GLOBAL COMPETITIVE ADVANTAGE

Using DFMA to understand and manage cost

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Boothroyd Dewhurst, Inc. 2018

September 11th, 2018

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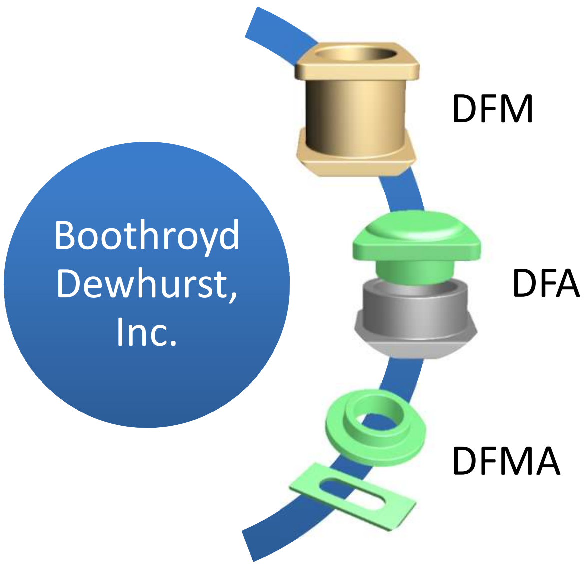
- Background in Mechanical Engineering
- Help clients understand the benefits of DFMA
- Apply DFMA to products on a consulting basis
- Helped companies around the world make DFMA part of their product development process

Boothroyd Dewhurst, Inc.

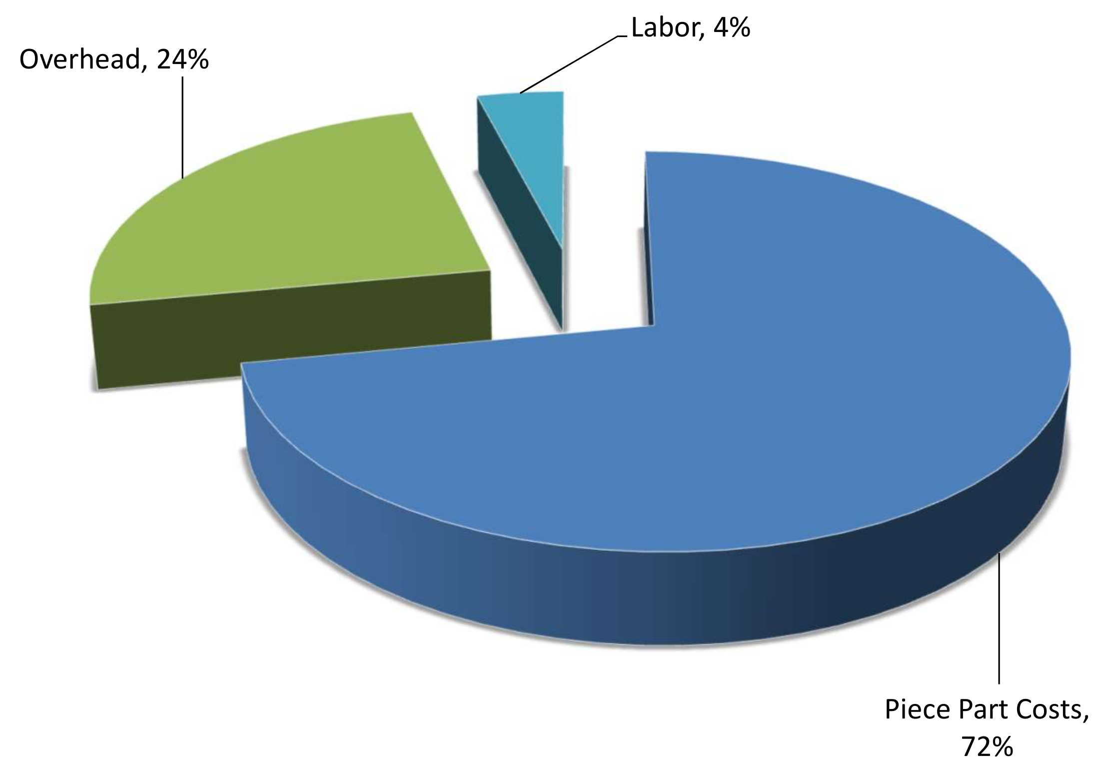
- Founded in 1981
- First Software in 1983
- 850 Companies from broad range of industries
- 1991 Winner of National Medal of Technology
- R&D continues today with new cost model development, new software interface design, and updated databases

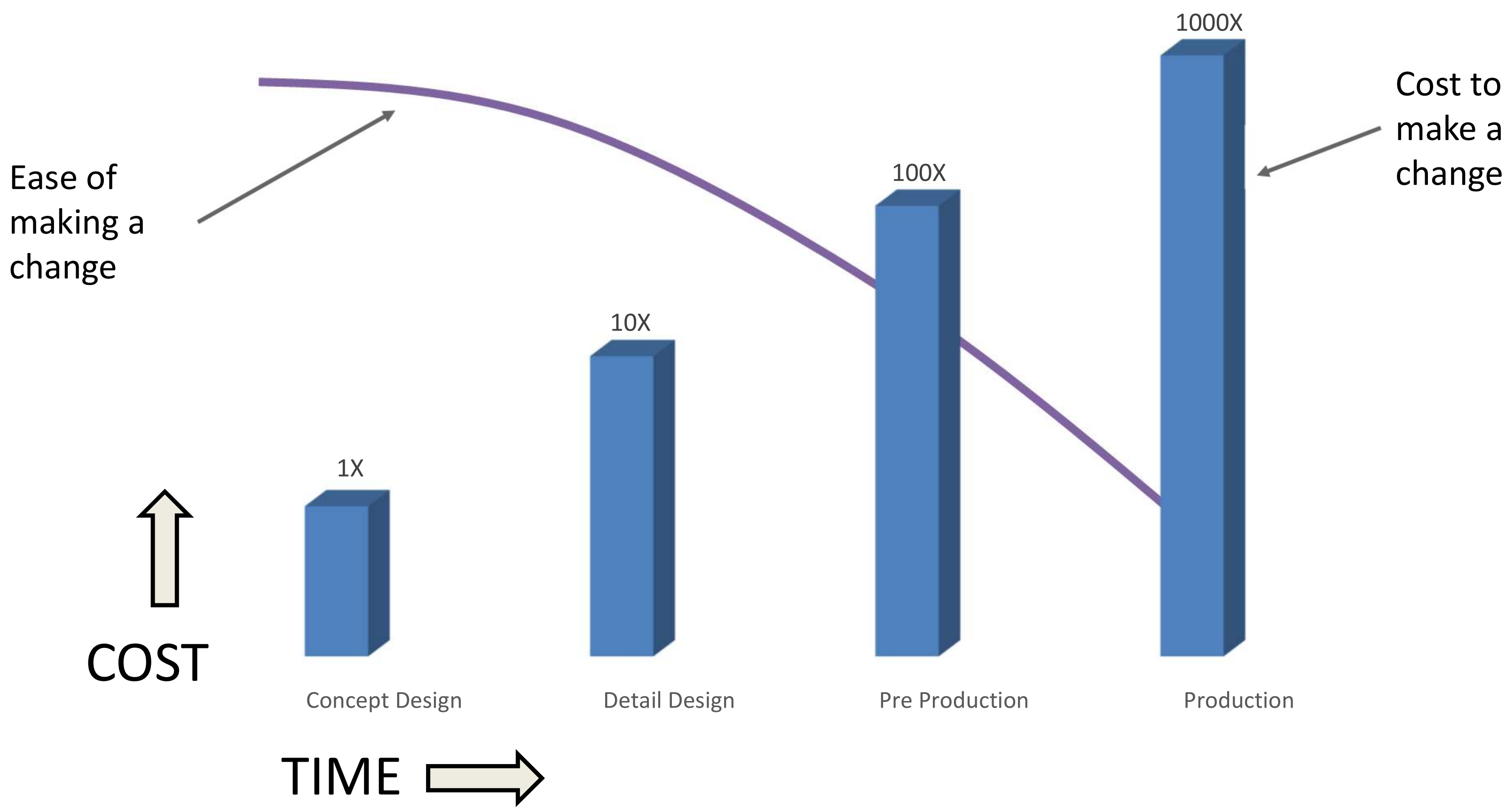
What is DFMA?



A suite of tools used to analyze and understand the cost of a product's design and its constituent parts.

Typical Product Cost Breakdown





Where should your focus be?

Average DFMA Cost Reductions

- Labor Costs 42%
- Part Count 54%
- Separate Fasteners 57%
- Total Cost 50%
- Weight 22%
- Assembly Time 60%
- Assembly Cost 45%
- Assembly Tools 73%
- Assembly Operations 53%
- Product Development Cycle 45%

Top ten responses quoted from over 170 case studies

(Presented in order of most commonly quoted responses)

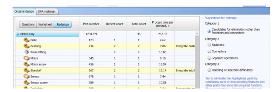
1 Project Scope & Definition

- Representative products, subassemblies or competitive units selected for baseline analysis
- Tear down or assembly sequence catalogued leveraging industry-leading DFMA® tools

3a DFA Opportunity Classification

Leverage DFA suggestions for redesign to generate ideas around:

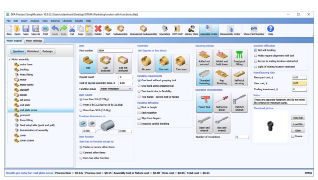
- Product simplification
- Ease of assembly
- Cost reduction / avoidance
- Classify redesign risk into Safe, Reach, and Stretch categories



1 Project Scope & Definition → 2 Baseline Analysis → 3a DFA Opportunity Classification / 3b DFM Cost Estimation → 4 Results Implementation

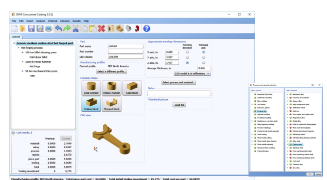
2 Baseline Analysis

- Capture assembly details using intuitive Design for Assembly (DFA) tool
- Answer minimum part criteria questions to arrive at theoretical minimum part count



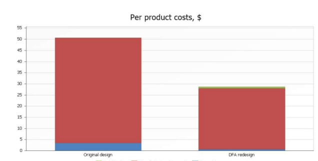
3b DFM Cost Estimation

- Generate forensic cost estimates using Design for Manufacture (DFM) for each component part to provide a "should cost" that can be compared to actual component part spend



4 Results Implementation

- Quantify ideas generated from DFMA® total cost estimation and define roles and responsibilities for redesign implementation



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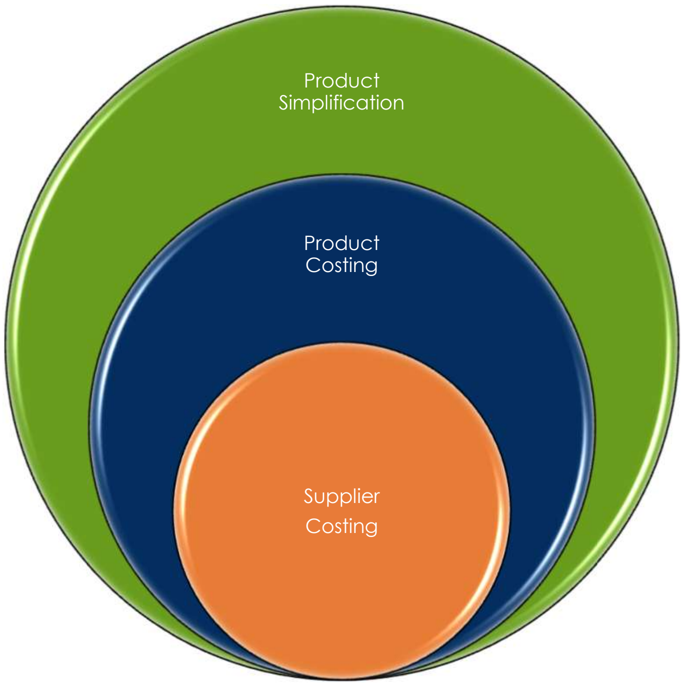


PRODUCT SIMPLIFICATION

Our real time approach to product simplification unlocks the potential for part count reduction within your assemblies

PRODUCT COSTING

Looking at the alternative process and/ or material combinations that may lead to potential piece part cost savings

SUPPLIER COSTING

Using the outputs from our DFMA software to better negotiate price in a real time fashion

The Three main uses of DFMA

Sample Case study

Supplier Negotiations

"According to our Product Management team we will sell 190,000 of these clips a year. So, it seems that the software helped us to negotiate a savings of $361,000 on this one item."

-VP of Engineering at a leading electronics company, May 2014

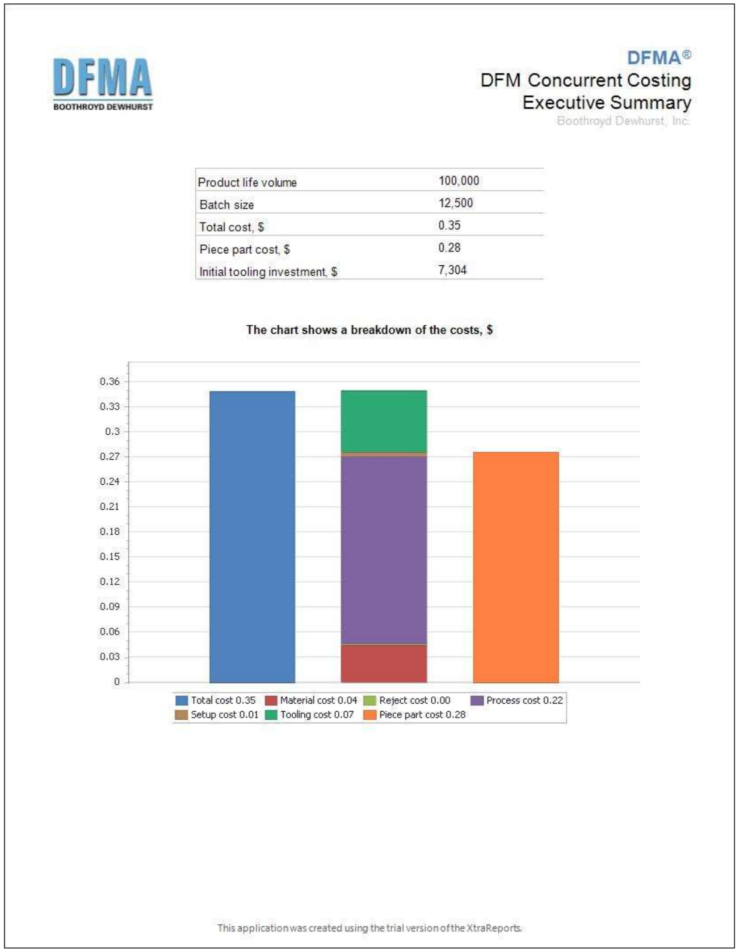
Challenge

Needed young project engineers to more actively support negotiations on high production volume products to ensure best possible price.

Solution

Use DFMA analysis to aide in the negotiation and apply information gathered from initial discussion to improve cost estimate accuracy in real time

Cost Result


DFMA
BOOTHROYD DEWHURST

DFMA®
DFM Concurrent Costing
Executive Summary
Boothroyd Dewhurst, Inc.

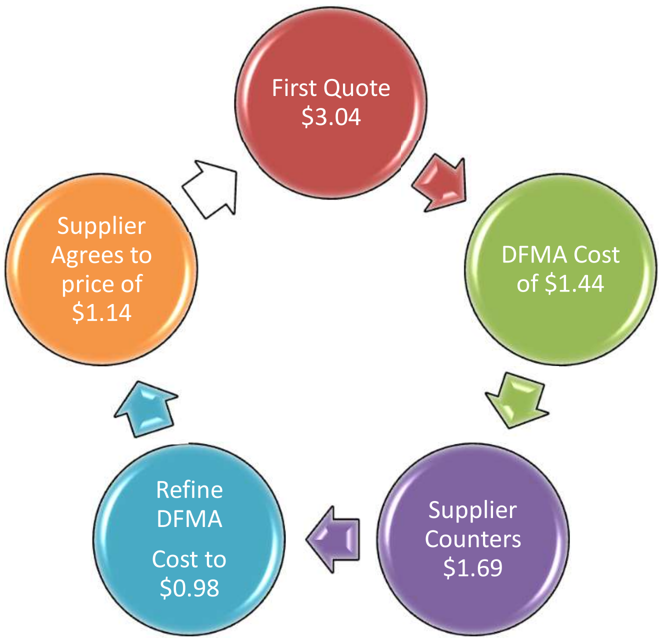
Product life volume	100,000
Batch size	12,500
Total cost, $	0.35
Piece part cost, $	0.28
Initial tooling investment, $	7,304

The chart shows a breakdown of the costs, $

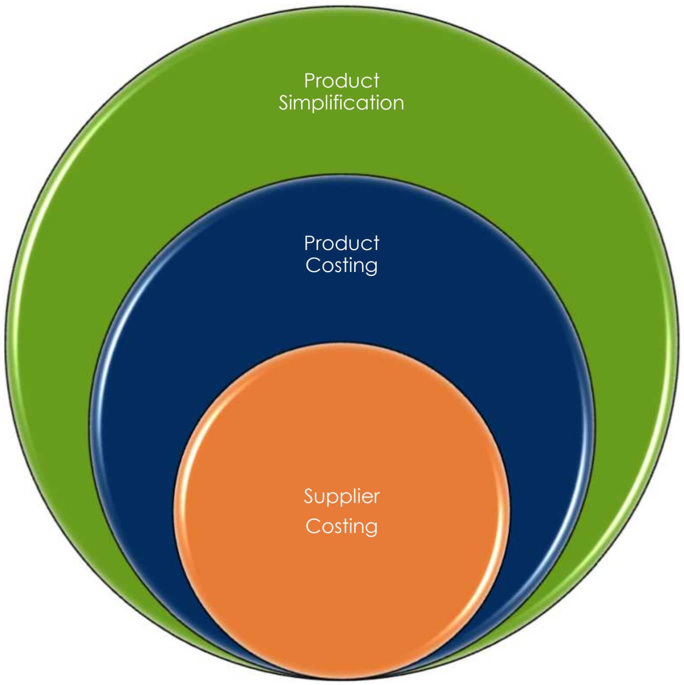
This application was created using the trial version of the XtraReports.

- Cost of $0.35 per part
- We get a detailed breakdown of the cost drivers
- Material
- Setup
- Process
- Rejects
- Tooling

Results – plastic clip assembly



- Annual Production Volume of 190,000
- ROI on software investment achieved on this single example
- Cost avoidance of $361,000 annually



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Decisions decisions decisions, what's a designer to do?

Part and manufacturing level decisions; “Product Costing”

- Cost is too high
- Corrosion is a problem
- Bending stiffness is critical and must be maintained
- Paint it, but what is the added cost?
- Might the paint crack around the mounting hole and allow for corrosion to begin?
- Make it from stainless, but what would that add in terms of cost?
- Make it from plastic but what would the tooling investment be and would we be able to maintain the stiffness requirement?

24 gage (0.61 mm) thick steel:

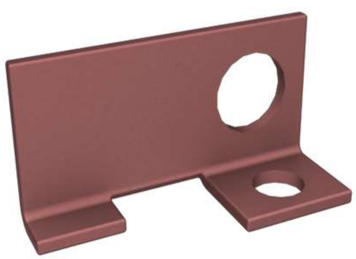
Alternative Designs

$A

24 gage (0.61 mm) thick steel

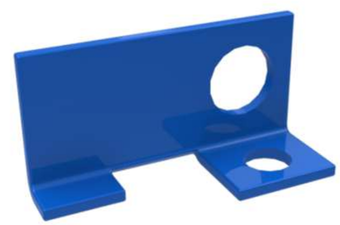
$C

stainless steel



$B

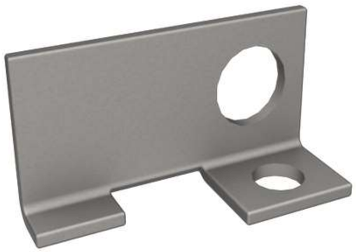
24 gage (0.61 mm) thick steel
painted



$D

Injection molded

Cost of alternatives

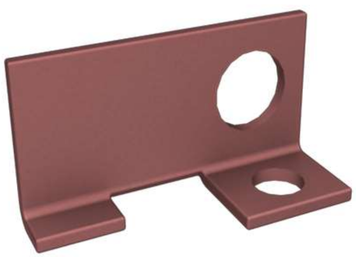


$0.75

24 gage (0.61 mm) thick steel

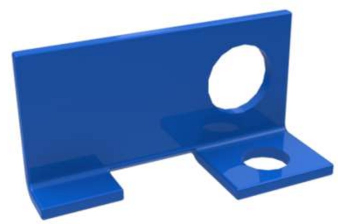
$2.42

stainless steel



$1.31

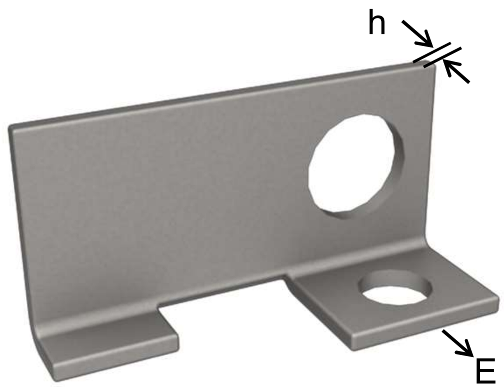
24 gage (0.61 mm) thick steel
painted



$0.61

Injection molded (commodity resin)

Injection Molding example



Bending stiffness depends upon $E\ h^3$

For equivalent stiffness of materials 1 and 2

$$E_2\ h_2^3 = E_1\ h_1^3$$

$$\text{or } h_2 = h_1\ (E_1/E_2)^{1/3}$$

Thickness with equivalent stiffness to 24 gage (0.61 mm) thick steel:

Polyethylene; $h = 0.61\ (207{,}000/925)^{1/3}$

$= 3.7$ mm

ABS; $h = 0.61\ (207{,}000/2{,}100)^{1/3}$

$= 2.8$ mm

Polycarbonate (30% glass); $h = 0.61\ (207{,}000/5{,}500)^{1/3}$

$= 2.0$ mm

Injection Molding example

Polymer Processing Data

Thermoplastic	Thermal diffusivity, $\propto$(mm^2/s)	Injection temp., T_i (°C)	Mold temp., T_m (°C)	Ejection temp., T_x (°C)
H.D. polyethylene	0.11	232	27	52
Polypropylene (40% talc)	0.08	218	38	88
ABS	0.13	260	54	82
6/6 Nylon	0.10	291	91	129
Polycarbonate	0.13	302	91	127
Polycarbonate (30% glass)	0.13	329	102	141

Injection Molding example

$$t_c = 4 + 15\,(w_t - 0.1) + kh^2$$

where w_t = shot weight, kg

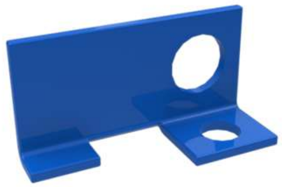
$$k = \frac{1}{\Pi^2 \propto} \log_e \frac{4\,(T_i - T_m)}{\Pi\,(T_x - T_m)} \text{ sec.}$$

h = maximum wall thickness, mm

Examples

Polyethylene;	$k = 2.16$ sec/mm^2
ABS;	$k = 1.74$ sec/mm^2
PC (30% glass);	$k = 1.56$ sec/mm^2
PP (40% talc);	$k = 1.93$ sec/mm^2

Injection Molding example

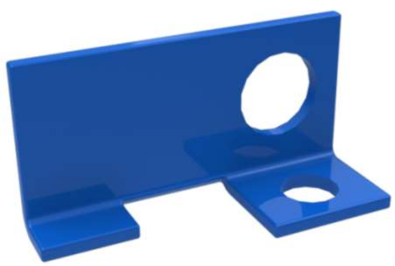


Criterion: Equivalent bending stiffness to 24 gage steel (0.61 mm)

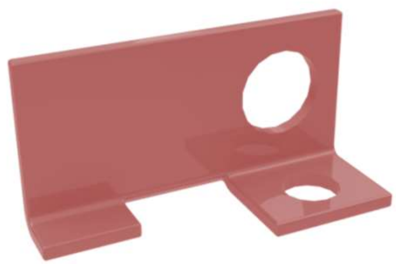
Material	Thickness (mm)	Cooling time (sec)	Process cost*
Polyethylene	3.7	29.6	$0.68
ABS	2.8	13.6	$0.31
PC (30% glass)	2.0	6.2	$0.14

** based on same machine; cooling time only*

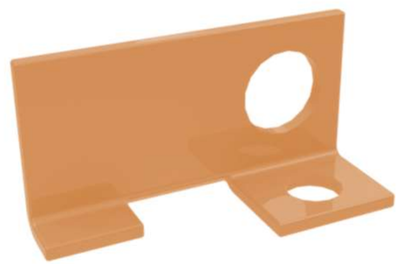
Injection Molding example material costs



2.0mm Wall Thickness
30% Glass PC
$2.60 / Lb.

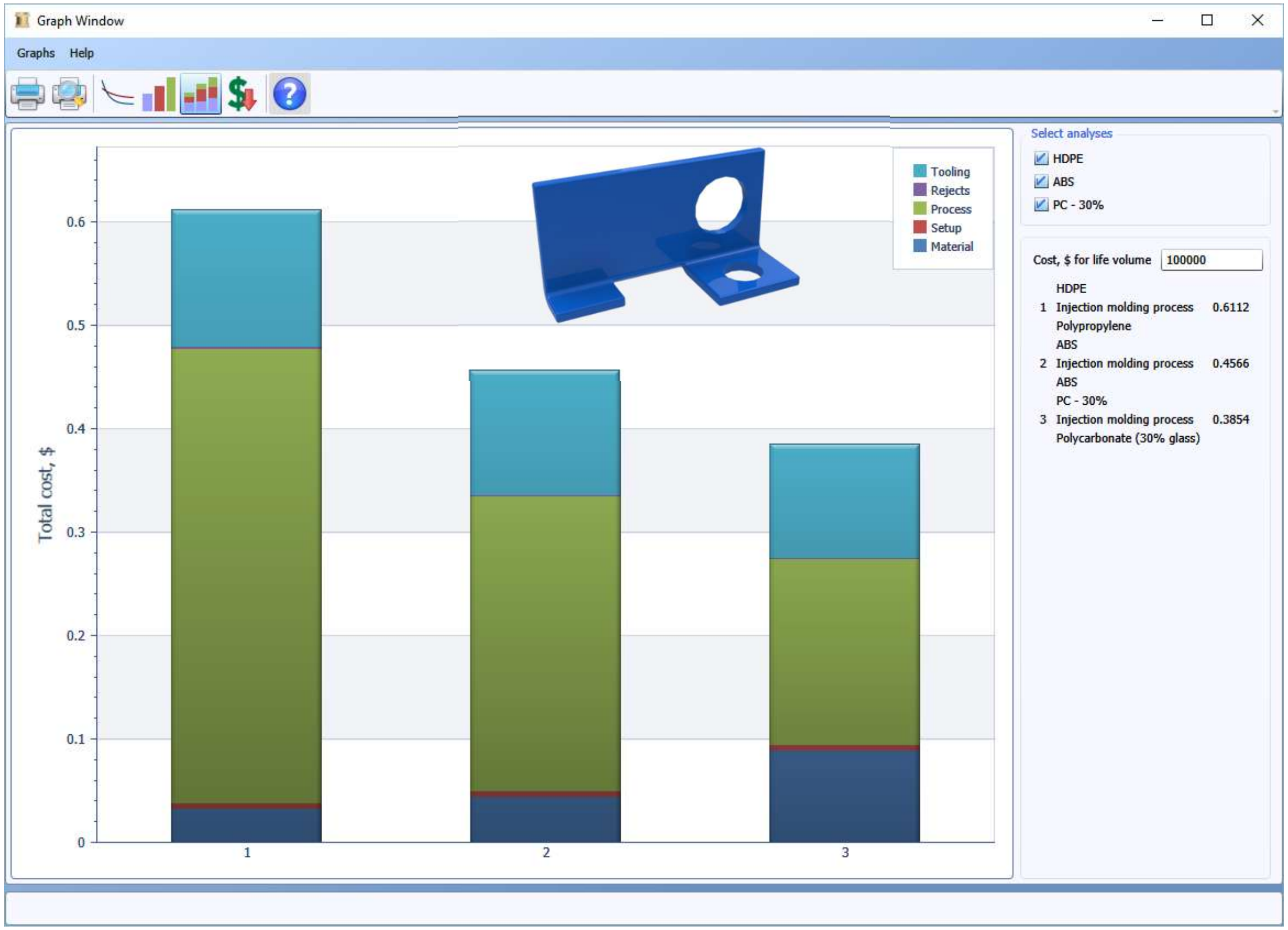


2.8mm Wall Thickness
ABS
$1.55 / Lb.

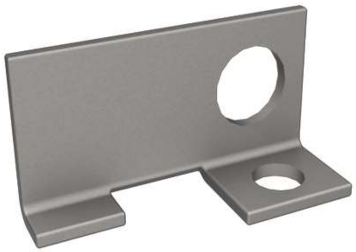


3.7mm Wall Thickness
Polyethylene
$0.95 / Lb.

Injection Molding example



Final Design Decision Result



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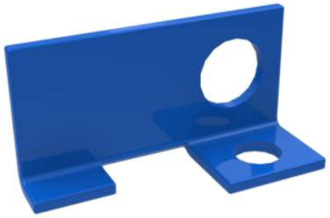
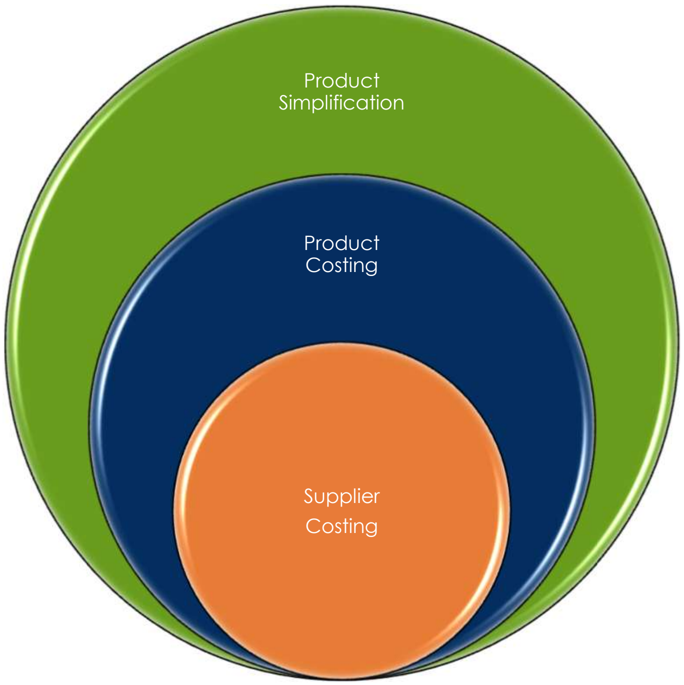


$0.61

$0.39

Includes amortized tooling cost

Injection molded



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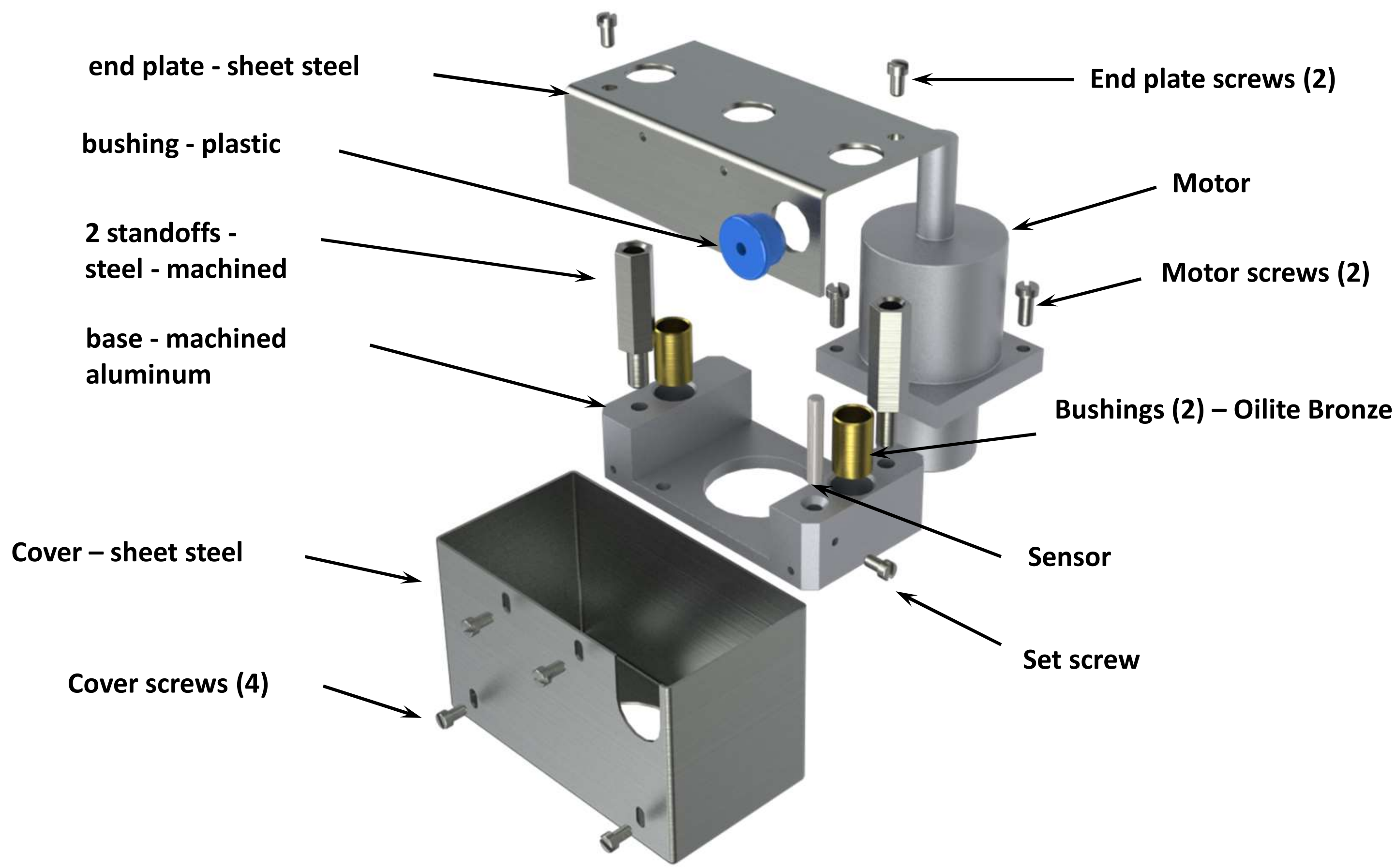
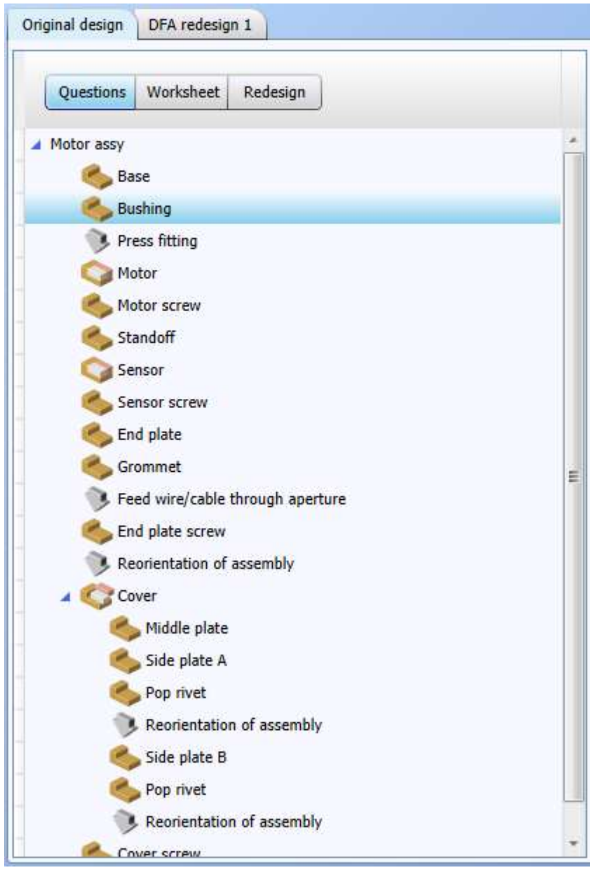
DFA as a design decision tool

- Guides a team through a series of steps to ensure part count efficiency
- Simply changes rarely have dramatic impacts on cost
- People are generally risk averse and making significant changes is difficult
- Better to implement early in the design process so there isn't as much to change
- Payoff in upfront design time is tremendous, you just have to believe



DFMA: Product Simplification

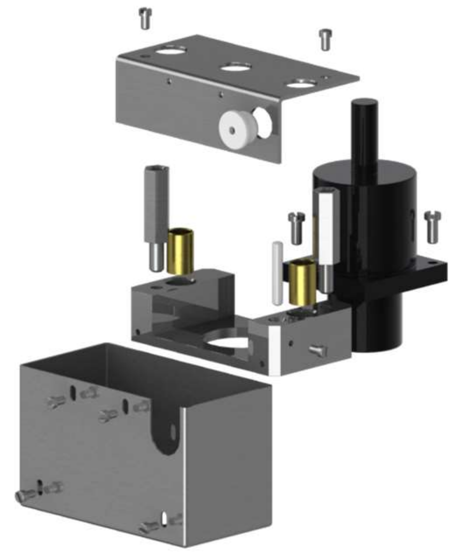


Minimum Part Criteria

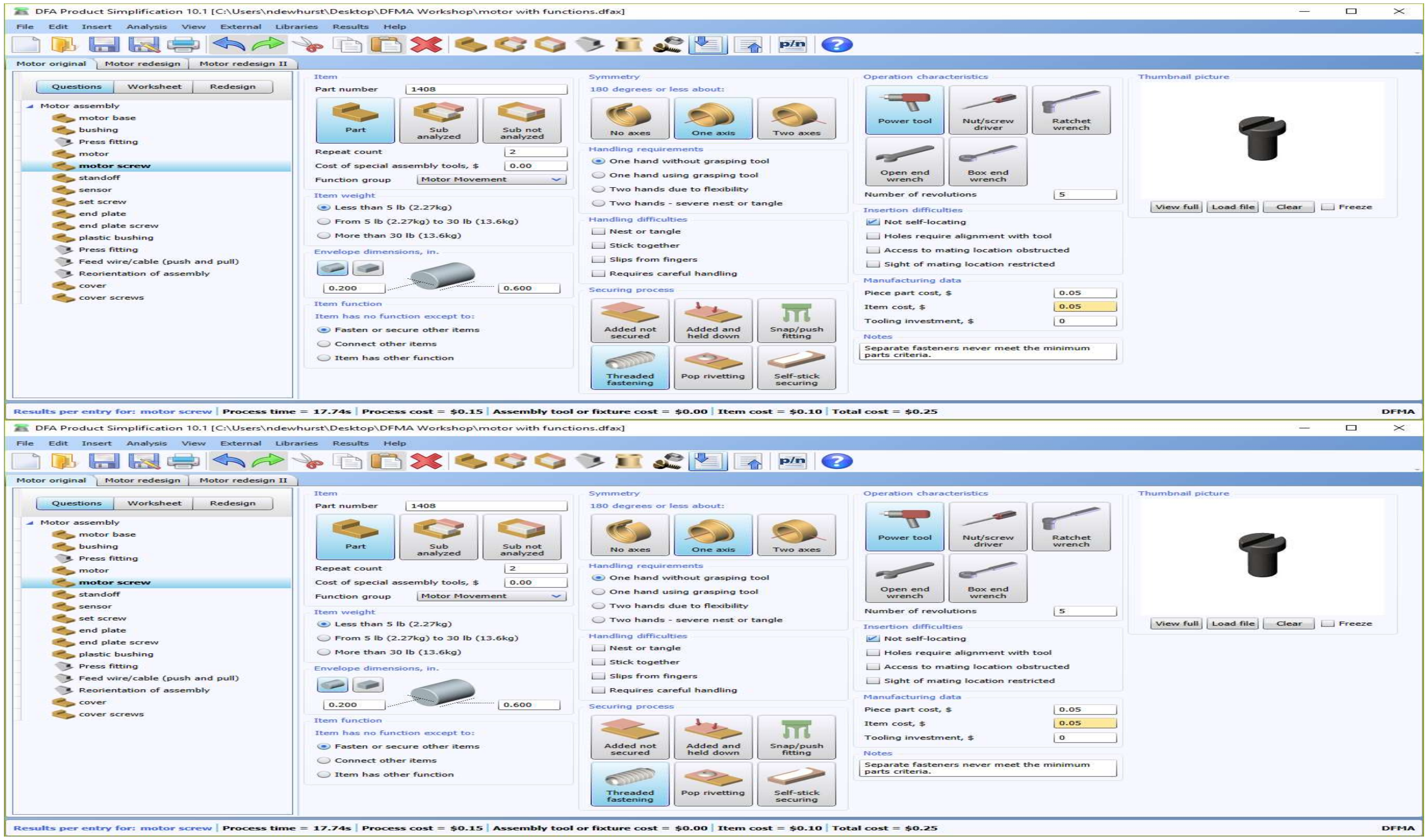
- Base Part / Chassis
- Fastening Function
- Connecting Function
- Different Material
- Relative Movement
- Assembly of Other Items

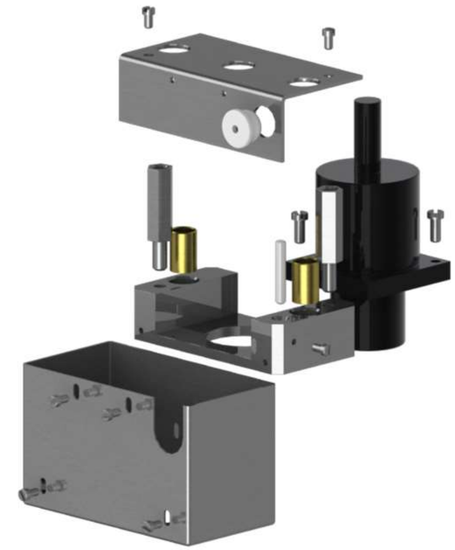
Handling & Insertion Difficulties

- Envelope Size
- Part Symmetry
- Alignment
- Nest or Tangle
- Other Restrictions, etc.



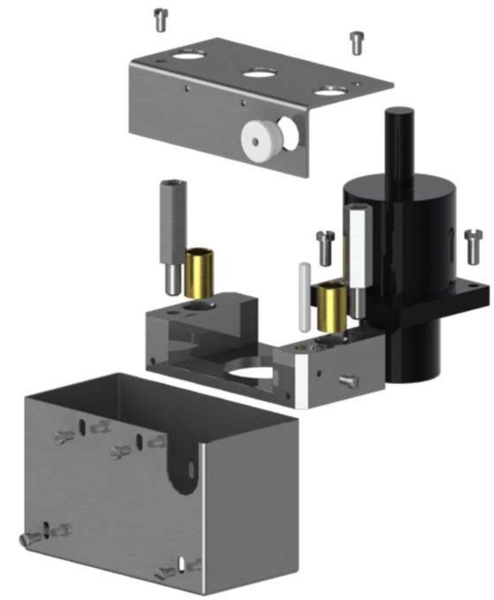
Product Simplification

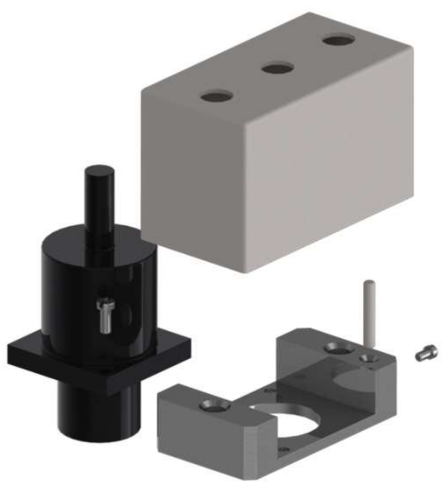




Product Simplification - Analysis

- 63 percent reduction in parts
- 4 suppliers removed from supply chain
- 63 percent reduction in detail drawings
- 74 percent reduction in assembly time
- Equal reduction in assembly labor cost



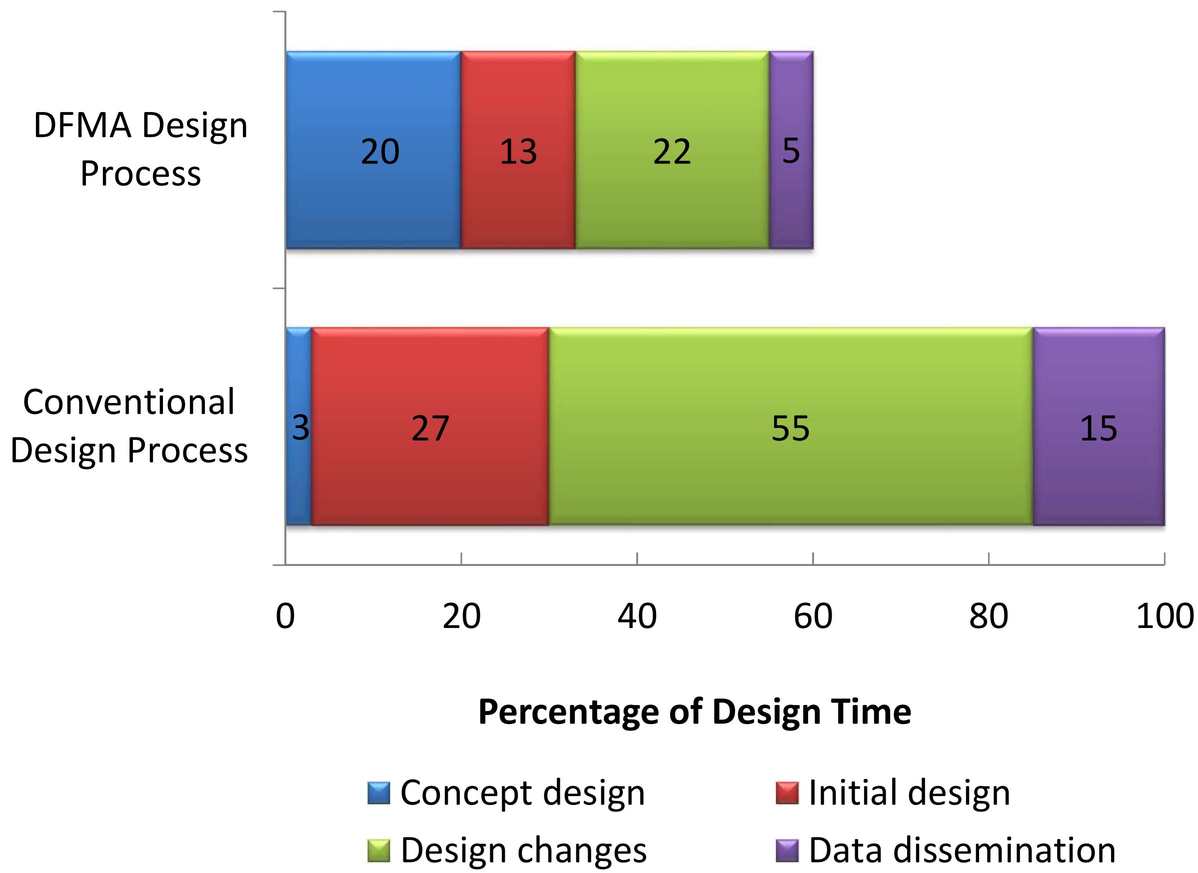


And let's not forget….

46% Reduction in Total Cost of the product

Results

DFMA's Impact on Design Cycle



Source: Plastics Design Forum

Summary & Conclusions

- Cost information in the hands of purchasing is invaluable
- Trade offs in part design, manufacture, and material must be considered early in the development process
- Time to design ‘simple’ parts individually is less than more complex ones
- Cost impact of products made from lots of ‘simple’ parts can be significant
- Tooling investments are often seen as a barrier to entry but true understanding of actual costs are rare
- Cost of production of products made from ‘simple’ parts are surprisingly high
- Labor impact on production is usually not the focus but can sway decision making
- Cost tools should really be a requirement in the design decision process
- If you aren’t using cost to make design decisions you really should
- Have engineers justify the cost of their designs