aPriori

A Practical Guide to Design for Manufacturability

In this guide, we provide an overview of design for manufacturability (DFM), a crucial methodology utilized by designers and engineers to avoid costly mistakes in the early stages of product modeling that could complicate and delay the manufacturing process and impede sustainability goals.

This guide defines this methodology, looks at its importance for manufacturing organizations, outlines some fundamental principles, and concludes with a look at some real examples of design for manufacturability in action.

01

The Basics of Design for Manufacturability

What is Manufacturability?

Manufacturability describes the degree to which a product can be effectively manufactured given its design, cost, and distribution requirements.

Therefore, a manufacturability issue could center on one, a combination, or all three.

OVERALL FEASIBILITY

A design using a routing that simply cannot be produced in the manner specified.

EXCESS COST

Manufacturability is a serious and multi-faceted concern. Since a product’s requisite manufacturing process is effectively locked in once a design is finalized, product designers ideally need a methodology for modeling manufacturing cost outcomes while designing a product.

SUSTAINABILITY

Carbon emissions regulations and consumer demands are driving sustainability initiatives. Early design and manufacturability of a product play an integral role on its environmental impact.

What is Design for Manufacturability?

Design for manufacturability or design for manufacturing (DFM) is the engineering practice of designing products to optimize their manufacturing ease and production cost given form, fit, and function requirements. In manufacturing operations, effective DFM relies on various analyses for different products and production methods, ranging from tight tolerances and cooling times for molded parts to material type or machine selection. As a result of many varied manufacturing processes like tooling and injection molding, the DFM process takes on a more critical role in ensuring manufacturability and product quality while keeping manufacturing costs in line throughout the product development life cycle.

Additionally, DFM sets quality standards for manufacturability such as raw material and components consistency, an efficient assembly process, and reducing the number of parts. The early stages of the product design phase are optimal for design for manufacturability effectiveness, resulting in better decisions throughout the design process, fewer redesigns and supply chain disruptions, a high-quality product, faster time to market, and significant cost savings. Discover the principles of DFM as well as some DFM examples below.

Applications of Design for Manufacturability

The precise applications of DFM can be as diverse as production processes themselves.

We take a look at some specific case studies later in the article.
Some high-level examples of DFM tasks include:

- Comparing design alternatives to understand which one has the fewest manufacturability issues and is least expensive to produce.
- Identifying design features that unnecessarily drive requirements for additional manufacturing operations or negatively impact sustainability initiatives.
- Uncovering why a design is returning higher bids from supply chain partners than expected.
- Ensuring that manufacturing issues don't surface in the later stages of the design lifecycle and hold up a time-sensitive product rollout.

With a large number of manufacturing processes and complex cost drivers, DFM product modeling has, historically, been a serious analytical challenge. Today, digital manufacturing simulation tools are enabling engineering organizations to institute deep DFM modeling that would have been computationally prohibitive in the past.

History of Design for Manufacturability

Any commercial design process is presumably conducted with at least some attention to how the underlying product will ultimately be produced. But design for manufacturability has evolved into a more formalized, analytical approach to this underlying concern—a dramatic break from historical practices.

Traditionally, design for manufacturability:

- **Relied on trial and error:** Aside from scaling up pilot production lines, manufacturers have had limited capabilities for truly modeling production. This limitation has evolved over the past few years with the mainstream adoption of 3D printing – but even this can be time consuming and expensive.
- **Leaned heavily on past experience:** In the absence of digital manufacturing simulation, comparable past projects are the only reliable source of data on manufacturability.
- Were limited to relatively **ad hoc calculations**. While tools like spreadsheet software are helpful for straightforward manufacturability calculations, they have few mechanisms for analyzing complex interrelationships between design, manufacturing process, sustainability and cost structure.
- Existed in a **separate organizational silo** from design. Completely separating the professional responsibilities of design and production engineers can be highly problematic since so many production parameters are effectively locked in at the design phase.

Today, powerful new software tools for DFM analysis have allowed organizations to bring a far more comprehensive understanding of manufacturability and sustainability issues into their design process. We provide more details on this software and its functionality below.

02.

Key Benefits of DFM

- A product's early design determines 80% of its environmental impact throughout the lifecycle. Without robust DFM modeling, manufacturability and sustainability issues risk coming to light once a product has already gone to production. The right DFM tools can identify manufacturability and sustainability issues while a product is still being designed, dramatically de-risking new product development and lowering its carbon footprint.
- The most powerful design for manufacturability tools don't just provide warnings about manufacturing issues, but actionable recommendations for resolving them. In many cases, a relatively simple design tweak can avert the potential issue.
- For existing product offerings, pinpointing opportunities for manufacturing process optimization may uncover insights and opportunities to lower costs and help reduce CO_2 emissions without unduly affecting a design's form, fit, and function. Optimizing designs for manufacturability can also help shorten production and distribution timelines.
- For organizations that design products and outsource manufacturing, sophisticated DFM analysis capabilities can speed up product development timelines. Instead of waiting for suppliers to provide quotes and feedback on manufacturability for each design iteration, engineers can analyze manufacturability in-house. For example, cycle time is a big driver of both cost and carbon. By leveraging calculations and analysis, we can layer sustainability on top of them, allowing a side by side comparison without any design lag. As a result, it allows manufacturers to iterate quickly to find an optimum solution between cost and carbon. Discover more about cost versus carbon offsets.

However vital, design for manufacturability is only one part of the puzzle when it comes to optimizing product costs and lowering the carbon footprint. **Learn more about how to optimize product cost engineering for your organization.**

Who is Responsible for DFM?

Design for manufacturability can be the domain of several manufacturing personas professionals depending on the organizational context.

- For organizations developing new products, designers and engineers can utilize DFM tools, insights, and methodologies to proactively prevent manufacturability and sustainability issues as well as cost overruns.
- Cost engineering professionals may bring DFM analyses to bear on current product offerings to pinpoint areas for manufacturability-driven cost reduction opportunities.

Design for Manufacturability vs. Design for Assembly

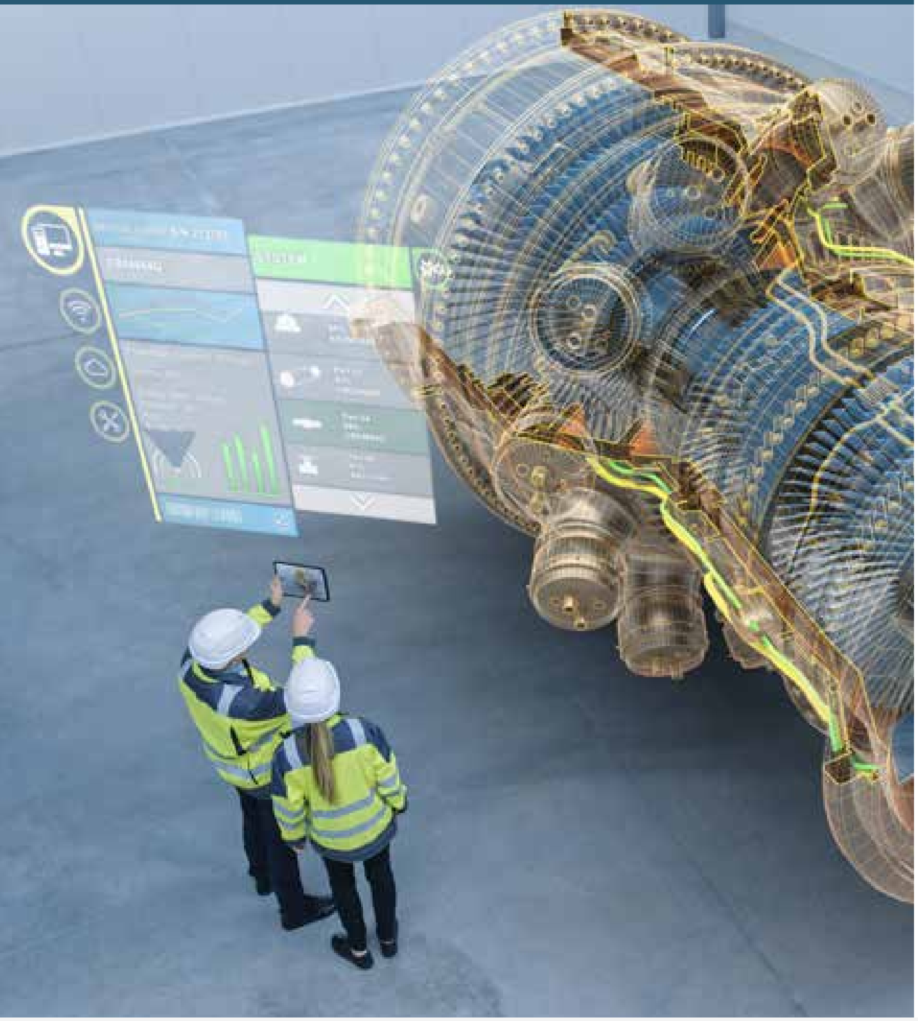
It can be helpful to distinguish design for manufacturability from the closely related idea of a design for assembly.

Design for assembly refers to designing a product to maximize how easily it can be assembled and disassembled for repairs and maintenance. This approach often focuses on principles like minimizing the total number of parts used, ensuring that parts are easily insertable, and confining assembly requirements to simple, repetitive motions. Many of these same attributes can be applied to sustainability. Reducing the total number of parts used and ensuring that they can be easily dissembled for repairs and maintenance all contribute to lowering the carbon footprint. On the other hand, design for manufacturability is a pre-emptive strike, creating products at the design stage that comprehensively lower the carbon footprint pre- and post-production.

This focus is much more specific than design for manufacturability, which can cover manufacturing processes ranging from sheet metal fabrication to plastic molding, casting and machining.

03

Design for Manufacturability Guidelines: Key Principles



We outline some of the most important foundational concepts of design for manufacturability below.

Each of these principles shares a common theme: tying manufacturability and sustainability issues directly to design decisions is in and of itself a substantial analytical feat.

Truly understanding how each and every design decision affects overall manufacturing needs requires and environmental impact tools capable of actually simulating dozens of different manufacturing processes based on design-level inputs like 3D CAD files. While the principles are a great start, digital manufacturing simulation is the key to unlocking the analytical problem at the heart of DFM.

Key Principles

MANUFACTURING PROCESS CHOICE

The choice of production processes has huge implications for a product's overall cost structure and carbon footprint. Functional design requirements often leave room to choose between multiple production methodologies if different component designs are being considered. A fully rationalized DFM strategy needs the ability to model each of these alternatives across multiple criteria: For instance, one production method may be marginally cheaper on a per-unit basis but entails distribution costs far in excess of this production advantage. Another example might be a potential product that might require many processes, **increasing** the carbon footprint rather than lowering it.

DESIGN CHOICES REFLECTING MANUFACTURING REALITY

We look at using should costs to nurture more effective supplier negotiations and relationships below. For a cost-oriented redesign, manufacturing cost modeling software can help pinpoint the precise factors causing a component to exceed cost targets—the ultimate cause could include anything from excess weight driving high transportation cost to manual welding needs pushing up labor costs.

SMART/MODULAR COMPONENT SELECTION

In many cases selecting off-the-shelf parts (or parts already being manufactured for another design) may greatly simplify manufacturability without hampering overall function. The right DFM tools should enable an apples-to-apples comparison of the manufacturability/cost implications of selecting off-the-shelf versus custom manufactured parts.

Key Principles

REQUIREMENT-DRIVEN TOLERANCES AND SPECIFICATIONS

Materials that are over-specified (or too broadly specified) relative to functional needs can necessitate the use of a much more costly production process than is necessary. Ideally, DFM tools can be used to more precisely optimize material specifications given functional requirements and cost targets.

TOOLING MATTERS

Even a component that is not particularly costly on a per-unit basis can dramatically complicate production if it requires an entirely different tooling setup or production line. A robust DFM approach needs to estimate the total costs imposed by tooling needs associated with different design decisions. For instance, a part that is slightly more expensive may end up being optimal if it does not necessitate transportation of the product(s) to a separate production line. Another example is additive manufacturing. It may be a bit more expensive upfront to use lightweighting when manufacturing a vehicle. However, it results in a lighter, faster, more fuel efficient one, reducing the carbon footprint and overall costs.

COMPLIANCE/TESTING

In many industries where quality is enforced by regulatory agencies, compliance concerns, along with the direct costs of testing different design alternatives, should be treated as an integral aspect of broader manufacturability. With many governments enacting environmental regulations and imposing fines to those that fail to lower their carbon footprint, it is crucial that manufacturers have a design for manufacturability solution that can factor in all aspects of design and production.
Learn more about sustainability legislation.

04.

Streamlining the Manufacturing Process and Beyond

Cost-Visibility at the Speed of Business

A design for manufacturability strategy goes hand-in-hand with other contemporary methodologies for integrating a more holistic approach to cost structure with product design.

The same simulation-driven tools and insights that make it possible to quickly generate process-specific manufacturability analyses are bringing unprecedented precision to manufacturing cost modeling.

We go into greater detail about how a comprehensive digital manufacturing simulation solution can provide in-depth manufacturing cost models faster than ever. Find out what your design will cost to produce. Download the whitepaper.

Manufacturing Cost Modeling Software's Key Role in Fact-Based Negotiations

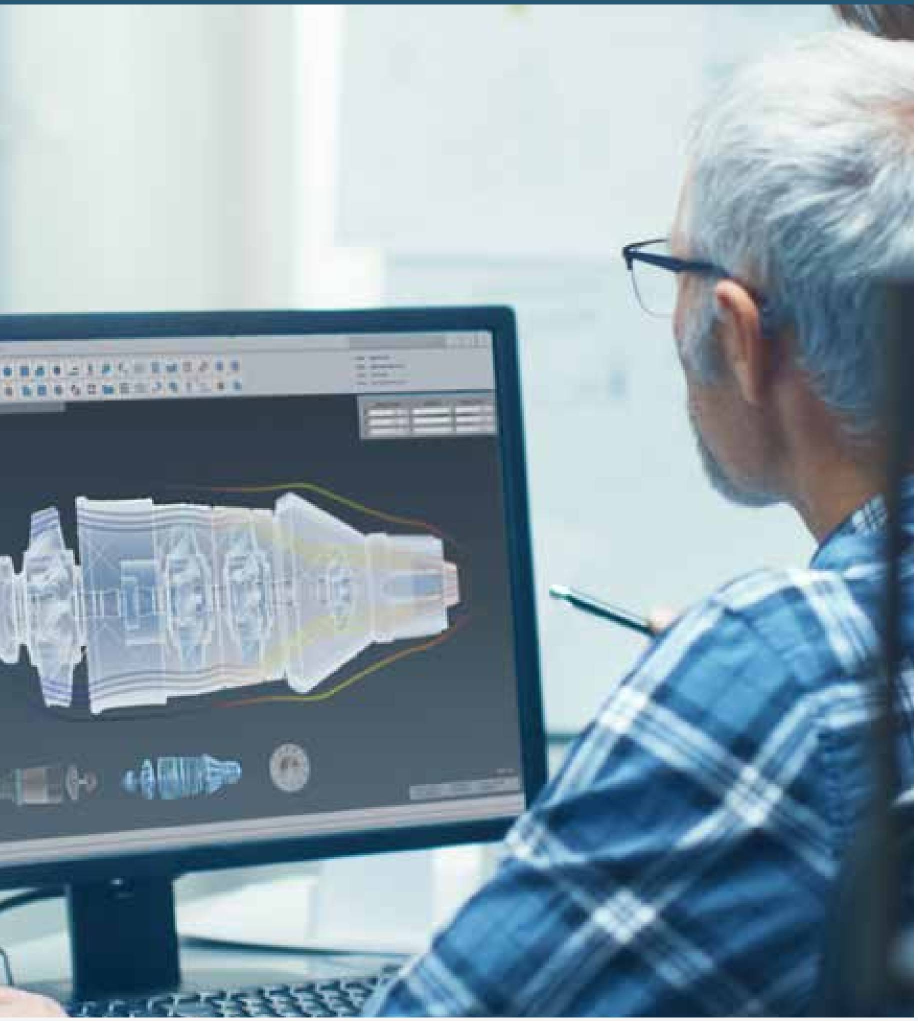
Generating actionable factors on suppliers' product costs requires detailed insight into underlying influences including:

- Material Costs/Manufacturing Process Costs
- Labor Costs
- Transportation costs and their impact on the carbon footprint
- Overhead
- Tooling/Facilities Investments

Calculating how these factors interact to contribute to a component's ultimate cost structure is a very complex analytical challenge. For instance, tweaking materials selection may require a different manufacturing process only available at another manufacturing facility with far higher rental and transportation costs.

The right manufacturing cost modeling software makes it much easier to generate detailed cost structure insights that can impactfully inform supplier negotiations.

05. Three Steps to Design for Manufacturability



1. Incorporate DFM Analysis as Early as Possible in the Design Process

The earlier manufacturing and sustainability are considered, the more changes can be made. Once tooling has begun, options for re-engineering become increasingly limited.

Unlocking all the benefits associated with DFM effectively requires a variety of computationally intensive analyses; all of which are most impactfully conducted when a product is still being designed. The right software is essential to conducting this in-depth analysis without inhibiting innovation, compromising sustainability efforts or delaying product development timelines.

2. Recognize Opportunities for Cooperative Product Development

If manufacturing is conducted in-house, DFM modeling must be a point of cooperation between production and design engineers. Manufacturing experts should work directly with designers to facilitate optimal design choices for the manufacturing resources and constraints at hand.

Similarly, when working with suppliers to manufacture new product designs, DFM provides a collaborative bridge between these two parties, improving identification and elimination of manufacturability issues and support sustainability goals early in the design lifecycle.

This type of constructive collaboration has become more essential as Original Equipment Manufacturers have increasingly outsourced product manufacturing to supply chain partners that may be located in another country or time zone, and possibly do not speak the same language. DFM analysis is based on digital manufacturing simulation that facilitates new designs review and markup, allowing these parties to collaborate in a way that was simply not possible a decade ago.

3. Integrate with a Broader Strategy for Manufacturing Cost Modeling

Manufacturability is one of the factors that can be most difficult to effectively analyze at the design stage. However, it's not the only factor that can influence a product's cost structure. Concerns ranging from product weight and size and material utilization and scrap to tooling costs, labor, and overhead all have huge implications for product cost structure (and are closely interrelated with manufacturability). Want to learn more on how you can reduce costs and save money? Listen to our podcast on managing cash in a downturn economy (p.s.-these tips work in any scenario).

06.

Examples of Design for Manufacturability

We provide three specific examples of design for manufacturability below. These actual clients used aPriori digital manufacturing simulation software to bring greater manufacturability modeling capabilities to their design process. We provide more detail on selecting design for manufacturability software below.

Rafael Uses DFM to Reduce Costs and Improve Sourcing

Rafael, an Israeli aerospace company, uses aPriori as their enterprise digital manufacturing simulation software including DFM analyses. One of the company's parts was returning all no-bids so they decided to analyze it using aPriori.

aPriori showed an almost impossible undercut in the routing. This design feature ended up being a largely arbitrary choice and eliminating it reduced cost by over 50%. The new design was not only far more cost-effective but drew many more bids from potential suppliers.
Learn more about this Rafael success story.

RAFAEL
SMART AND TO THE POINT

Carrier Transforms Business with DFM and aPriori

Carrier wanted to break down manufacturing siloes and empower their engineering team to leverage the power of aPriori to streamline should costs and quotations without interrupting or delaying the design process.

In this video, discover how Carrier uses aP Design to deploy and conduct late stage cost modeling as its going through the traditional gates such as the PLM as well as the design process. aPriori helps Carrier innovate and validate new value streams efficiently and cost-effectively.

How Spirit Aerosystems Uses aPriori to Identify Early Cost Outliers

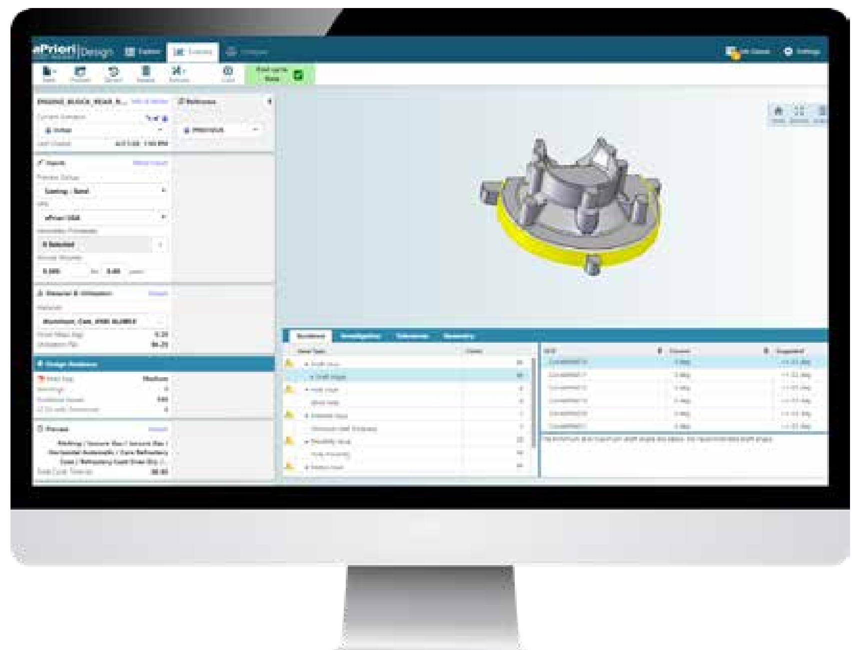
Spirit Aerosystems is the world's largest tier one aerostructures manufacturer.

In this video, you'll hear how Spirit Aerosystems uses aPriori's manufacturing insights to evaluate parts for cost drivers and to identify cost reduction opportunities. Discover how Spirit Aerosystems used aP Pro to support the development of internal fabrication discrete parts estimates.

07.

What to Look for in Design for Manufacturability Software

To maximize its impact, design for manufacturability software not only needs highly-specific analytical capabilities covering many different manufacturing processes, but the ability to deliver this insight to design engineers in real-time—enabling designers to rapidly look at the implications of diverse manufacturing scenarios for various design alternatives.



DFM Software Should Be Fast and Easy to Use

To generate manufacturing analyses during the design stage, your software must be extremely fast and very easy to use. With aPriori, the modeling process begins by analyzing a 3D CAD model to generate a digital twin. After specifying a few basic inputs such as production volume, manufacturing process, and manufacturing location, aPriori can then simulate production in a "digital factory" to generate manufacturability, sustainability, and cost models in seconds.

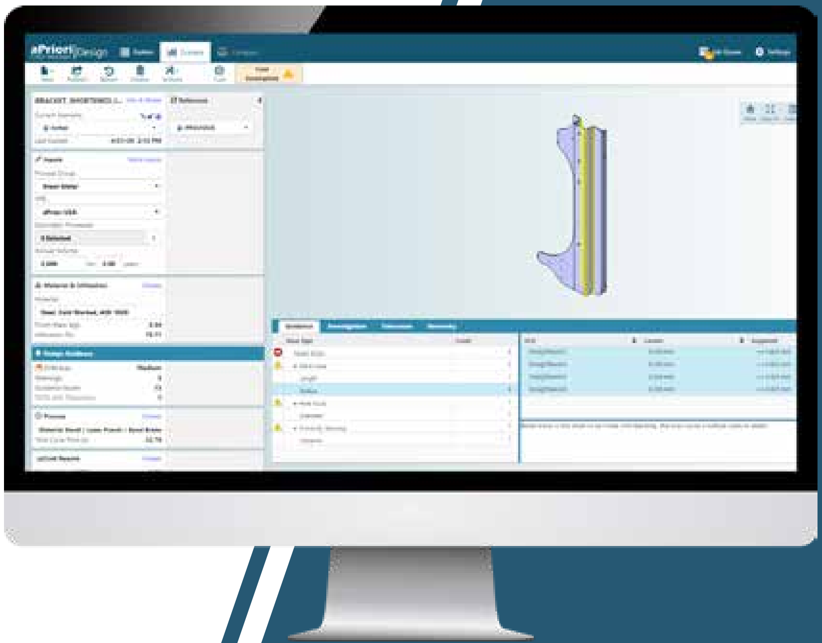
In addition to running manufacturing simulations quickly, the output of the analysis should be extremely easy to interpret. Identification of potential manufacturability issues should be highly graphical and pinpoint areas for improvement. For example, the system should be able to quickly identify any machining operations where the cycle time is abnormally high. While there may be a good reason for this, it may also identify a design flaw that, if corrected, could dramatically accelerate the manufacturing process and drive down cost accordingly.

The Most Effective DFM Software Simulates Key Manufacturing Processes

To generate in depth DFM insights, there is no substitute for detailed digital manufacturing simulation.

This simulation needs to include a wide variety of potential production processes so that the digital factory can be ready to model nearly any potential design. For instance, a short representative list of manufacturing processes supported by aPriori out-of-the-box include:

- Sheet Metal (Soft Tooled/Stamping/Die Stamping/Hydroforming)
- Metal Casting (Die Casting, Sand Casting)
- Extrusions
- Plastic Molding
- Machining (Milling/Turning/Grinding)
- Wire Harness & PCB Assembly
- Welding & Other Joining/Assembly processes
- Heat & Surface Treatments



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

08.

Summary: Selecting the Right Software is Vital to Maximizing Your DFM Strategy

As we have explored in this guide, the analytical capabilities needed to truly understand a design's manufacturability and sustainability can drive multi-faceted business value: accelerated product development timelines, a lower carbon footprint, unprecedented cooperation between designers and manufacturing engineers, and ultimately, products that are as cost-competitive as possible.

To leave no stone unturned in this analysis, DFM software should be comprehensive, with the ability to estimate manufacturability implications ranging from production and labor to distribution. But even the most comprehensive analysis won't unlock the benefits discussed in the guide if it's not applicable in the context of fast-paced, collaborative design effort. That's precisely why selecting the right DFM toolkit is critical.

We've created a detailed guide chockful of practical advice to help prospective buyers select the most impactful software for their business needs.

Find out how aPriori's product costing software can turn anyone into a costing expert.

aPriori Provides Actionable Insights for Better Manufacturing

aPriori is the leading provider of digital manufacturing simulation software that brings product design and sourcing teams closer to production. By leveraging the digital twin within our digital factories, we automatically generate manufacturing intelligence that helps manufacturers collaborate across the product development process to make better design, sourcing, and manufacturing decisions that yield higher-value products in less time.

aPriori solutions are now available in the cloud or on-premise. Headquartered in Concord, Mass., aPriori also has offices in Belfast, Northern Ireland, and Munich, Germany. To learn more about aPriori, visit www.apriori.com.

Visit aPriori.com

aPriori

300 Baker Ave Concord, MA 01742 | aPriori.com | 978.371.2006 | ProductCost@apriori.com