DFMA DESIGN DECISION

Understanding total product cost

Nicholas P Dewhurst

Boothroyd Dewhurst, Inc. 2016

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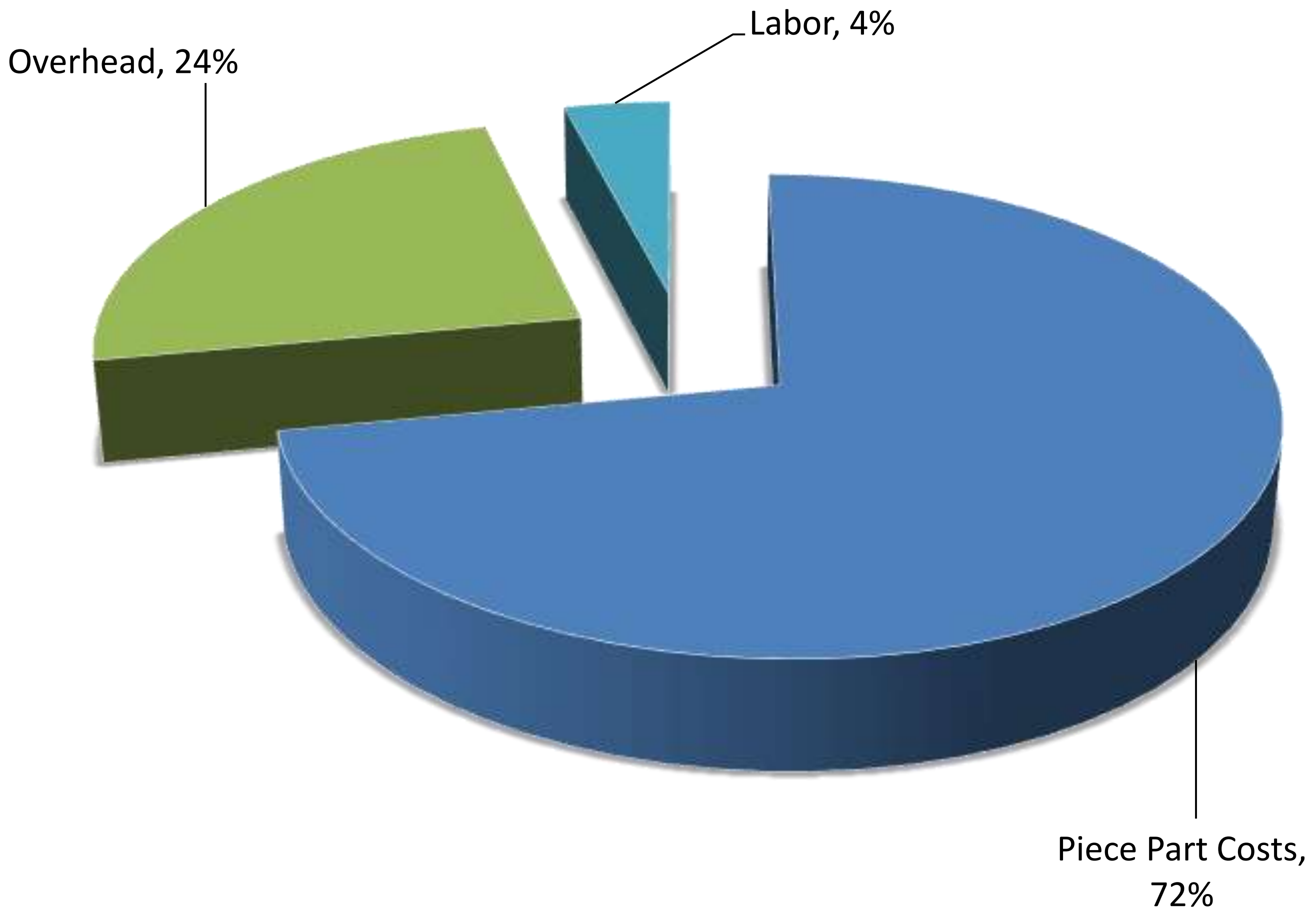
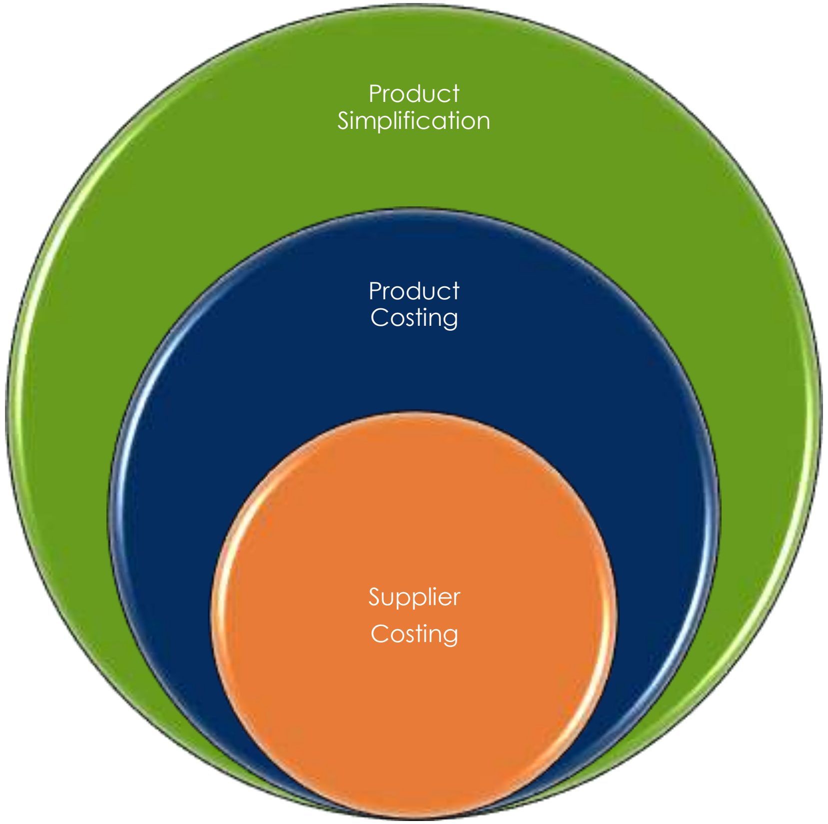
Nicholas P Dewhurst

Executive Vice President
Boothroyd Dewhurst, Inc.
ndewhurst@dfma.com
(401) 783 5840 x 103

- 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

Typical Product Cost Breakdown





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

Its design decision not purchasing decision

- Purchasing can obviously use information generated by DFMA to generate savings.
- Conference title is DFMA Design Decision so that's where focus will be
- One quick case study example

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

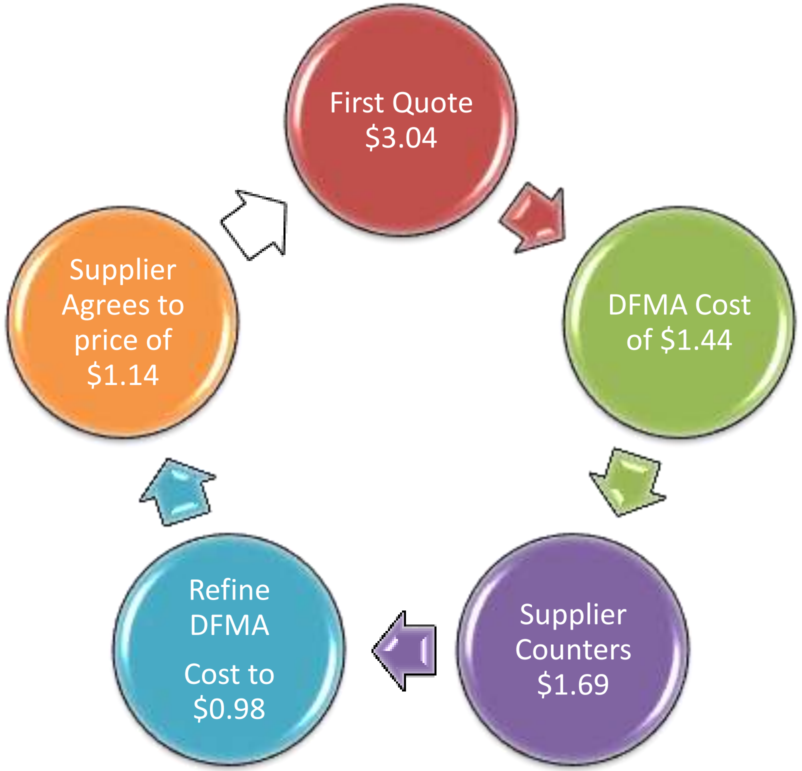
Challenge

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

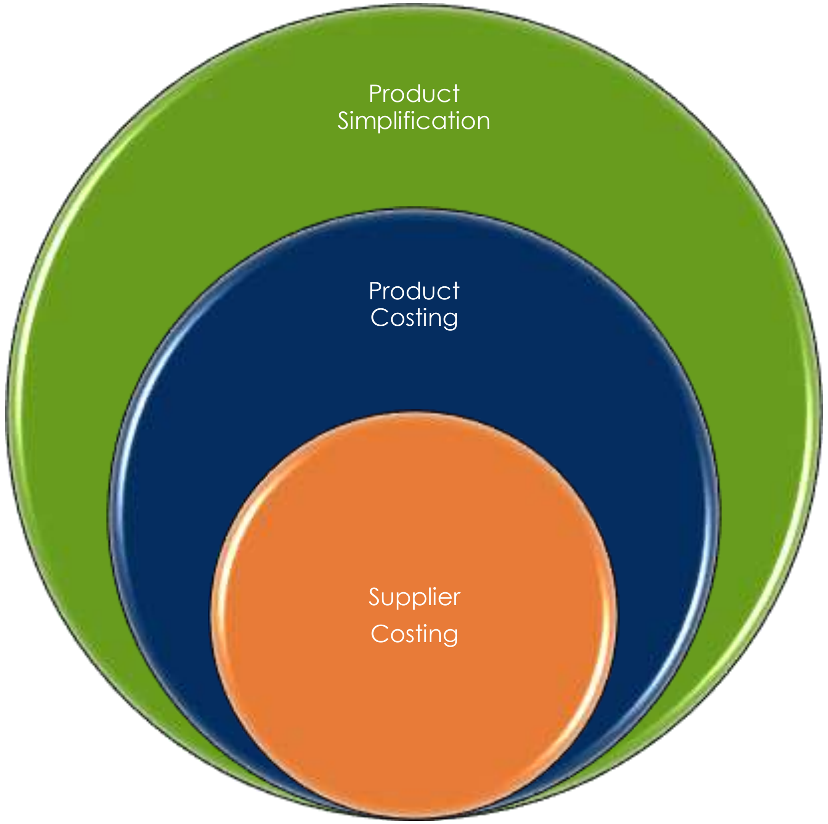
Solution

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

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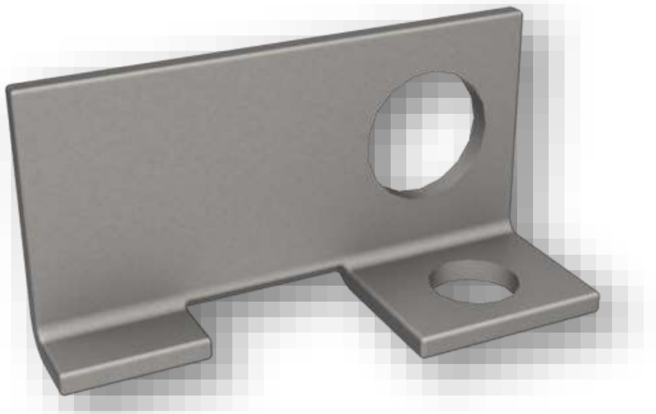
Decisions decisions decisions, what's a designer to do?

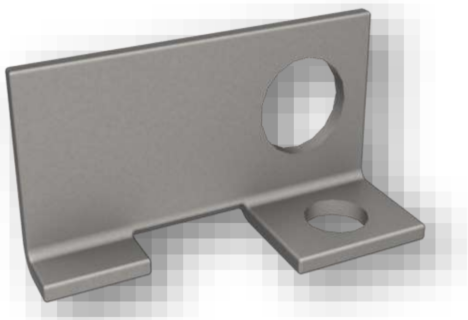
Part and manufacturing level decisions; “Product Costing”

- 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?



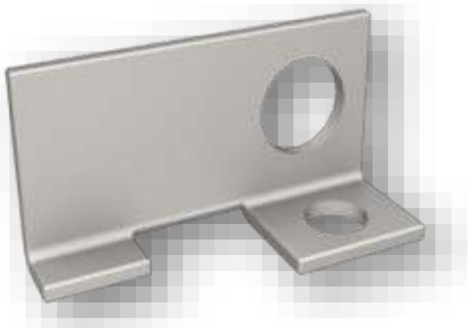
24 gage (0.61 mm) thick steel:

Alternative Designs



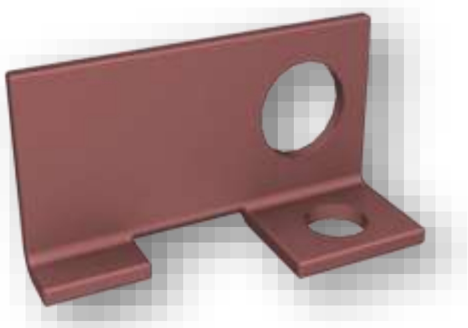
$A

24 gage (0.61 mm) thick steel



$C

stainless steel



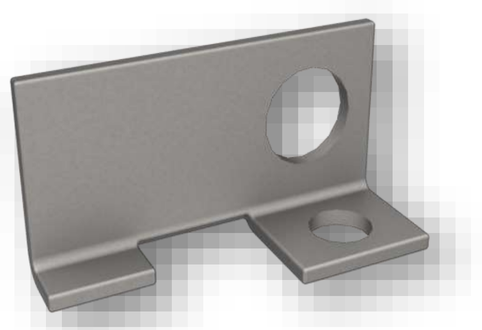
$B

24 gage (0.61 mm) thick steel
painted

$D

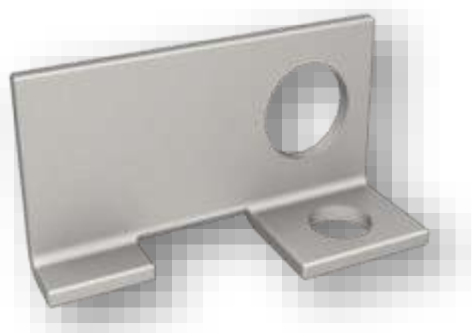
Injection molded

Cost of alternatives



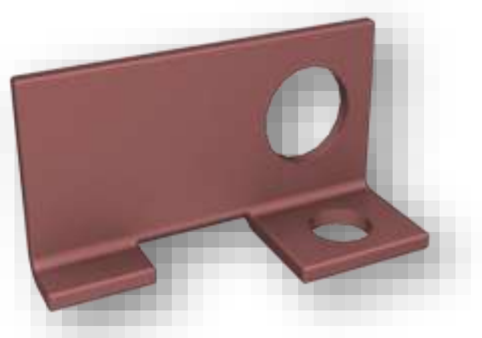
$0.75

24 gage (0.61 mm) thick steel



$2.42

stainless steel



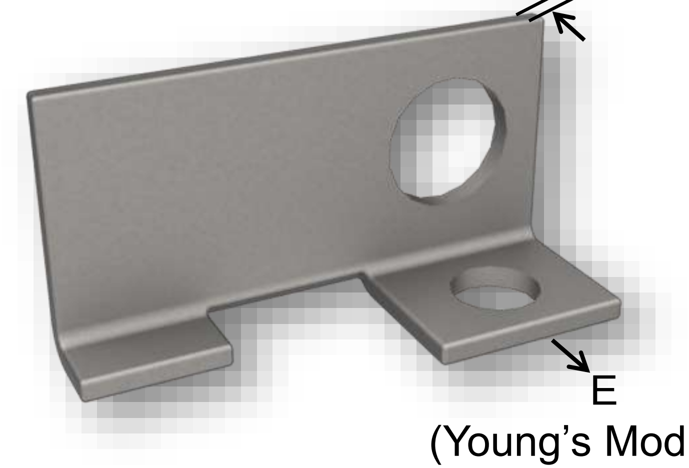
$1.31

24 gage (0.61 mm) thick steel
painted

$0.61

Injection molded

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

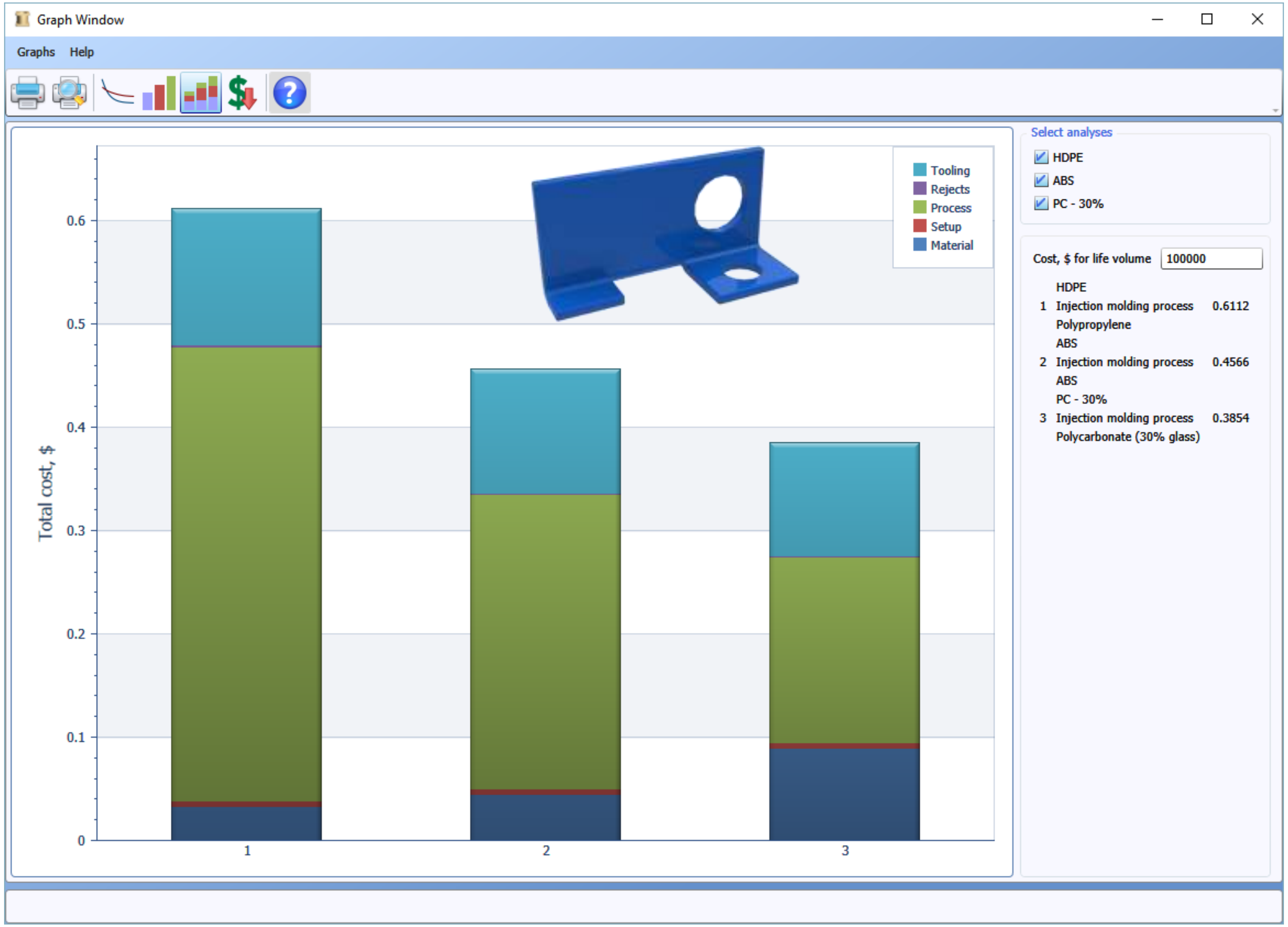
Injection Molding example

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

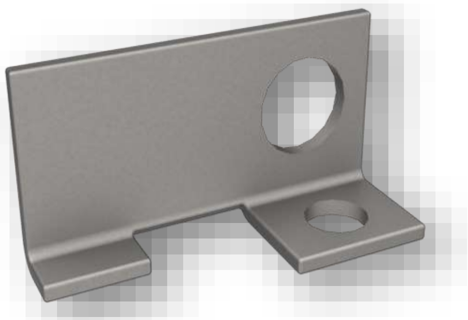
Material	Thickness (mm)	Cooling time (sec)	Process cost*
Polyethylene	3.7	29.6	$0.68
ABS	2.8	13.6	$0.31
PC (30% glass)	2.0	6.2	$0.14

** based on same machine; cooling time only*

Injection Molding example

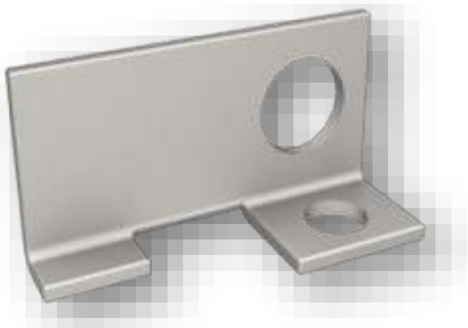


Final Design Decision Result



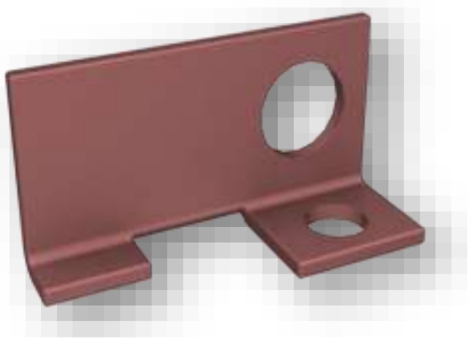
$0.75

24 gage (0.61 mm) thick steel



$2.42

stainless steel



$1.31

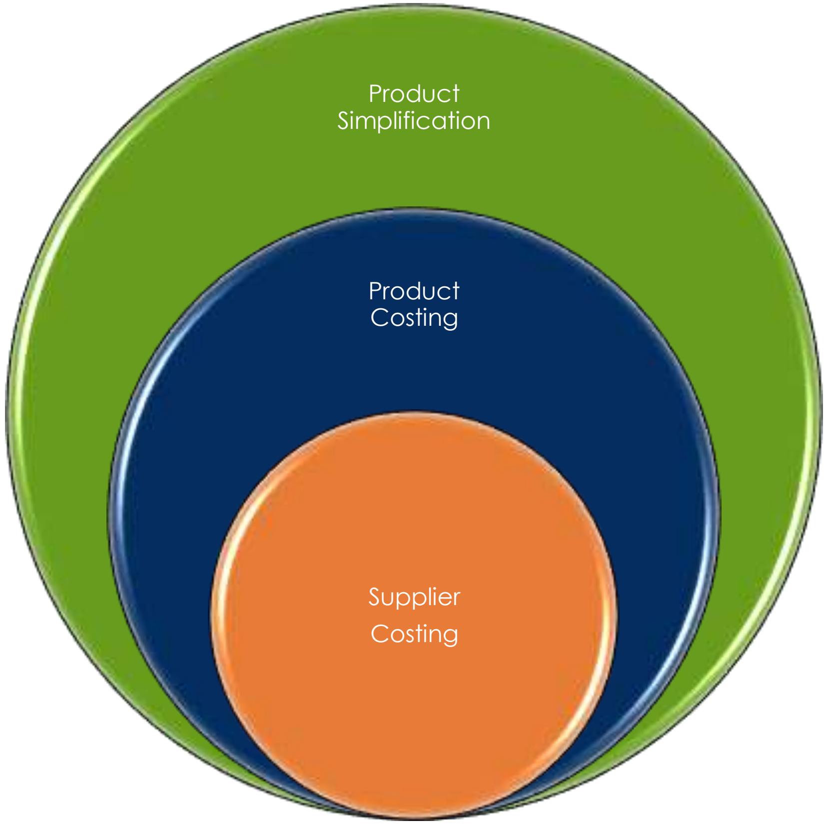
24 gage (0.61 mm) thick steel
painted

$0.61

$0.39

Includes amortized tooling cost

Injection molded



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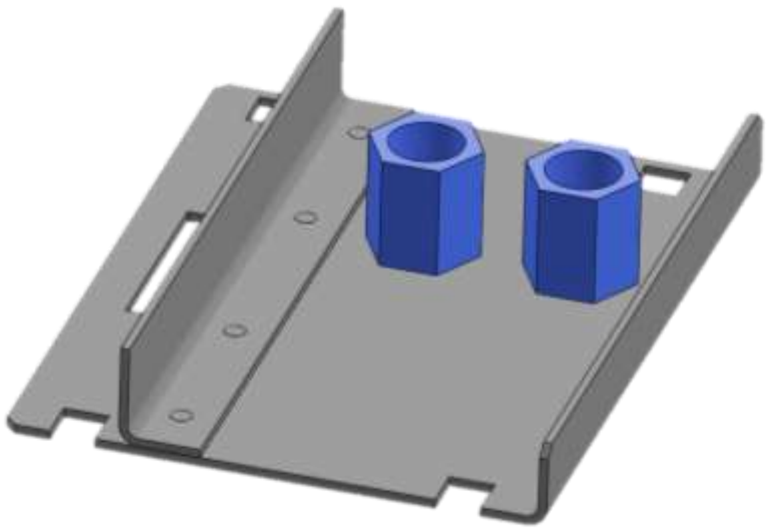
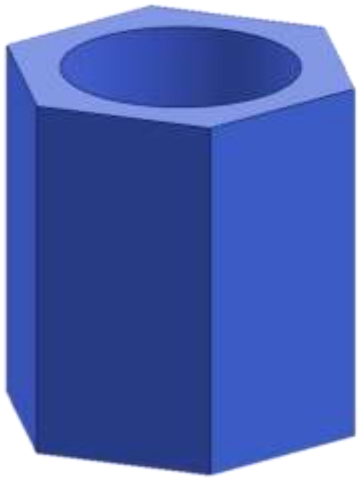
DFA as a design decision tool

- 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

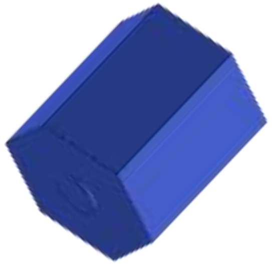
Sample Product Design

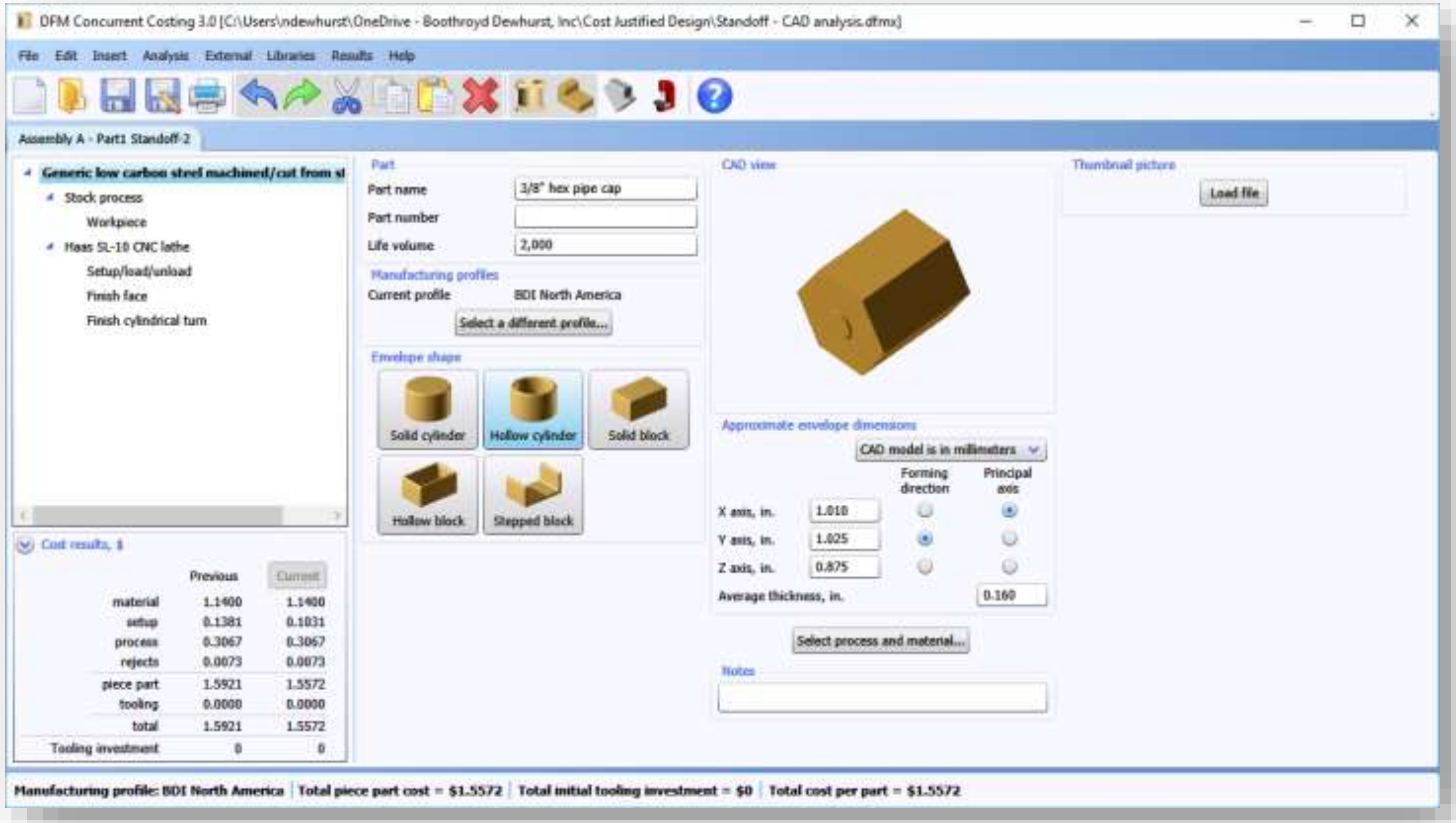


- Simple to design
- Use of off the shelf components
- No tooling investment required
- Fixtures required for welding and alignment
- Prototype or production



Sample Assembly – Part 1

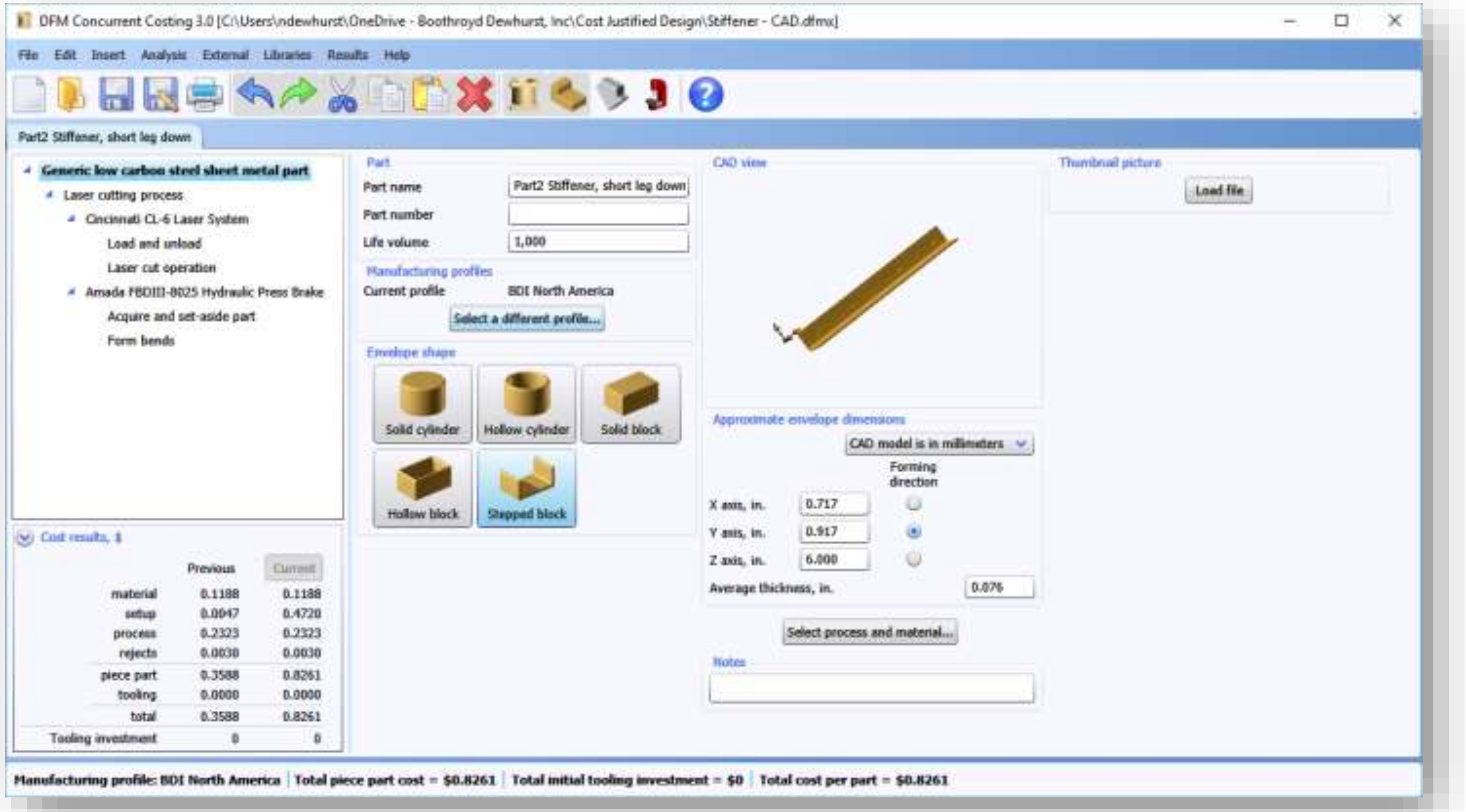


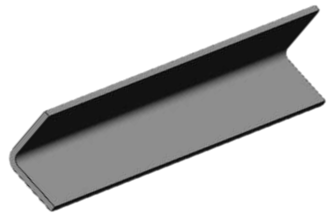


Cost Breakdown	Cost, $
Material	$1.1400
Setup	$0.1031
Process	$0.3067
Rejects	$0.0073
Piece Part Cost	$1.5572

Part 1 Analysis – Details

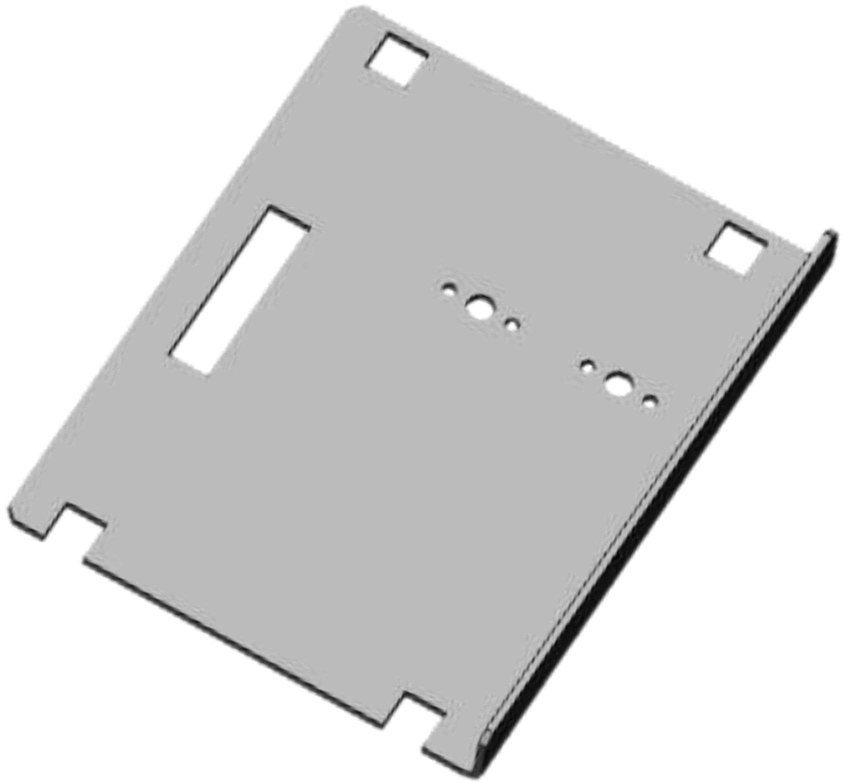
Sample Assembly – Part 2



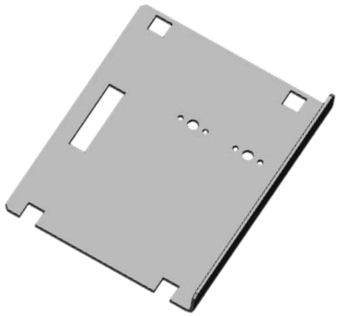


Cost Breakdown	Cost, $
Material	$0.1188
Setup	$0.4720
Process	$0.2323
Rejects	$0.0030
Piece Part Cost	$0.8261

Part 2 Analysis - Details



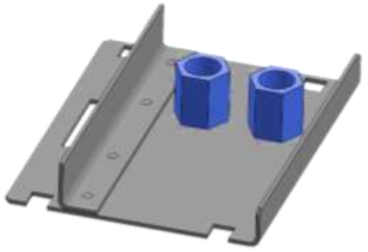
Sample Assembly – Part 3

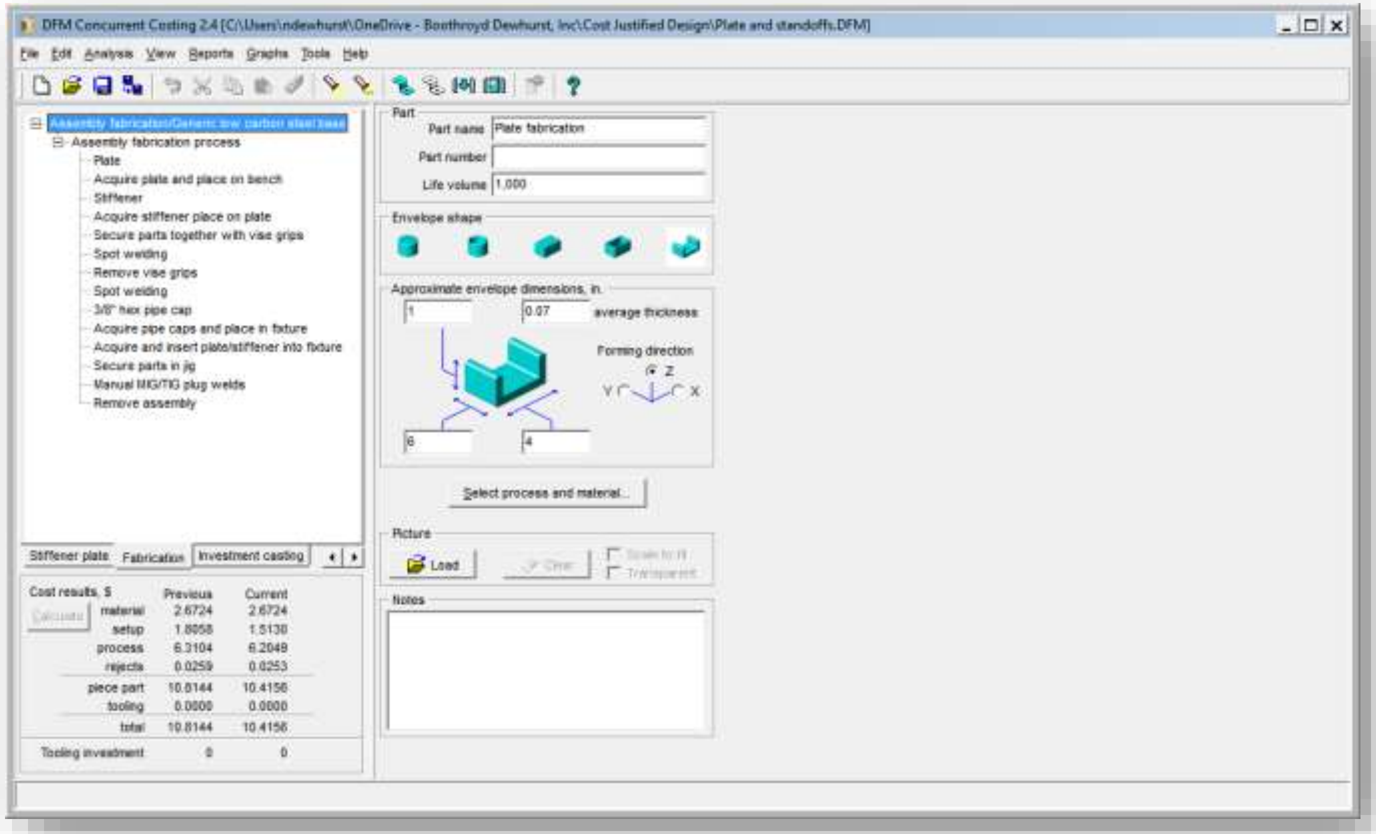


Cost Breakdown	Cost, $
Material	$0.3197
Setup	$0.4720
Process	$0.5582
Rejects	$0.0080
Piece Part Cost	$1.3579

Part 3 Analysis - Details

Assembly Fabrication

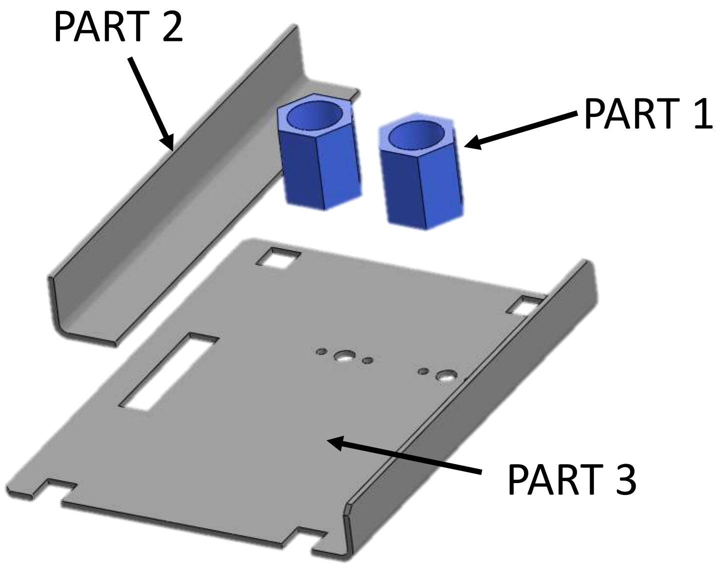




Cost Breakdown	Cost, $
Material	$2.6724
Setup	$1.5130
Process	$6.2049
Rejects	$0.0253
Piece Part Cost	$10.4156*

*Total cost including assembly and welding at a rate of $65/hr.

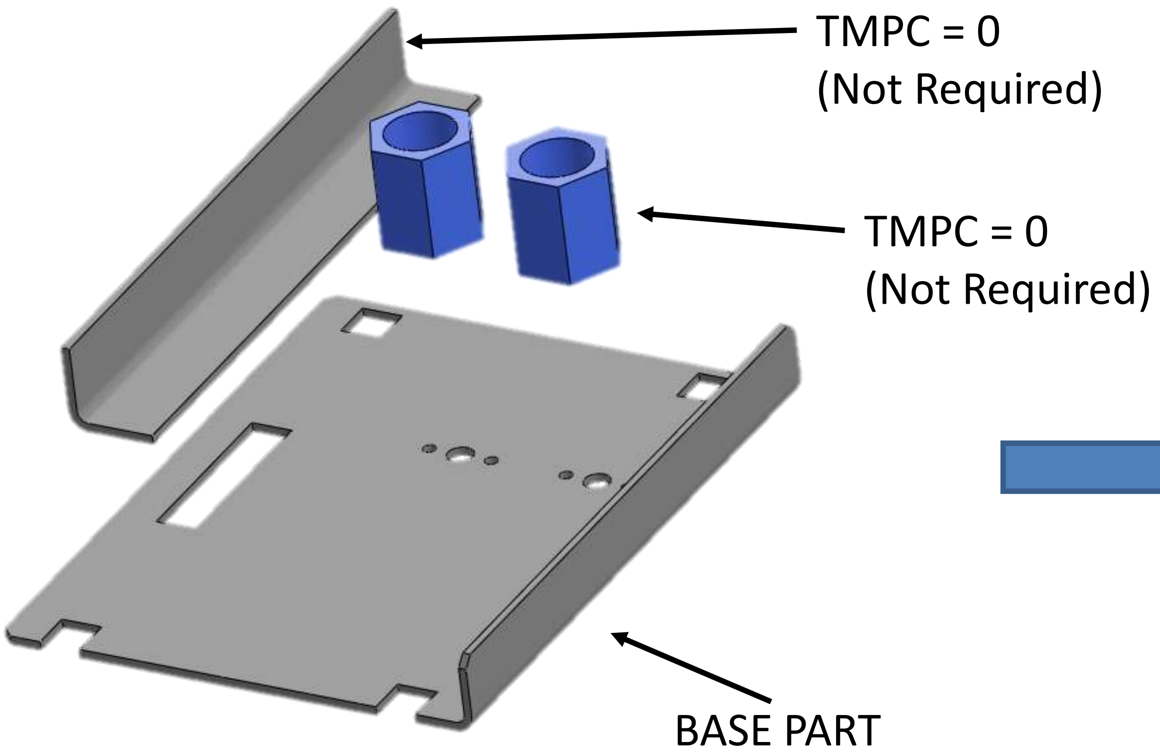
Cost Summary

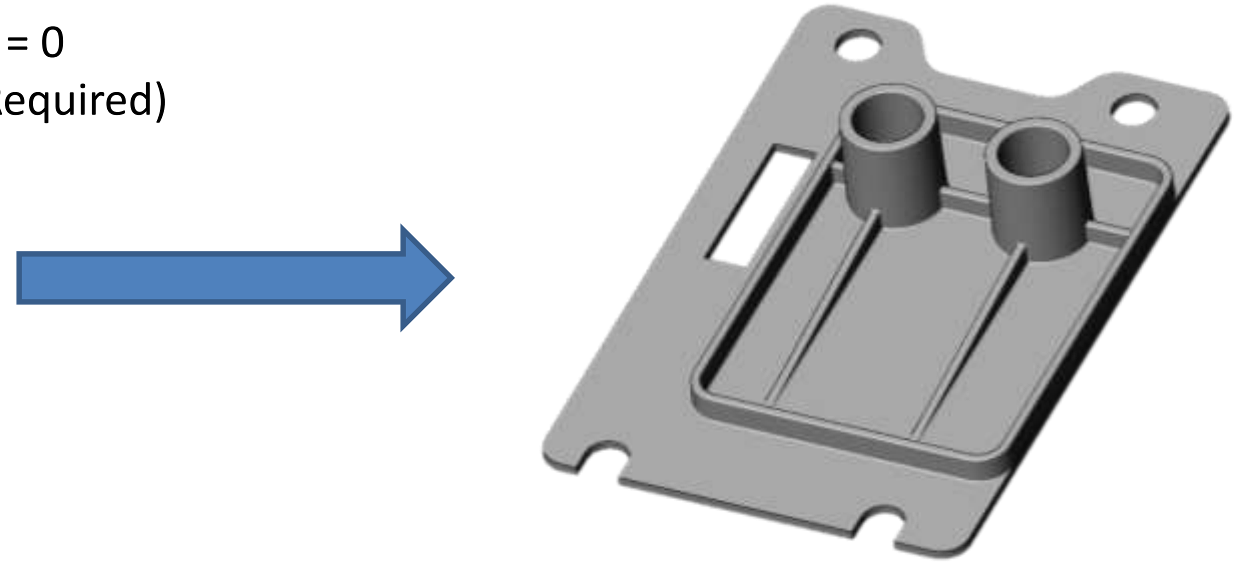


Cost Breakdown	Cost, $
Part 1	$1.5572
Part 2	$0.8261
Part 3	$1.3579
Assembly Time	3.715 min.
Assembly Fabrication	$10.4156*

*Total cost including assembly and welding at a rate of $65/hr.

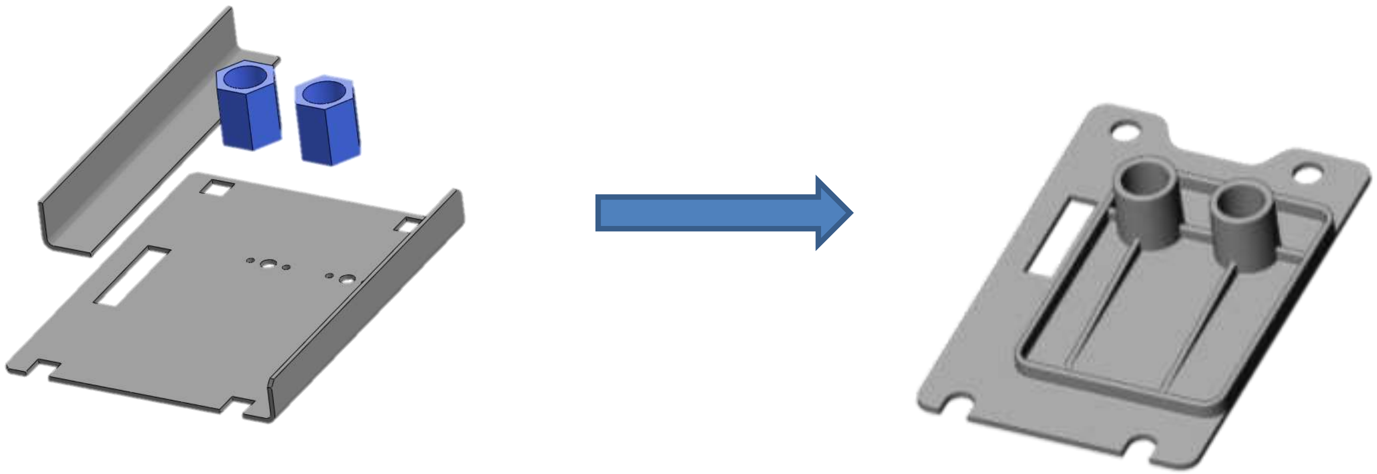
Apply DFA



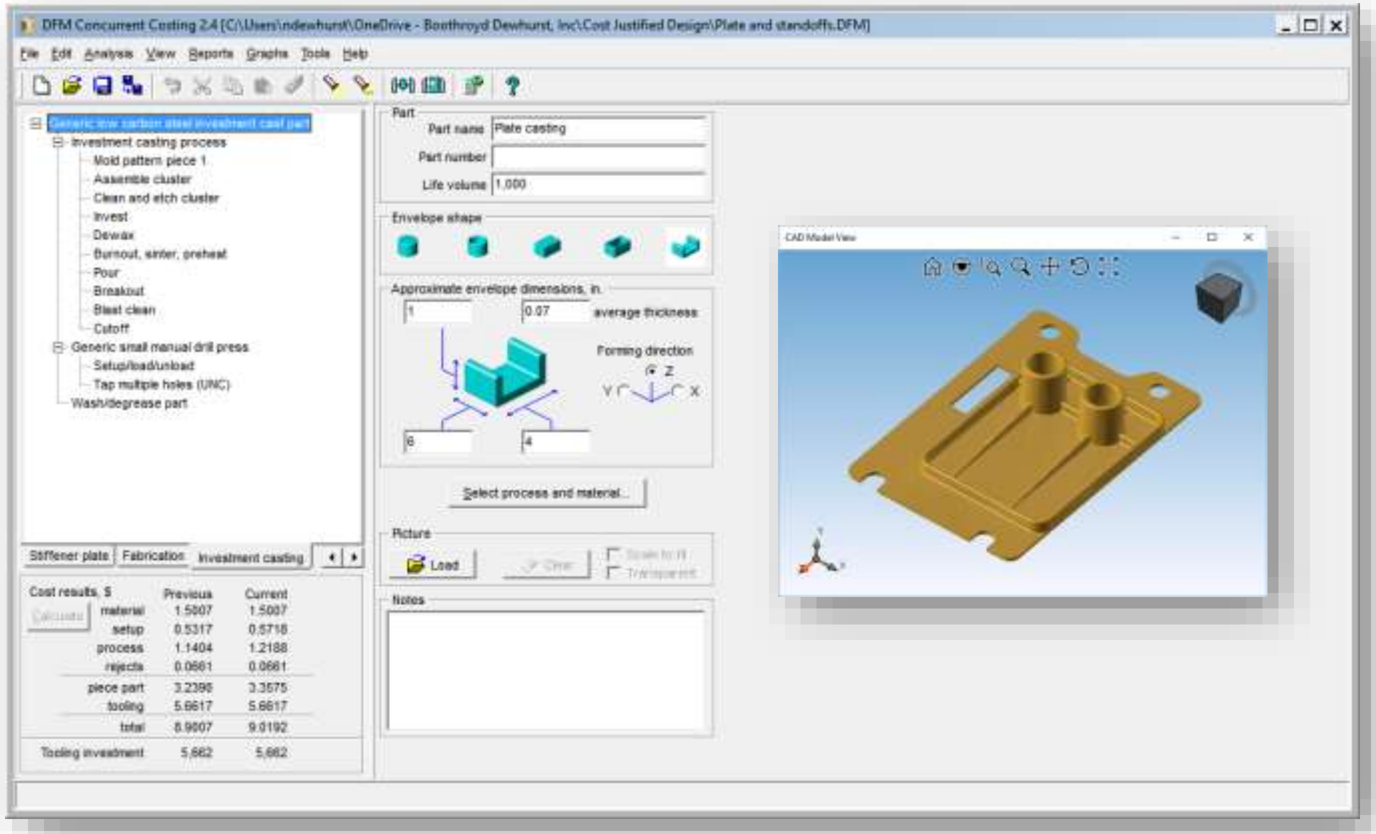


Single Piece Investment Casting

Apply DFMA



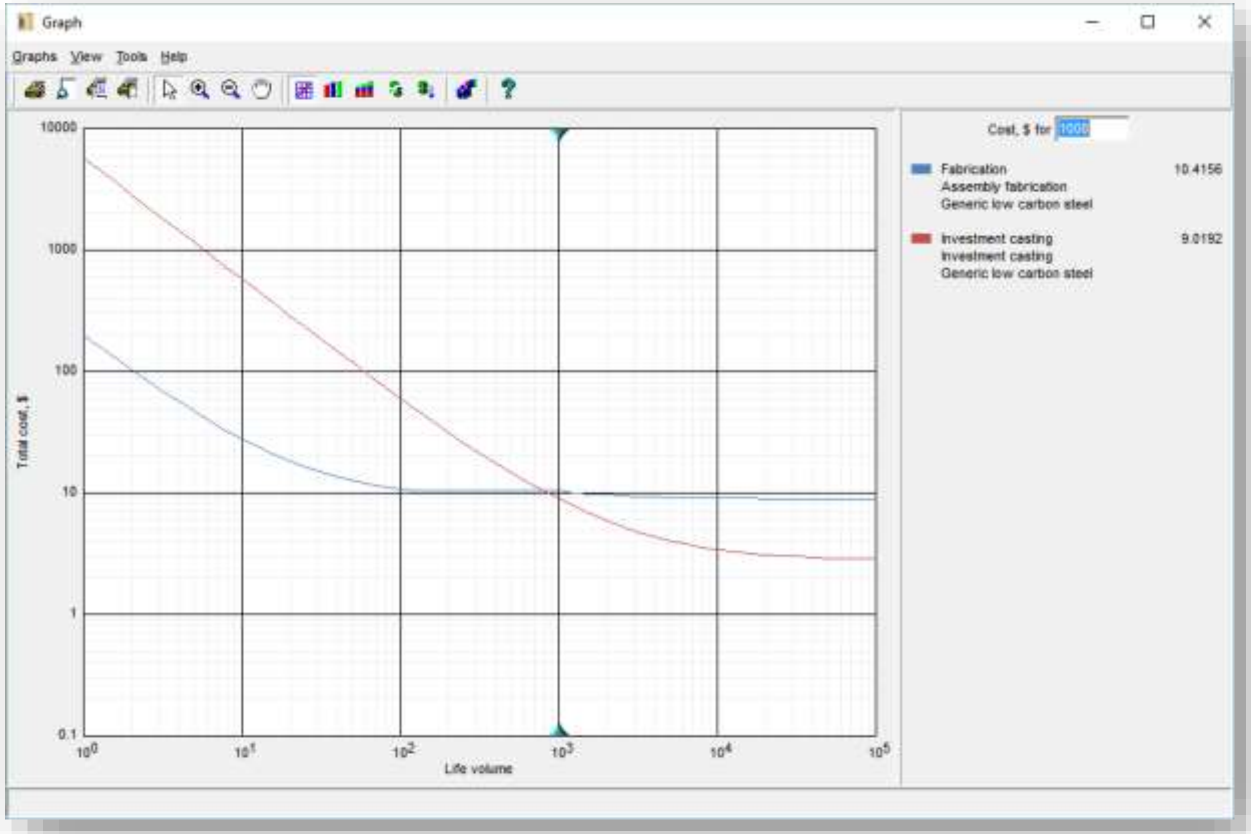
Great DFA idea and a great concept but what will it cost to manufacture?

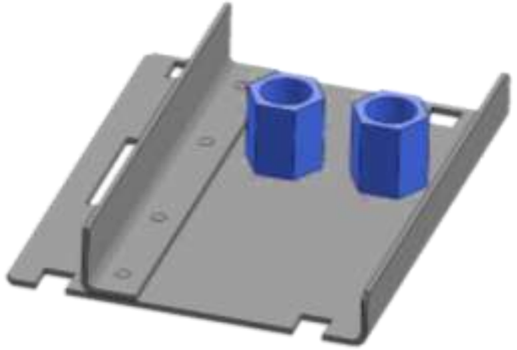


Cost Breakdown	Cost, $
Material	$1.5007
Setup	$0.5718
Process	$1.2188
Rejects	$0.0661
Piece Part Cost	$3.3575
Tooling Investment	$5,662
Total Cost	$9.0192

Production part – Details

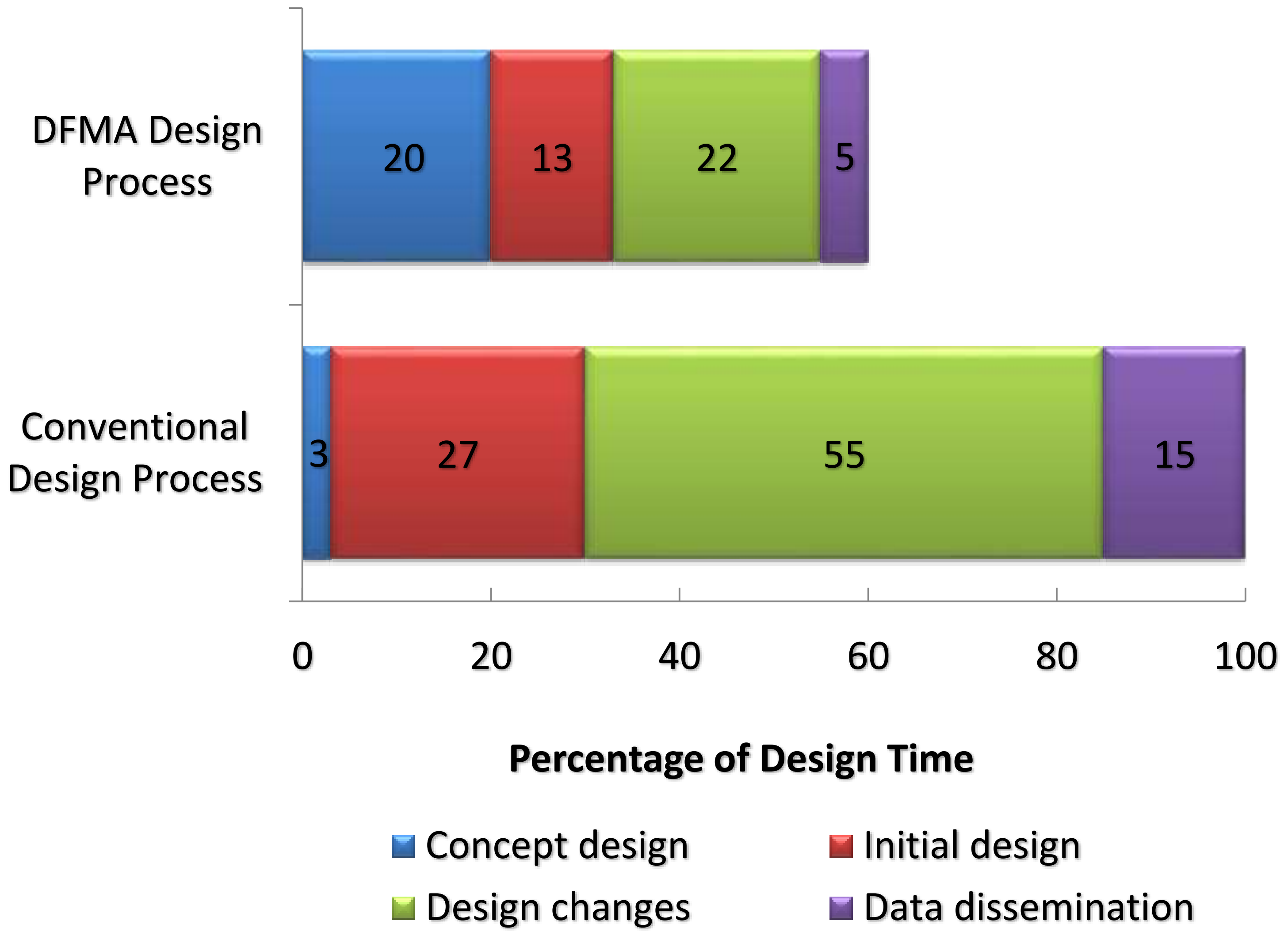
Summary Results Using DFA Design Decision





Design	Cost, $
Assembly Fabrication	$10.4156
Investment Casting	$9.0192

DFMA's Impact on Design Cycle



Source: Plastics Design Forum

Design Decision 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