DFM (Design for Modularity)

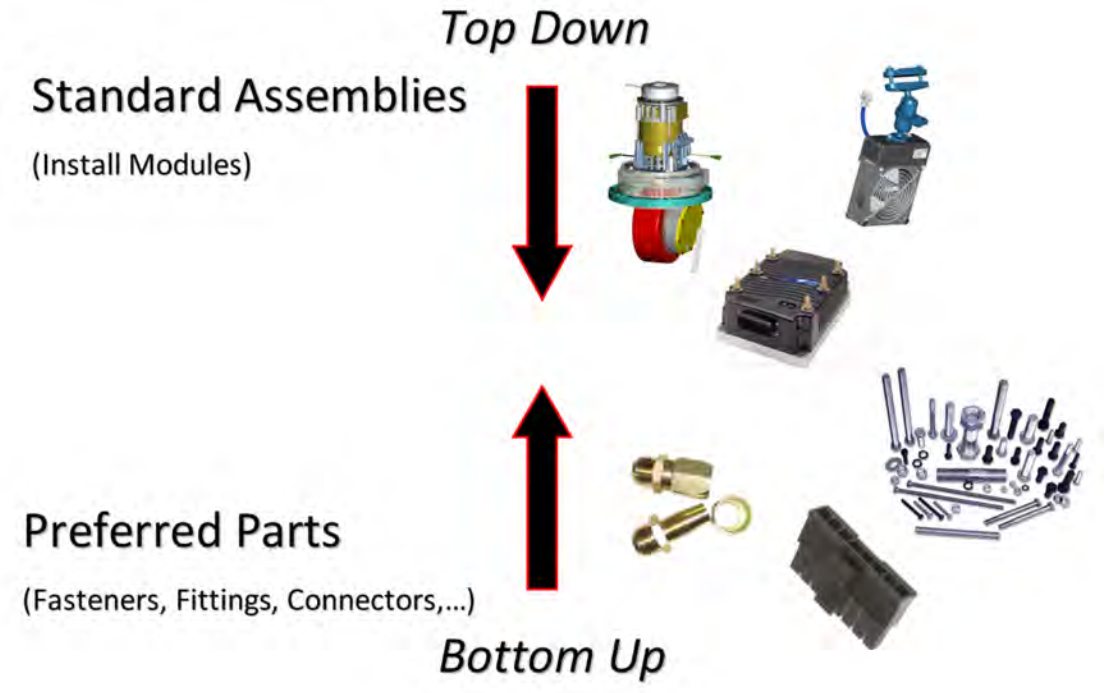
Design for Modularity

Modular design is quickly becoming an “engineering household name,” as has lean and Toyota Production Systems (TPS). There are a multitude of possible benefits to incorporating this into a business, at the same time it can have its drawbacks. More often than not, the value of modularization greatly out weighs any possible issues that can be brought about by standardizing product lines. However, with all the obvious benefits it is often hard to fully capture the value of modular development. Standardizing parts and assemblies can seem to be a daunting task, but you have to start somewhere.

Customized Customer Base

The Raymond Corporation designs, builds and markets material handling equipment within the Toyota Material Handling North America group. Being very closely affiliated with Toyota, TPS is a large part of our culture. We strive to cut costs at all levels and optimize our processes. Modularization is something we are moving forward on currently. There have been several projects standardizing sub assemblies that could be deployed on multiple product lines.

Our customers demand specific requirements for different applications in their warehousing operations. Goods need to be handled in a variety of situations and this requires a wide range of material handling products to satisfy our customer’s needs. When a customer orders a truck there are a large amount of configurations that need to be determined. For example, we have around 10 distinct product lines. One specific product line has 8 models, one model has 5 weight classes, and each weight class offers 86 different height ranges. This is just a glimpse of the complexity of configurations we have, the intricacy of this can tend to be staggering. To the outsider, this may seem borderline ridiculous, but it is integral to accommodating our customer’s specific needs and requirements. Mass customization is our business.



Bottom Up Modularization

Fasteners, terminals, fittings, etc… Most OEM's have vast amounts of part numbers and resources dedicated to purchasing, stocking, tracking, sorting, and dispersing them. All these processes add up to a significant cost, not to mention the designers time to choose the correct hardware for their designs. What if you could cut costs here? Bottom up modularity is one method of cutting costs right at the source. Less part numbers equals less cost.

We are going through our released parts and picking ones to become "preferred parts." We have extensive amounts of these standard parts; fasteners, hydraulic fittings, hoses, and other piece parts. As technology has changed and the business grew, tracking these parts became more arduous. Product data management systems (PDM) were deployed to sort out and track these parts and streamline the business. But as the company continued to expand and absorb other business entities, the PDM has become difficult to wade through to find a particular part. We are developing software PDM queries that alleviate wasted time searching for part numbers. These "wizards" will also inform designers which of these parts are labeled as preferred. We hope taking these steps will limit the amount of stocked bottom level parts and increase the quantities of preferred parts to allow procurement more leverage on cost.

Top Down Modularization

Standardizing on assembly interfaces can be another beneficial initiative. Top down modularity involves designating specific interfaces between sub assemblies on the completed product. This is currently common practice among large industry such as automotive. Most options in new vehicles are a good example of modules. They are used in several different models and the vehicle can accommodate multiple different modules to create mass amounts of customization without a lot of troublesome work.

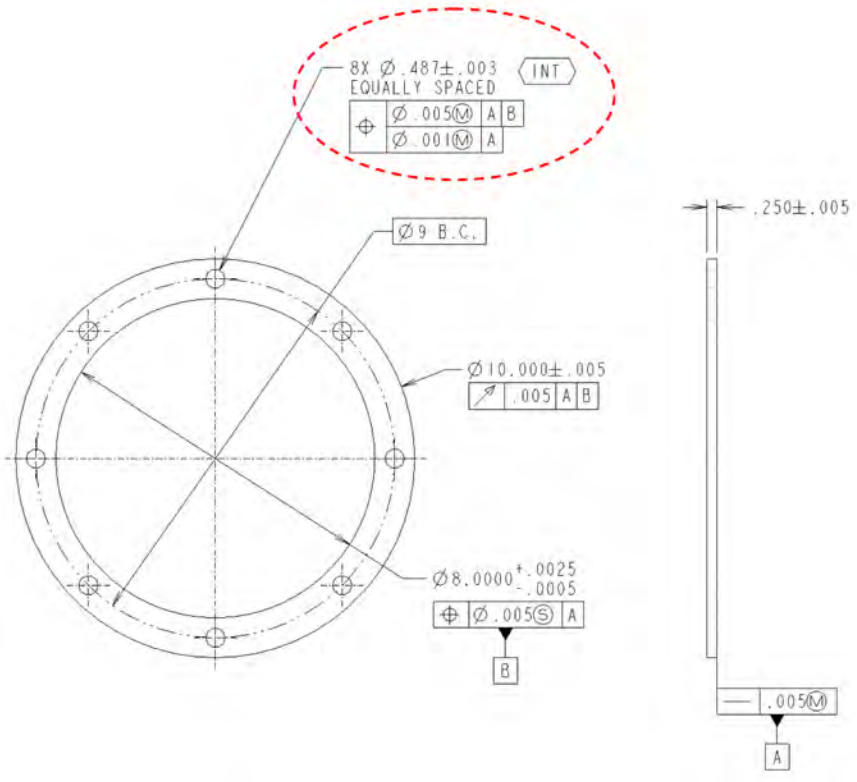
This design mentality can greatly benefit smaller companies as well. There are many reasons to incorporate controlled modules into development engineering. There are opportunities for savings in more than just manufacturing. Increasing the volume of a given sub assembly, to use on multiple product lines, should decrease costs. With the increased volumes; leaner, more efficient processes may be used to produce the parts. Part number reduction is a natural result of this process, reducing administrative and stock costs. Utilizing standard interfaces for assemblies also increases flexibility to accommodate customer needs by including and excluding modules. These standard building blocks will expedite design times for new products incorporating standard modules and interfaces.

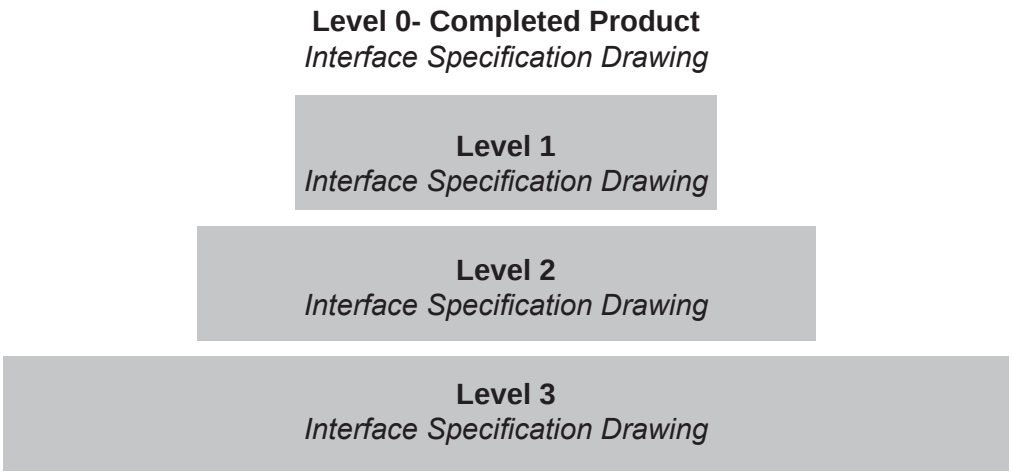
Introducing top down modularity into an organization can be challenging. However, if properly deployed, the benefits will be highly visible.

Interface Specifications

If modularity is an initiative, interfaces are the key to success. Properly thought out interfaces are the most critical element to top down modularity. If the chosen interfaces cannot be used in a wide array of applications the assembly will loose its value as a module.

Once an interface is chosen it needs to be strictly controlled through-out it's life cycle. Special considerations need to be made how to structure your documentation. Figure 2 (below) shows a bolt circle being designated as a controlled interface, alerting people that any change needs to be thoroughly evaluated. Interface specification drawings and other module control documents can be used (see fig. 3). Other considerations with interface specifications include CAD structure, and how the engineering change process will handle modules.





Utilizing DFMA Software in Modular Product Development

The Boothroyd Dewhurst software package can be very useful in supporting modular development. A major goal of modules is to increase volumes to in turn offset cost. At the same time usage increase, sensitivity to cost increases. Optimizing a modules design to control costs using the Design for Manufacturing and Assembly (DFMA) software up front, in the development stage is very beneficial to the success of a module. Usually a given module needs to accommodate the requirements of multiple product lines. An example illustrating this issue is an entry level product receiving the same sub assembly as a high level product. This principle of modularity can sometimes be challenging to accept. If the modules design has been thoroughly evaluated for cost and the processes optimized the cost effect, if any, is minimized. Moreover an optimized product saves more than what is easily captured in part cost roll-ups. Simplicity and process reliability are value adders that are complex to capture.

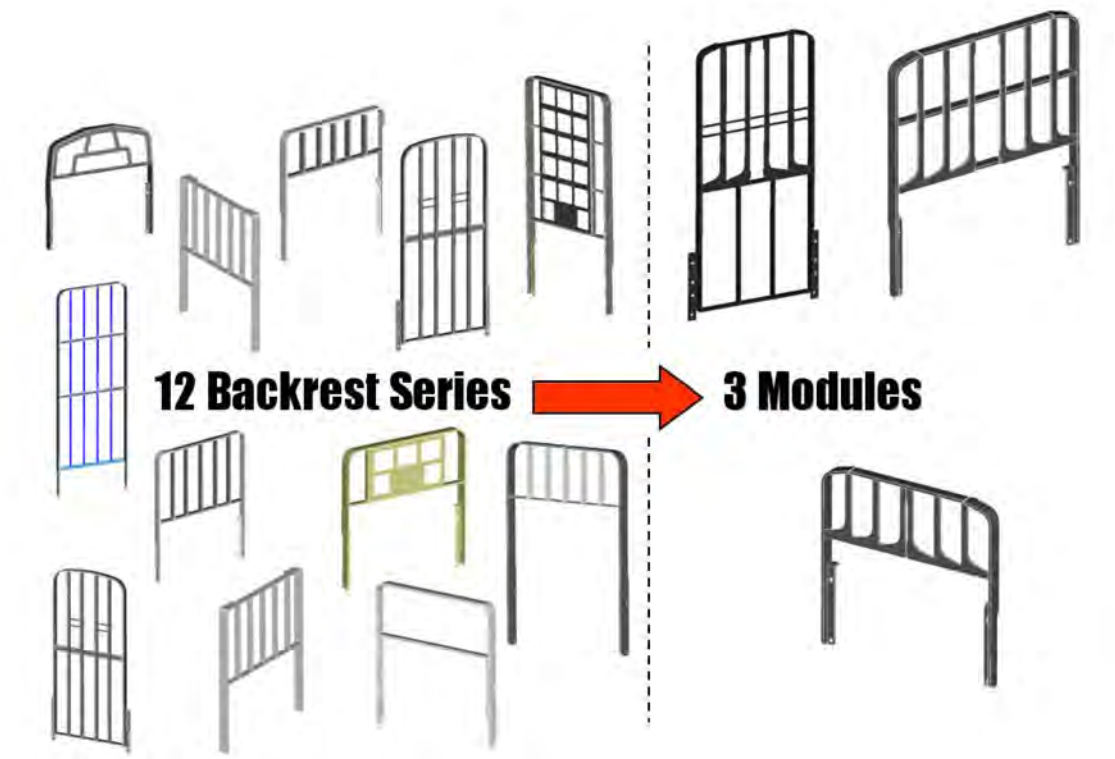
The software design tool has allowed several projects at The Raymond Corporation to succeed. The Design for Manufacture (DFM) and Design for Assembly (DFA) software enhanced our abilities to predict costs early in the design stage, allowing for better design decisions to be made. The figure below shows where DFM and DFA can be deployed in modular development projects.

(FIG. 4)

We found that involving manufacturing early in the design process expedites the project schedule. Sharing of DFMA results can reduce the amount of assumptions made while creating concurrent costing estimates, generating more reliable data to make the best decisions. Ensuring good communication among all steak holders is essential during module development projects.

Case Study: Load Backrest

The aforementioned process was utilized by The Raymond Corporation to simplify a variance of load stabilizing weldments (illustrated in figure 5) to a modular and adaptable design. The requirements were studied and multiple design concepts were generated. Each design concept was analyzed using the DFM tool and the results and concepts were reviewed with representatives from manufacturing and design engineering. The concept was chosen and formal design work began, including modular documentation and interface constraints. It was found that the original twelve different series of load backrest (LBR) weldments could be reduced to three modular series of designs, sharing common parts throughout. The new LBR's were designed to utilize simple, repeatable manufacturing processes. The design concept also allows for the robotic welding fixture to accommodate future dimensional changes, thus creating a standard assembly for all future and current product for the duration of the modules life cycle.



In Closing

The challenges of the current economy have left none un-touched. Markets are dramatically reduced in nearly all facets of the economy. Now is the time to act, not only to ensure stability during uncertain times but to position oneself for future economic growth. The turning point is today, the future of American manufacturing is unpredictable, but controlling costs through better design is the key to reviving a once great manufacturing juggernaut. The DFMA community is aware of this, let's ensure others hear us.