aPriori

MANUFACTURING COST ESTIMATION: A STRATEGIC GUIDE

GET STARTED

In this ebook, we provide a guide that's designed to introduce Manufacturing Cost Estimation, examine the business problems it can help solve, and point to some real use-cases for today's costing technologies.

As you'll learn, the right cost estimation approach is essential for optimizing product design and building value-driven products capable of competing in today's global marketplace.

1. WHAT IS MANUFACTURING COST ESTIMATION?

Manufacturing Cost Estimation is the collection of methodologies and tools used to project the expected final cost of a manufactured product.

This analysis informs essential manufacturing decisions—such as which products will be profitable, which suppliers are offering a reasonable price, and which current product offerings need to be re-engineered to stay cost competitive.

The depth of this analysis can range from some back-of-the-envelope calculations to a comprehensive, simulation-driven cost management platform like aPriori.

DESIGN FOR MANUFACTURABILITY

It is critical that manufacturers identify and eliminate cost drivers early in the lifecycle, before an error is compounded with additional layers of design detail that are expensive to unwind. Manufacturing simulation software is now capable of identifying features on your 3D CAD model that are very expensive or impossible to manufacture. Further, a fully mature manufacturing simulation application will provide guidance to the end user on how to eliminate these cost drivers.

VALUE-DRIVEN DESIGN

Cost estimates for alternative design decisions help ensure that a product's cost is optimal given its form, fit, and function requirements (ultimately determined by what features drive customer value).

LEAN MANUFACTURING COST REDUCTION

Lean manufacturing techniques prioritize eliminating waste—cost that doesn't drive value. Separating waste from the costs generating real ROI requires tying individual design, manufacturing, and logistics decisions to their specific effects on overall cost structure.

SMART PROCUREMENT

Robust cost estimates that provide detailed manufacturing data (e.g., machine selection, routings, machine cycle time, material utilization, scrap, labor time and both direct and indirect overhead costs) inform fact-based negotiations with suppliers to push down costs.

2. WHY IT MATTERS: THE COST ESTIMATION IMPERATIVE FOR MANUFACTURERS TODAY

As product development and quoting timelines become shorter, more and more manufacturers are leveraging enhanced cost estimation capabilities to pursue lean manufacturing and other cost reduction strategies. Manufacturers that do not keep pace with these strategies will find themselves unable to compete successfully in the global marketplace.

This relentless drive toward cost optimization has been made possible by new technology supporting these novel cost reduction methodologies. As these tools proliferate, this trend toward highly competitive manufacturing only appears set to accelerate.

To understand where manufacturing is headed—and why better cost estimation techniques are driving a manufacturing revolution—it's helpful to briefly consider how manufacturers have handled estimation in the past.

3. THE EVOLUTION OF MANUFACTURING COST ESTIMATION TECHNIQUES

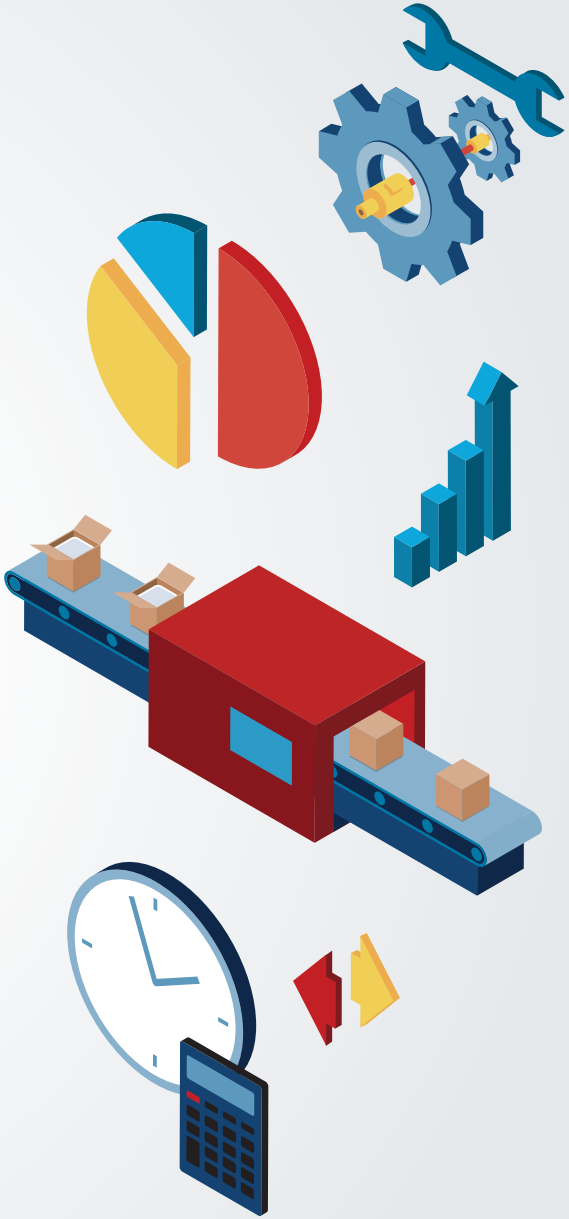
Any manufacturing process needs to use at least some basic cost estimation to try to ensure profitability. At the lowest level, this task might simply involve using recent market prices to tally up expected input costs, then adding a mark-up for packaging, shipping and profit. If this estimate appears to be above current market prices, production isn't viable.

Companies that take this particular approach have often relied on homegrown databases of historical information. In 1985, MS Excel was introduced and has become the most common tool used to support this costing strategy. This approach may work fine if you are a small supplier with just a few cost estimators all working in the same office. However, once you are faced with designing, manufacturing and sourcing on a national or global scale, it simply becomes too complicated to try and manage the extreme number of cost variables in a spreadsheet.

Direct costs like wages and raw materials are not only tied to the efficiencies of underlying production processes but are themselves potential variables when estimating design alternatives.

Also first released in the early-mid 1980s was the first commercially available, specialized manufacturing cost estimation software. Most of these software applications were designed to meet the needs of cost estimators and required significant training and expertise to utilize effectively. Furthermore, these early systems did not leverage modern database technology and often caused significant cost model consistency challenges for design and sourcing teams located in different geographic regions.

By the early 2000s manufacturers were starting to look for manufacturing cost estimation systems that would allow designers and engineers to quickly and easily understand if their new design - represented by a 3D solid CAD model - is over or under target cost early in the design process. Sourcing managers were also beginning to see the need for a "should cost" estimation with rich manufacturing detail to enable more fact-based negotiations with their suppliers. And, cost estimation teams - often severely understaffed - wanted more of an automated costing system that allowed for things like batch costing of hundreds of CAD models to identify cost outliers. Evolving job requirements like these are progressively moving manufacturers towards solutions that have a modern database architecture, are available through a role-based web browser and have extensive libraries of material and machine data.



Lean Manufacturing: A More Holistic Conception of Cost, Waste, and Value

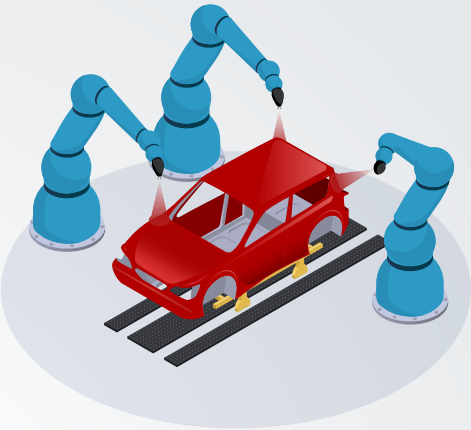
Another cost optimization strategy introduced in the mid-1980s was Lean Manufacturing. At the time, the United States business community experienced a wide-spread panic about what felt like the insurmountable efficiency of Japanese manufacturers. Business leaders in the rest of the world became eager to study and emulate the methodologies driving Japanese successes. Japan's industrial sector had gone from being completely devastated in World War II to becoming the world's envy less than 40 years later. And the world's manufacturers needed to understand how they had become so efficient.

"Lean Manufacturing" became one of the foremost principles popularized by study of Japanese business practices. In short, these lean practices center on a comprehensive commitment to eliminating "waste," or *muda*, within a manufacturing organization.

Here's the key takeaway: "waste" isn't just materials that go unused or product that goes unsold. In the lean manufacturing paradigm, waste is any cost that doesn't directly contribute to a product's final value. This waste can range from workers left idle while waiting for a shipment, to unnecessarily long shipping from a cross-country warehouse, to secondary products or scrap going unsold.

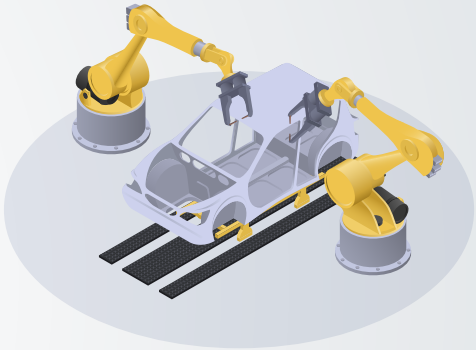
While the successes of Japanese manufacturers popularized the "Lean" terminology, the expansive benefits of eliminating waste – and the danger of letting inefficiencies linger due to under-analyzed practices and design-decisions–have always been on the mind of innovative manufacturers.

Better cost estimation has always been an essential enabler of more efficient production: to eliminate an efficiency, you must first recognize it. In his autobiography, mass production pioneer Henry Ford opined:



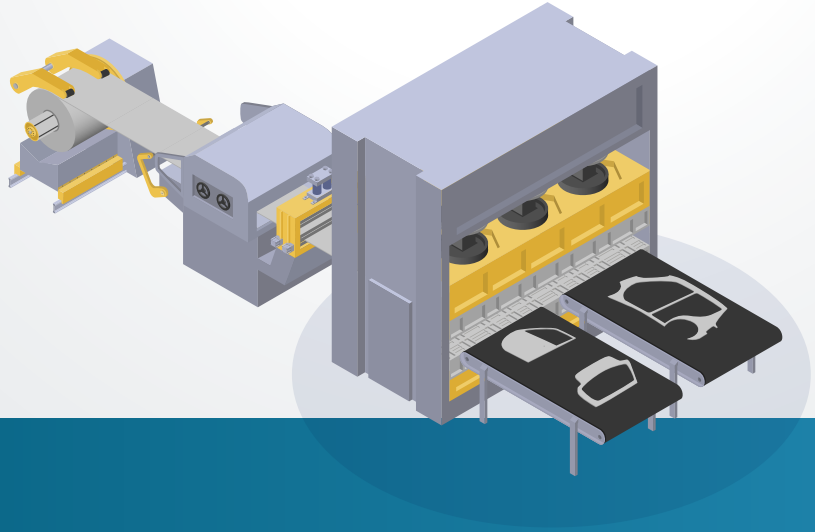
"I believe that the average farmer puts to a really useful purpose only about 5% of the energy he expends.... Not only is everything done by hand, but seldom is a thought given to a logical arrangement. A farmer doing his chores will walk up and down a rickety ladder a dozen times. He will carry water for years instead of putting in a few lengths of pipe."

For Ford's farmer, better cost management is simply a matter of recognizing the potential for process improvement and capital investment.



But for today's manufacturers, identifying cost is a much more complex analytical problem: virtually every aspect of a product's cost structure is closely related to key characteristics like form, fit, and function—in addition to process requirements for manufacturing, sourcing, and distribution.

No amount of earnest study can provide rigorous estimation of this complex interplay of engineering and business variables without the right technology.



Costing Systems Technology: The Key Limit on Cost Estimation Speed and Quality

To try to capture at least a vague approximation of the complex variables aggregated in a product's final cost, manufacturers have continued to made use of successive waves of technology tools. Better cost estimation techniques have always been tied to technological capability. For most of history, manufacturing cost estimation has been a matter of slow and steady experimentation.

Technologies from the personal computer to the enterprise spreadsheet made this experimentation more efficient and allowed for consideration of more calculation-intensive variables. But these traditional cost estimation procedures are always, at some level, vague and ad hoc. Complex variables are abstracted through practical (but ultimately imprecise) methods like comparing to similar past projects or assigning linear, per-unit costs to employed materials.

A collection of Excel spreadsheets for tallying component and labors costs is certainly better than resorting to overly simplified cost-plus pricing. But spreadsheet software doesn't really begin to tie estimates to design-level decisions. That capability has only become accessible to manufacturers with the growth of manufacturing costing technologies that integrate engineering-level analytics with broader cost management concerns like supply chain, manufacturability, and labor costs.

4. THE RISE OF MANUFACTURING COST ESTIMATION SOFTWARE

The success of innovative cost reduction strategies like lean manufacturing is inexorably tied to successful manufacturing cost estimation. To determine which costs ultimately drive value, a manufacturer needs a tool for tying them to functional features of a product design.

That's precisely what the most advanced Manufacturing Cost Estimation Software can provide: a simulation-driven analysis of every aspect of a product's cost structure. This analysis is available in a matter of minutes or less, giving designers actionable data on the anatomy of product cost (click here to download our whitepaper on the true economic cost of manufacturing). This comprehensive accounting needs to include details like cost of raw materials, material utilization, scrap buy-back, purchased parts/components, cost of tooling, labor cost, machine depreciation, and a wide array of indirect facility related costs.

A modern manufacturing cost estimation technology should include a role-based user experience that can be leveraged by all of the key stakeholders in the product development process, including:

PRODUCT DESIGNERS & ENGINEERS

PROCUREMENT/SOURCING/ SUPPLY CHAIN MANAGERS

COST ESTIMATORS

These complex analytical capabilities add up to a toolkit that doesn't just make cost estimation faster and more accurate (though the right software certainly accomplishes this) but allows designers to explore robustly costed alternatives while a product is still being designed. The ability to integrate dynamic, simulation-driven cost estimates with the design process itself allows manufactures to transform the way they think about cost.

The right technology allows cost to be treated not as an ad hoc limit placed on product design, but an independent variable of the design process itself.

When simulation-driven estimation first became a technical possibility, it was only the domain of dedicated experts in Computer Aided Engineering. But the market has seen a rapid democratization of simulation, with providers like aPriori offering advanced cost estimation software that can be used by product designers and costing experts alike.

As this design-driven approach to cost estimation continues to rapidly advance into the daily practices of manufacturers across the globe, strategies founded on this capability are beginning to proliferate. The most important is Design to Cost.

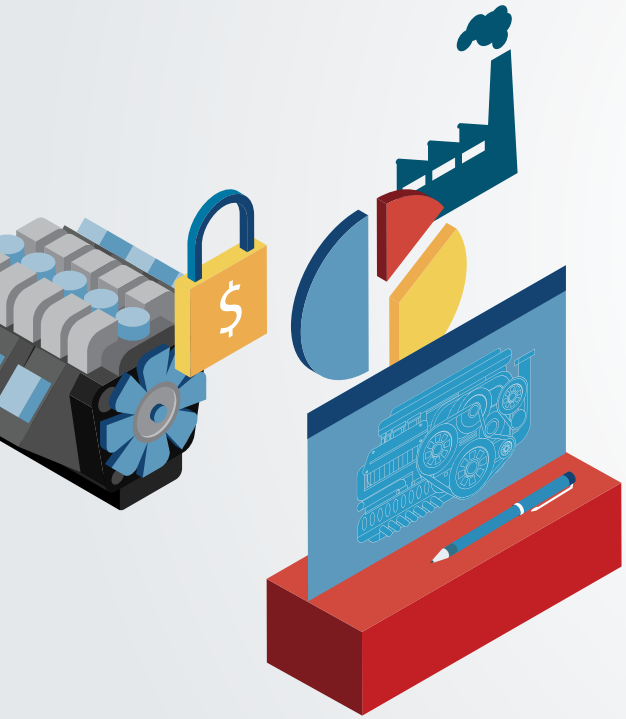
5. DESIGN TO COST: BRINGING ROBUST COST ESTIMATION PROCEDURES INTO THE DESIGN PROCESS

Design to Cost is an organizational methodology for integrating cost management with decision making at the design stage.

We review this essential concept in more detail in our article here.

In short, Design to Cost moves beyond using arbitrary cost-cutting targets as the basis for cost management. Product Managers work with designers and engineers to establish a specific cost target for a new product introduction that is based on current market conditions and will allow the company to achieve maximum profitability. That cost target is established within the software and becomes accessible to designers on demand. Each time they add a new layer of detail to the model, they can quickly run a new cost estimate to identify and eliminate cost drivers. This ultimately allows the product team to achieve target cost (and profitability) more consistently.

6. UNDERSTANDING PRODUCT COST DRIVERS



Treating cost as a true, fully quantified design variable is vital because around 80% of product cost is effectively locked in once a design is set. Costs locked in at the design stage extend far beyond the direct cost of specified materials. To help understand why, we outline some prototypical cost-drivers for manufacturers below.

While we divide these cost drivers into direct and secondary categories, the key to a robust cost estimation approach is recognizing and evaluating the complex interrelationships between all these cost drivers. In many cases, these lines can be very blurry: if a new part requires a more sophisticated machining process best sourced from a factory in another country with higher tariffs but lower labor costs, is this an intelligent business decision? Should the design be changed so the machining process is no longer required, and the part can be manufactured locally?

These are the sorts of questions that manufacturers are asking today. This level of sophistication simply cannot be answered by spreadsheet type solutions.

7. COST DRIVER EXAMPLES IN MANUFACTURING

DIRECT PRODUCT COSTS

MATERIALS

Raw materials add direct costs and have implications for almost every other cost driver in this list.

- Added weight can force more expensive packaging and shipping costs.
- Materials with steeper machining, cooling, or storage requirements can force changes to the manufacturing process.

LABOR (TIME AND COST)

- A variety of factors can affect a product's final labor costs. More complex designs can require more manual labor time. A need for hand wiring, welding, or other specialized skills can introduce the need to support a project with additional specialized workers at higher hourly rates.

MANUFACTURING PROCESSES

- **Equipment Investments:** Processes that can't be supported with existing equipment will require investing in new tools or certification of a new supplier. ROI for new equipment hinges on high-level planning factors like anticipated total production volume, energy costs, depreciation costs and required operator expertise (cost of labor).
- **Energy:** every manufacturing process has an accompanying energy cost that can vary by facility location.

SECONDARY PRODUCT COSTS

FACILITIES

Factors ranging from manufacturing process expertise, to labor rates, to tariffs and transportation costs all go into determining where a product can be most efficiently manufactured.

CAPITAL COSTS

The long-term financing costs of investments in equipment and facilities determine which design choices are cost optimal. The per product impact of capital costs can vary widely depending on total production volume.

SHIPPING/PACKAGING

Physical product attributes determine how a product needs to be packaged and stored.

SUPPLIER COSTS

Minimizing supplier costs may help cut costs even after a design is completed. But involving suppliers at the design stage is the best way to open options for mutually beneficial savings opportunities. We provide some added insight on how data-driven product costing can help ensure a productive negotiation in our blog here.

8. HOW-TO-ESTIMATE PRODUCT COST

The first step to estimating product cost is to evaluate current production parts to identify opportunities for either negotiation or re-engineering for cost reduction.

This evaluation needs to generate benchmarks for what an efficient cost for a component should be. These benchmarks fall into two high-level categories:

SHOULD COST ESTIMATION

Manufacturing costing systems generate estimates for what a component "should" cost if efficient manufacturing processes are followed. While not every supplier will be perfectly efficient, this analysis allows you to pinpoint cases where the delta is significant between the cost you are currently paying and the should cost generated by your manufacturing cost estimation software. This delta may be driven by an inefficient supplier or a design flaw driving unnecessary excess cost.

Once cost outliers have been identified, they can be reduced through re-design or re-negotiation: you can read about the wide variety of potential sources for savings in our article on Manufacturing Cost Reduction here.

COST VERSUS MASS ANALYSIS

A high-level technique for identifying design inefficiencies, this approach generates an expected cost given a similar mass, material specification, and manufacturing process. If a component dramatically diverges from this expectation, there's a higher likelihood it employs unnecessarily complex design choices.

We offer a more detailed guide for conducting a spend analysis in our blog here.

Costing Systems Technology: The Key Limit on Cost Estimation Speed and Quality

To generate cost-analyses during the design stage, your manufacturing cost estimation software must be extremely fast and very easy to use.

With aPriori, for instance, the analysis begins by importing a 3D CAD file. After specifying a few basic inputs such as production volume, manufacturing process, and manufacturing location, aPriori can generate a comprehensive cost estimate in seconds.

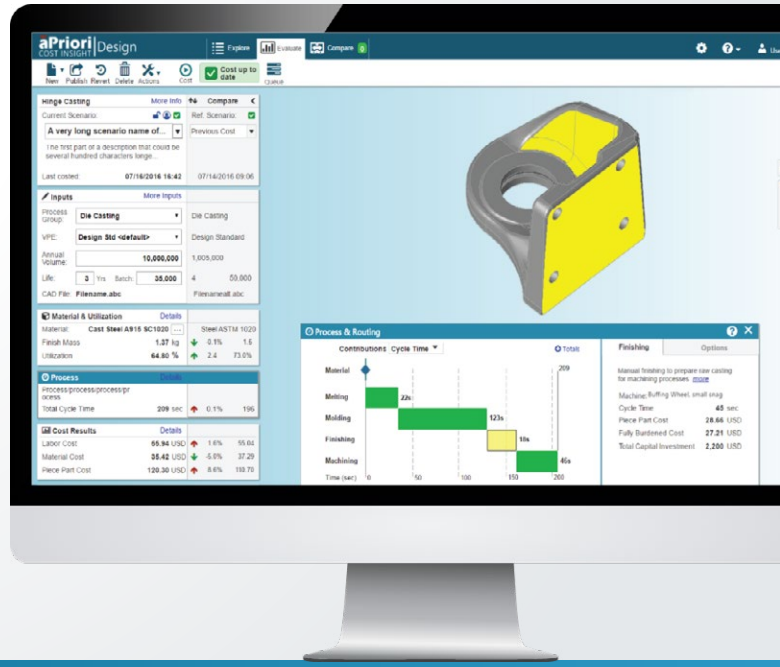
As changes are made to the CAD design (or manufacturing/supply chain selection), new estimates can be generated within a few seconds to ensure the design team is adhering to established cost targets. The ability to conduct rapid analysis of alternative scenarios using simulation-driven costing is essential for informing the design process without bogging down engineers. To generate the most cost-effective option, estimation tools capable of analyzing every production process used in each potential routing are essential.

Product Cost Estimation Techniques: Comprehensive Tooling for Optimal Cost Estimation

To provide this analysis, tools like aPriori need to include a comprehensive library of Out of The Box (OOTB) cost models. Further, the software must include an extensive suite of Regional Data Libraries, (including material libraries with both properties and cost) and machine libraries that represent all of the different types of machines employed by manufacturing centers around the world.

A *short representative* list of manufacturing cost models available from aPriori OOTB include:

- METAL CASTING (DIE CASTING, SAND CASTING)
- HEAT & SURFACE TREATMENTS
- PLASTIC MOLDING
- WIRE HARNESS & PCB ASSEMBLY
- SHEET METAL (SOFT TOOLED/STAMPING/ DIE STAMPING/ HYDROFORMING)
- MACHINING (MILLING/ TURNING/GRINDING)
- CLEANING
- EXTRUSIONS
- LOGISTICS
- WELDING & OTHER JOINING/ ASSEMBLY PROCESSES



For the full list of models employed by aPriori, download our data sheet.

To realize the full value of the insight provided by your manufacturing cost estimation software, the final ingredient is a culture shift toward a cost-conscious product engineering culture. Engineers are trained to think about functionality and reliability first, and design-stage cost management represents an added analytical complexity. **A willingness to re-think a product from the ground-up is an essential element for generating the most impactful estimate.**

For a comprehensive overview of our Regional Data Libraries, download our data sheet.

9. REAL LIFE EXAMPLES OF PRODUCT COST ESTIMATION

One aPriori customer, Spirit AeroSystems, used our software to uncover the fact that a few aesthetic choices by a young new designer lead to a part costing 11% more than necessary. You can watch a video about this cost estimation victory here.

If a few unnecessary machining requirements can leave a product costing over 10% more, consider the potential for savings across a product's full cost structure. *We dive into a few more real-life examples of product cost estimation below.*

Shortened Development Timelines for Improved Innovation

Traditional cost estimation practices are not only imprecise, but time-consuming.

aPriori customer Soucy manufactures aftermarket parts for power sports equipment. The time it took to receive quotes from Chinese product manufacturers was delaying their ability to innovate in response to market opportunities.

Now Soucy uses aPriori to quote faster than ever before—a key competitive advantage: read more here to learn how they cut their product costing timeline from 9+ to 2.5 days.

Should-Costing for Efficient Sourcing

When sourcing parts, generating a "Should Cost" is essential for identifying inefficiencies. From there, a better deal can be negotiated, or a more efficient vendor can be sourced.

General Electric uses aPriori to generate costing models when purchasing manufactured parts. In one case, they found a vendor charging over 250% of optimal cost. They were ultimately able to find another vendor offering only a 20% gap. While these numbers are dramatic and not common to most parts analyzed, they demonstrate the sort of inefficiencies that can lurk in a supply chain that goes under-evaluated.

You can learn more about how General Electric uses aPriori in a video presentation here.

Finding Cost-Effective Design Improvements for Aerospace Defense

The Israeli aerospace company Rafael uses aPriori to help select cost-efficient designs relative to performance considerations.

Rafael's design approach formulates both "complex" and "simple" routing alternatives for prospective designs. While the complex version offers reliability and performance advantages, it is potentially far more costly to produce. With aPriori, Rafael can conduct precise analysis of both versions for each prospective design—identifying opportunities where improved performance has a relatively small cost margin.

You can learn more about how Rafael uses aPriori here. In one case, a more complex design choice only ended up costing 8% more—a key example of quantified analysis revealing an opportunity that didn't necessarily lead to a cost savings, but could potentially help drive revenue by adding more value to the product for a minimal cost increase.

10. NEXT STEPS TOWARD A NEW FRONTIER IN MANUFACTURING

The global manufacturing industry is only beginning to tap the full potential of modern cost estimation tools. The more these tools proliferate, the more we can expect market leaders who leverage these tools effectively to put added cost and pricing pressure on their competition. And, we can expect product manufacturing to remain extremely competitive for the foreseeable future: any forgone opportunity for cost optimization is a potential threat to market share.

To navigate this market and generate actionable cost estimates at the speed demanded by today's customers, choosing the right manufacturing costing software is essential. For a more detailed guide to the features a cost management platform needs for maximum business impact, you can read our article on the key functionality to look for in cost estimation software.

APRIORI PROVIDES ACTIONABLE INSIGHT FOR BETTER MANUFACTURING

aPriori works with manufacturers to bring simulation-driven cost estimation into the design process, empowering organizations to treat cost as a true independent variable in the design process.

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