Bringing Cost into Design Optimization

Amanda Bligh

aPriori

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2017

ELYSIUM Parker Aerospace NORTHROP GRUMMAN BOEING

Bio

Amanda Bligh has been with aPriori for over a decade and is currently focusing on advanced capabilities research and helping customers with advanced solutions to manufacturing costing questions.

During her time at aPriori, she has built numerous manufacturing cost models, worked with a wide selection of customers both in the US and Europe and has been heavily engaged in understanding customers' needs and use cases.

She completed her BS at MIT in mechanical engineering and her MS at the University of Rhode Island in manufacturing and systems engineering, focusing her research on improving tools within the product development process. At URI, she has also taught classes on design for manufacturability to undergraduates and graduate students.

She is currently working on her PhD in manufacturing and systems engineering. In her free time, Amanda enjoys mountain biking, indoor rock climbing and reading.

Two Statements

Simulation toolsets have provided engineers with a powerful ability to understand a product's performance earlier in the development cycle than ever before.

Manufacturing cost is the most critical non-performance constraint on a product's design.

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Agenda

- Simulation & Optimization Review
- aPriori and 3D Costing Introduction
- 3D Costing in Simulation & Optimization Workflow
- Fitting into your Process
- What's Coming

Simulation & Optimization Review

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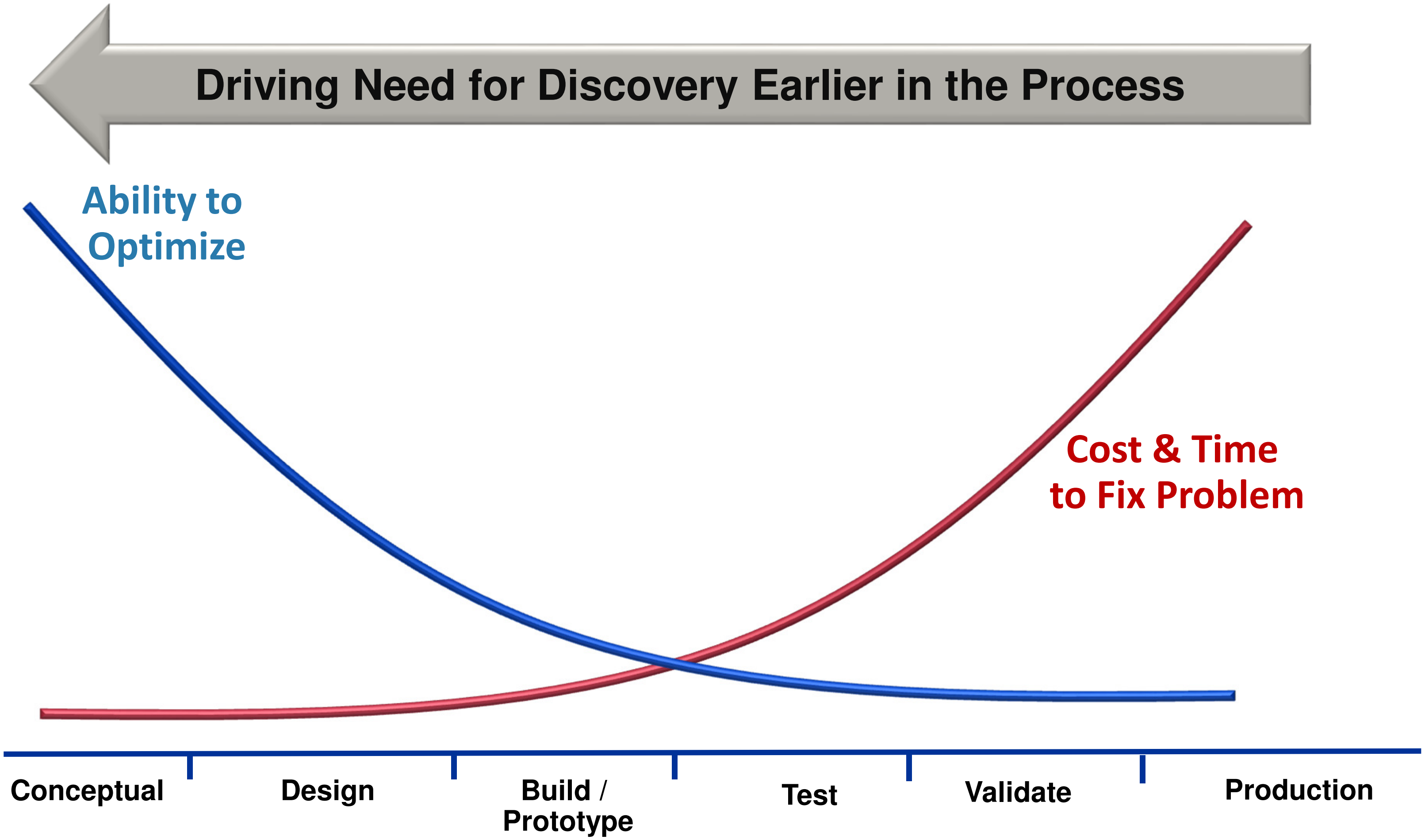
Competitive Pressures Challenging the Traditional Product Develop Process



Competitive Pressures Challenging the Traditional Product Develop Process

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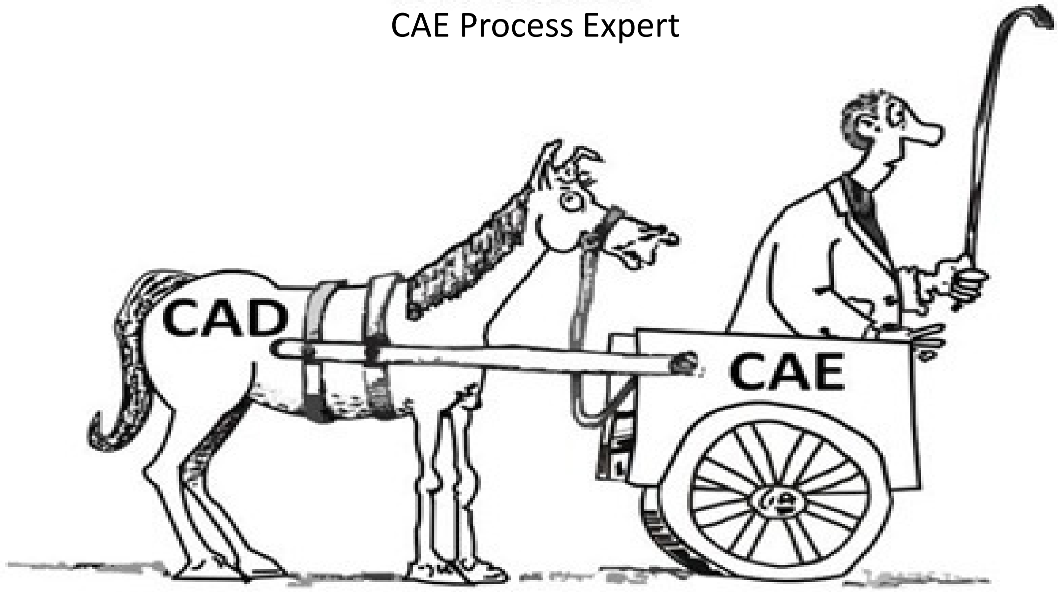
“Design-driven simulation is backwards.”

-Jeff Waters
CAE Process Expert



Generalized Flow for PIDO (Process Integration and Design Optimization)

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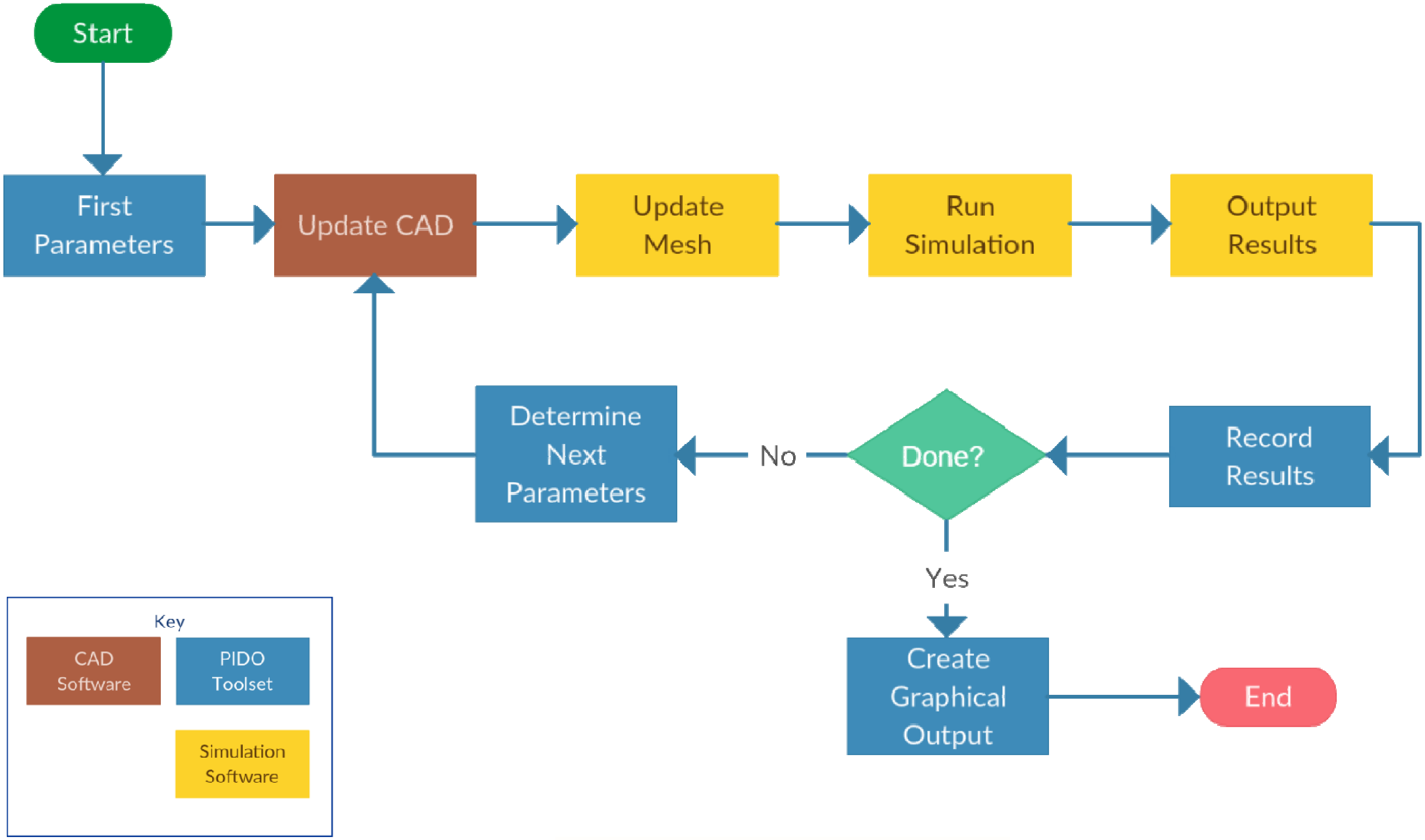
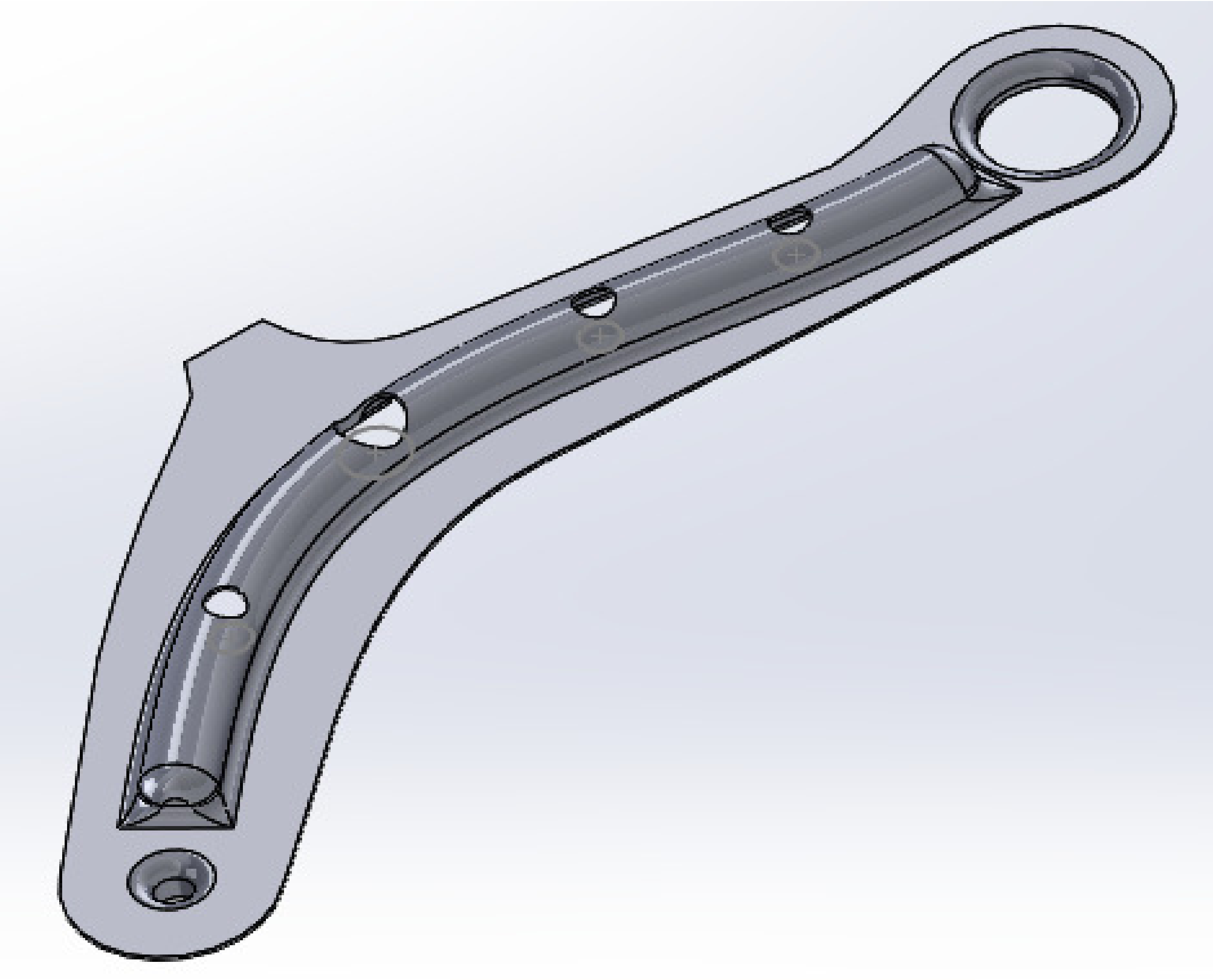
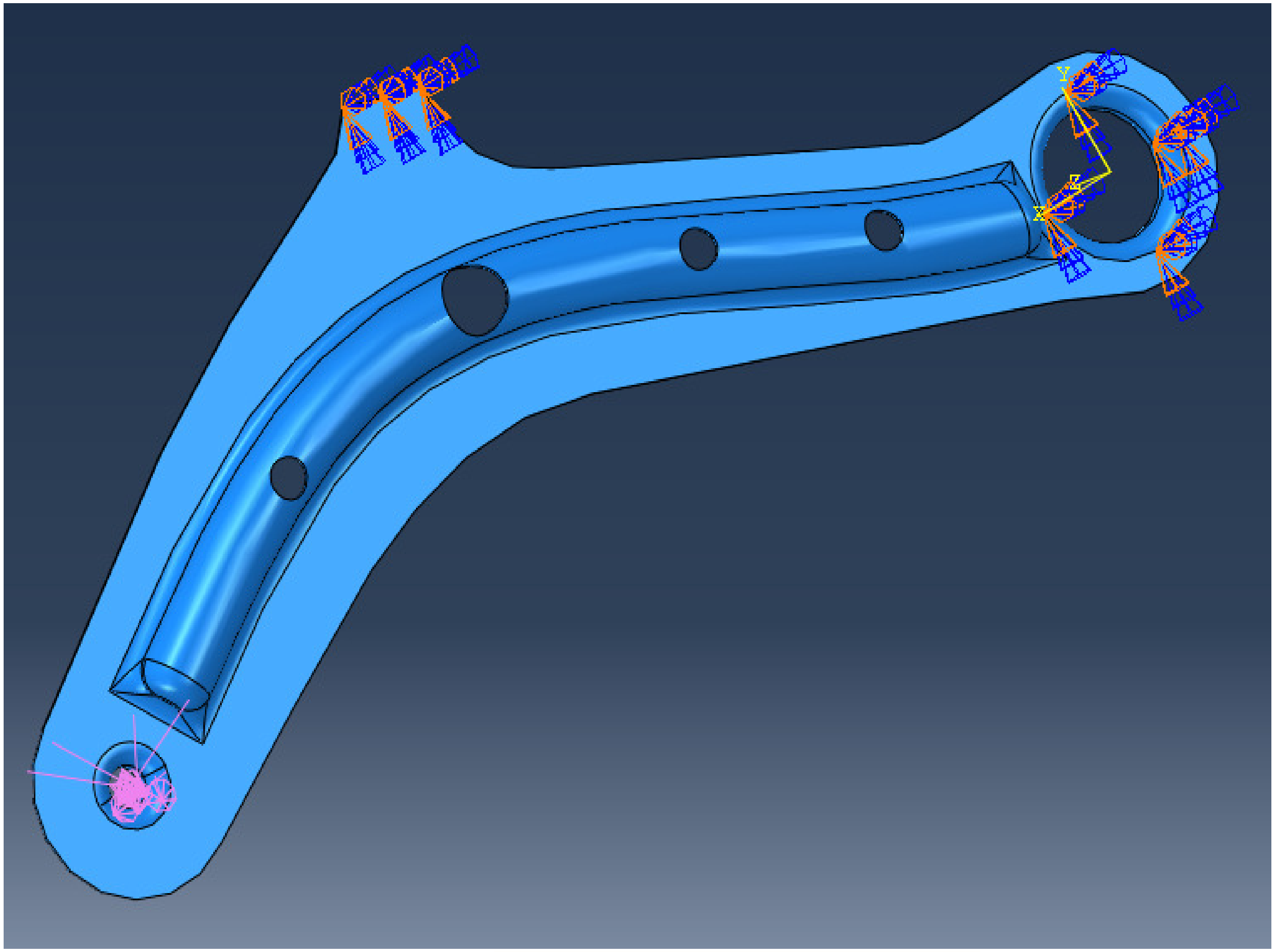


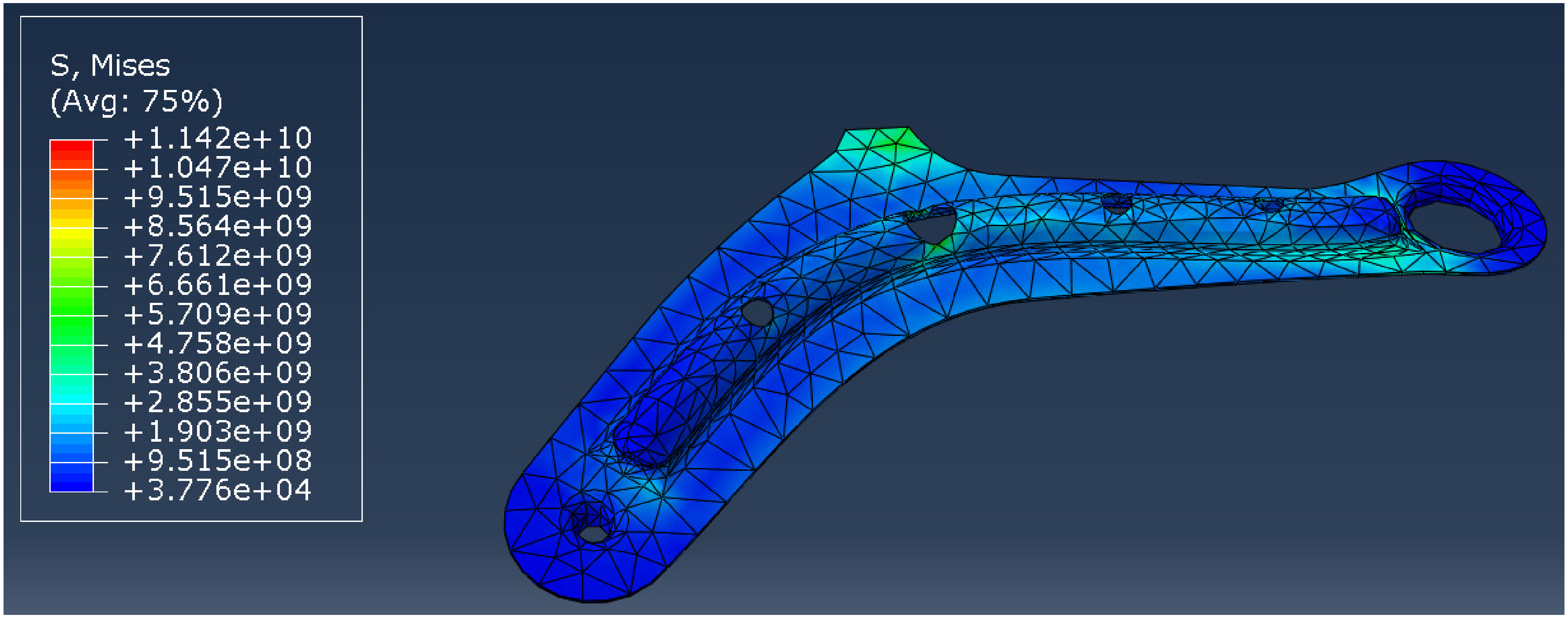
Example: Suspension Arm



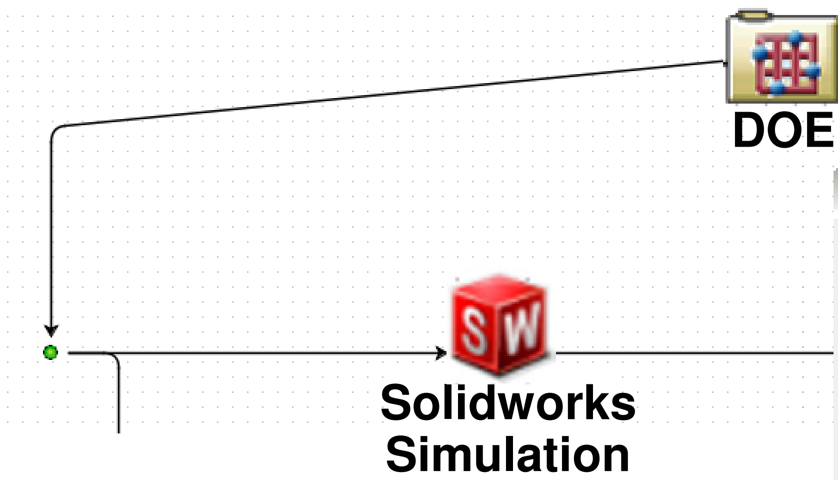
Example: Suspension Arm (continued)



Example: Suspension Arm (continued)



Example: Suspension Arm (continued)



General | Factors | Design Matrix | Postprocessing

Show: Values

	Thickness@Boss-Extrude1@stampedAuto_noFlange_Part
1	0.028125
2	0.03125
3	0.034375
4	0.0375
5	0.04375
6	0.05
7	0.05625
8	0.0625
9	0.0703125
10	0.078125
11	0.09375
12	0.109375
13	0.125

Example: Suspension Arm (continued)

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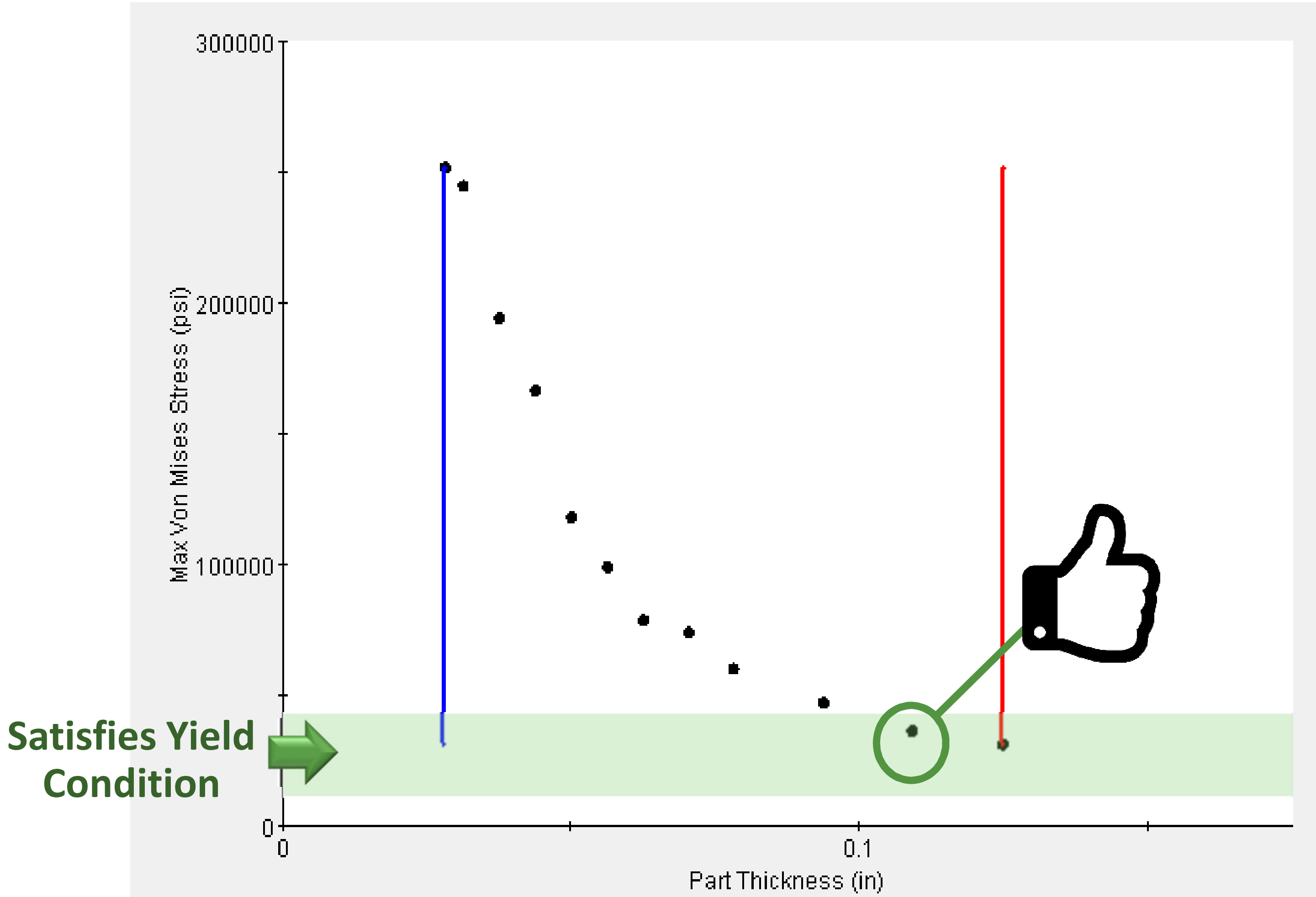
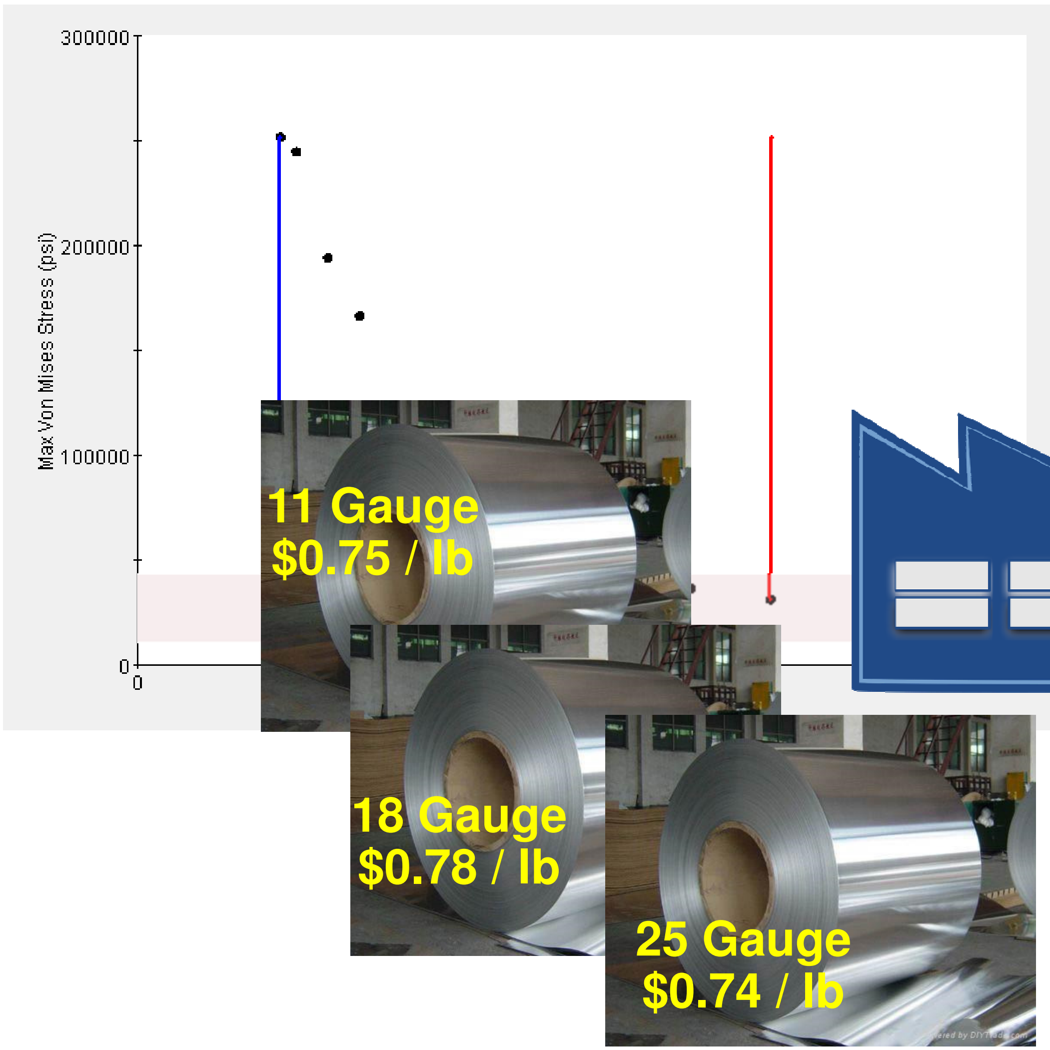
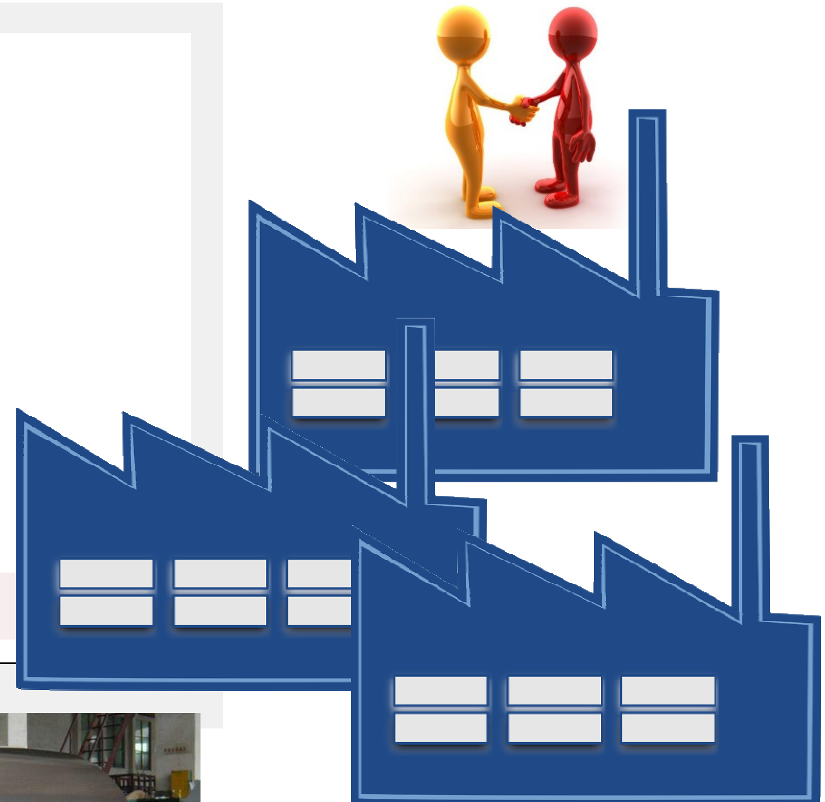


But the Reality is…

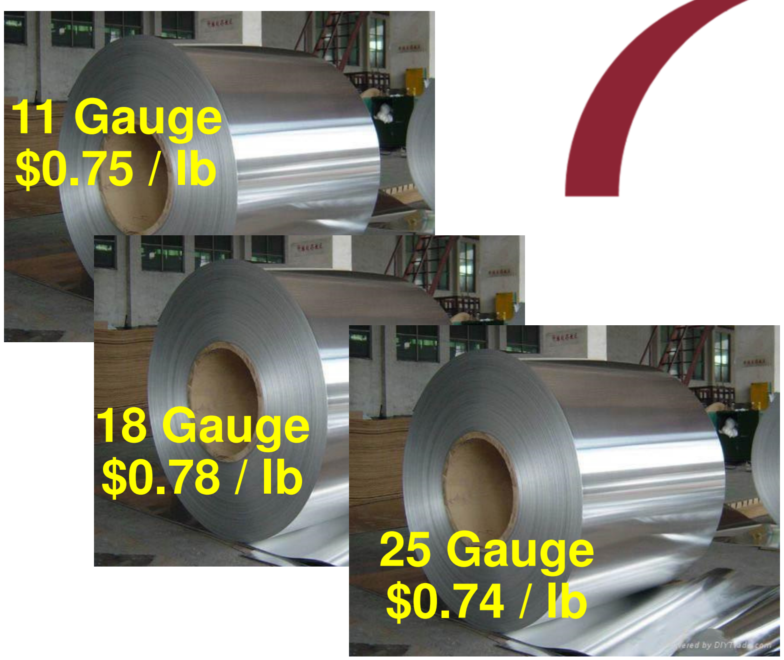




Other Thicknesses:
$1.00 / lb

Question

How do we get the cost information into the hands of the engineer or analyst to avoid early decisions that drive down stream costs?



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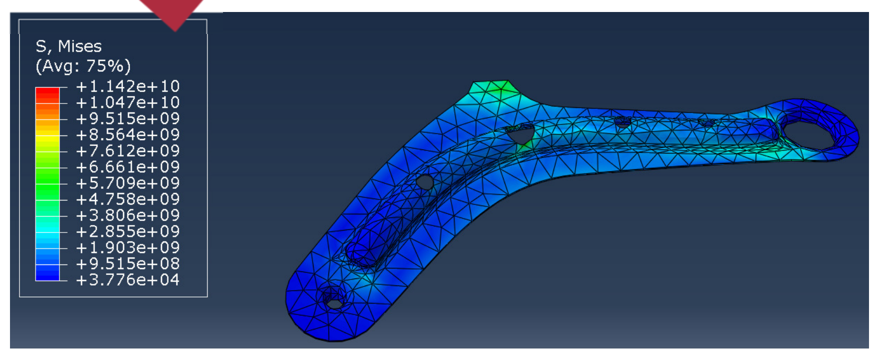

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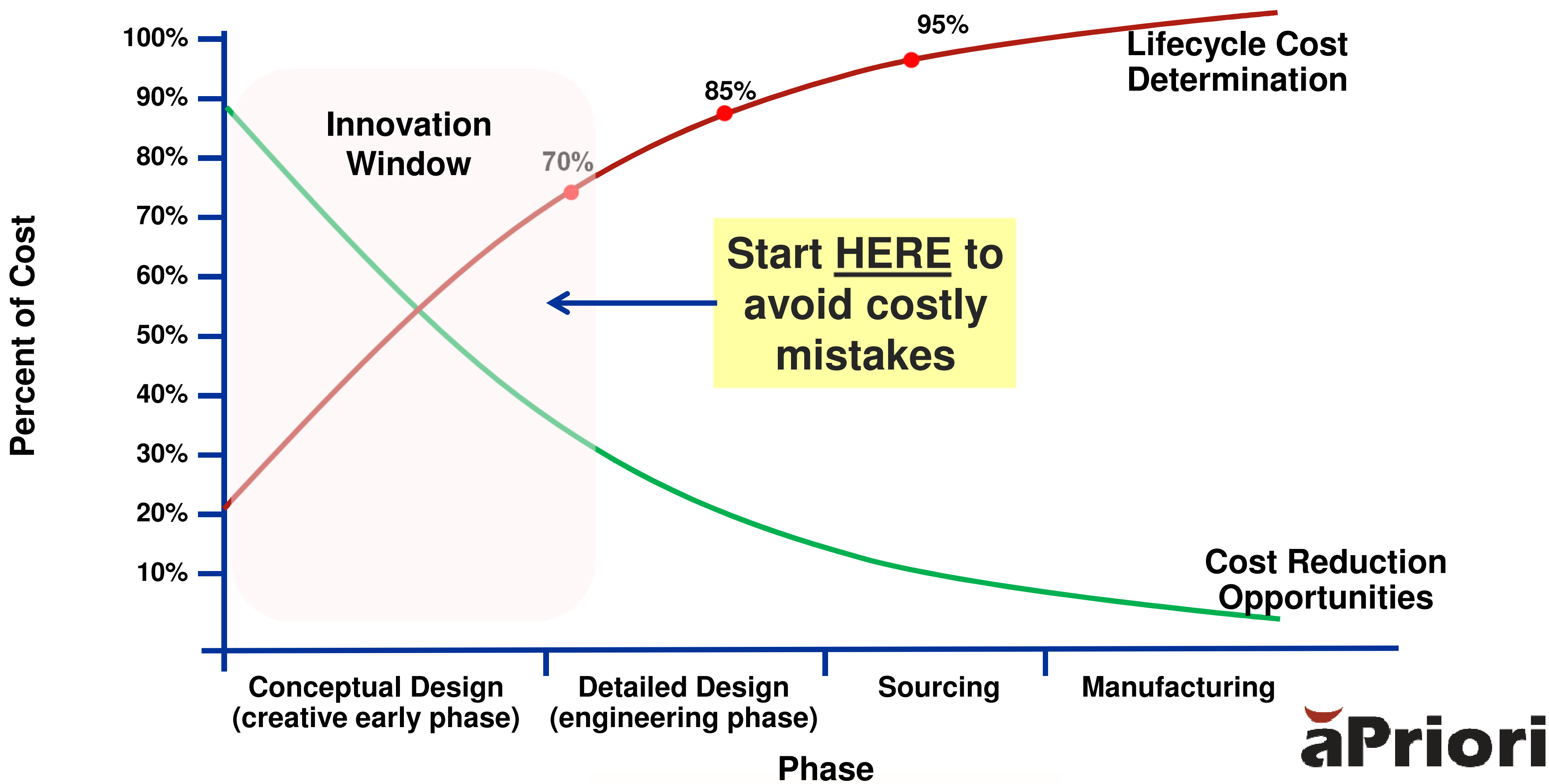
3D Costing In aPriori

Product Cost Tradeoff Decisions Start Early



Internal Systems & Processes

MANUFACTURING & SUPPLIERS

COST SPECIALISTS/ SOURCING

Not Optimized for Cost Management Challenges

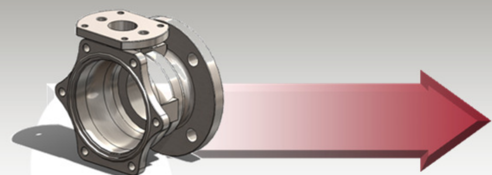
- Cost management processes are most robust within key functions – less well established across functional groups
- Cost data is stored in disparate, unconnected locations
- No consistent view of cost across the organization
- Understanding of cost varies significantly across the organization

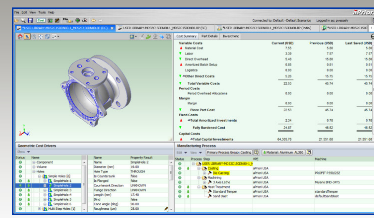
PRODUCT DESIGN

MANAGEMENT

aPriori – Our Unique Value

STEP 1 Automatically pulls details about the part from 3D solid CAD model…

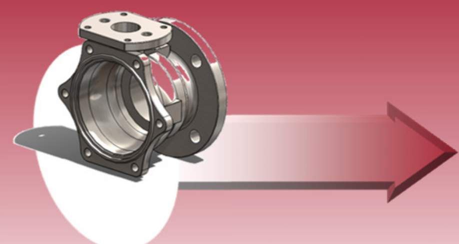


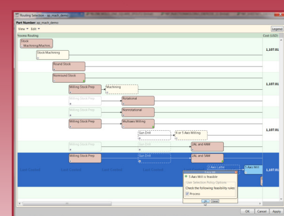


aPriori Evaluates:
- ✓Design Geometry
- ✓Material Type
- ✓Production Volume

All major CAD systems supported

STEP 2 Based on the details from the CAD model, automatically evaluates all the different ways the part could be manufactured…



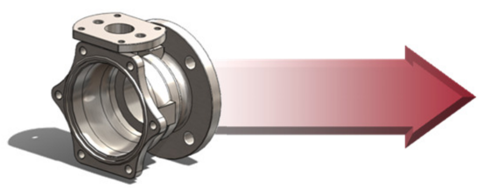


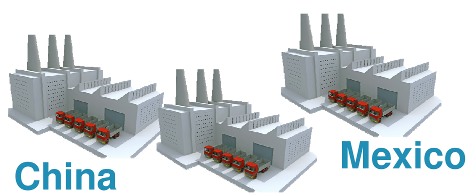
aPriori Evaluates:
- ✓Manufacturing Process
- ✓Machine Rules
- ✓Facility Rules

Dozens of manufacturing processes included out of the box

STEP 3 Automatically calculates costs across different geographical locations/factories…

*Data from 60+ major global geographies





aPriori Considers:
- ✓Labor Rates
- ✓Material Rates
- ✓Overhead rates

aPriori Product Cost Management
Managing Cost Across the Product Lifecycle

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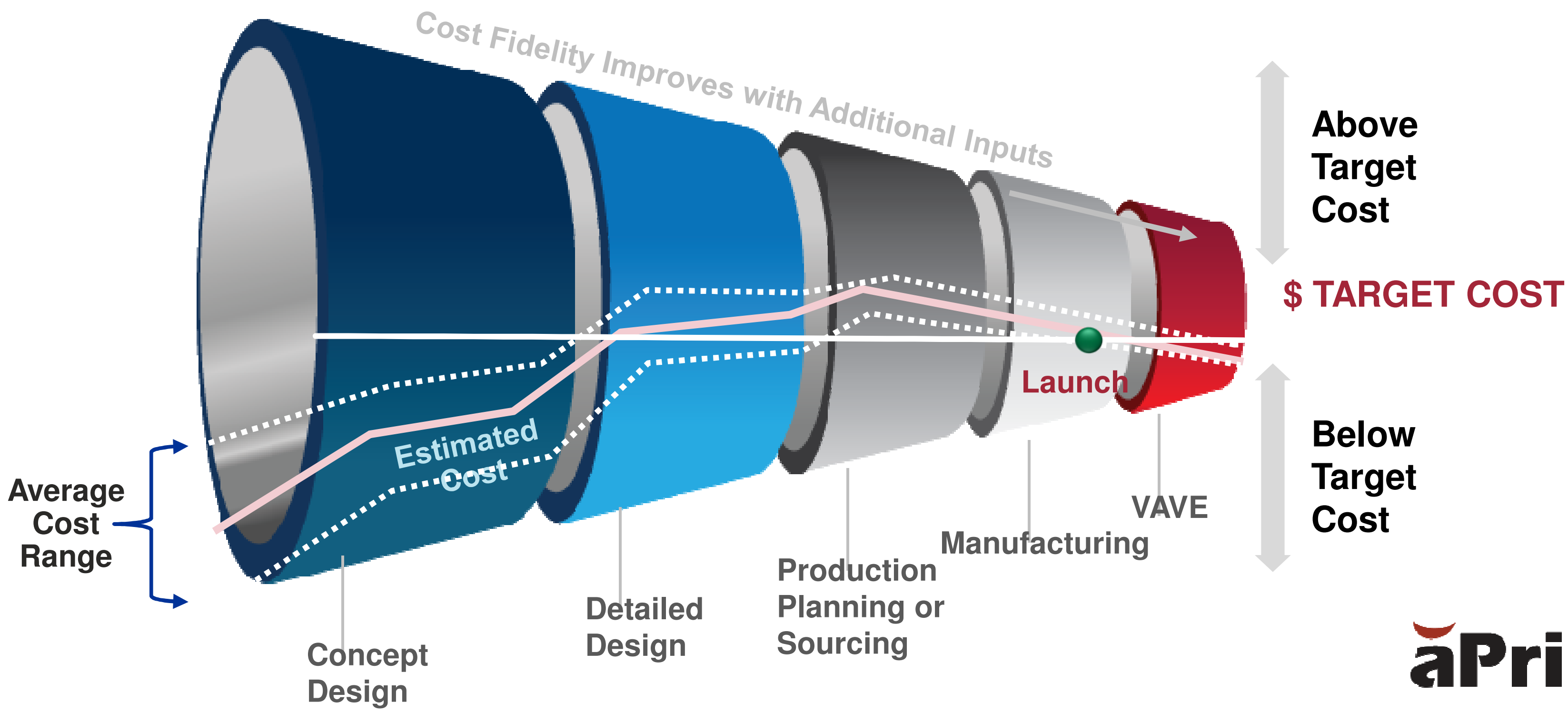
EARLY ESTIMATES
- Automated processes
- Use default settings,
- Update as design changes

SHOULD-COST ESTIMATES
- Refined estimate
- During collaboration, override inputs for actual routing, rates, etc.

MANUFACTURING ESTIMATES
- Adjusted for actual production volume, routing, factory



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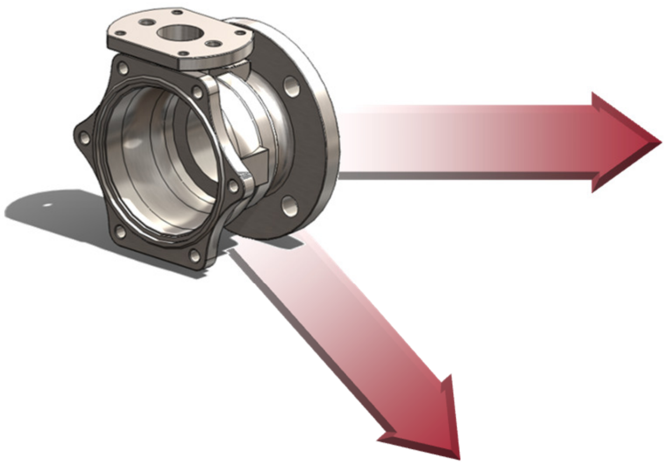
Manufacturing & Cost Analysis Output



Design Summary | Cost Summary | Part Details | Investment

Cost Information

Currency:	USD
Fully Burdened Cost:	2.36
Target Cost:	
% of Target:	
Tooling Cost:	0.00

Production Information

Annual Volume:	5,500
Batch Size:	458
Production Life:	5.00
Lifetime Volume:	27,500

Material Usage

Utilization(%):	47.24
Rough Mass (kg):	1.13
Finish Mass (kg):	0.54
Target Mass (kg):	

Cost by Category (%)

Material:	41.8
Labor:	24.3
Direct Overhead:	12.6
Amortized Batch Setup:	2.0
Amortized Investment:	0.0
Other:	19.4

Process	Percent Cost
Material Stock	0.0
Laser Cut	91.8
Bend Brake	8.2

Material: Steel- CR- 1020

5.00 mm x 1,219 mm x 2,438 mm (Virtual)

Unit Cost (USD / kg): 0.87

Summarized Manufacturing Cost Drivers

Cost Summary | Part Details | Investment

Edit | Table View | Options

Status	Name	Scenario	Annual Volume	Labor Time (s)	Finish Mass (kg)	Material Composition	Material Cost (USD)	Labor (USD)	Direct Overhead (USD)	Amortized Batch Setup (USD)	Logistics (USD)	Other Direct Costs (USD)	Total Variable Costs (USD)
*	Current	Initial	5,500	▲ 2,606	3.34	Aluminum ...	12.48	▲ 21.93	▲ 18.66	▲ 0.98	0.00	1.54	▲ 55.59
	Casting		-	▲ 193	3.34	[illegible]	[illegible]	[illegible]	[illegible]	▲ 0.75	0.00	0.00	▲ 16.91
	Die Casting		-	65	3.34	[illegible]	[illegible]	[illegible]	[illegible]	0.68	0.00	0.00	14.56
	Xray Inspect		-	128	0.00	[illegible]	[illegible]	[illegible]	[illegible]	0.07	0.00	0.00	2.35
	Machining		-	2,413	0.00	[illegible]	[illegible]	[illegible]	[illegible]	0.23	0.00	1.54	38.68
*	Previous	Initial	5,500	2,478	3.34	[illegible]	[illegible]	[illegible]	[illegible]	0.91	0.00	1.54	53.24
*	Last Saved	Initial	5,500	65	3.34	Aluminum ...	7.97	0.53	0.87	0.68	0.00	0.00	10.05

Detailed Manufacturing Results

Automating aPriori with External Commands

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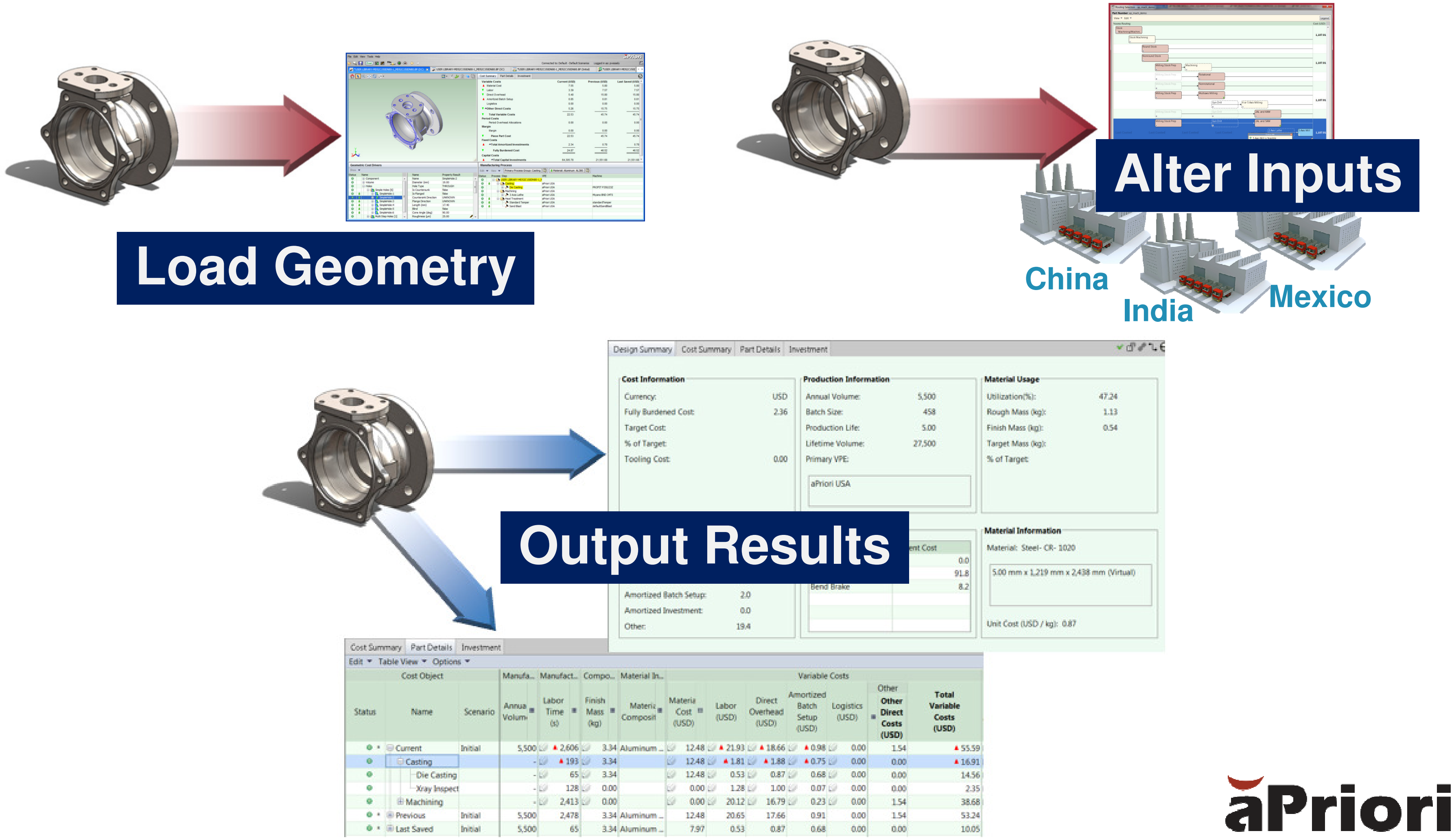

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	Current	Initial	5,500	2,606	3.34	Aluminum ...	12.48	21.93	18.66	0.98	0.00	1.54	55.59
	Casting		-	193	3.34		12.48	1.81	1.88	0.75	0.00	0.00	16.91
	Die Casting		-	65	3.34		12.48	0.53	0.87	0.68	0.00	0.00	14.56
	Xray Inspect		-	128	0.00		0.00	1.28	1.00	0.07	0.00	0.00	2.35
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	Previous	Initial	5,500	2,478	3.34	Aluminum ...	12.48	20.65	17.66	0.91	0.00	1.54	53.24
	Last Saved	Initial	5,500	65	3.34	Aluminum ...	7.97	0.53	0.87	0.68	0.00	0.00	10.05

aPriori Product Cost Management for the Enterprise

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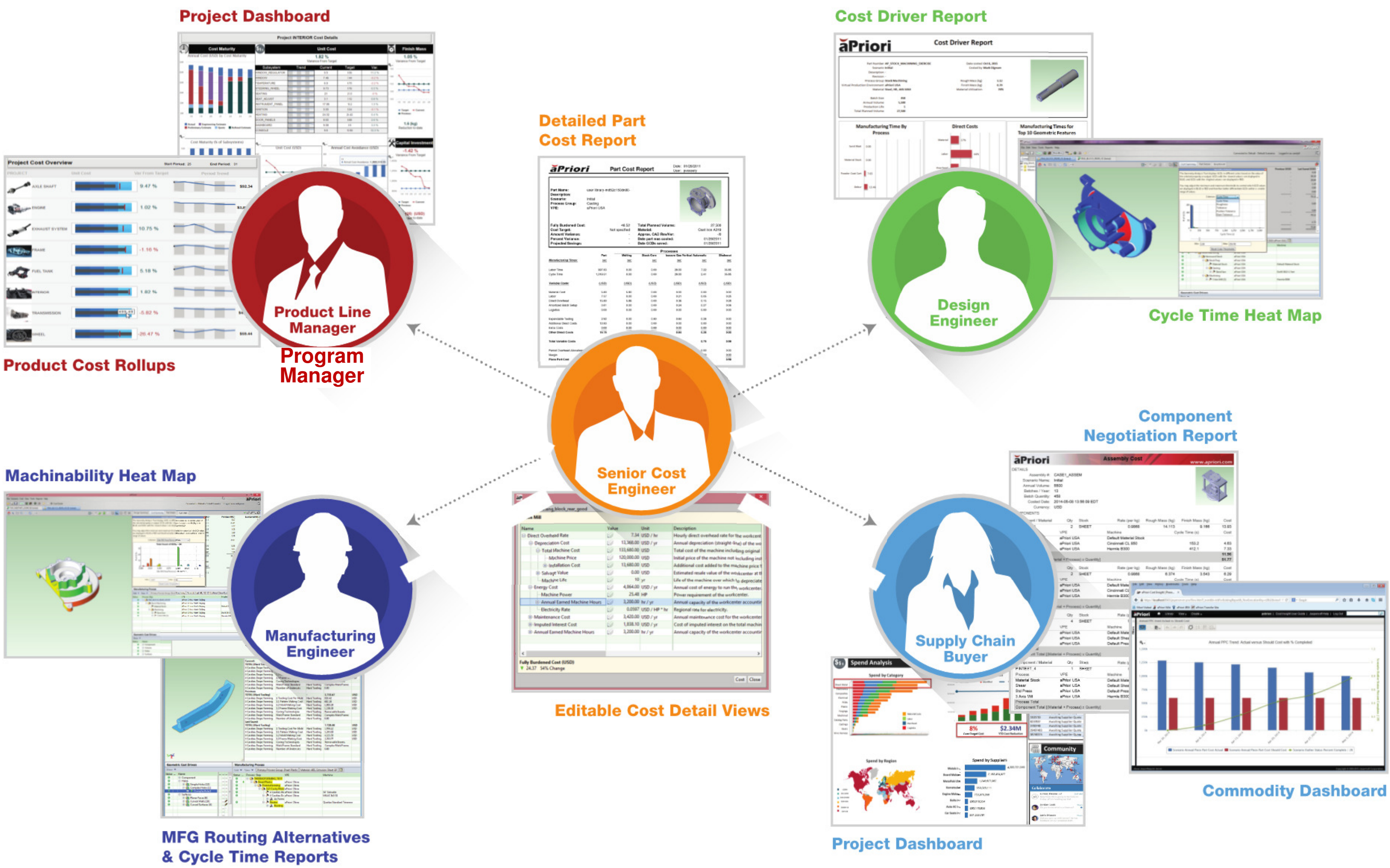

3D Costing In Optimization Workflow

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3D Costing in Optimization Workflow

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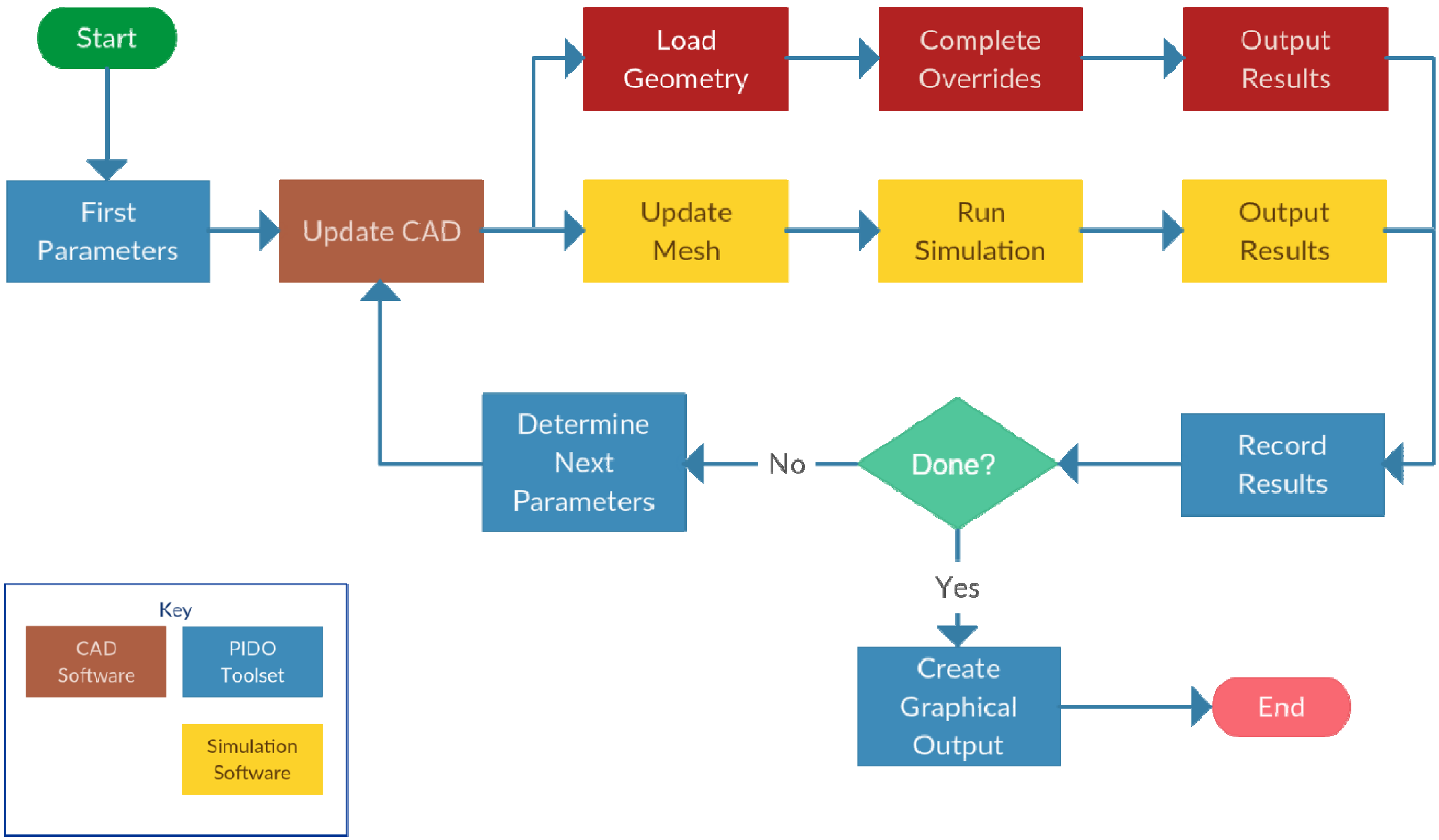

Example: Suspension Arm

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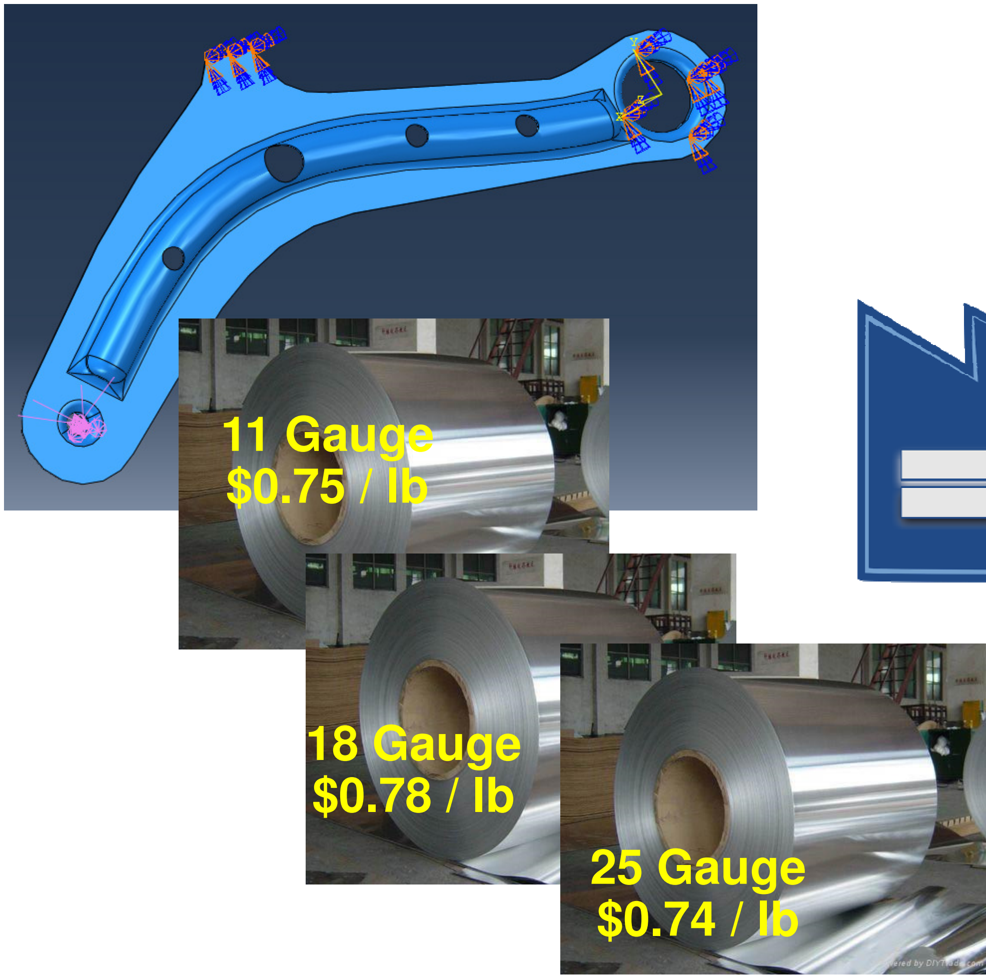
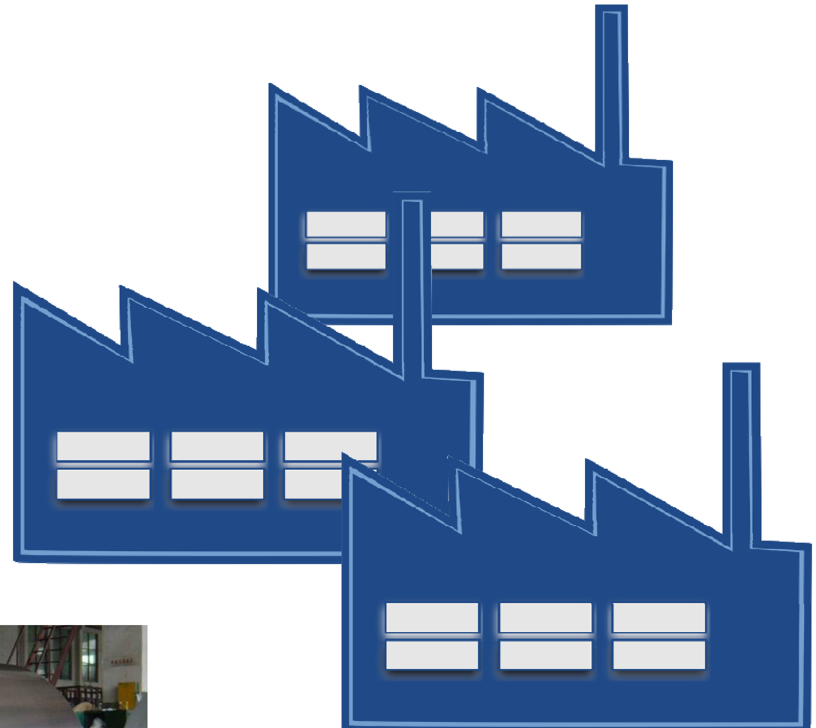
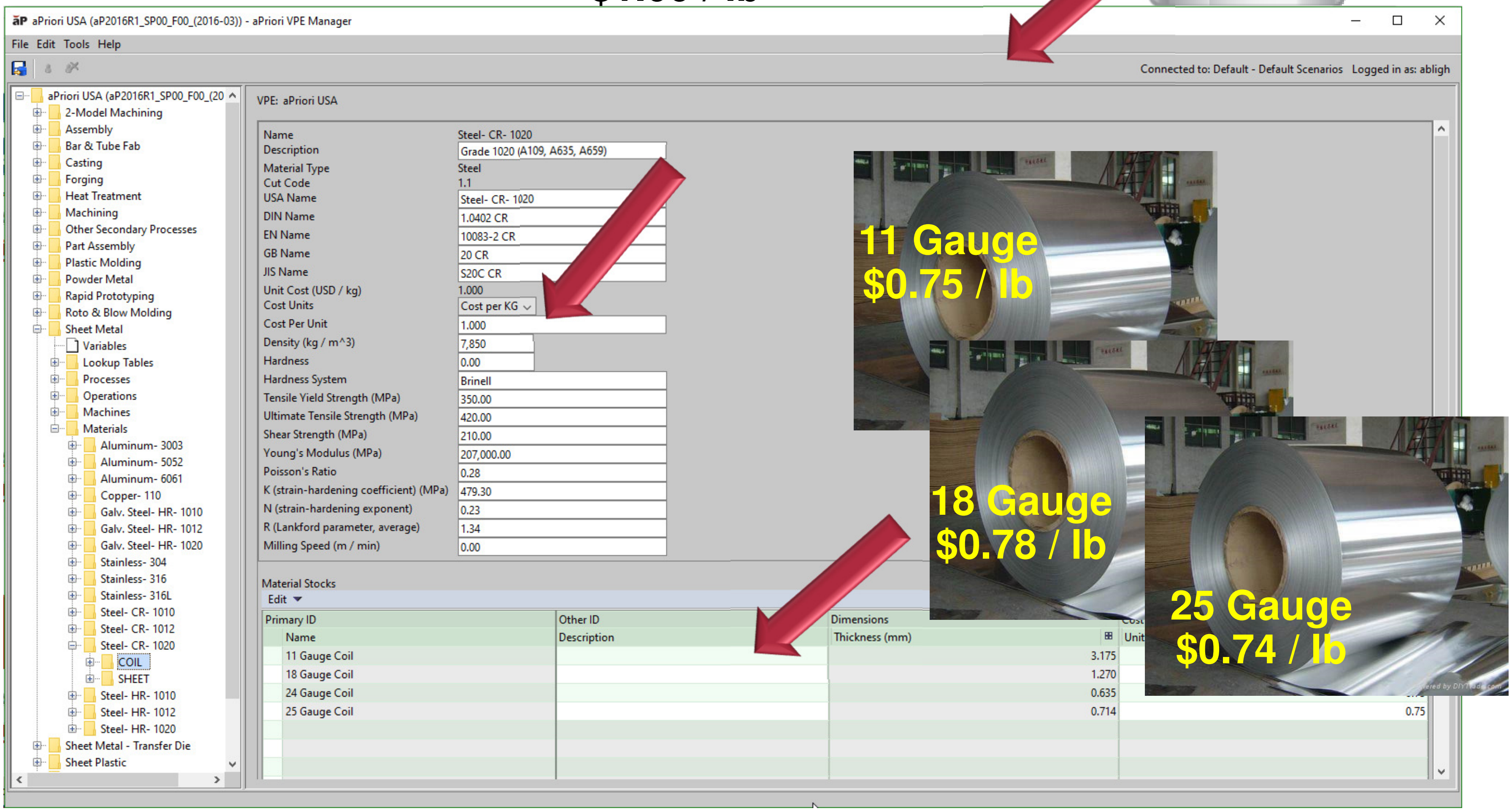




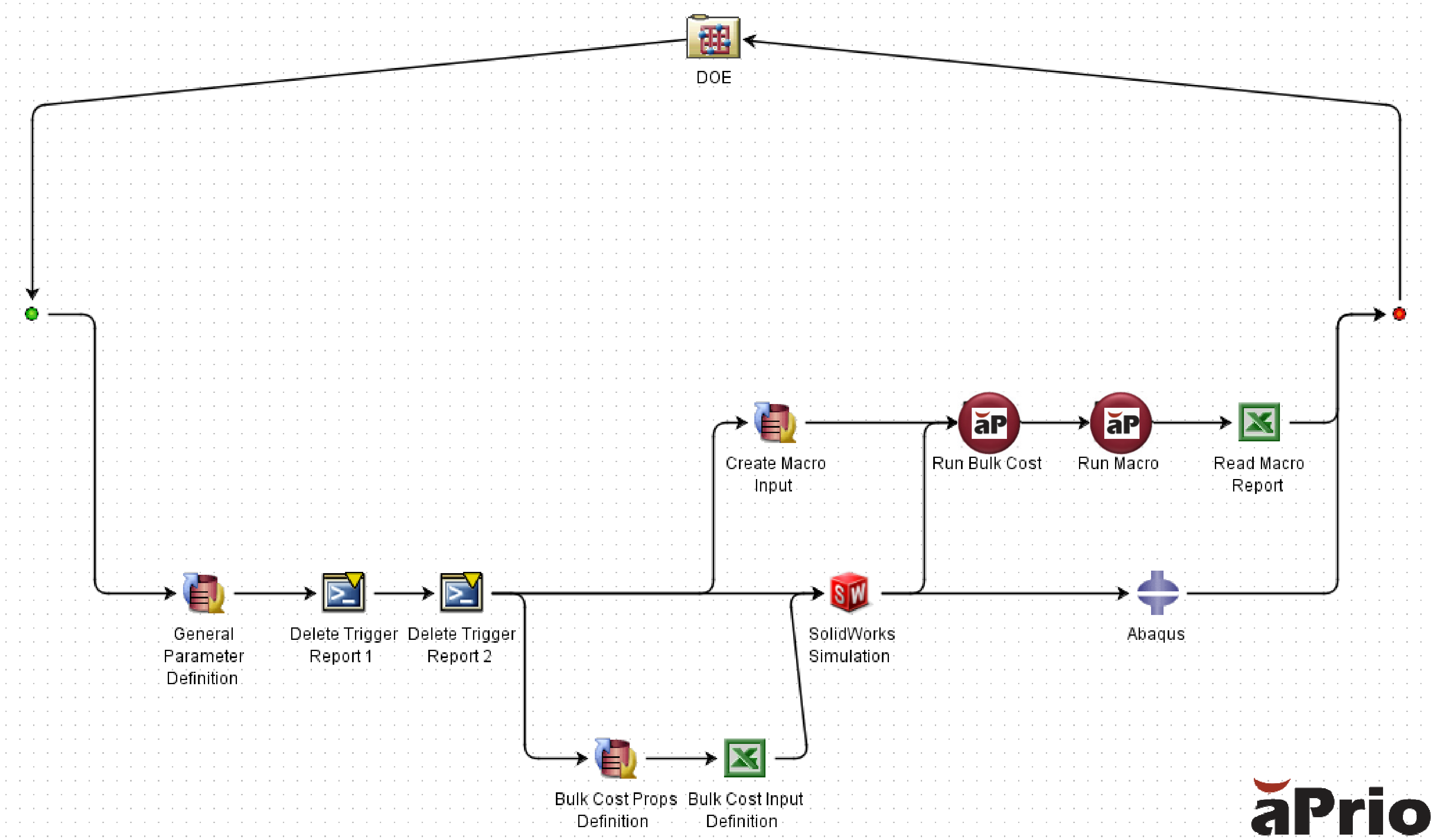
Custom Thickness: $1.00 / lb

Example: Suspension Arm (con't)

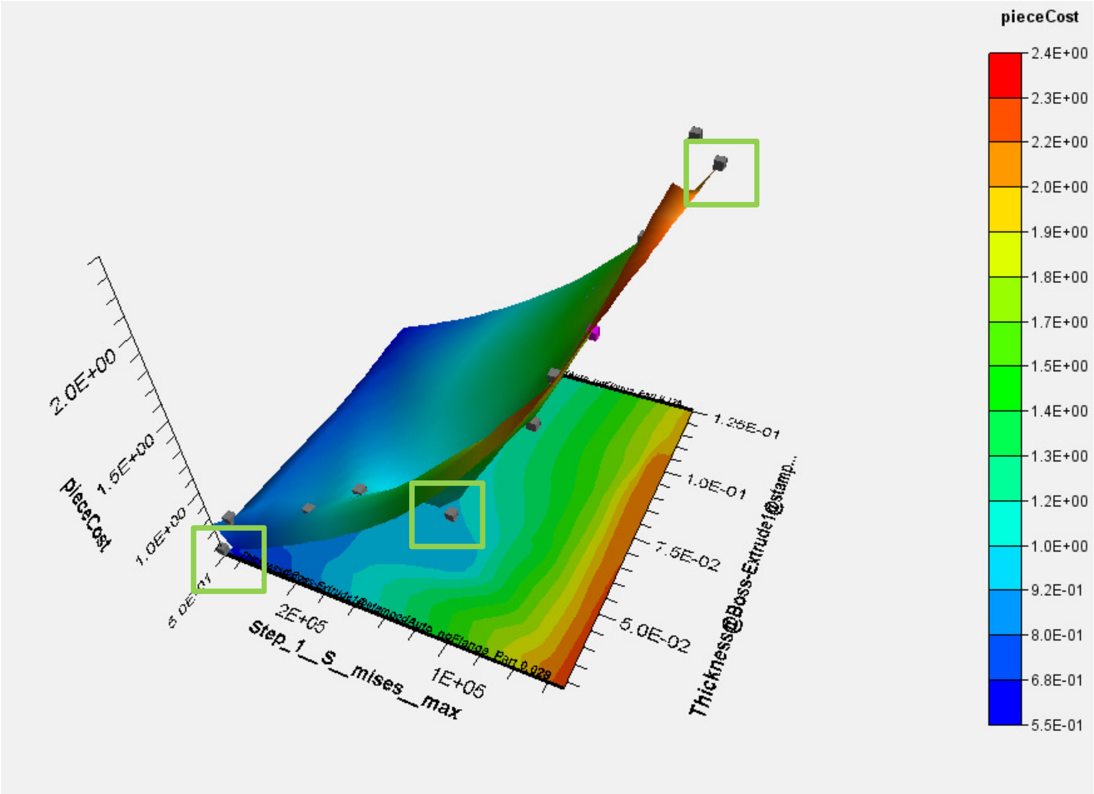
Other Thicknesses:
$1.00 / lb



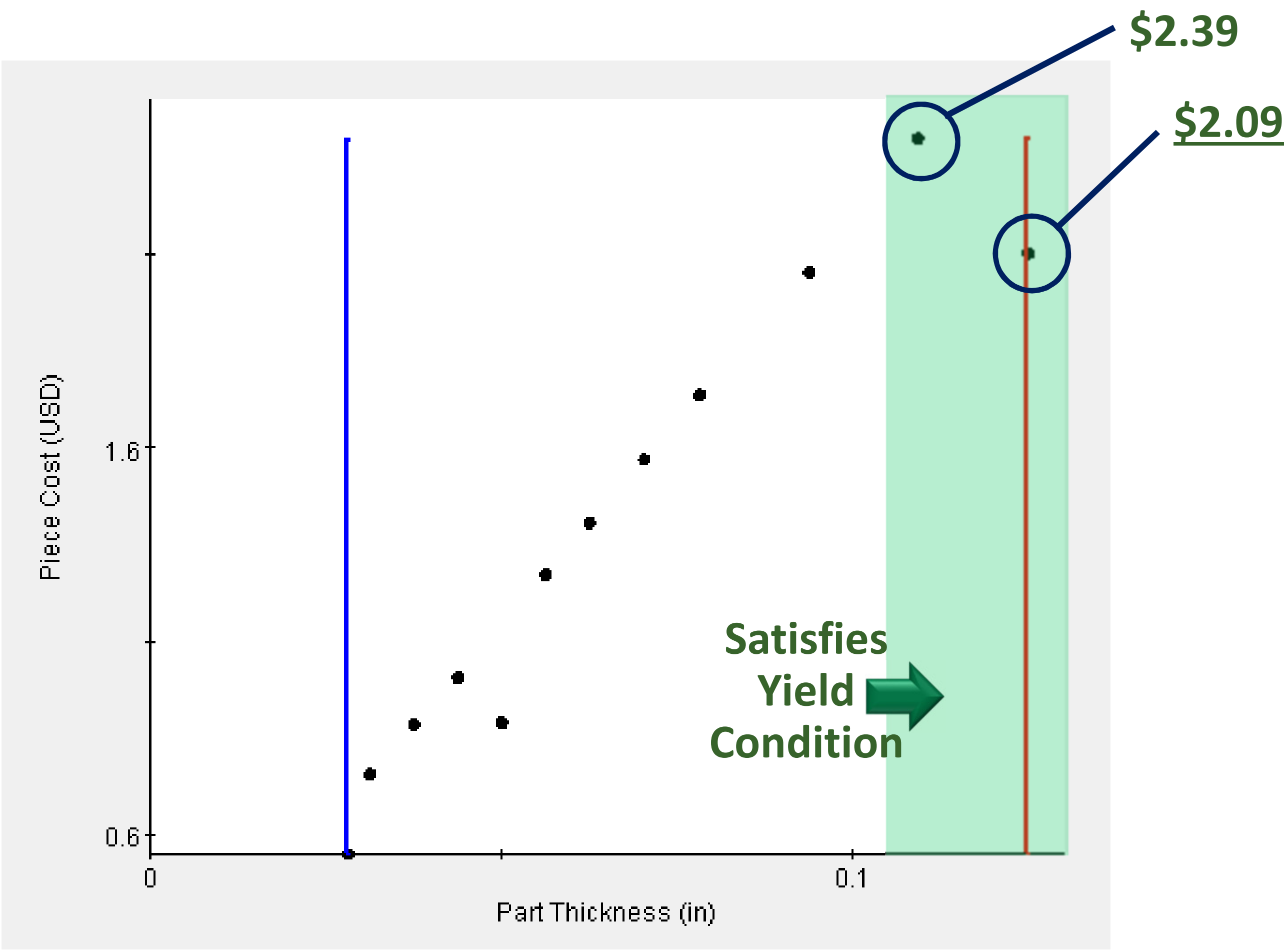
Example: Suspension Arm (con't)



Example: Suspension Arm (con't)



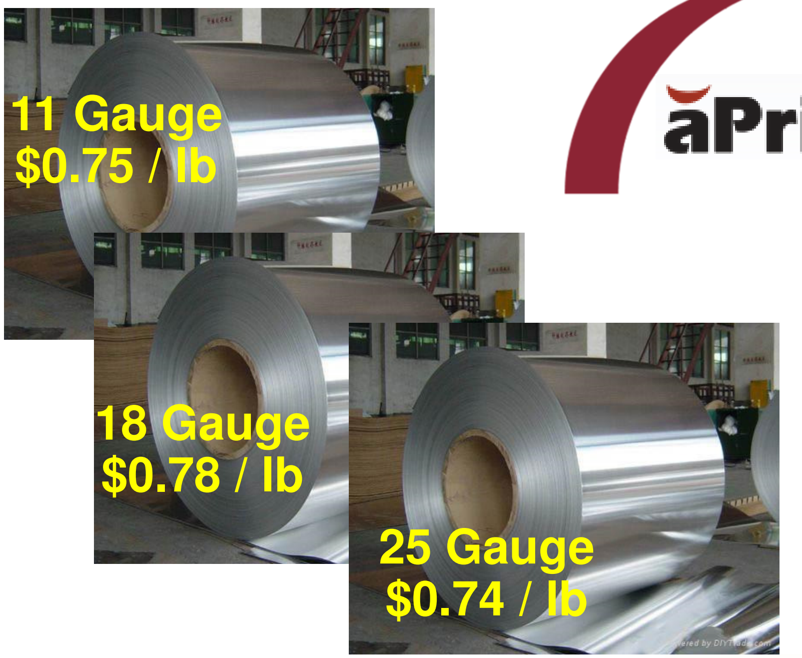
Example: Suspension Arm (con't)



@ 500,000 parts per year, $150,000 avoidance on a *SINGLE* Part

Question

How do we get the cost information into the hands of the engineer or analyst to avoid early decisions that drive down stream costs?



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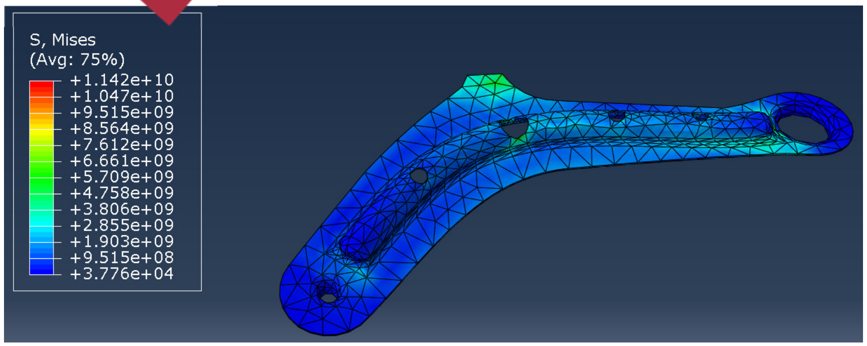


More Auto-Costing Qs

Cost Engineer

How sensitive is my cost to changes in labor, material and overheads?

Which manufacturing processes drive the best results?*

How will changes in electricity and other overhead inputs change cost?

Design Engineer

What design gives the best material usage?

Which geometry is most cost effective?

What part features drive part & tooling costs?

What is the cost impact of tolerances?*

Buyer

What is the best batch size for this part?

What are the impacts of regional sourcing for manufacturing & cost?

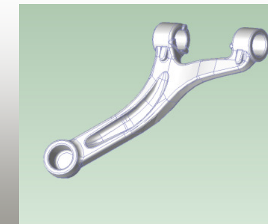
Impacts of regional sourcing on tooling costs?

- Existing Capability in aPriori User Application, Emerging Capability in Automated Costing / Design of Experiments

Impact On Development

Krauss-Maffei Wegmann
Semi-Trailing

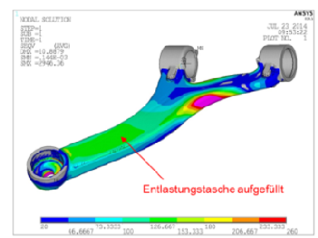
Start:
Cast Steel Part

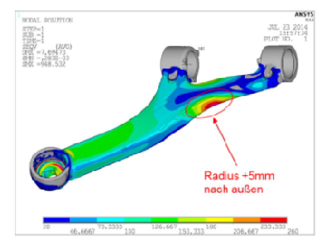


Challenge: Part optimization in costs **and** weight without producing prototypes or getting quotes from suppliers

Application of aPriori

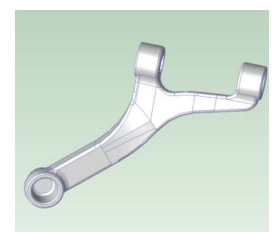
- **Run many different calculation loops of part designs, production processes and materials**
- **Together with FE-Calc. we got an optimized part**
- **The required time was only weeks instead of months**





Results

- **Cost Savings: 415 €; (670 € -> 260 €)**
- **Weight Savings: 29 kg; (46,5 kg -> 17,5 kg)**
- **5 Year Savings: 415.000 €**



Finish:
Aluminium Forged Part

Fortune 25 Manufacturer
Integrating Design and Costing

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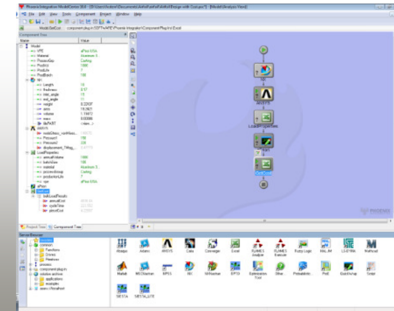
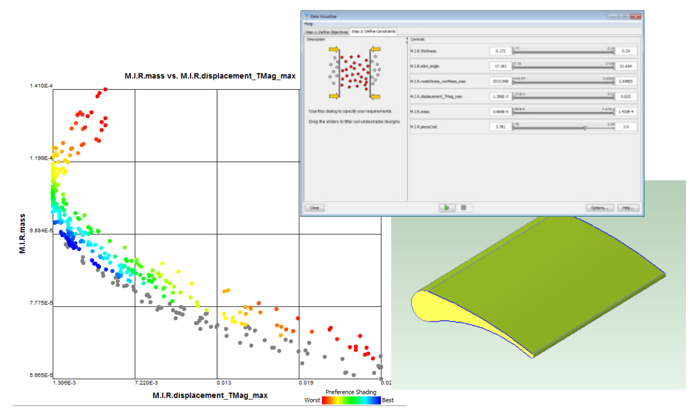
Challenge: Cost analysis was not integrated into the new product development process. Cost was not considered CTQ (Critical To Quality) and was not factored into trade-offs.



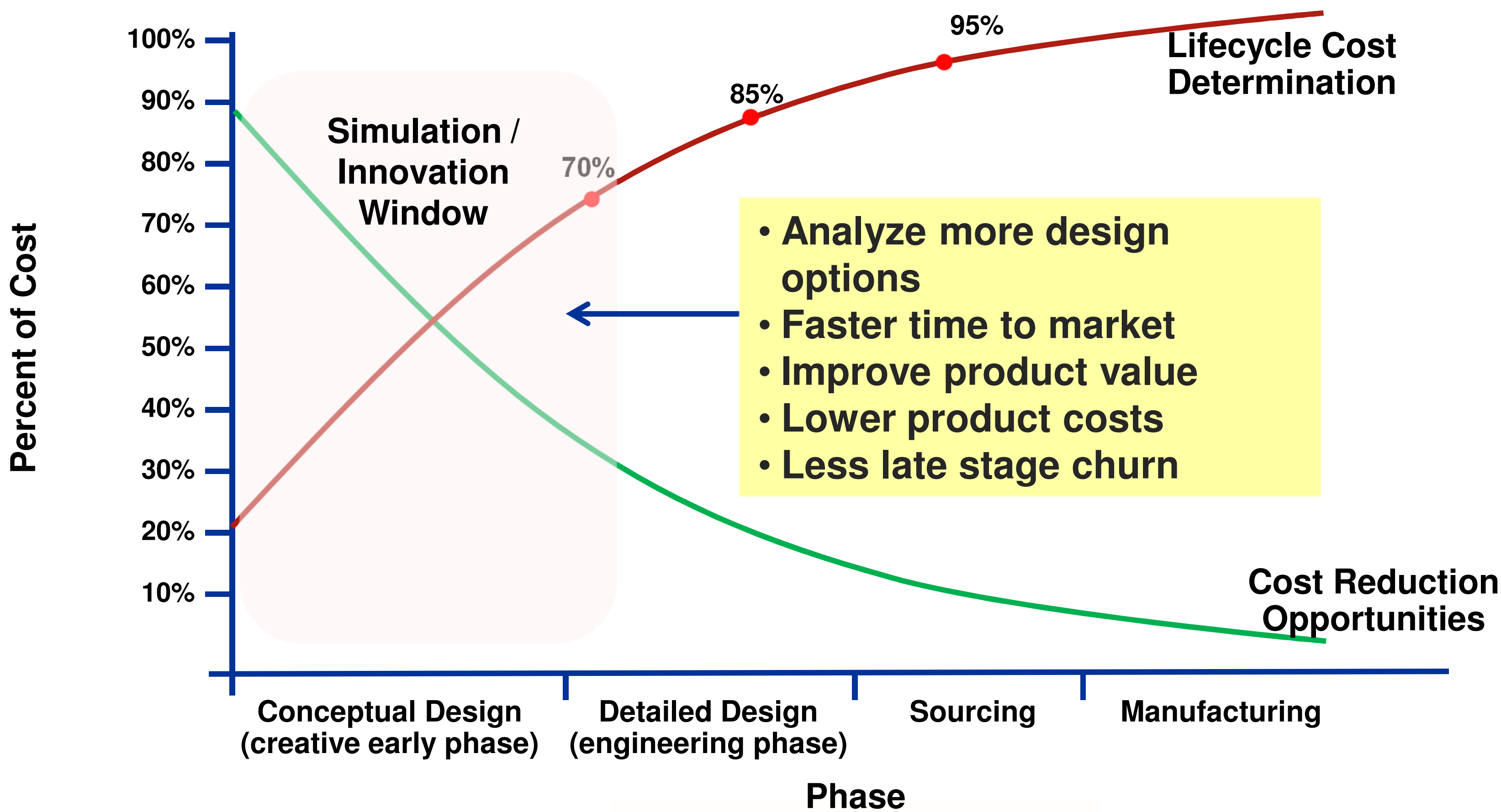
Solution: Using aPriori's Bulk Costing and Analysis capabilities, cost was integrated into a Design of Computer Experiments with CAD and FEA, enabling engineers to perform cost/performance trade-offs and meet CTQ requirements

Results

- Articulated cost impacts to design
- ~30X increase in part design studies
- 15-25% reduction in design cycle time



Benefits for Integrating Cost Analysis into Simulation-Driven Design



Thank You!

Amanda Bligh
Principal Consulting Engineer / Solution Architect
aPriori Technologies