction

Design To Cost (DTC)

Origins

In order to fix the problem of $700 dollar hammers the defense department created MIL-STD-337 Design To Cost. It provides specific requirements to ensure effective control of design related production and ownership cost. Abandoned by the military in favor of CAIV program.

Definition

Design-to-Cost (DTC) is a Systems level total product cost management approach that rigorously identifies and captures step-change cost improvements through the cross-functional application of data-driven tools to achieve cost transparency

Application

Can be used in new design and redesign

Product Cost Reduction

Cost as an Independent Variable

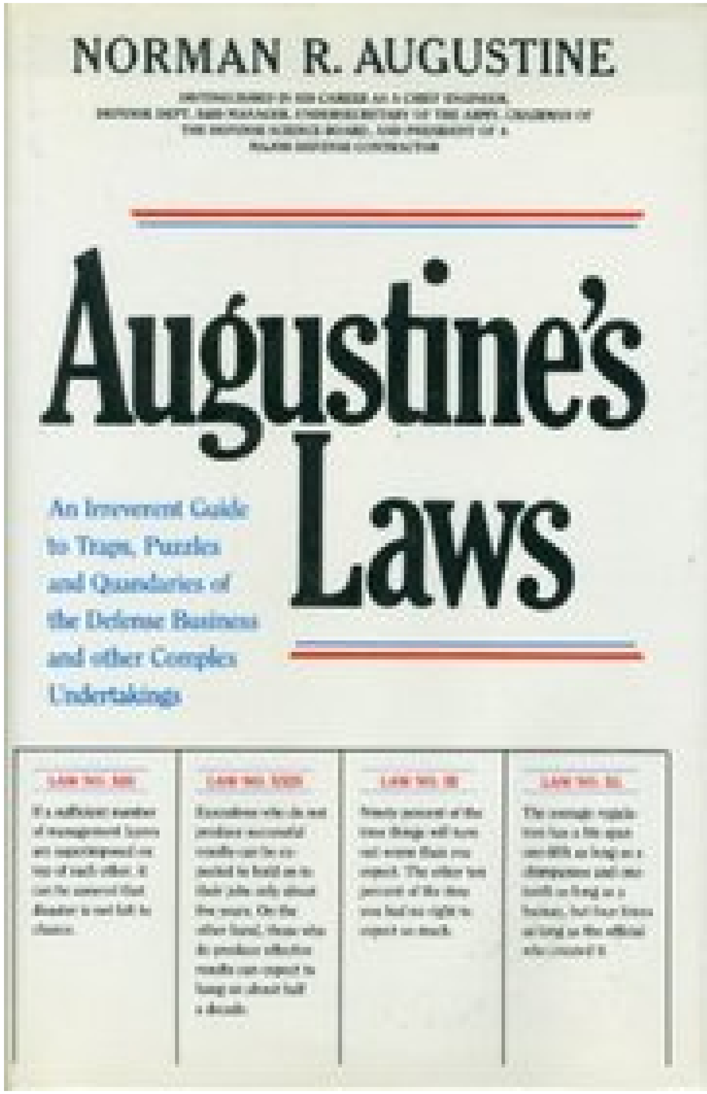
<u>Origins</u>
CAIV is a system acquisition process that the U.S. government embraced in the mid-1990s to counter massive program acquisition and sustainment cost overruns. DoD 5000.2-R for ACAT I,II,III programs.

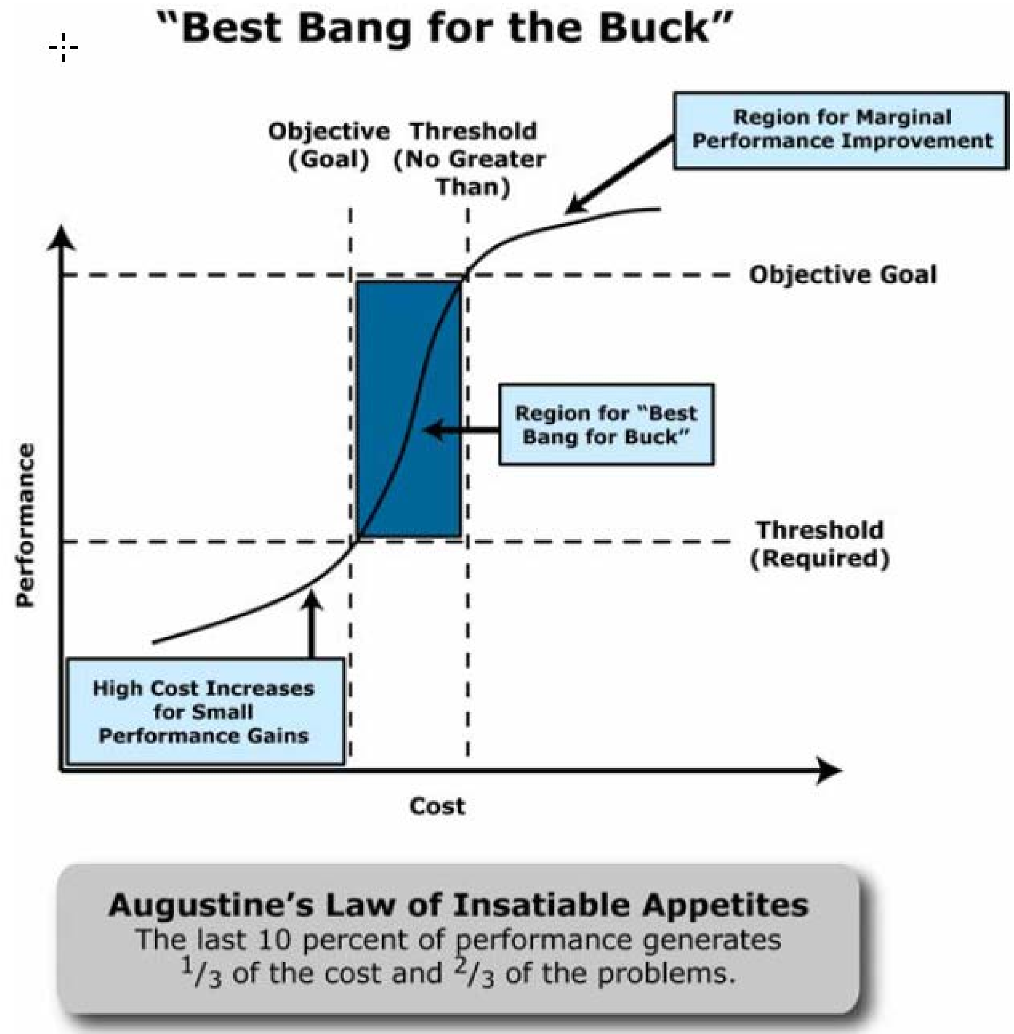
<u>Definition</u>
The purpose of a CAIV study is to ensure that an affordable design solution meets threshold performance requirements. One key tenet to remember is that design can converge on cost rather than allowing cost to converge on design.

- **Performance is not sacred and certain performance requirements may be challenged if significant cost savings are possible**

- **The CAIV process continually challenges the requirements when affordability is at stake**

<u>Application</u>
Can be used in new design and redesign


NORMAN R. AUGUSTINE
Augustine's Laws
An Irreverent Guide to Traps, Puzzles and Quandaries of the Defense Business and other Complex Undertakings


"Best Bang for the Buck"
Objective (Goal)
Threshold (No Greater Than)
Region for Marginal Performance Improvement
Objective Goal
Region for "Best Bang for Buck"
Threshold (Required)
Performance
High Cost Increases for Small Performance Gains
Cost
Augustine's Law of Insatiable Appetites
The last 10 percent of performance generates 1/3 of the cost and 2/3 of the problems.

Product Cost Reduction

Should Cost

<u>Origins</u>

Federal Acquisition Regulation FAR 15.407-4 which deals with the federal government and their existing contractors, usually but not always the military contractors.

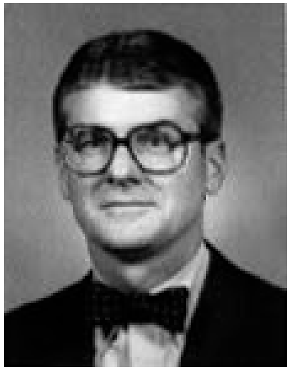
<u>Definition</u>

Code of Federal regulations 48 15.407-4 creates administrative law for the government to conduct should-cost reviews, which is a specialized form of cost analysis:

<u>Application</u>

A should-cost review has historically taken on the connotation that a contractor costs are out of line with what efficient design and manufacturing practices would dictate as fair and reasonable.

Product Cost Reduction

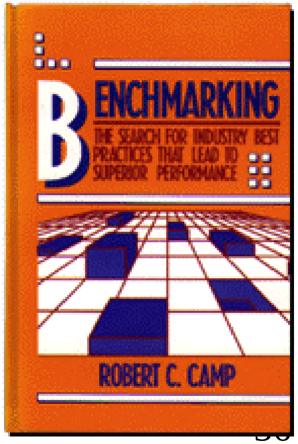


Benchmarking

<u>Origins</u>
Xerox corporation in its quest to understand its competitors lower cost created the process of Benchmarking

<u>Definition</u>
The continuous process of measuring products, services and practices against the toughest competitors or those recognized as industry leaders.

<u>Application</u>
Use in new product design to drive competitiveness and set targets in redesign



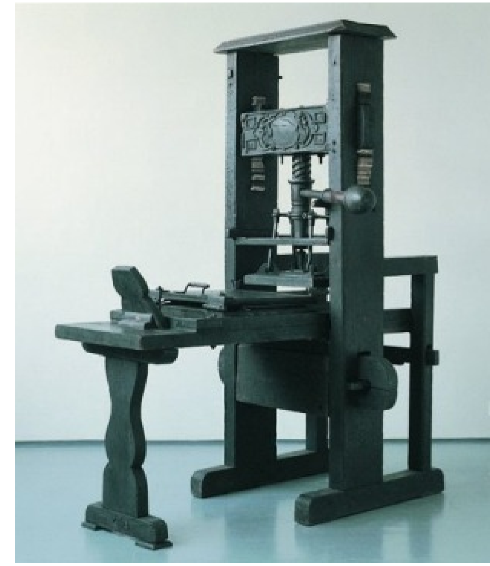
Product Cost Reduction Methodologies

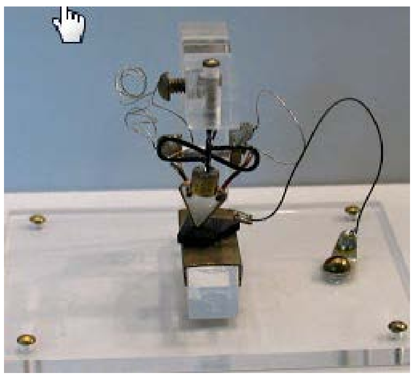
Methodology	Origins	Definition	Data
Value Analysis (VA)	1940's WWII GE Larry Miles looking deal with material shortages and cost	Better performance at a lower cost or increased value	Product data especially quantification of functional requirements as well as customer requirements
Design for Manufacturing and Assembly (DFMA)	NSF funded research into parts handling for the robot revolution. Methodology applied to products, subassemblies, and parts.	DFMA is an analyze technique to look at product structure simplification. It also enables a more detailed view of product costing using cost estimating Techniques	Data collection on parts / subassembly related to cost, assembly sequence, product structure, theoretical part counts
Design to Cost (DTC)	Mil-STD-337 Design to Cost. Primary focus is on projected average unit procurement cost by identifying drivers of downstream cost.	System Level cost analysis looking to optimize total product cost by data driven tradeoff decisions	Data on parts / subassembly and long term costs projections

Product Cost Reduction Methodologies

Methodology	Origins	Definition	Data
CAIV	Created to replace DTC - DoD 5000.2R, March 1996 CAIV	CAIV focuses on Cost, schedule ,performance: CAIV treats cost as the independent variable of the three, allowing performance and schedule to vary somewhat in an attempt to keep weapon systems affordable	Typical data you would find in traditional program product with the addition of a lot of tradeoff data
Should Cost	Code of Federal regulations 48 15.407-4 creates administrative law for the government to conduct should-cost reviews, which is a specialized form of cost analysis:	Evaluation of the contractor's existing work force, methods, materials, equipment, real property, operating systems, and management.	Massive amounts of data both a project level and at a company level
Benchmarking	Xerox in the late 1970's started its quest to understand how it competitor could sell at a price lower than their cost to mfg.	The Continuous process of measuring products, services and practices against the toughest competitors or those recognized as industry leaders	Data collection on competitive products and sources of industry leadership on a continuous basis

Cost Estimating:

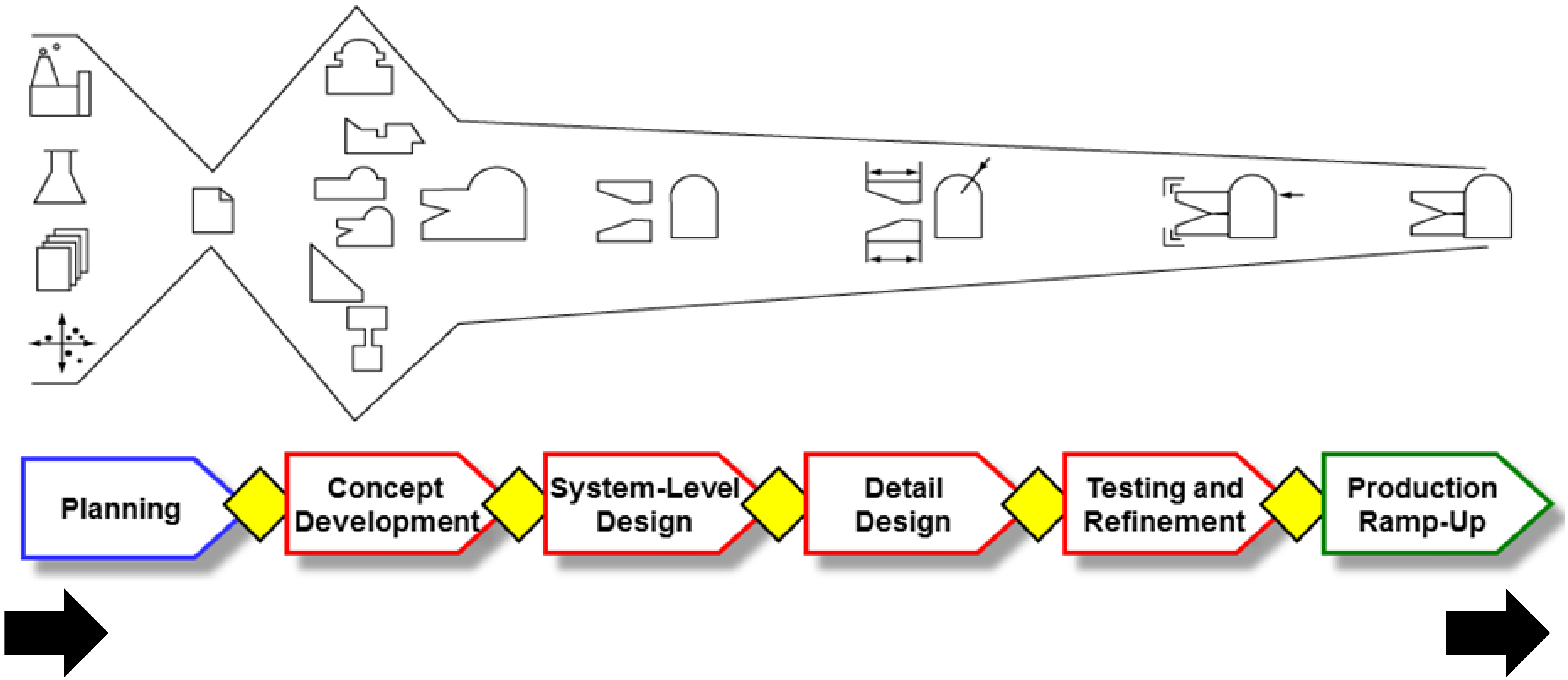




What can it do for you ?

Cost Estimating can be used through the entire Product Development Cycle

- From idea to product



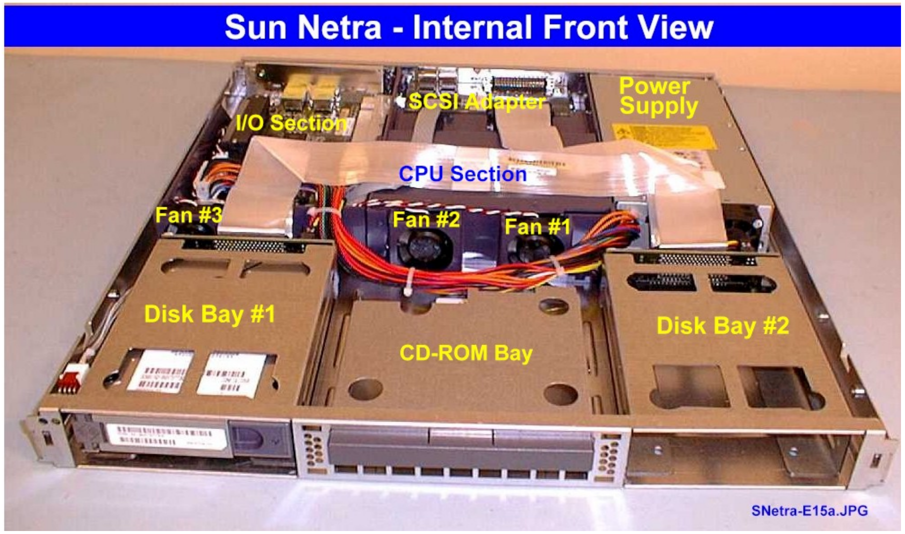
Cost Estimating Cost Estimating Cost Estimating

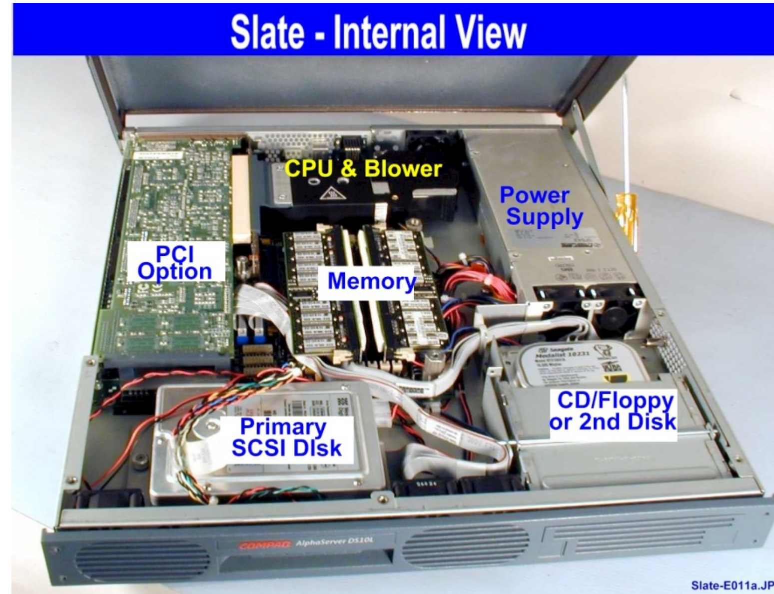
Why cost estimating important

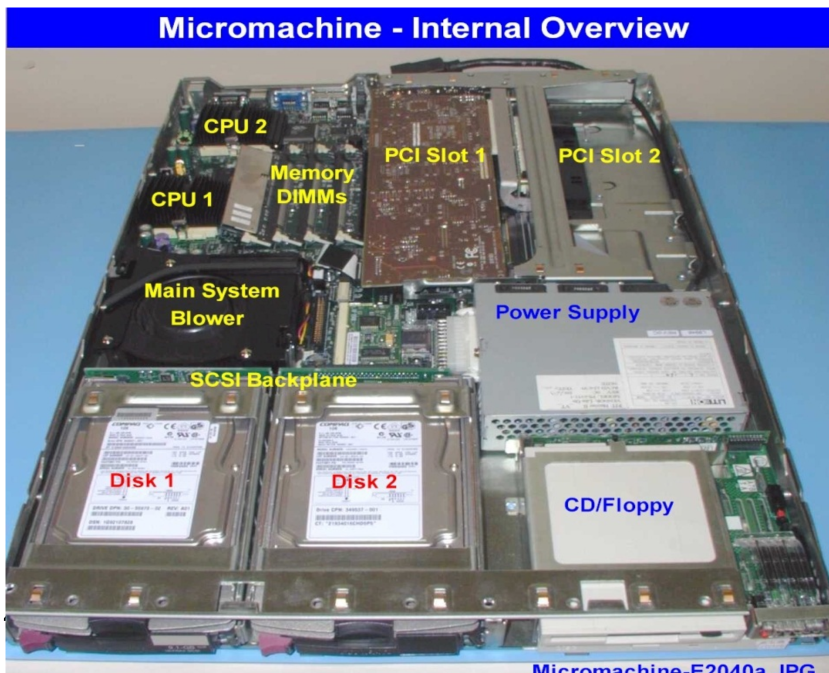
- Needed for business plan
- Understand competitors and their margins
- Use in Vendor negotiations
- Helps make design tradeoffs between two design concepts
- Help estimate total product cost BOM
- Aid in designing cost optimized parts
- Lots of other applications …………

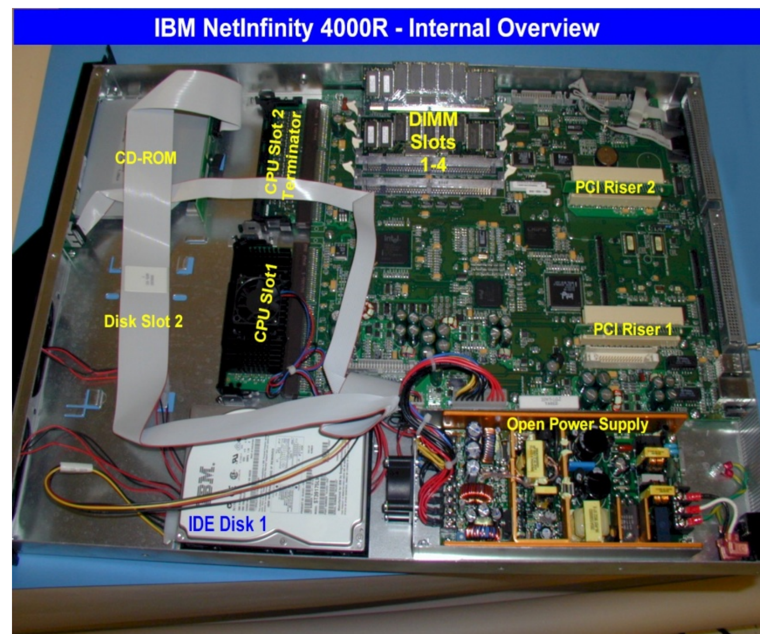
A Comparison of 1U Servers

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**	

Don’t have to Buy to Look

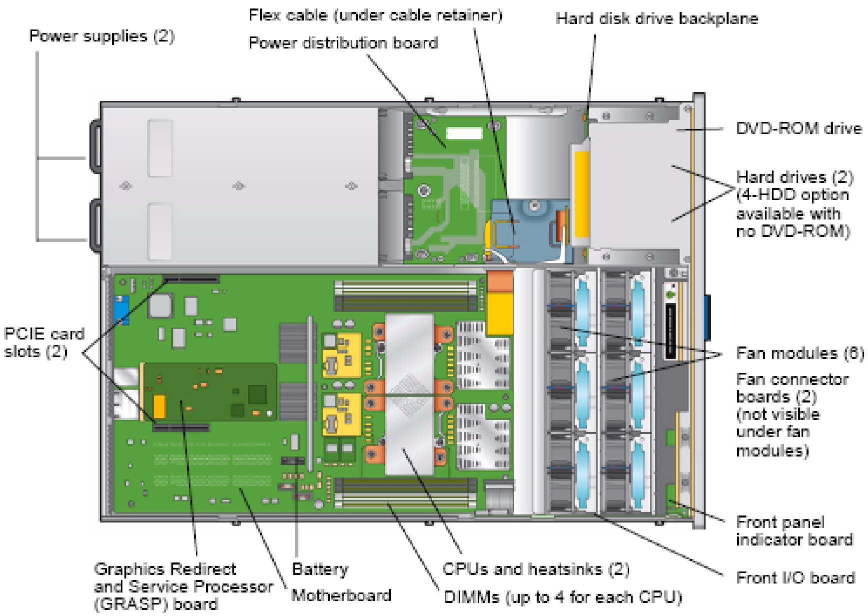


FIGURE 1-4 Sun Fire X4100 M2 Replaceable Component Locations

1.2.1 Sun Fire X4100/X4100 M2 Server Front Panel

FIGURE 1-1 shows the features of the front panel.

FIGURE 1-1 Sun Fire X4100/X4100 M2 Server Front Panel

1.2.2 Sun Fire X4100/X4100 M2 Server Back Panel

FIGURE 1-2 shows the features of the back panel.

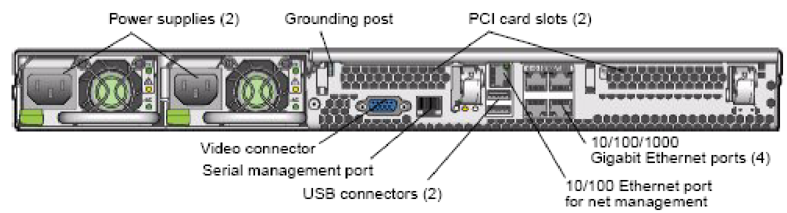
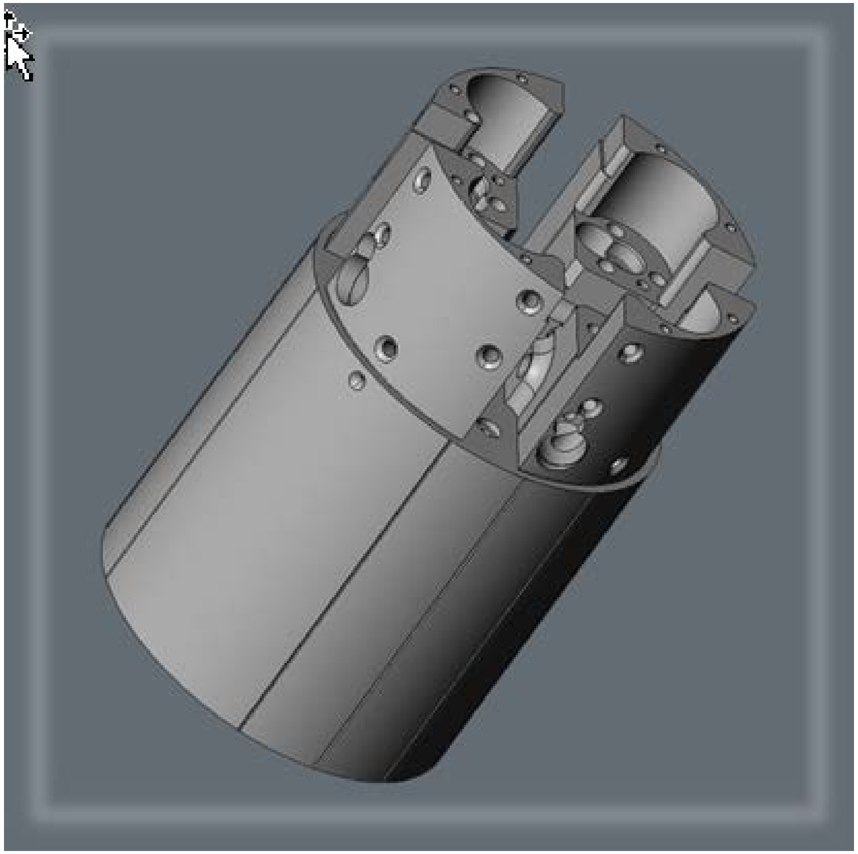


FIGURE 1-2 Sun Fire X4100/X4100 M2 Server Back Panel

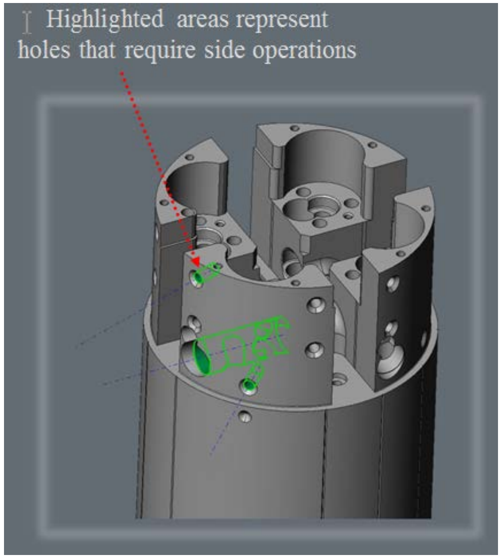
Often service manuals, product reviews provide excellent reference material with enough detail to calculate costs.

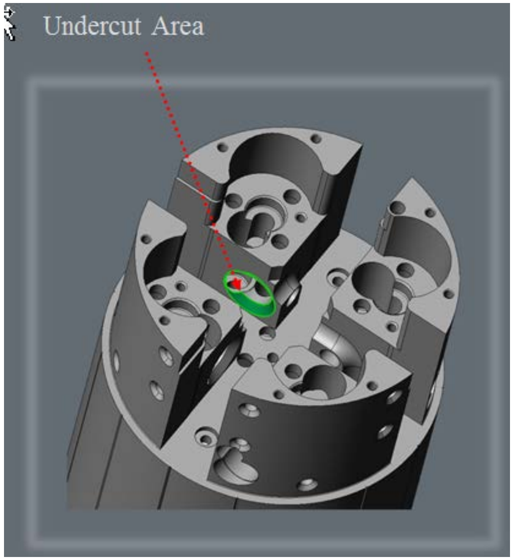
Cost Estimating Example

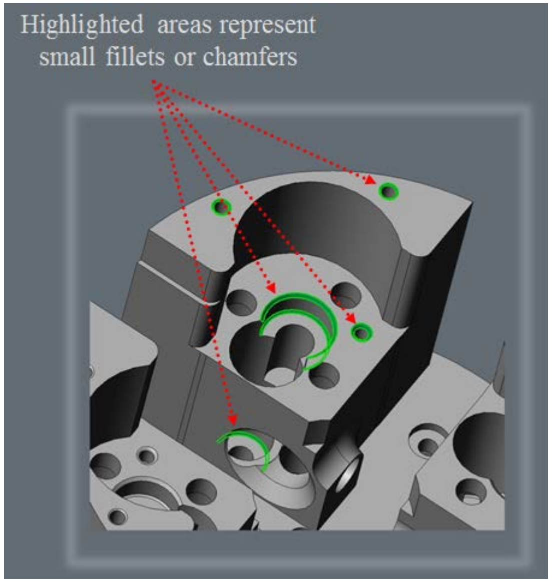


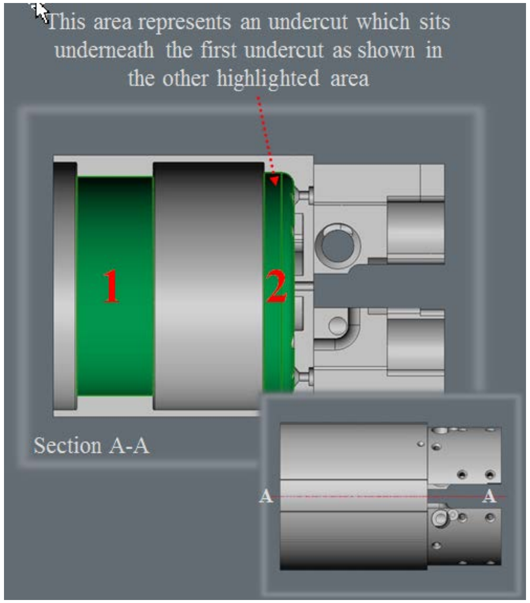
- Machining estimate
- Machining estimate with recommendations
- Alternative manufacturing methods

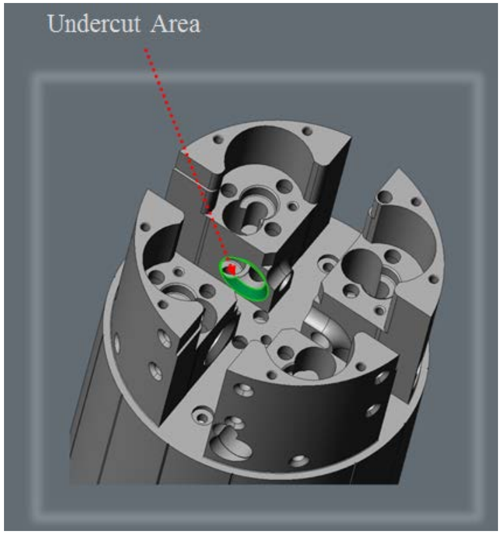
Machining issues

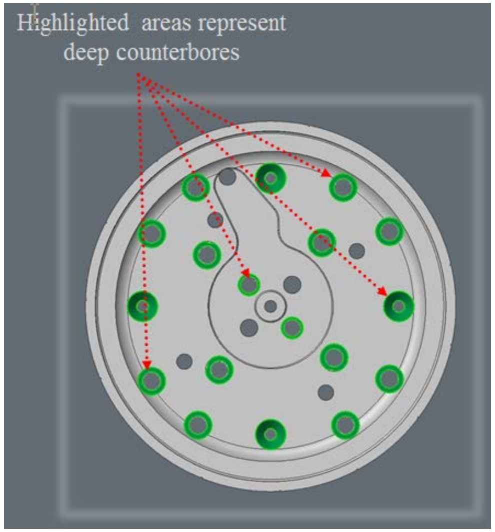




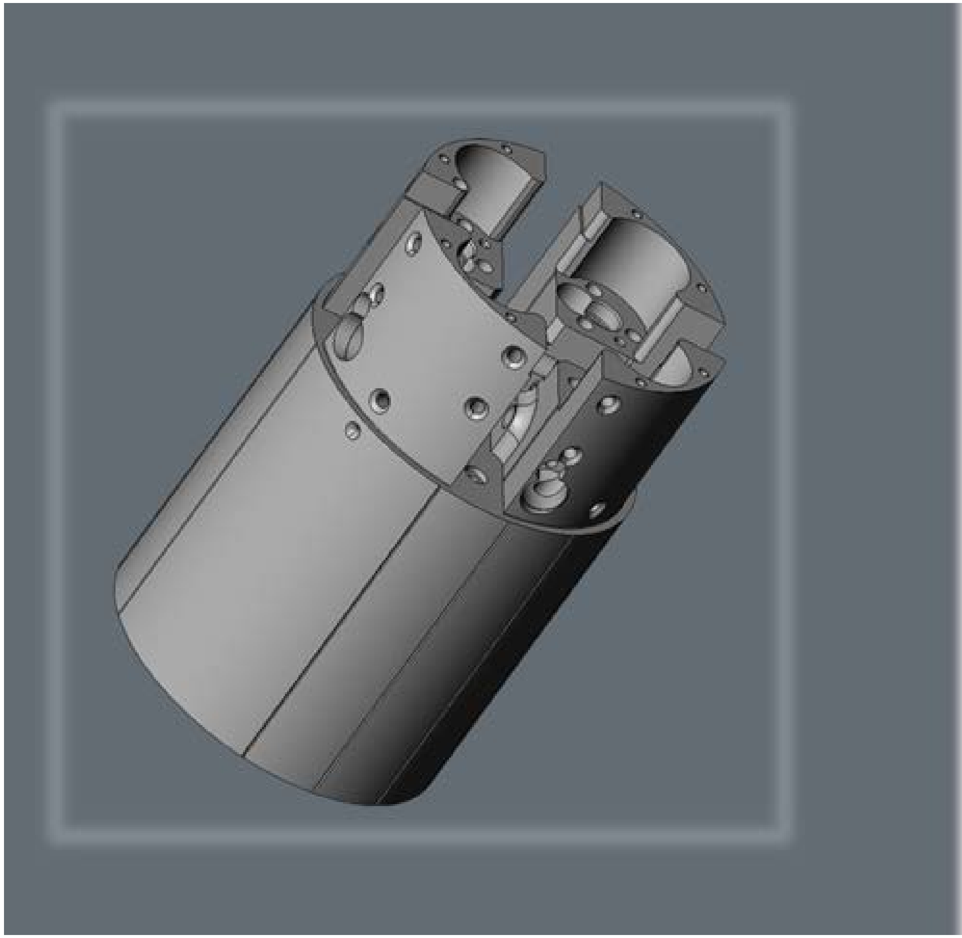








Machining Estimate



Current:

Time = 12 - 15 hrs

Cost = $ 780 - 975

With Recommendations:

Time = 7 - 10 hrs

Cost = $ 455 - 650

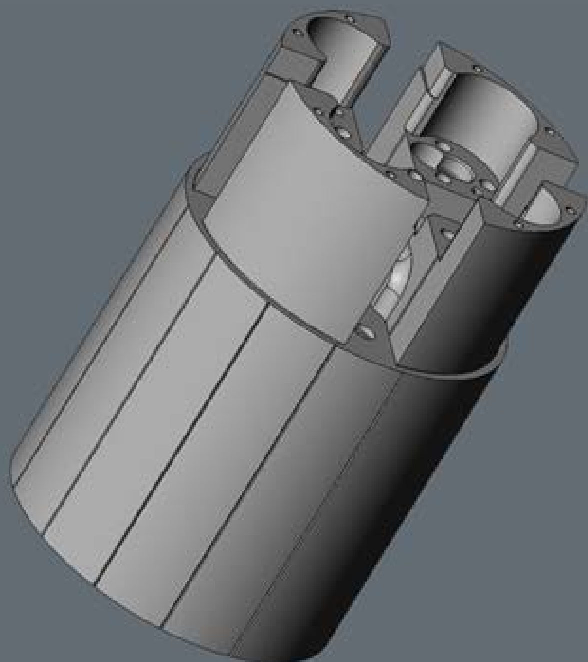
Total Savings = <u>$ 325 / part</u>

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:

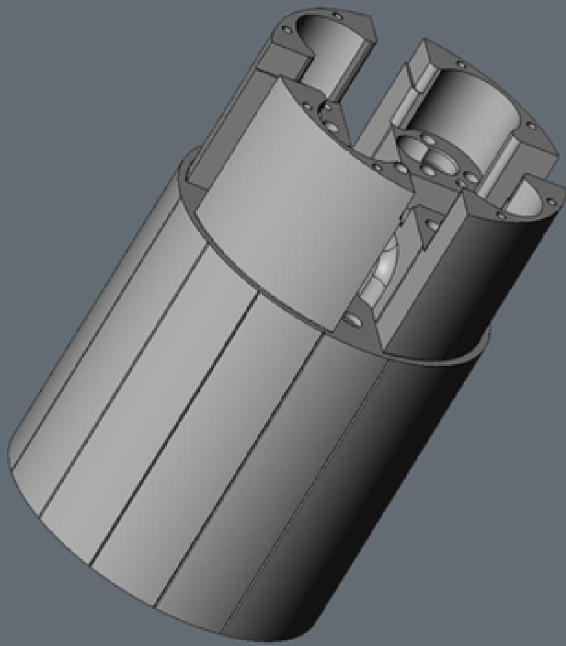
< $\$135^{.00}$ each

Alternative Methods Estimates (Metal Injection Molded)

Metal Injection Molding

DaTuM 3D
Design To Manufacture

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

Things you can find

MODULE AND SYSTEM LEVEL BENEFITS OF HIGH FLUX HEAT PIPE HEAT SINKS

Dan Cromwell
Hewlett-Packard Company
8000 Foothills Blvd.
Rossville, CA 95747
Tel: (916)785-5058
Fax:(916)785-3096
Email:sdc@rosemail.rose.hp.com

Scott D. Garner
Thermacore Inc.
780 Eden Road
Lancaster, PA 17601
Tel: (717)569-6551
Fax: (717)569-4797
Email:scott.garner@thermacore.com

ABSTRACT

Higher powers in smaller packages has trended to the point where junction to case resistances are the majority of the overall allowable thermal resistance. This has pressured the sink to ambient resistances to the point where standard cooling solutions are no longer a viable option. Current trends are pushing chip fluxes into the range of 50 to 100 W/cm^2. At these fluxes it is critical to optimize the overall system resistance by studying the tradeoffs between spreading, interface, conduction, and airside resistances.

This paper discusses one case study and outlines the module and system levels benefits of heat pipe heat sinks capable of handling high heat fluxes. At the module level the heat pipe uses two phase boiling heat transfer from the large specific surface area of a powder metal wick structure to remove the high heat fluxes generated at the die level. This minimizes conduction and spreading resistances. At the system level, heat pipes isothermalize the entire fin area, allowing designers to make optimum use of fin volume and flow areas to achieve minimum thermal resistances with lower velocity and lower pressure drops.

INTRODUCTION

Although this case study is specific to a single application, the problem solved is typical of current and future processor power levels and fluxes. The approach used to get from problem definition to end solution is applicable to a broad range of applications and the conclusions drawn should expedite solutions for similar applications. The solution selected in this case study a "tower" heat pipe heat sink, was dictated by the allowable fin geometry. The chip level and system level benefits are applicable to a family of heat pipe assisted heat sinks including vapor chambers and towers.

PROBLEM DEFINITION

Figure 1 and the data listed in the Table 1 sufficiently define the requirements and provide enough information to begin the process of evaluating alternative solutions

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

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

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

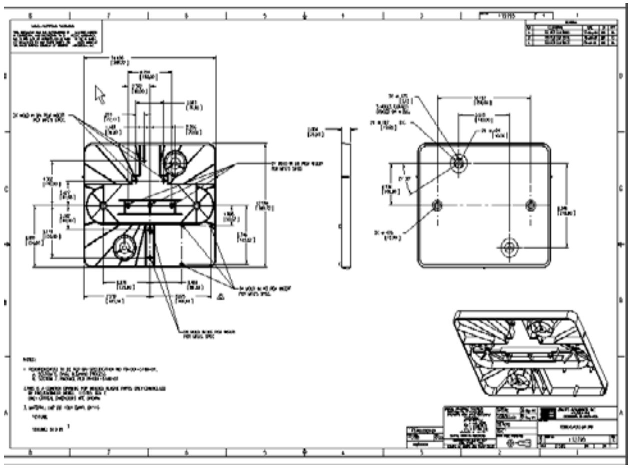
Process Time Historical Results

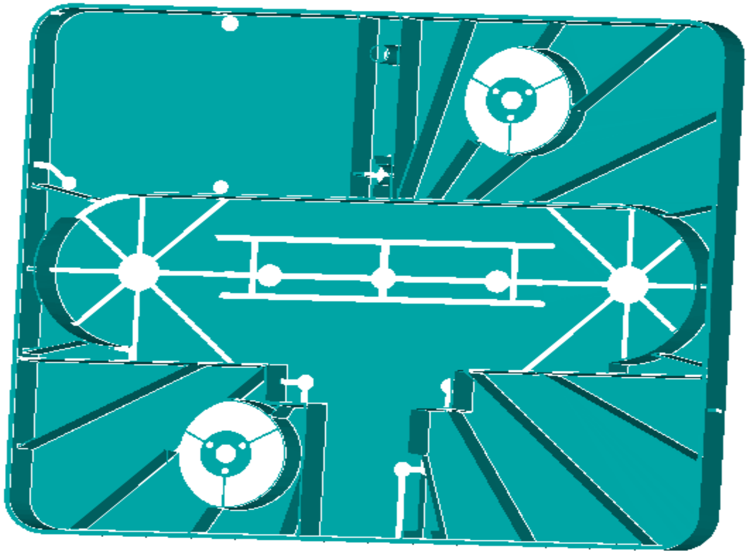
B&D standard tool accuracy with generic macros to within 5-15% of MTM-UAS times.

DFMA Example-Comparing Estimates Against Vendor Quotes

B&D Estimates Against Actual Quotes

Item Description	QTY	Cost	B&D Estimate
DOOR,	250	$22.34	$9.40





DFMA Example-Vendor Quote

Item Description	QTY	Cost	B&D Estimate
DOOR,	250	$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

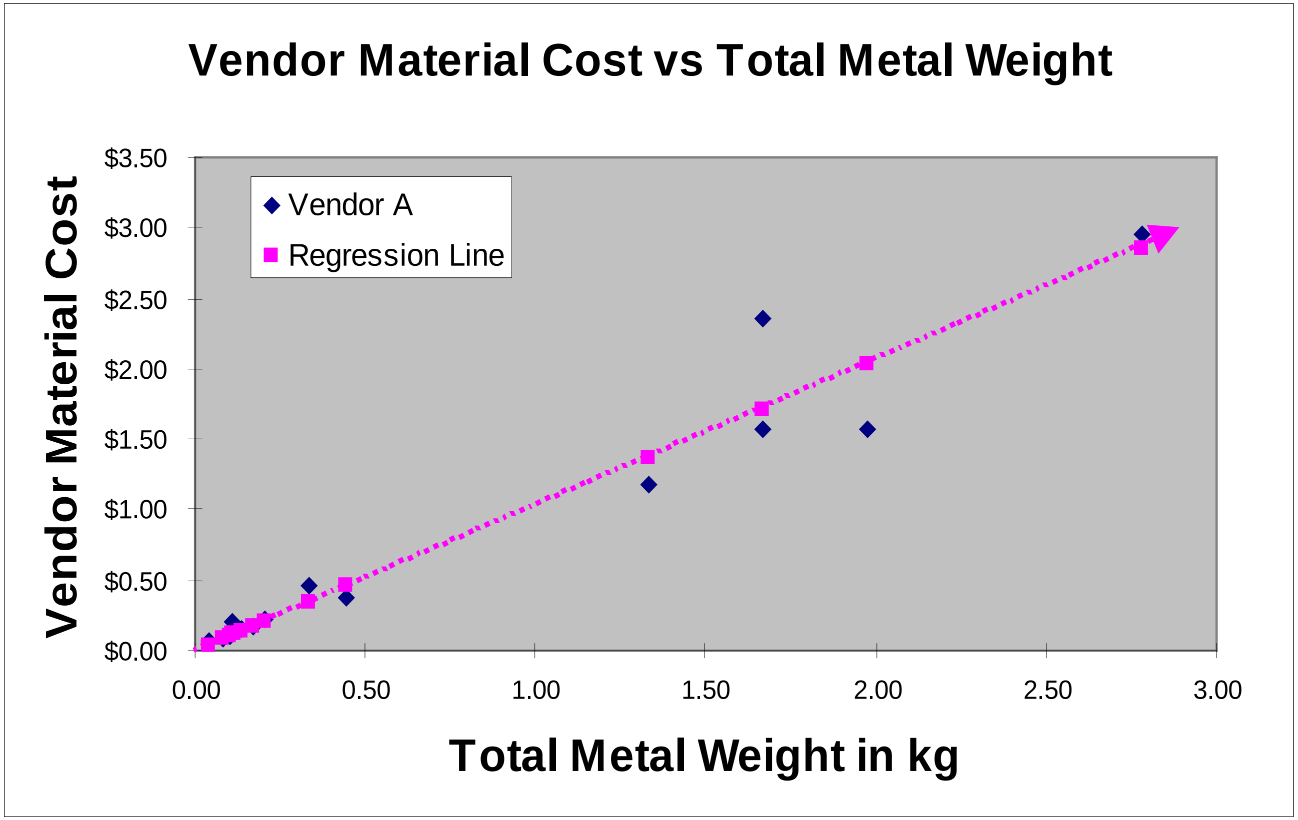
7350 Dry Creek Parkway
Longmont, CO 80503
303-652-2500

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

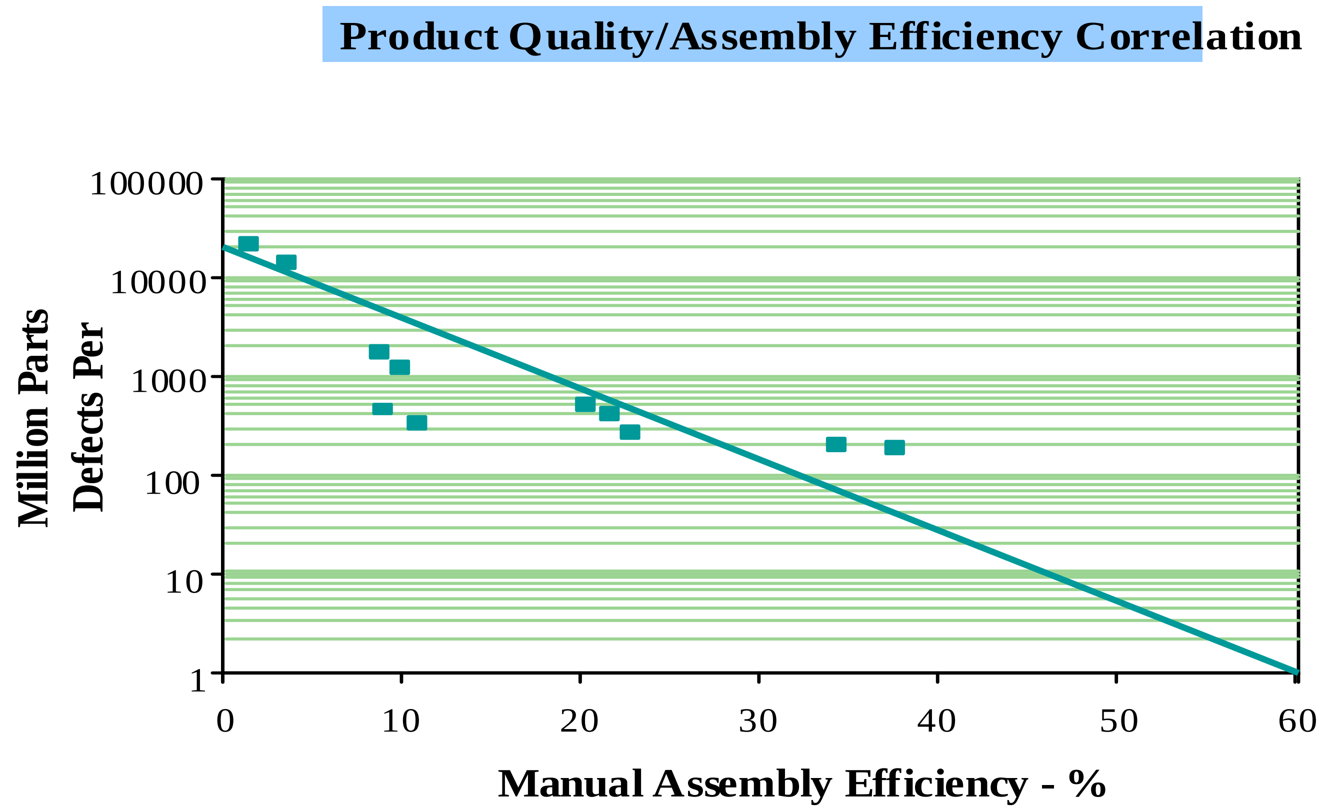
Standard Error

$0.228/kg

- Indicates Strong Correlation
- Based on believed market rates = a material adder of 30-40%

Quality Tool

Design for Assembly



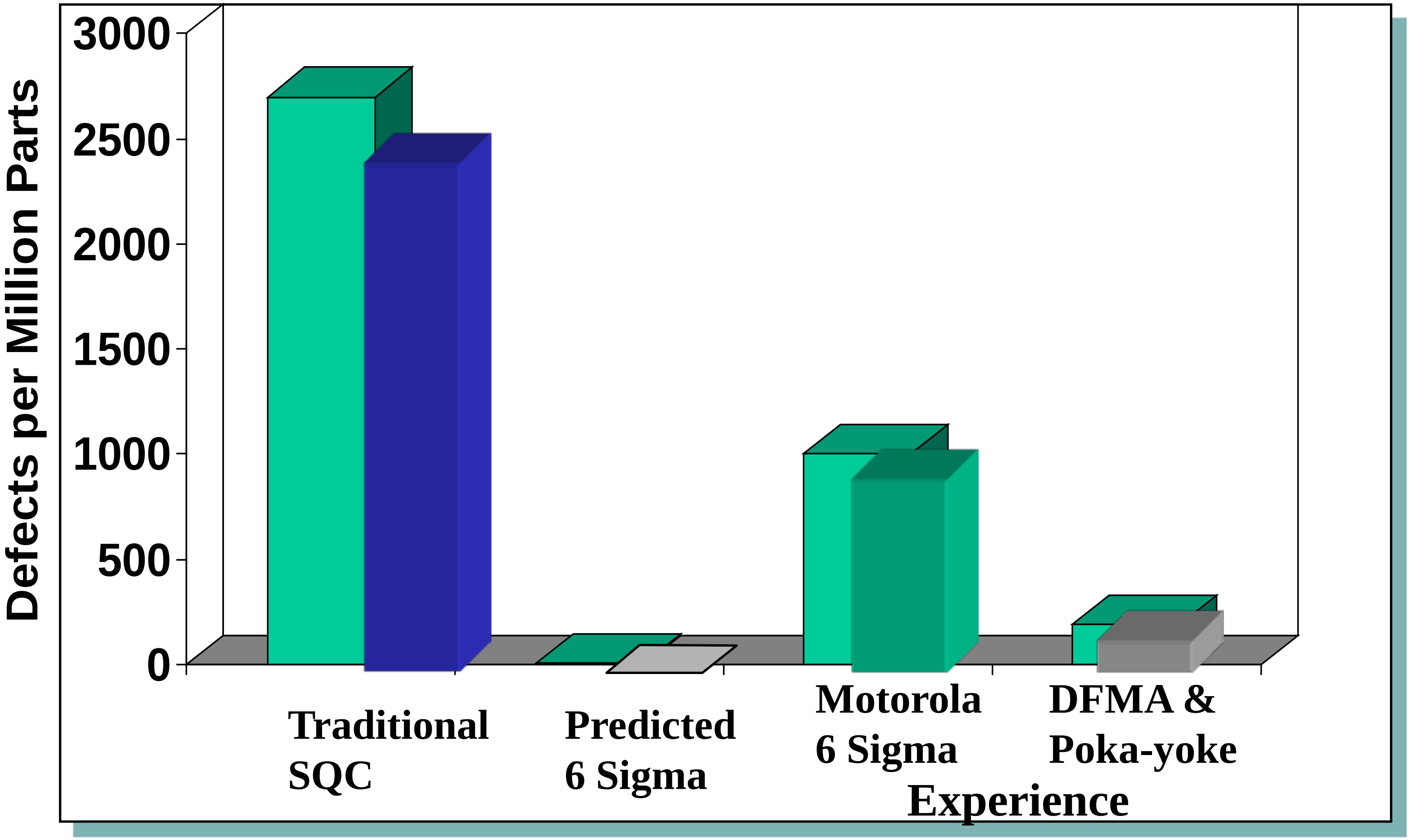
Every one second of assembly penalty time causes an average of 100 DPM

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.

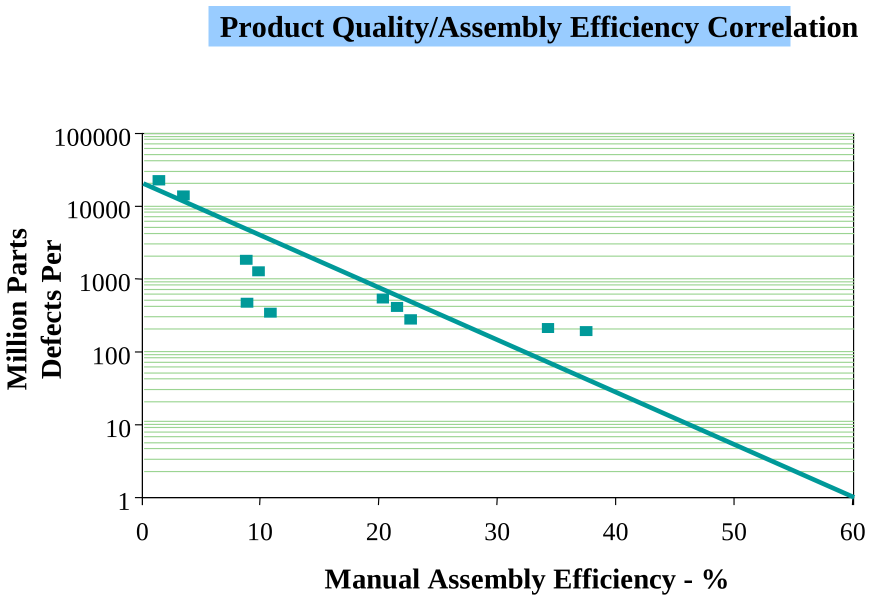
Mistake-proofing achieves superior results, faster, and with less efforts.

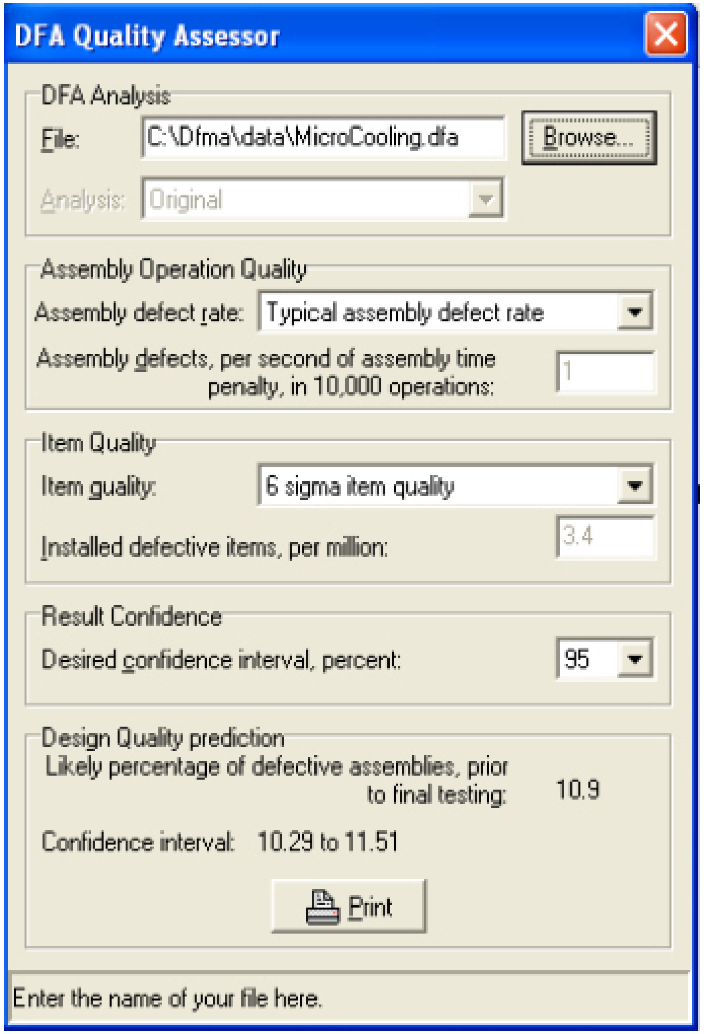


Source: Make NO Mistake – A Mistake – Proofing Methodology C. Martin Hinckley B&D conference June 2003

Quality Prediction

Design for Assembly





In Memory of

Jim was good friend and colleague. He had a kind heart, was brilliant and had an encyclopedic mind. Throughout his career, DEC, Compaq, HP, Sun and Oracle Jim was the best electrical cost estimating engineer of all time. He will be missed by all who knew him

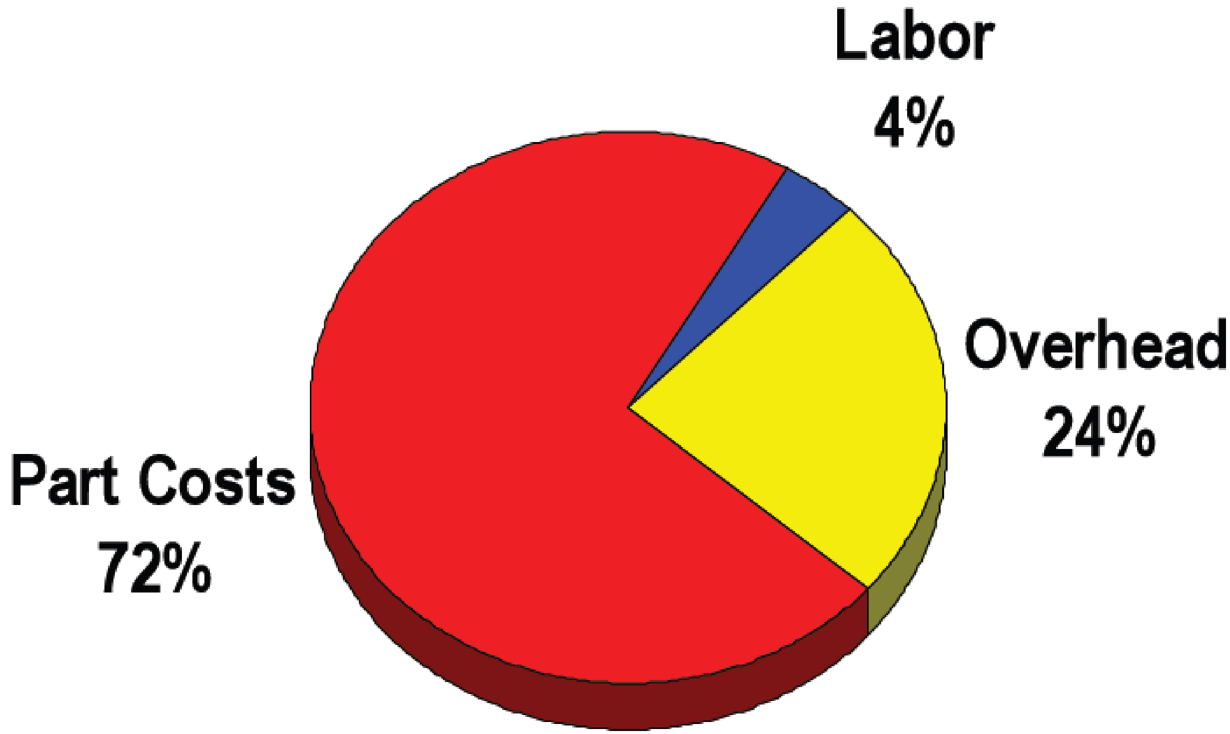
Francis “Jim” McWilliams May 20, 1952 – March 22,2012


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

Blooper slides

- Can hire outside folks to do this for you.
- The learning is in the act of doing and the subsequent journey grasshopper

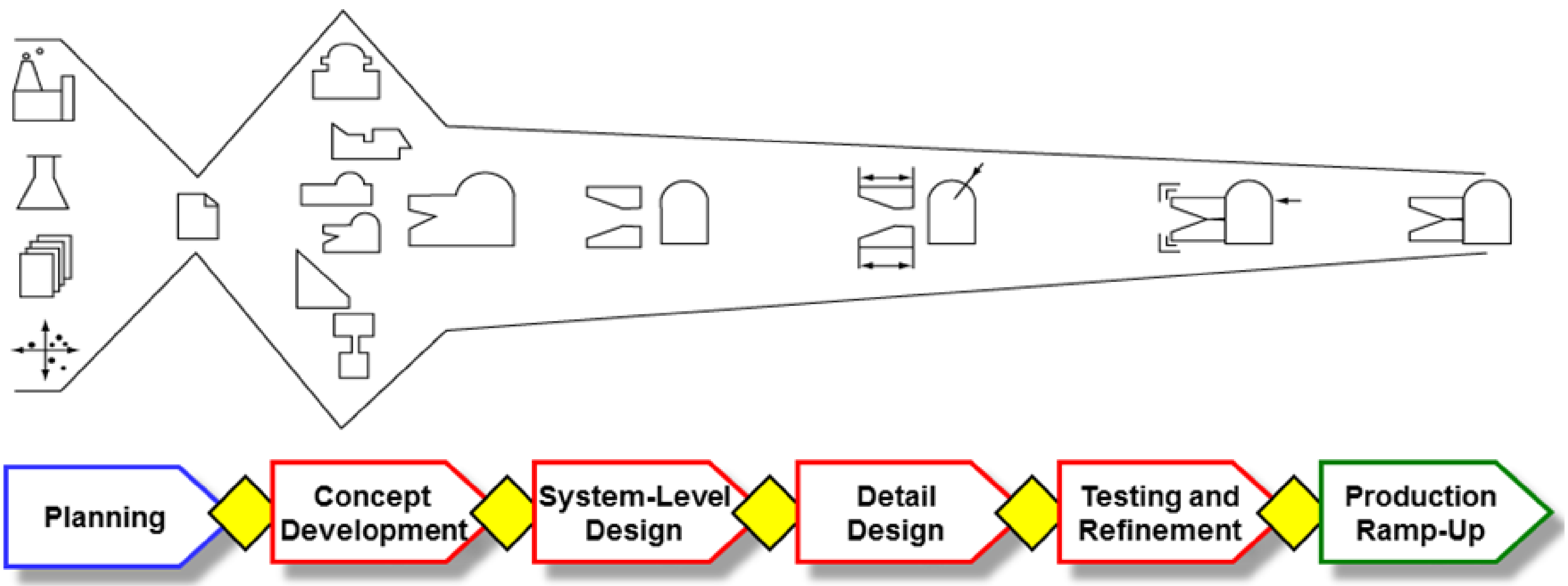
Typical Product Cost Breakdown



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

Cost Estimating can be used through the entire Product Development Cycle

- From idea to product



Cost Estimating Cost Estimating Cost Estimating

Early Supplier Involvement:

- Capture the vendor's know how and experience early.
- Share a commitment to the product by working together from the start.
- Optimize the part design to take advantage of the vendor's capabilities and processes.
- Optimize the part design for ease of manufacture with input from the vendor on the emerging design.
- Set target cost for tooling and parts using cost models to support the products cost goals. Use this data to open communications with vendors.

Mark twain quote :

- It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.
- Mark Twain

Even if you know the absolute most correct cost doesn’t mean you can buy it for that

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

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