A PRACTICAL GUIDE TO DESIGN FOR MANUFACTURABILITY

GET STARTED

In this article, 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.

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.

1. THE BASICS OF DESIGN FOR MANUFACTURING

Manufacturability Definition: What is Manufacturability?

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

A manufacturability issue, therefore, could center on either or both:

OVERALL FEASIBILITY

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

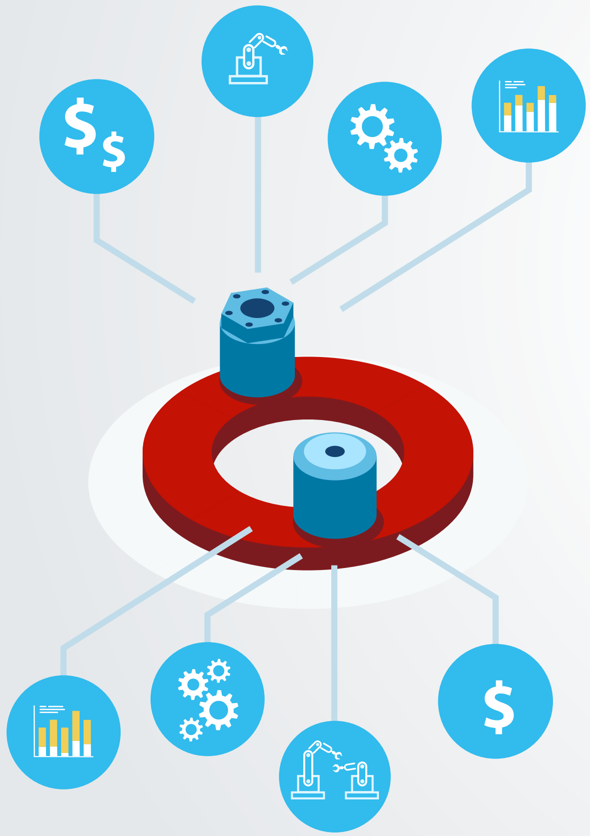
EXCESS COST

Manufacturability is a serious and multi-faceted concern. And, because a product's requisite manufacturing process is effectively locked-in once a design is finalized, product designers ideally need a methodology for predicting manufacturability outcomes while designing a product.

Design for Manufacturability Definition

Design for manufacturability is the engineering practice of designing products to optimize their manufacturing ease and cost given form, fit, and function requirements.

Because manufacturing processes are so numerous and varied, effective design for manufacturability may hinge on very different analyses for different products, including anything from cooling times for molded parts to the type of material or machine selected.



Applications of Design for Manufacturability

The precise applications of DFM can be as varied 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 least manufacturability issues and is least expensive to produce.
- Identifying design features that unnecessarily drive requirements for additional manufacturing operations.
- 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.

The sheer variety of production processes underlies the fact that generating robust DFM insights has, historically, been a serious analytical challenge. Today, however, advanced manufacturing simulation tools are enabling engineering organizations to institute robust DFM procedures of a depth that would have been computationally prohibitive in the past.

History of Designing 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 today describes a more formalized, analytical approach to this underlying concern—a dramatic break from historical practices.

Historically, designing for manufacturability:

- **Relied on trial and error:** with limited ability to understand manufacturing scenarios aside from scaling up actual pilot production lines. This limitation has evolved over the past 3-5 years with the mainstream adoption of 3D printing – but even this can be time consuming and expensive.
- **Leaned heavily on past experience:** without technology tools capable of physics-driven manufacturing simulations, comparable past projects are the only reliable source of data on manufacturability.
- Was necessarily 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, and cost structure.
- Often 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 issues into their design process. We provide more details on this software and its functionality below.

2. KEY BENEFITS OF DFM

- Without a robust DFM approach, manufacturability issues risk coming to light once a product has already gone to production. The right DFM tools can **identify manufacturability issues while a product is still being designed, dramatically de-risking new product development.**
- 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 **opportunities to lower costs** 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 feedback on manufacturability for each design iteration, engineers can analyze manufacturability in-house.

However vital, design for manufacturability is only one part of the puzzle when it comes to optimizing product costs. For a deeper look at cost reduction, we recommend our whitepaper here.

Who is Responsible for DFM?

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

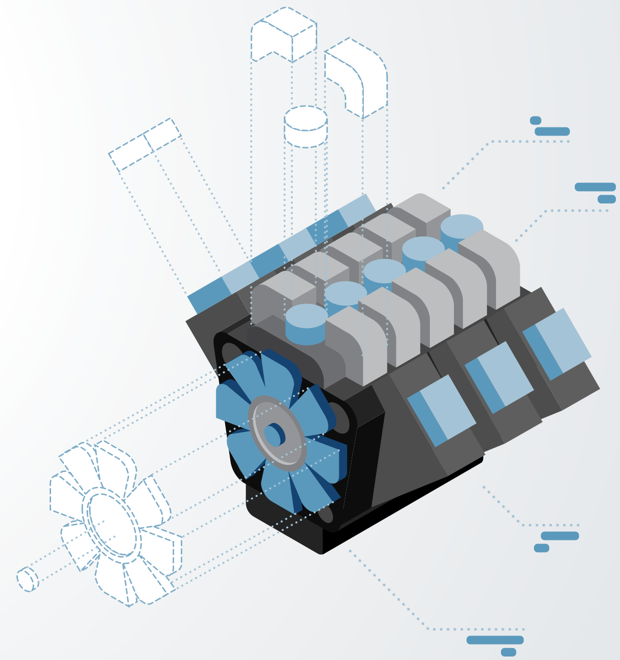
- For organizations developing new products, **designers and engineers** can utilize DFM tools and methodologies to proactively prevent manufacturability issues and cost overruns.
- **Cost engineering leaders** may bring DFM analyses to bear on current product offerings to pinpoint opportunities for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

Design for Manufacturability and 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.

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



3. DESIGN FOR MANUFACTURING 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 issues directly to design decisions is itself a substantial analytical feat.

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

KEY PRINCIPLES

MANUFACTURING PROCESS CHOICE

The overall choice of production processes has huge implications for a product's overall cost structure. 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 analyze each of these alternatives across multiple criteria: for instance, one production method may be marginally cheaper on a per-unit basis but introduce distribution costs far in excess of this production advantage.

DESIGN CHOICES REFLECTING MANUFACTURING REALITY

Designers can easily make seemingly innocuous choices that have profound implications for the production line. For instance, unnecessary variation in the thickness of a molded part (perhaps chosen simply for minor aesthetic reasons) can dramatically increase a part's cooling time. A robust DFM strategy needs to provide designers with tools for directly understanding how design choices relate to production concerns.

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

Material specifications that are over-specified (or too broadly specified) relative to functional needs can necessitate the use of a much more costly production process than 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. A part that is slightly more expensive may end up being optimal, for instance, if it prevents the products from needing to be transported to a separate production line.

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.

4. STREAMLINING THE MANUFACTURING PROCESS AND BEYOND: COST-VISIBILITY AT THE SPEED OF BUSINESS

A design for manufacturing strategy goes hand-in-hand with other contemporary methodologies for integrating a more holistic understanding of cost structure with product design.

The same simulation-driven tools that make it possible to quickly generate process-specific manufacturability analyses are bringing unprecedented precision to manufacturing cost-estimation, for example.

We go into greater detail about how a comprehensive product cost management platform can help understand manufacturing costs, and beyond, in our white paper here.

5. THREE STEPS TOWARD INSTITUTING DESIGN FOR MANUFACTURING

1. Incorporate DFM Analysis as Early as Possible in the Design Process: the earlier manufacturing is considered; the more changes can be made. Once tooling has begun, options for re-engineering become increasingly limited.

Unlocking all of 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 tooling is essential to conducting this in-depth analysis without inhibiting innovation or delaying product development timelines.

2. Recognize Opportunities for Cooperative Product Development: if manufacturing is conducted in-house, DFM processes and tooling need to be a point of cooperation between production and design engineers, with manufacturing experts working 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 bridge between these two parties to improve identification and elimination of manufacturability issues early in the design lifecycle.

This type of constructive collaboration has become even more essential as Original Equipment Manufacturers have increasingly outsourced product manufacturing to supply chain partners that may be located in another country, in another time zone, and possibly not even speak the same language. DFM analysis of a 3D CAD model on a platform that facilitates review and markup of new designs allows these two parties to transcend these challenges in a way that was simply not possible even five years ago.

3. Integrate with a Broader Strategy for Product Cost Management: manufacturability is one of the factors that can be most difficult to effectively analyze at the design stage, but it's not the only factor that can be decisive for a product's cost structure. Concerns ranging from product weight and size, material utilization and scrap, tooling costs, labor and overhead costs all have huge implications for product cost structure (and are closely interrelated with manufacturability). We take a more comprehensive look at instituting a strategic approach to managing product costs in our white paper here.

6. EXAMPLES OF DESIGN FOR MANUFACTURABILITY

We provide three specific examples of design for manufacturability below. These companies are real clients who used aPriori software to bring greater manufacturability optimization 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

The Israeli aerospace company Rafael uses aPriori as their enterprise cost management platform, including DFM analyses. They were struggling with a part that was returning all no-bids and decided to analyze the part using aPriori.

aPriori showed an almost impossible under cut in the routing. The 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 far more bids from potential suppliers

You can learn more about this Rafael success story in our video here.

Honeywell Aerospace Uses DFM as Part of a Broader Cost Management Strategy

DFM simulation drives even more value when deployed as part of a broader cost management campaign. Honeywell Aerospace, a globally recognized maker of aircraft engines, avionics, and other systems, provides a great real-life example.

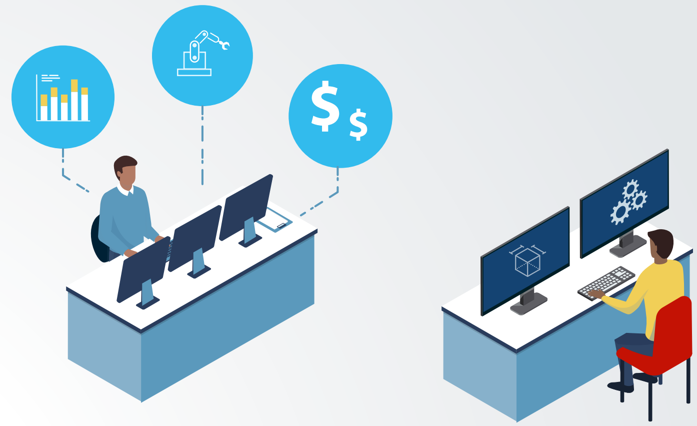
In the video available here, you'll see real examples of Honeywell using aPriori for Should Costing Analysis, supplier negotiation, manufacturability analysis, and more. You'll see how Honeywell engineers preemptively discovered potential manufacturing issues in a key redesign effort. In addition to eliminating these issues, Honeywell was able to source bids for this part that were closer to estimates than ever before.

Spirit Aerosystems Pinpoints Design Choices Driving Manufacturing Cost Outliers

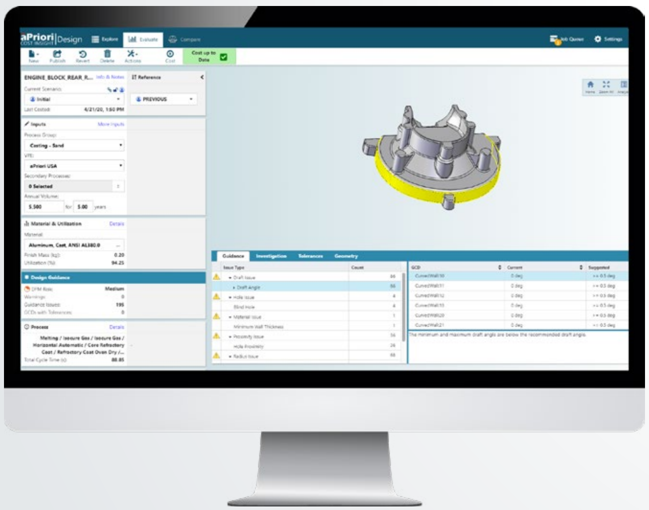
Spirit Aerosystems is the world's largest tier one aerostructures manufacturer.

In the video linked below, you'll see a great example of how a few seemingly innocuous design choices can have serious implications for cost structure by making a part more complicated to produce. **In this case, a few features like external radii and fine aesthetic filleting were causing a part to cost 11% more than necessary.**

7. WHAT TO LOOK FOR IN DESIGN FOR MANUFACTURING SOFTWARE



To maximize its impact, design for manufacturing 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 different manufacturing scenarios for different design alternatives.



Design for Manufacturing 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, for instance, the analysis begins by importing a 3D CAD model. After specifying a few basic inputs such as production volume, manufacturing process, and manufacturing location, aPriori can generate manufacturability and cost estimates in seconds.

In addition to running manufacturing simulations very fast, 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 accordingly drive down cost.

Design for Manufacturing Software Needs Broad Coverage of Key Manufacturing Processes

The ability to conduct rapid comparisons of alternative scenarios using simulation-driven analysis is essential for informing the design process without bogging down engineers. To generate the most cost-effective and production-friendly option, DFM software must be capable of analyzing a wide variety of manufacturing processes.

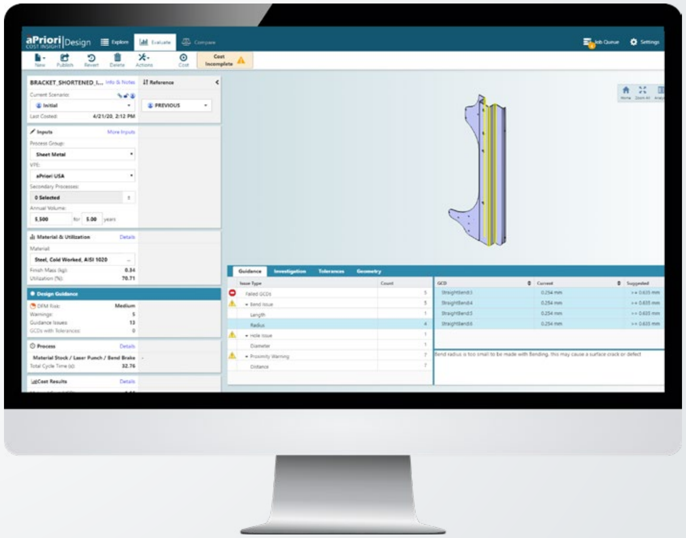
For instance, a *short representative* list of manufacturing processes supported by aPriori DFM software out-of-the-box include:

- 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.

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.



Selecting the Right Software is Vital to Maximizing Your DFM Strategy

As we have explored in this article, **the analytical capabilities needed to truly understand a design's manufacturability can drive multi-faceted business value:** accelerated product development timelines, 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 needs to be comprehensive, with the ability to estimate manufacturability implications ranging from production, to labor, to distribution. But even the most comprehensive analysis won't unlock the benefits discussed in the article if it's not usable in the context of fast-paced, collaborative design effort. **That's precisely why selecting the right DFM toolkit is so important.**

If you're interested in a detailed guide to picking the right software for your business, we've created a resource specifically to help prospective buyers select the most impactful possible DFM software.

Click here to read our article on what to look for in Manufacturing Cost Estimation Software here.

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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