Bringing Cost into Design Optimization

Amanda Bligh

aPriori
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.
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
Competitive Pressures Challenging the Traditional Product Develop Process

Driving Need for Discovery Earlier in the Process

Ability to Optimize

Cost & Time to Fix Problem

Conceptual  Design  Build / Prototype  Test  Validate  Production
“Design-driven simulation is backwards.”

-Jeff Waters
CAE Process Expert
Generalized Flow for PIDO (Process Integration and Design Optimization)
Example: Suspension Arm
Example: Suspension Arm (continued)
Example: Suspension Arm (continued)
Example: Suspension Arm (continued)
Example: Suspension Arm (continued)

Satisfies Yield Condition
But the Reality is…

11 Gauge $0.75 / lb
18 Gauge $0.78 / lb
25 Gauge $0.74 / lb

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?

11 Gauge $0.75 / lb
18 Gauge $0.78 / lb
25 Gauge $0.74 / lb
3D Costing In aPriori
Product Cost Tradeoff Decisions Start Early

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Innovation Window

Start HERE to avoid costly mistakes

Lifecycle Cost Determination

Cost Reduction Opportunities

Percent of Cost

10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Conceptual Design (creative early phase) Detailed Design (engineering phase) Sourcing Manufacturing

Phase

85% 95%

85%

70%
Internal Systems & Processes

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
**aPriori – Our Unique Value**

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

All major CAD systems supported

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

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

Dozens of manufacturing processes included out of the box

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

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

*Data from 60+ major global geographies

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

*China, India, Mexico*
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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Cost Fidelity improves with Additional Inputs

Above Target Cost

Below Target Cost

Average Cost Range

Estimated Cost

Concept Design

Detailed Design

Production Planning or Sourcing

Manufacturing

Launch

VAVE

$ TARGET COST
# Manufacturing & Cost Analysis Output

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### Cost Summary

<table>
<thead>
<tr>
<th>Cost Object</th>
<th>Manufacturing</th>
<th>Composition</th>
<th>Material</th>
<th>Variable Costs</th>
<th>Other Direct Costs (USD)</th>
<th>Total Variable Costs (USD)</th>
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<td>Direct Overhead</td>
<td>Amortized Batch Setup</td>
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<td>3,34</td>
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</tbody>
</table>

### Material Usage

- Utilization (%): 47.24
- Rough Mass (kg): 1.13
- Finish Mass (kg): 0.54
- Target Mass (kg): 0.00

### Process

- Material Stock: 0.00
- Laser Cut: 91.8
- Bend Brake: 8.2

### Unit Cost (USD / kg): 0.07

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Automating aPriori with External Commands

Load Geometry

Output Results

Alter Inputs

China
India
Mexico
aPriori Product Cost Management for the Enterprise

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- Project Dashboard
- Detailed Part Cost Report
- Cost Driver Report
- Cycle Time Heat Map
- Component Negotiation Report
- Commodity Dashboard
- Editable Cost Detail Views
- MFG Routing Alternatives & Cycle Time Reports
- Machinability Heat Map
- Manufacturing Engineer
- Program Manager
- Senior Cost Engineer
- Design Engineer
- Supply Chain Buyer
- Product Line Manager

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3D Costing In Optimization Workflow
3D Costing in Optimization Workflow

Start

First Parameters

Update CAD

Load Geometry

Complete Overrides

Output Results

Update Mesh

Run Simulation

Output Results

Determine Next Parameters

No

Done?

Record Results

Yes

Create Graphical Output

End

Key:
- CAD Software
- PIDO Toolset
- Simulation Software
Example: Suspension Arm

Custom Thickness: $1.00 / lb

11 Gauge $0.75 / lb
18 Gauge $0.78 / lb
25 Gauge $0.74 / lb
Example: Suspension Arm (con’t)

Other Thicknesses:
$1.00 / lb

11 Gauge
$0.75 / lb

18 Gauge
$0.78 / lb

25 Gauge
$0.74 / 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?

11 Gauge
$0.75 / lb

18 Gauge
$0.78 / lb

25 Gauge
$0.74 / lb
More Auto-Costing Qs

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?*
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?

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?

- Existing Capability in aPriori User Application, Emerging Capability in Automated Costing / Design of Experiments
Impact On Development
**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 €
**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

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- Analyze more design options
- Faster time to market
- Improve product value
- Lower product costs
- Less late stage churn
Thank You!

Amanda Bligh
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aPriori Technologies