Tech-Clarity

Issue in Focus:

Designing Products for Performance, Risk, and Compliance

Leveraging Product Analytics to Optimize Design Decisions and Tradeoffs

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Introducing the Issue

What do product weight, environmental compliance, part obsolescence, and product cost have in common? These, among other product attributes, are important factors that impact the revenue and profitability of a product. In addition:

- They result from a series of design decisions including component, material, and supplier choices
- They are very difficult to change late in the design process
- Designers rarely have the right data to make optimal choices (or even understand the impact of their decisions) to influence them during design

This is why Tech-Clarity's Making Product Development Tradeoffs concludes that "*Leading companies are building compliance, cost, and sustainability analysis into their design processes*." They do this because they recognize that design decisions impacting product characteristics must be made early in design, while design flexibility is at its highest and there is time to react. They have also learned the pain and disruption caused by late changes that lead to excess cost, delayed time to market, and sub-optimal products. Many have also realized how much time and effort goes into ineffective, after-the-fact processes like "Value-Added Engineering" when issues could have been dealt with much more readily upfront.

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Unfortunately, few companies are able to provide visibility to the impact of design decisions in time for engineers to incorporate the feedback into designs. In many cases the lag time between a decision and visibility to the impacts takes long enough that the information is irrelevant because the bill of material (BOM) has already changed. Ideally, designers would have feedback so rapidly that designers could explore more options and review more "what if" scenarios to optimize the resulting product characteristics. Product analytics is an emerging discipline aimed at helping engineers optimize designs based on timely feedback.

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One area that manufacturers have already invested in analytics is to address regulatory compliance. Compliance has taken priority because regulations such as RoHS, REACH and their regional derivatives, a host of other regulations, and now the Dodd-Frank regulations on "conflict minerals" threaten revenue streams due to brand damage and

blocked market access. To address this, leading companies have invested in an automated, repeatable process to design for compliance. As the "Product Tradeoffs" report recommends "*Enable design for product environmental compliance, sustainability, and cost … with integrated processes and systems for efficiency and to allow product developers to see the whole picture*." This report discusses how this same infrastructure, the "Product Analytics Platform," can be extended to help designers make the right decisions to optimize products and mitigate risk with a holistic approach that addresses product characteristics beyond compliance.

A New Addition to the Enterprise Ecosystem for Manufacturers

Making optimal design decisions requires the ability to rapidly evaluate product structures and determine the resulting impact on product characteristics, or "Product Analytics." Product analytics is becoming an important part of the enterprise systems landscape for manufacturers. The solution was initially developed to meet challenges in environmental compliance. In the process, however, it had to address the primary challenges faced in any "design for" or "DFX" process, including:

- Capturing requirements in a logical way
- Analyzing complex and ever-changing BOMs against requirements
- Providing designers with visibility to the right information in time to make decisions

Prior to the advent of Product Analytics, providing the right information was difficult because manufacturers didn't have the necessary infrastructure to manage changing requirements, changing BOMs with all their variants, and capture the required data from the supply chain and other information sources. Each of these steps is hampered by challenges. The number and complexity of requirements is staggering. Products change rapidly and consist of more variants than ever. And collecting the right supply chain information involves long cycle times, high cost, and the ability to accommodate varying degrees of information quality.

Prior to the advent of Product Analytics, providing the right information was difficult because manufacturers didn't have the necessary infrastructure.

Today, applications are available that integrate with PLM and other data sources to help with compliance. Compliance, though, is only one of the factors that go into developing a profitable product. There are many commercial and technical attributes and risks that must be addressed early in design. Today, however, these are typically handled as one-off problems. Product analytics looks to change that, moving analysis from ad-hoc, disconnected processes to an enterprise-class process with supporting technology. With this approach, companies can use information in the context of products to make

optimization and tradeoff decisions between design options, as seen in this representative spider chart illustrating design tradeoffs (Figure 1). There is a significant opportunity to apply the same enterprise-class, repeatable process to a broader range of issues, leveraging product analytics to help designers analyze their designs and make tradeoffs across product characteristics early in the design process.

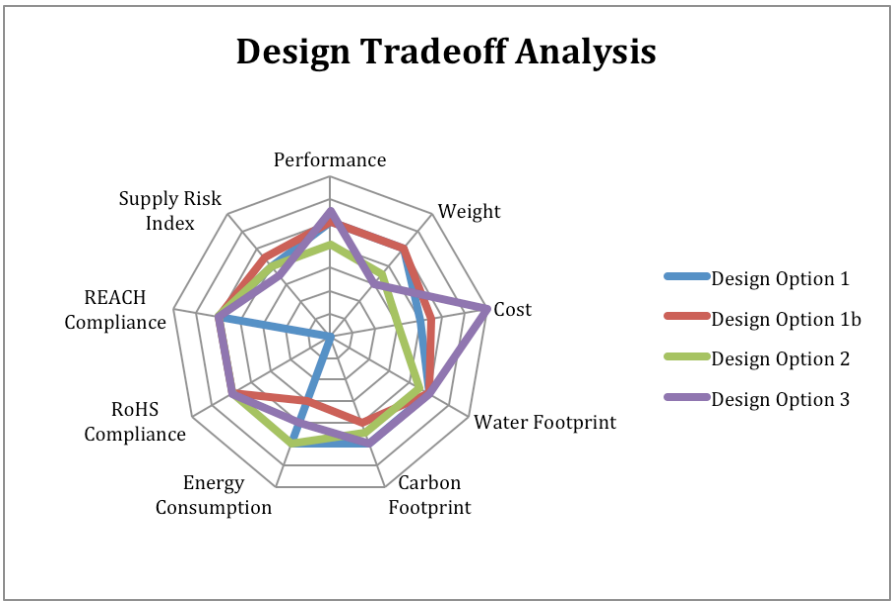

Figure 1: Tradeoffs between Product Requirements

Leverage a Product Analytics Platform

As the maturity of product analytics as a discipline has evolved, it's time to put forward a framework to help manufacturers understand the processes and capabilities required to support a holistic product analytics program. The product analytics framework approaches optimizing product designs for various characteristics as a class of related issues as opposed to one-offs. An effective, enterprise-class product analytics approach provides standard processes required to develop profitable, low-risk products. It simplifies the process and opens up economies of scale by addressing challenges such as gathering, cleansing, and aggregating supply chain data in a way that leverages the data across attributes.

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Because design optimization must be accomplished early, starting with conceptual design, a product analytics platform must be integrated to the authoring systems where

design decisions are made. Analytics must be tightly linked with PLM because that is where work in process BOMs are developed and the product can be analyzed as a whole. PLM is also where engineering change orders (ECOs) are typically generated and managed. Of course product analytics must also exist beyond initial design as products and product requirements change, remaining linked with PLM but also potentially linked with execution and business management systems such as ERP.

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The following framework (Figure 2) suggests a set of integrated processes that together provide cohesive support for product analytics. A product analytics platform should embody and enable the processes in the product analytics framework and integrate them around shared data, allowing increased efficiency and better results by addressing product design and analytics holistically.

This framework is based on Tech-Clarity's Product Compliance Framework, which has now been extended to represent the broadening factors analytics are used for beyond environmental compliance. It can be applied to compliance, but is also meaningful to design for cost, weight, energy consumption, sustainability, and much more. See practical examples of how the framework (and an associated Product Analytics Platform) can solve practical business problems in the "Applying the Product Analytics Platform" section. The next seven subsections will describe the Product Analytics Framework in more detail.

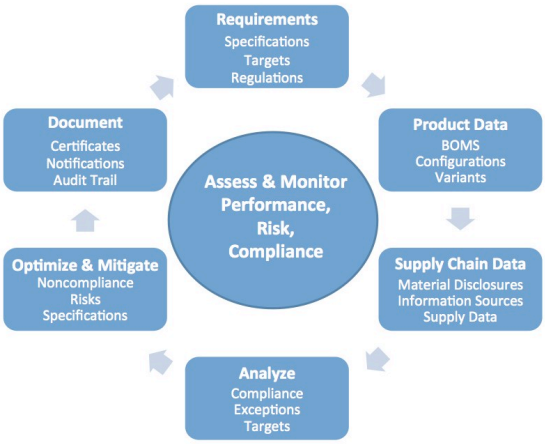

Figure 2: Product Analytics Framework

Develop Requirements

Products have multiple, complex, and often competing targets that must be hit, whether it's a cost target, a power threshold, or a regulatory constraint. The first step in optimizing products for those targets is documenting the requirements in a logical way and putting them in a form that can be electronically interpreted to determine if they are met. These requirements might be calculated like a weight, logical checks such as the availability of a certification document, targets such as a range of values, or even rolled up values like the amount of a substance of very high concern in a final assembly.

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A product analytics solution should be able to manage multiple requirements to address overlapping (and potentially conflicting) regional mandates, exceptions, and effectivity dates. The solution should manage all of the requirements in a central location and provided a "netted out" set of targets that must be met. Again, this must be in a form that can be automatically interpreted, effectively creating a set of consolidated requirements for the product BOM.

Access Product Data

As products are developed they move from a conceptual product structure to a more concrete BOM and approved material list (AML) identifying valid components and suppliers. This information is a critical input to analyzing whether requirements are met. Many companies have complex, multi-level BOMs and define variant configurations that represent different product options. These BOM structures must be easily accessible and interpreted in order to allow rapid feedback to designers as they make design decisions. As designers progress the definition of the product, for example selecting a particular component or supplier, that change should be immediately available to the analysis engine so designers can get real-time feedback on the implications of their decisions.

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Collect and Manage Supply Chain Data

Very few manufactures are fully vertically integrated. To produce their products they must rely on a supply network to provide quality materials and components. The suppliers in this network also need to provide quality data on the items they provide so the manufacturer can determine the makeup for their product. This can be a significant challenge. It's not enough to have a repository to store the information, the platform should support a process to identify information gaps, request data from the appropriate suppliers, validate the information received, and translate it into a standard format that can be interpreted by the analysis engine. This process must be highly efficient, as data collection can be one of the most time consuming and costly parts of product analytics.

The data collection process should allow information to be collected centrally and used to analyze a variety of attributes.

In addition to being efficient, data collection and management processes must be flexible. They should be able to assimilate data in multiple forms and from multiple sources. For example, companies may access reference data from a standards database, collect compliance information from an industry database such as IMDS, or accept data directly from suppliers. It should also be able to access information from other systems such as ERP or Supply Chain systems. The data collection process should allow information to be collected centrally and used to analyze a variety of attributes, particularly as more leading companies move to gather "full material disclosure" from their suppliers to gain a more complete picture of the products in their portfolio.

Analyze and Compare to Targets

Product data, supply chain information, and requirements come together in the analytics engine. The analytics engine reviews product structures and calculates attribute values at all levels of the BOM. The engine must be able to perform simple rollups, percent of composition, and perform logical checks. Of course "simple" rollups may still be complex due to complicated calculation rules and the need to review multiple product configurations. For example, the engine might provide a minimum and maximum value for an attribute across all variants.

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While there are some standard rules to follow, the analysis engine must be flexible to allow the platform to span across different forms of requirements to identify

nonconformance and risk. In addition, the engine should be able to recognize and report on data gaps or uncertainty and provide a view to data confidence where information is missing or estimates are utilized.

Optimize Designs and Tradeoffs

Perhaps a good portion of the work required to make design tradeoffs happens outside of the framework. As risks and nonconformance situations are identified they must be mitigated. In addition, as seen earlier in Figure 1, many design decisions result in tradeoffs between competing requirements. These design changes will be performed in CAD or other authoring systems and reflected in PLM. The analytics engine does not control this process, but it needs to rapidly report the resulting parameter values so designers can perform what-if analysis and optimize designs across metrics, effectively using the analytics engine to develop tradeoff studies for competing design approaches.

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Validate and Document Results

A complete product analytics process requires reporting. Products require significant documentation for legal, technical, and risk management purposes. The product analytics platform must be able to provide documentation to support compliance and conformance claims. This documentation may come in many different forms, requiring a flexible approach. In addition, the reporting should archive information to document the rationale for design decisions and support audits as required. These documents must also be kept up to date as products change, creating new revisions of documentation.

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Monitor for Risk

The original Product Compliance Framework was pictured as a circular process to represent an ongoing process. The Product Analytics Framework goes further by showing a monitoring process at the center. It's important to recognize that requirements, data, and products all have their own lifecycles. The information used to analyze risk, conformance, and compliance is highly dynamic, so a product analytics platform must have the ability to continuously monitor products and

variants, look for engineering changes, identify new or changing requirements, and take into account changes in (or expiration of) supplier declarations.

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In addition, the framework should be able to perform ad-hoc, on-demand, what-if analysis. For example, a company should be able to find out what would happen if they need to eliminate a certain material, reduce mass by a certain percentage, or if a commodity price is expected to spike. Again, the engine should be able to recognize and identify uncertainty to properly assess risk.

Applying the Product Analytics Framework

The Product Analytics Framework (and the enabling Product Analytics Platform) has as many uses as products have attributes that can be measured. While most companies will venture into using the platform for product compliance to protect top line revenue, the infrastructure has many uses once it's in place. With a common approach, companies can apply a consistent methodology, share data across functions, and ensure that they use the most up-to-date, accurate BOMs instead of a prior extract from the system. The framework can be applied to several classes of problems, which will be detailed in the next subsections, including managing supply chain risk, mitigating commercial risk, and achieving technical targets.

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Apply Analytics to Mitigate Supply Risk

Nothing could be more frustrating than designing a great product that can't be produced due to supply issues. A product that meets form, fit, and function but hasn't been analyzed for potential supply issues has the potential to excite customers but then fail in the market because of component shortages or dramatic cost spikes due to material or supplier issues. These issues should be addressed during design by analyzing for risky supply scenarios such as single sourced items, parts sourced from a single region, long leadtime items, obsolete (or soon to be obsolete) parts, scarce commodities, or items that are susceptible to counterfeiting.

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On the other hand, manufacturers can mitigate the risk of disruptions, excess cost, and customer dissatisfaction by ensuring products are properly designed for supply. For example BOMs can be scored on the inclusion of preferred parts, the percent of commercial off-the-shelf (COTS) parts, or adherence to strategic targets like part reuse. Analytics can also help determine the impact of unforeseen supply disruptions, for example determining company exposure to a price spike, reliance on a material in a part of the world that is at unrest, or the consequences of a major supply chain disruption like the recent earthquake and tsunami in Asia.

Manage Commercial Risk

There is no shortage of commercial risk facing today's products. Perhaps the most pressing today are the environmental compliance regulations such as REACH, RoHS and all of their local variants. Manufacturers should expect no relief from environmental regulation and expect it to be more complex than ever due to regional variations and growing lists of controlled substances. In addition, companies have to address additional regulations such as the Dodd-Frank act that regulates the use of "conflict minerals."

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Environmental compliance is only one of the commercial risks that a product analytics platform can address. Other factors such as recycled material content and country or regions of origin are highly dependent on material choices during design and good candidates to be managed through analytics. In addition, many import / export regulations should be analyzed during design to ensure that unexpected commercial restrictions don't limit market reach.

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There are many other regulatory demands that must be met before shipping a product, such as ensuring a product has the proper UL or FCC documentation and labeling. In addition to regulation, commercial requirements such as customer and corporate environmental standards must be addressed. This view is rapidly growing to cover a broader impact of the product, including Life Cycle Assessment (LCA) to manage the consumption of resources such as water and energy and the carbon footprint across the life of the product. These are all in addition to cost, of course, which is an important target to manage for all but a few manufacturers.

Measure Attainment of Technical Targets

Product designs still need to meet form, fit, and function in addition to meeting supply and commercial demands. Designers must navigate a variety of technical and operational requirements such as target weights and energy consumption. Many of these are dependent on design choices and the resulting BOM. Other factors such as reliability are also good candidates to manage early in design to ensure that the proper materials and components are specified. Other, more complex analytics may also be analyzed. For example if positional information for components and assemblies is available, product attributes such as center of gravity can be calculated and compared to product targets.

Factors such as reliability are also good candidates to manage early in design to ensure that the proper materials and components are specified.

Conclusion

Product Analytics is becoming an important competency for today's manufacturers. Effective and timely product analytics helps manufactures design products right the first time, hit their targets, and mitigate risk. Following the product analytics framework of processes offers manufacturers the opportunity to transition design validation from an ineffective, expensive, ad-hoc approach to a proactive, enterprise methodology. It helps designers make tradeoffs and optimize design decisions when they are most flexible and can make the most positive impact.

Effective and timely product analytics helps manufactures design products right the first time, hit their targets, and mitigate risk.

An effective product analytics platform enables the processes of the product analytics framework. This platform supports the "must do" need to design products for product environmental compliance and extends those capabilities to a class of issues ranging from technical requirements to supply chain characteristics. An effective solution makes DFX feasible by providing transparency and timely feedback to designers. At the same time, the solution can improve efficiency by reducing the overall cost of compliance and design. The product analytics platform is rapidly becoming an indispensible part of the enterprise systems ecosystem for manufacturers.

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Recommendations

Based on industry experience and research for this report, Tech-Clarity offers the following recommendations:

- Manage product requirements centrally and net out requirements, recognizing that many will compete and require tradeoffs
- Analyze the impact of design choices in the context of the BOM by leveraging product data – configurations, BOMs, components – as it is developed
- Provide feedback during design, before it is too late and while flexibility is at its highest
- Validate against requirements and generate product documentation with efficiency and confidence, supporting audits and inquiries
- Extend compliance processes to support supply risk, commercial risk, and attainment of technical targets in a consistent, cohesive methodology
- Monitor adherence to requirements over the lifecycle of products as designs and requirements change
- Leverage a platform approach to product analytics to enable efficient, consistent processes integrated around shared data

About the Author

Jim Brown is the President of Tech-Clarity, an independent research and consulting firm that specializes in analyzing the true business value of software technology and services. Jim has over 20 years of experience in software for the manufacturing industries, with a broad background including roles in industry, management consulting, the software industry, and research. His experience spans enterprise applications including PLM, ERP, quality management, service, manufacturing, and others. Jim is passionate about improving product innovation, product development, and engineering performance through the use of software technology and social computing techniques.

Jim is an experienced researcher, author, and public speaker and enjoys the opportunity to speak at conferences or anywhere that he can engage with people that are passionate about improving business performance through software technology.

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