Model-Based Definition for the Masses

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A White Paper Prepared by

Collaborative Product Development Associates, LLC for

Right Hemisphere Inc.

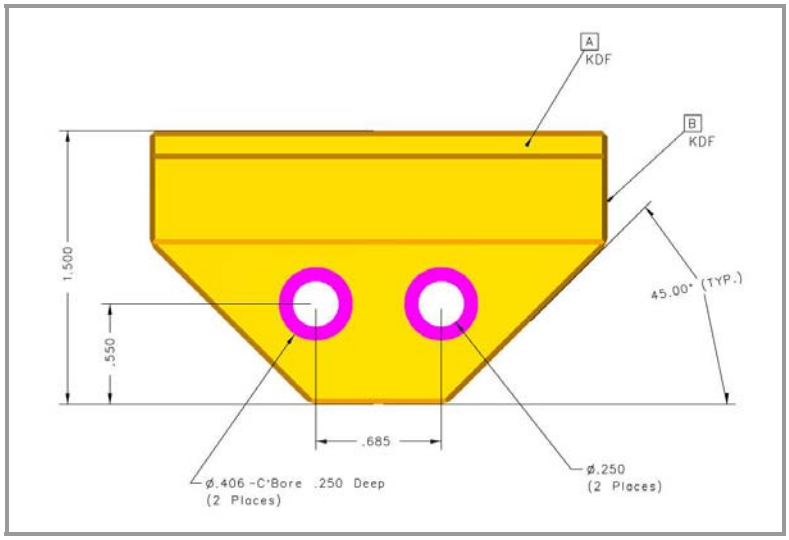
TABLE OF CONTENTS

Model-Based Definition

Leading edge product manufacturers rely upon a new emerging design collaboration concept to improve and accelerate their design and manufacturing process: **MODEL-BASED DEFINITION**. With a constant need to streamline process in order to gain and maintain competitive advantage, these leaders in highly engineered product markets focus attention on 3D model data exchange as their data communication conduit across internal product disciplines and with their supply chain partners. Key players in the aerospace and defense industry vertical stand on the forefront as early adopters of the technology trend.

The central concept embodied in model-based definition is that the 3D product model is the most appropriate vehicle for delivery of all the detailed product information necessary for downstream organizations to perform their part of the product delivery cycle. Any number of *views* of the 3D model can be composed, detailed, and annotated for specific downstream groups such as manufacturing planning, product services, procurement, and marketing/sales. For example, a "live" 3D model with a sequence of prepared views containing key dimensions and tolerances provides a manufacturing partner in the supply chain a more intelligent communication of what must be produced. To the manufacturer, the 3D model is live because they can accurately make additional measurements of the product that would have been impossible (or worse, measured incorrectly) if only 2D drawings of the product were delivered.

FIGURE 1
A Model-Based Definition containing GD&T



For most companies, the highest priority of model-based definition data passing based on expected return on investment (ROI) is between a design engineering group and its manufacturing partner. Therefore, the information attached to the 3D product model includes dimensions, tolerances, material properties, and other information needed for manufacturing process planning, tooling, and shop floor production. This data is often referred to as Product Manufacturing Information (PMI) or Product Geometric Dimension and Tolerance (GD&T) information.

Additional views of the model are dimensioned and selectively annotated for other downstream groups such as quality assurance and validation of industry and regional standards compliance. With the proper notations on the model for size and materials, costing analysis is accomplished and that information is passed on to procurement organizations.

Collaborative Product Development Associates (CPDA) recently conducted a series of in-depth interviews with leading edge product manufacturing companies in the Aerospace and Defense industry vertical. The goal of the study was to assess how far they were into adoption of the model-based definition process, what were their business drivers, and a discussion of both the technical and cultural challenges they faced. In addition, CPDA interviewed a few selected companies outside of aerospace/defense to compare and contrast their experiences.

BUSINESS DRIVERS

Companies were asked to articulate the specific business drivers that led them to adopt a model-based definition process. As expected the themes of reduced cost, shortened development cycle times, and better product quality were noted. Their individual responses, however, highlighted a deeper understanding of the root causes of problems in their current process.

A sampling of their statements included:

- Lean down a process accurately and just-in-time for construction
- Improved accuracy working with all suppliers and manufacturing partners
- Reduce the amount of drafting; reduce downstream printing of drawings
- Interrogate models more efficiently
- Improved quality from a single data state – no spawned data. The 2D drawing, for example, could end up being the master
- Overcome breakdowns in associativity between models and 2D drawings

Many saw model-based definition as the next logical evolutionary step in design from 2D-only, to 3D with 2D drawings, to now 3D model "views." In order to remain competitive in their market segment, each felt the need to track and adopt best-in-class approaches within the product development process.

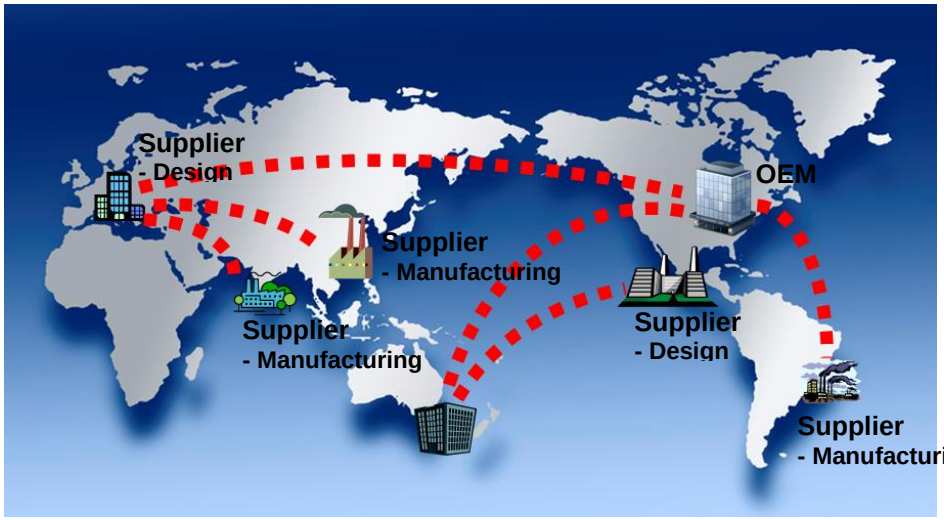
Exploring which organizations were targeted as consumers of model-based definition data drew responses that covered the complete gamut of product development disciplines. While the interaction between the OEM and suppliers, whether for outsourced design and/or manufacturing was the most common response, diverse groups mentioned included: procurement, marketing, technical publications, services, and logistical support.

Most companies indicated that their first priority centered on the communication between design engineering and the manufacturing realm, both with manufacturing process planners who decided and detailed *how* a product would

be manufactured and with production and assembly staff on the manufacturing floor. A majority of the companies emphasized that manufacturing was outsourced to their supply chain and the important role model-based definition played in their interaction with those suppliers.

Many of the companies interviewed, because of their size and product complexity, dealt with an extensive network of suppliers around the world (Figure 2). Accurate communication between companies was considered a critical issue in meeting product program and schedule goals, especially since levels within the supply chain could easily go three or four levels deep.

FIGURE 2 The OEM and Supply Chain Communication Network



Not all the companies interviewed saw the exchange of 3D model-based definitions fully replacing the need for 2D drawings. One company indicated they were working towards a goal of allowing automatic generation of 2D drawings from the 3D model-based definitions for those consumers of the data who felt they needed 2D. On the opposite side of the argument, one company who did target the elimination of 2D drawings reported an impressive 4-to-1 reduction in manpower cost.

ROAD MAPPING

Based on "lessons learned" from early adopter of the technology, the introduction of model-based definition requires leadership from key individuals, not just in design engineering, but across the product development process. Most companies reported that the seed ideas for the use of model-based definition began in engineering from individuals who recognized existing problems in their workflow across organizations and into the supply chain. Rework was happening throughout the product cycle, introducing hidden costs. Engineering also noticed the call for "full digital data" appearing as a preference in product proposals from clients.

Design engineering is the *authoring* organization for model-based definitions, but acceptance of the concept across the company requires buy-in from the *consumers* of the 3D data. Identifying forward-looking players in each of those organizations and making them part of the unified team promoting the model-based definition concept is critical to its success. Management support comes only when there is a coalition of support evident within each key product domain.

Each company interviewed as part of this research made special note that they needed to assess each of their suppliers on their maturity level to accept and work with full 3D data. Many held informational meetings with their suppliers to review the new process and resolve any issues.

TECHNICAL CHALLENGES

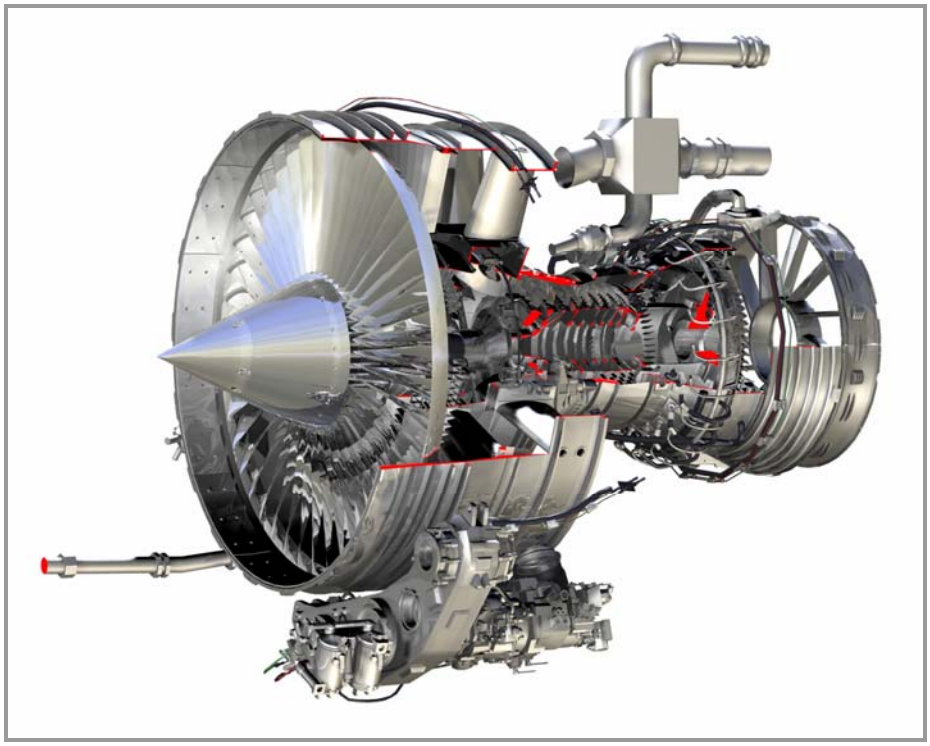
During the interview process, CPDA questioned end users at length concerning their expectations of the technical issues they would face in establishing their first model-based definition process, whether those issues proved true, and what technical surprises occurred. Their responses were consistent regarding technical challenges that arose during their pilot programs, although a few end users admitted that they did not have initial concerns except to know that they would face problems.

Four recurring issues were common across the majority of companies:

1. **DATA VOLUME** – the process needed to generate and manage very large data models and assemblies;
2. **DATA CONTENT** – the information required by downstream consumers of the model-based definition files covered a broad range of subject matter, not all of which was available in the CAD application;
3. **DATA TRANSFER** – the mechanism chosen to transfer data between authors and consumers would likely put pressure on the varied consumers of the data, whether in geographical distributed company sites or in the supply chain, to have the proper IT infrastructure and viewing software tools; and
4. **DATA PRESENTATION** – consumers of the model-based definition data varied widely in technical expertise, which subset of data they required, and in how they wished that data to be displayed.

That users would face a data volume issue was a reasonable assumption given the size and complexity of products designed and manufactured in the aerospace/defense industry vertical. For the most part, users relied on their product data management (PDM) system to store and track changes. They knew, however, that their choice of model-based definition files being transmitted to the consumers of that data could not be in a CAD design application format. The expense of the software license and the level of technical knowledge to use a CAD product were for the most part beyond their consumers' capabilities.

FIGURE 3
Model-Based Definition of a Complex Jet Engine With Cross Section View to Highlight Detail



All chose some form of lightweight viewing file format. The design engineers being the authors of the model-based definition data were already very familiar with the existence, capabilities, and benefits of using lightweight viewing files. That choice, however, did not totally alleviate their need to pay close attention to the generation of lightweight data – assuring that they remained synchronized with the 3D CAD models, were organized for easy transfer and access by the consumers, and supported the ability to notify consumers when a change occurred.

Data content actually posed a much bigger issue for most companies. One concern voiced by a number of interviewed companies – how much data is too much? – remains an open question. One company articulated the issue the best, saying that there are 100s of data attributes related to a product model, not all of which are needed by every consumer of the model-based definition data. They are still actively reviewing which are essential for their downstream consumers, hoping to avoid the complexity of managing them all.

Surprises did arise at many companies as to exactly which application generated and maintained specific pieces of product data. It was not uncommon to discover that the CAD application did not contain all the data they assumed. Further, some data, while available in the CAD system, was determined to be best handled by a PDM system. An example given was product weight. Although a CAD system can compute current weight, there was a need to define and track *required* weight, *target* weight, and other variations.

Another common issue dealt with by most companies was data stored in legacy systems. This information now needed to be accessed and presented in the model-based definition files. All companies avoided the pitfalls of trying to replicate a copy of the data into the model-based definition files, eliminating the nightmare of data synchronization. Most chose to embed a link to the original data location, although that required consumers have the correct infrastructure to follow the link. One company chose to bundle the data in multiple data files, managed by a mini-PDM solution from a commercial vendor.

The data transfer mechanisms they chose relied as expected on the internet, however, they paid close attention to the burden being placed on the consumers of the data. Often, the wide range of consumer profiles they dealt with exhibited varied levels of maturity in their infrastructure capabilities. In addition, they were now imposing a burden on the consumers to buy, learn, and maintain a software viewing application to access the data.

Finally, the most difficult issue they faced – one that consumed a large amount of pre-planning – was data presentation. Each consumer of the model-based definition data had a different task to complete and worked in a wide range of disciplines, including manufacturing, technical publications, product services, and marketing.

Data needed to be graphically presented in a manner best suited for their needs. Often the same data needed to be presented differently to different users. For each consumer, they were forced to ask the questions: *what* data was necessary, *how* data should be graphically presented, and *how* could the data be easily accessed. Companies were quick to offer up interesting examples. One hard edged manufacturing consumer complained that without a 2D drawing and its partitioning zones of A, B, C, and 1, 2, 3, across the drawing borders, he was unable to communicate with colleagues over the telephone and easily indicate the location of a specific dimension in a complex model. The response: Zone labeling added to the 3D Model views.

The best-in-class companies have employees whose job is to interview consumers, document specifications for what and how, and then take responsibility for preparing the needed model-based definition files from CAD models supplied by engineering. A number of companies wrote scripts to automatically generate the needed 3D views and add the appropriate data content.

Another common thread arose during the in-depth technical discussions. Most companies who have been pursuing the model-based definition trend over the past three-to-five years noted that commercial tools have evolved over that period of time. Three years ago, a given capability end users needed might not have been available, where it is today. Over that time, each company struggled with solution workarounds in order to meet their internal schedules and goals.

CULTURAL CHALLENGES

Interviewed companies were quick to emphasize the need to "manage change." One explained that their efforts to transition their company to a model-based definition process and away from 2D drawings was "90% psychological" in that serious efforts were needed to convince the diverse range of product stakeholders that there was a new, better way to do business.

Most noted that the consumer side of the equation was the most difficult. Authors of model-based definitions, typically in or aligned with design engineering organizations, readily accepted the change, being very used to working with 3D. Consumers of data, however, especially in manufacturing organizations, have relied on 2D drawings for years. The model-based definition approach represented a radical departure from their way of doing business.

Their best advice offered in overcoming these hurdles all centered on the need for open communication. One end user warned that "rumors and misconceptions" will be rampant, unless information is made readily available. Many companies accomplished this by one-on-one meetings with consumers of the data. One company went so far as to stage a conference of all their suppliers to present the new methodology, and then work out concerns in split-out meetings.

A number of companies did advise, however, that management buy-in was critical. At some point, stragglers in accepting the new way of doing business needed management direction.

SUMMARY AND OPINION

Within aerospace and defense, product development companies experience unrelenting pressure to deal with rising complexity in business relationships, product composition, and technology. In this environment, accurate communication and collaboration between all product stakeholders is paramount. Competitive pressures will continue to increase. Accurate, informative communication and collaboration between all stakeholders in product manufacturing represents a critical factor for success. The active participation of all business, engineering, and manufacturing domains, including all supply chain partners, must remain focused on delivering product. Discussions with a few selected companies outside the aerospace and defense vertical confirmed each and every point.

Transition to a model-based definition process, however, requires planning and the active support of product domain leaders. Product development cannot shut down suddenly and start up with a fully new process in place. The transition must be road-mapped and carefully undertaken in logical steps. The early adopters recommend that return on investment measurements be taken along the way to gain the support of management.

No company indicated that technical issues encountered along the way were insurmountable. They did, however, advise that certain best practices be followed:

- Work closely with each consumer organization to identify the details of what information is needed on the 3D model
- Understand the consumer's task and working environment to graphically present the data in the manner best suited to their needs
- Expect that some consumers will not voluntarily buy into change and work with their management to smooth the transition

Each and every company interviewed for this research stood by their decision to adopt a model-based definition process. Each spoke of the positive benefits their companies have already attained while adding their convictions that the full value of the technology provided to their companies was only just beginning to be realized.