RENAISSANCE SERVICES

Ensure Affordability with Design for Manufacturing

White Paper

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Design for Manufacturing—Lots of Talk, Limited Results

It is intuitively obvious that if something is designed up-front to make it easier to manufacture, it will cost less. This is one of those acknowledged truths—akin to a law of physics—that we knowingly repeat. We have nodded, stroked our chins and talked about this truth for a long time, but too often that is where it stops—at the talking stage.

Over 30 years ago, the Air Force published a "guide to producibility" in one of the earliest attempts to define methods and processes for achieving design for manufacturing (DFM). More recently, versions of the concept have emerged with the "Willoughby Templates," "design for six sigma," "design for manufacturing/assembly", "integrated product/process teams," and a myriad of other buzzword-dripping approaches for bringing design and manufacturing together to both make a better product and reduce cost. These concepts have, in theory, been enabled by sophisticated tools to create 3D digital images and by tools geared to promoting collaboration between major companies and their suppliers.

Despite all of these efforts, we still read annual reports from the GAO that military programs are overrunning their costs by substantial amounts. We learn that large commercial programs have greatly exceeded their cost objectives, even as they more openly miss their schedules. Based on all of this history, three questions need to be asked:

1. Why is the seemingly simple concept of design for manufacturing so hard?
2. Are all of these high sounding concepts for achieving DFM just so many passing fads?
3. If we really are serious about DFM, how can we make it happen?

This white paper will address some of the common excuses attributed to question #1. It will leave question #2 for the reader to ponder. It will then offer suggestions for how question #3 can be answered, with one *caveat*: the operative phrase is "serious about DFM." Any reader that is not serious about applying the discipline necessary to make it happen can stop reading now and go back to mouthing the buzzwords.

The World of Design for Manufacturing

1. Why is DFM so Difficult?

There are plenty of reasons offered for why DFM remains elusive. These include:

1. Insufficient resources (both dollars and people) are allocated early in the product lifecycle
2. There is lack of understanding of process capability relative to design intent—and perhaps even more troublesome, even when such knowledge exists, there is too often no practical way to apply it
3. Performance requirements are not properly defined and/or performance scope creep during the design process inhibits definition of manufacturing processes
4. The design calls for application of materials for which processes are not mature
5. Production sources are not understood well enough to work within their known process capabilities
6. Design tolerances exceed process capability

2. Making DFM Work

At this point, the logical question is: What do we offer that has not been tried? That is, what is there within this white paper that is new, what is there that will add to the dialogue and not simply re-hash the conventional wisdom? First, it is important to acknowledge that there is no silver bullet. It must further be acknowledged that discipline and adherence to the fundamentals—what Dr. Deming referred to as "constancy of purpose" or to use the football analogy, "blocking and tackling"—are still essential to success.

But let's assume that the disciplines are in place and that there is a commitment to doing things differently. This assumption is based on selection of the right project for DFM—that is, it is representative of the current and future product base and top management has communicated its commitment to success of DFM application. In addition, the project team—including prospective suppliers—is aware of the DFM approach and has had some training. Finally, the team willing to make DFM and does not revert to the old culture when things become "too hard." These are the very basic cultural shifts that must happen to nurture and grow a spirit of DFM success.

In such an environment, there are six basic considerations that will then enable successful DFM:

- Understanding Characteristic Accountability
- Knowledge Application
- Timing
- Tool Application
- Setting Expectations and Defining Success
- Supply Chain Engagement

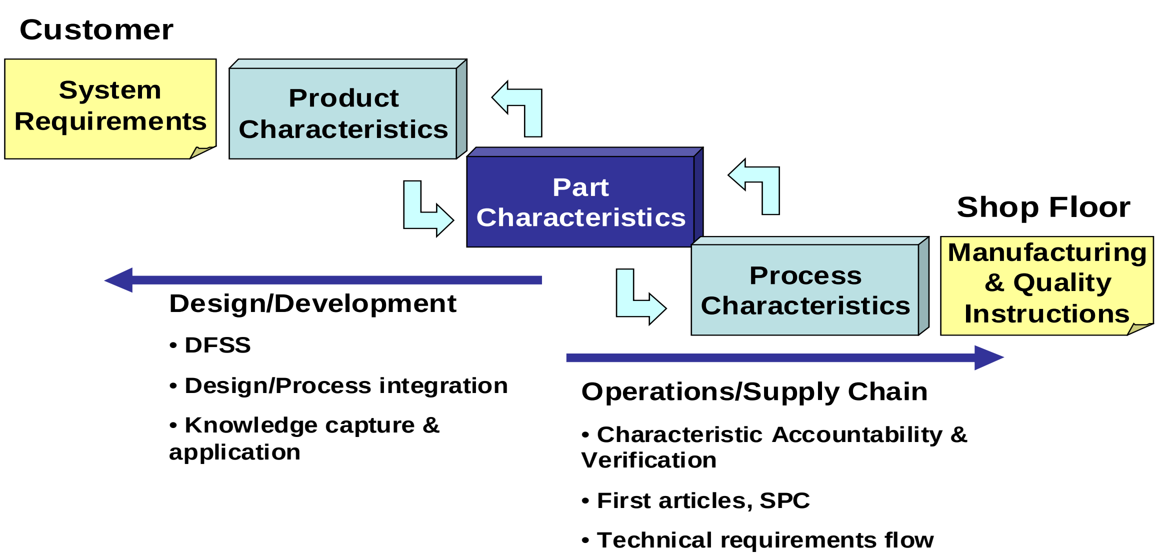
Each of these considerations can be explored in greater detail.

3. Understanding Characteristic Accountability

Characteristic understanding is to product definition as atoms are to physics. A product is the sum of the dimensions, geometries, notes, and specification references that define what it is, how it will perform, how it must be made, and how it will fit with the next higher assembly.

Characteristics are discretely measurable and comprise the building blocks that create product features—if a hole is a feature, the diameter, depth, and surface finish of the hole are characteristics. Individual part characteristics are the center point where design intent and process capability come together. They form the bridge between abstract design and tangible hardware which is essential to successful DFM.

A discrete part's characteristics are determined by its relationship to the larger product, which is the result of the overall system requirements. Converting these part characteristics into a real part is a factor of how capable the selected processes are in efficiently making this conversion.



Starting with the part and its characteristics, it is possible to look upstream at the design/development process and downstream at the operations/supply chain process. The upstream process is one of knowledge capture and application; the downstream process is one of knowledge execution. Both are dependent on a clear understanding of characteristics and their relationships to design requirements and process capability, coupled with a disciplined approach to making those relationships work.

4. Knowledge Application

A significant impediment to DFM is the difficulty in capturing fundamental knowledge of design practices/constraints and process capability at the component part level. Without a clear grasp of such knowledge, it is virtually impossible to apply it early enough in the product lifecycle so that downstream problems are avoided during production.

Many companies appear to have mastered the concept of "envelope DFM," which is using digital tools to ensure that outer dimensions of components fit properly within the larger product envelope. This approach focuses on how components come together for higher assemblies, ergonomic factors, and interference avoidance. These are very important considerations, but they do not explain the creation of a design that yields a producible product at the part level.

Part level producibility is the key to successful DFM. An assembly might indeed come together seamlessly, but the individual components that make up the assembly drive performance, schedule, and affordability. Achieving DFM objectives at the part level depends on three factors:

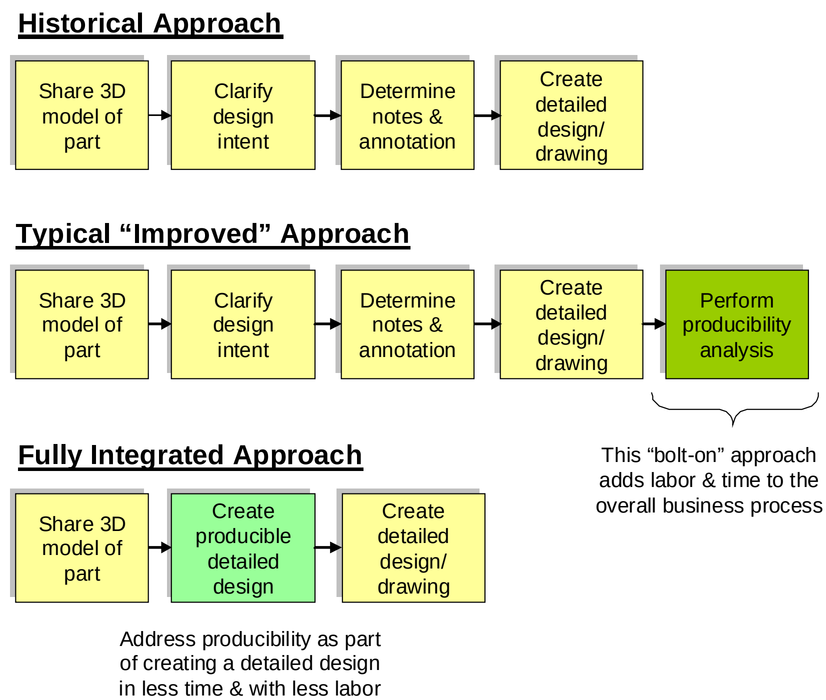
- *Knowledge capture & reuse.* The understanding of process capabilities and limitations, and the documentation of known design practices and constraints are essential pieces of knowledge that are seldom well documented. This captured knowledge, when coupled with a common interpretation, consistent application, and ease of access/reuse provides a common starting point during design.

- *Knowledge application.* Having the necessary knowledge is a good start. Applying and integrating it so that characteristic-level process capability can be weighed against design requirements is a critical step in the realization of DFSS.

- *Knowledge exchange.* The ability to take the knowledge, apply it in such a way that informed decisions can be made, and adjust accordingly is a function of collaborative exchange. However, to be effective, exchange among the disciplines involved in product development must be timely and integral to the process.

5. Timing

While bringing manufacturing engineers into the design process is a popular concept, it is where and when their knowledge enters the process that determines effectiveness. Many companies provide for a "producibility assessment," but often near the end of the design process, as a "bolt-on" activity during an obligatory review. This approach has limitations, because the manufacturing input often means changes to the design, which in effect creates "rework" for the design engineer.



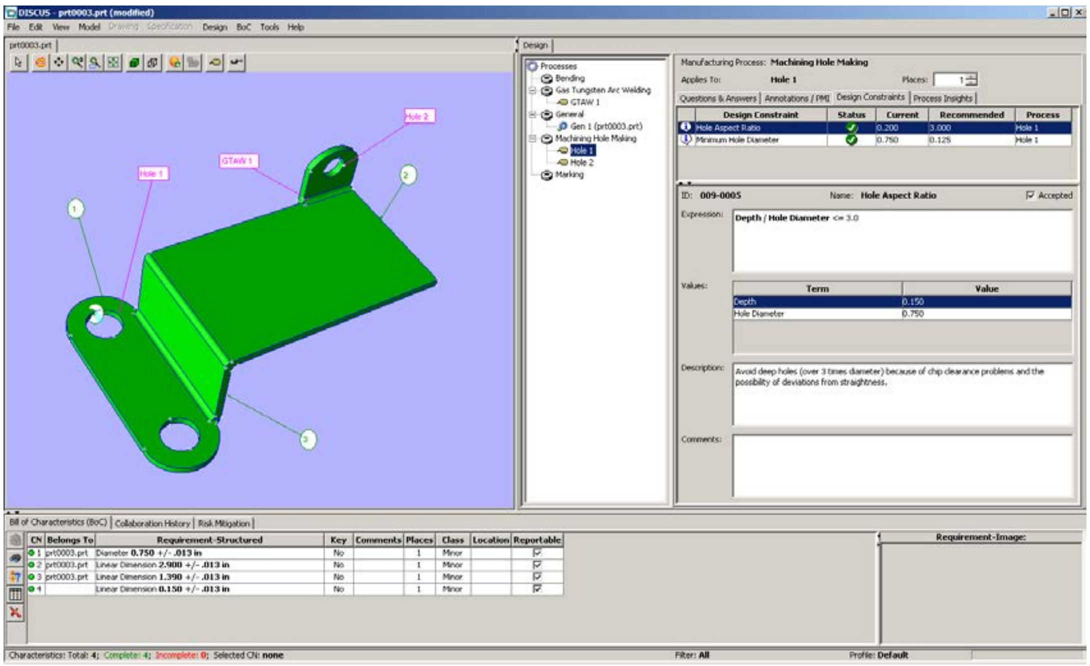
The bolt-on approach, while better than no manufacturing input, does not represent a truly integral collaborative knowledge exchange process. Making the manufacturing engineer integral to the process is clearly the best approach, but it is also challenging—both culturally and technically.

Overcoming the cultural hurdle of making manufacturing an integral partner is only the first step. Even if the process allows for the manufacturing engineer to be at the design engineer's side from the beginning, resource limitations make this impractical. However, there are ways to achieve an enlightened design process, so that the three factors of *knowledge capture & reuse*, *application,* and *exchange* can come together seamlessly a the component part level. The enabling technology for this merger is beginning to emerge as new software products become available.

6. Tool Application

There are software tools that can serve as the technical platform for integration of process knowledge and design practices, enabling component part characteristic-level DFM. It must be noted however, that tool application is clearly the fourth step in the DFM process. Without a commitment to achieve the three activities described above, application of any tool will simply lead to disappointment.

Assuming application in a digital design environment, such a tool should be "CAD neutral," allowing the manufacturing engineer to receive, evaluate, and annotate a solid model image during that dynamic period when a part approaches detailed design, but before it is too late to make meaningful suggestions. Using the combined design and manufacturing knowledge, the system can both store and dispense essential process insights, specification references that apply to individual processes, and design constraints. It then enables the application of this knowledge as direct characteristic-level annotations to the design. These annotations are then systematically captured in a "bill of characteristics" that allows them to be managed going forward over the product lifecycle.



7. Setting Expectations and Defining Success

Design for manufacturing compared to what? If the historical track record is one sigma, achieving two sigma is a roaring success, but it is hardly world class. Likewise, driving for six sigma past the point of diminishing returns is not practical. Defining DFM in terms of cost targets is another approach, but too often the expectation is to characterize a still fluid design/process relationship with cost objectives that are multiple places to the right of the decimal point.

It is no surprise then, that with such ill-conceived objectives, the tendency is to fudge the metrics at the expense of a truly producible design. The key is setting realistic, measurable objectives that reflect the nature of the design and the capability of the processes that must fulfill the design. As such, a simple "plus/minus" approach to DFM can work early in the design process. That is, using the available knowledge, is the selected approach for a given feature/characteristic more or less producible and/or expensive than an alternative? What factors—such as tolerance revision, process improvement/change—can enhance producibility? If the more expensive alternative was selected, what was the rationale? Finally, for a given component design, do the combined producibility advantages outweigh the negatives? Can this be projected as a downstream Cpk value or some other tangible expectation?

In many respects, the ultimate gauge for DFM progress is identifying a positive trend toward an objective versus fixating on an arbitrary goal.

8. Supply Chain Engagement

This is not really the last consideration—it must be factored into the DFM equation as early as possible. However, the other disciplines and tools need to be in place to make it work within the supply chain. Unfortunately, despite many claims to the contrary, supply chain collaboration is too often "here's the design, now make it." Cost improvements are achieved later when the supplier is brow beaten into providing them, often with the admonition "if you can't make it for this, we'll find somebody who can."

If a bill of characteristics, as described above, is made part of the technical data package (TDP) provided to the supplier, a common reference point for collaboration and candid discussion of process capabilities can be established. Using the software tools described above will enable collaboration with suppliers, even as the design evolves. Moreover, National Aerospace Standard 3500, *Technical Data Package: Composition, Communication, and Application,* provides an interactive platform for collaboration.

Admittedly, the culture for working with suppliers still lags the technology. Obstacles remain that often preclude establishing partnering relationships with suppliers early in the design cycle. These obstacles must be dealt with—often on a case-by-case basis—in order to fully extend DFM into the supply chain.

Ultimately, it is about the Fundamentals

Let's return to the question: "Why is DFM so difficult?" It is hard because achieving it is not a quick fix—it requires commitment and discipline. It can be enabled by some very good tools and methods, but ultimately it truly is about adhering to the fundamentals—the blocking and tackling—that are the hallmarks of success in any endeavor.

To learn more about how Renaissance Services can help you with DFM, contact:

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