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RESEARCH & TECHNOLOGY EXECUTIVE COUNCIL®

# › **Modular Design Playbook**

Guidelines for Assessing  
the Benefits and Risks of  
Modular Design

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<sup>1</sup> Pseudonym.





WHAT THE BEST COMPANIES DO

# Executive Summary

## OVERVIEW

Companies employ modular design to be more agile and competitive in rapidly changing market environments, while driving cost-efficiencies internally. Using modular design allows companies to recombine modules across product lines and increase product variants to satisfy changing customer needs. Furthermore, manufacturing becomes more cost and time efficient by capitalizing on economies of scale and streamlining assembly lines. Benefits notwithstanding, implementing modular design is a complex and vast undertaking with enterprise-wide implications that will challenge many organizations. Nevertheless, companies across industries increasingly adopt modular design and are therefore continually developing new methods and tools to successfully implement and manage a modular product architecture.

## KEY TAKEAWAYS

- 1. Definitions of Modular Design Vary Across Companies, but Fundamental Ideas Remain the Same**—Although exact definitions vary, the fundamental principles of modular design are common: break systems into discrete modules, ensure modules can interchange with each other, and provide well-defined interfaces. Furthermore, modular design facilitates the design of modular product architectures and/or the creation of modular manufacturing processes.
- 2. Benefits of Modular Design Accrue Across the Firm**—Employing modular design has myriad well-documented benefits, the most common from cost-savings and product line diversification. Companies that employ modular design can produce benefits across the organization, in R&D, Manufacturing, Procurement, and Marketing and Sales.
- 3. Manage Against Less Well-Known Implementation Risks of Modular Design Early on to Minimize Chances of Business Disruption**—Although employing modular design can provide numerous benefits, companies face less well-known implementation risks associated with new suppliers, changes in talent skill profiles, IP protection, and coordination execution complexity. Companies that do not consider and manage against these risks early on can lose out on the benefits of modular design and significantly damage operations.
- 4. Do Not Determine the Degree of Modularization Based Solely on Cost-Efficiency Opportunities**—Many companies seek to make both new and existing

products as modular as possible to capture the greatest possible internal cost-efficiencies. However, executives must consider many factors to determine the extent of product modularization. Besides the requisite focus on a product's technical efficiency and reliability, companies must also consider the effect modular designs will have on customers' perceptions and cross-functional risk exposure. Companies should identify and employ design alternatives that satisfy all fronts, not just cost-efficiencies.

- 5. Select High-Volume Products with Multiple Shared Components Across Products Lines**—Any product could potentially be modularized, but companies must be selective in choosing which products to redesign, especially when first piloting modular design. To more easily benefit from the advantages of modular design, successful companies initially target products that have a large number of shared components with other product lines, high sales volumes, and/or contain platform technologies.
- 6. Secure Early Internal Stakeholder Buy-In for Modular Design to Enable Successful Implementation**—Companies that implement modular design fundamentally change their product and manufacturing architecture, which impacts the entire organization. Implementation barriers for modular design arise from the lack of early widespread support. For successful implementation, executives need to obtain buy-in from internal stakeholders from the outset.
- 7. Use Direct Customer Voice to Screen Modular Redesigns Before Implementing**—Executives need to ensure that new design alternatives are aligned and accepted by the market to prevent alienating existing customers. Companies should test and screen any new product design directly with the customer before adoption.
- 8. Establish a Cross-Functional Team with Broad Technical and Market Skills to Evaluate Modular Design Alternatives**—As R&D and engineering teams are traditionally comprised of individuals with particular niche expertise in their fields, this specialization can inhibit the ability of individuals to look across product lines to distill modular components. Companies should establish a cross-functional team that possesses a broader technical skill set as well as acute market insight to understand and explore the full range of modular design possibilities that exist across product lines.





# The Modular Design Concept

DEFINITION

To offer greater product variations at lower costs, many companies employ a modular strategy that explicitly leverages and reuses existing product design ideas and materials. To fully understand the modular concept, it is important to contrast modular product design with a more conventional approach<sup>1</sup>:

Conventional Versus Modular Product Design

	Design Approach	Development Approach
<p><b>Conventional Product Design:</b> R&amp;D and Marketing conduct market research to determine “optimal” attributes of product design.</p>	<p>Desired functionality decomposed into components, but component interfaces are not specified in detail.</p>	<p>Component development and product design co-evolve in an iterative process. Product architecture is defined at the completion of the development process by the final product design.</p>
<p><b>Modular Product Design:</b> R&amp;D and Marketing create product platforms upon which they will architect product variations according to market needs.</p>	<p>Modular product architecture fully specifies component interfaces and limits subsequent component development.</p>	<p>Component development processes are concurrent, autonomous, and distributed. Product architecture is defined at the design stage and does not change during development.</p>

Modular design offers an efficient method for mass customization, enabling multiple product variations while keeping costs low. Especially in turbulent economic times with unpredictable customer behavior, R&D teams can reconfigure products quickly to react to changing customer needs. Companies use different definitions of modular design depending on their specific organizational context.

<sup>1</sup> Liang, Wen-Yau, and Peter O’Grady, “A constrained evolutionary search formalism for remote design with modules,” *International Journal of Computer Aided Manufacturing*, Vol. 13, no. 2 (2000): 65–79.

**Client Perspective: Descriptions of Modular Design**

“It is the breakdown of a product into building blocks (modules) with defined interfaces, driven by strategic goals.”  
VP, Global Technology  
Consumer Product  
Manufacturing Company

“All design is modular; we try to break all our code down into the most granular components that can then be reused.”  
Technology Engineer  
Aerospace and Defense  
Company

“[In modular design]... components are created that can be easily changed to be adapted to different products.”  
Director, Engineering  
Electronics Company

Although exact definitions vary, the fundamental ideas are common throughout:

- Break systems into discrete modules.
- Ensure modules can interchange with each other.
- Provide well-defined interfaces.

Modular design facilitates the design of modular product architectures and/or the creation of modular manufacturing processes.

The Research & Technology Executive Council’s definition of modular design is broadly applicable for most organizations:

**The Council’s Definition of Modular Design**  
Modular design is the organization of a complex system into a number of smaller, complementary, and distinct components, which can be designed separately and then assembled to form the entire system again seamlessly. Driven by strategic goals, module interfaces must be well defined with interchangeable components. The individual components can be used to create other systems and therefore drive multiple functionalities.





# Advantages and Disadvantages

## I. ADVANTAGES OF MODULAR DESIGN

Employing modular design has many well-documented benefits, the most common of which are cost-savings and product line diversification. However, employing modular design can produce benefits across the organization, in R&D, Manufacturing, Procurement, and Marketing and Sales.

### Research and Development

The product design and development process fundamentally changes as a consequence of employing a modular process. As opposed to an integrated design approach where product designs only aim to address specific market needs, a modular approach seeks to address market needs as well as employ a framework that can house and leverage a variety of discrete modules. Furthermore, companies can significantly shorten the development process by using existing know-how and modular components when creating a new product.



“There are several benefits we have seen as a result of using modular design, like standardizing manufacturing processes, decreasing assembly lines, and reducing changeover costs, plus part counts are down and products are easier to service...but this all comes down to delivering cost-efficiencies.”

Manager, Product Engineering  
Construction Materials Company

### Manufacturing

A key component of modularization is the ability to standardize independent modules and drive scale. This can translate into huge cost savings from manufacturing simplification and consolidation.

### Procurement

Modular design decreases the number of unique parts needed in a product, as modules and interfaces become more standardized. This can reframe supplier management to drive more strategic partnerships with fewer suppliers and enhance negotiating power with scale.

### Marketing and Sales

Modules provide specific functions and benefits to the overall product, which companies can map to customer needs and segments. For example, companies can use a high- versus low-performing module in a product to target a high- versus low-income customer segment. This provides Marketing with the ability to offer

customers a wider product range.



“We have been able to reduce part numbers, which has helped inventory, direct cost reductions, increased product quality, and standardized assembly lines. We work with fewer suppliers, too, which means we have better partnerships and purchasing conditions.”

Manager, New Product Development  
Industrial Manufacturing Company

*The following table contains a full overview of the specific advantages that many individual departments can achieve as a direct result of implementing modular design:*

Department	Specific Benefits	Description
<b>Research and Development</b>	Increased reliability	R&D can test individual modules to identify specific problem areas more easily than with integrated product design. By improving individual modules and interfaces, the entire system becomes more robust.
	Reuse of design and materials	Assembling and reusing modular components in multiple combinations to form different products creates savings known as economies of substitution. Leveraging existing designs and materials saves time and money.
	Diversification of product lines	Although the number of unique components in any given product typically decreases through modular design, the number of potential product variations increases, providing a more diverse product portfolio.
<b>Manufacturing</b>	Assembly line reduction	Reducing the number of unique manufactured components often enables companies to consolidate and retire nonessential or redundant assembly lines.
	Changeover cost reductions	A higher volume of more standardized modules leads to a reduction in changeover costs and the number of tools required for production.
	Shared process planning	With different product lines using the same module design, Manufacturing can implement shared processes across product lines.
	Agility and flexibility	Assembly lines can manufacture modules independently and concurrently, enabling more agile and flexible resource planning.
<b>Procurement</b>	Inventory reduction	Reducing the number of unique parts required in design also reduces the inventory of spare parts required. This consolidation of unique purchased materials also leads to simpler stock keeping and inventory management as there are fewer product categories to manage.
	Improved supplier management	Managing a smaller supply base with higher volumes enables the development of strategic supplier relationships, which can translate into higher trade credits, prolonged payment deadlines, and better pricing.

<b>Procurement (Continued)</b>	Increased supplier design collaboration	Asking suppliers to create self-contained modular units that interface with a variety of products often requires deeper and new technical skills from suppliers. By more closely integrating suppliers into the modular design process, companies can improve feasibility testing and benefit from unique supplier design capabilities.
<b>Marketing and Sales</b>	Increased customization	Modular products can be easily customized by switching different components across product lines and interfaces. Changing customer requirements can be more readily met, and new product variations can be created to capture new market segments or more market share.
	Incremental upgrades	As companies create new or “next-generation” modules, they can offer new features for product lines using these new modules either in the form of a chargeable feature upgrade or a new premium product line.
	Quicker servicing and repair	With modular design, defects generally do not affect the entire function of the product. Defects can be traced to specific malfunctioning modules or interfaces and quickly rectified through repair or replacement without a complete product overhaul. Customers value the faster service turnaround times and decreased cost of repair.
	Faster time to market	Modular design significantly decreases the time it takes to move a product from concept to commercialization through design reuse and quicker manufacturing.
	Simpler sales process	Reduced complexity in product design simplifies the sales pitch and enables sales teams to offer a higher degree of customization to meet customer needs.

## II. DISADVANTAGES OF MODULAR DESIGN

Although employing modular design provides a number of advantages across the organization, companies must also consider the less discussed risks when evaluating the decision to implement modular design or reviewing existing modular processes.

### High Initial Investment

The initial costs to reconfigure existing systems and processes are high. Modular design is a significant undertaking, which may disrupt the existing flow of the product pipeline. Visualizing and predicting the possible return and benefits of such an investment is done speculatively with no direct link between investment and return. As such, some R&D departments struggle to secure buy-in from the rest of the organization.

### Lack of Customer-Centricity

In an integrated design, companies determine product specifications based on customer needs; however, a modular architecture uses both customer needs and

cost-efficiencies. With a dual goal, companies can become too internally focused while searching for cost-efficiencies and lose sight of customer needs. At its worst, this can lead to lost market share and revenue. (See Beta<sup>1</sup> solution on page 33.)



“The danger of modular design is that if it is taken to the extreme or done wrong, the product will not meet customer needs, while a customized process will always create something that meets customer specifications.”

Manager, New Product Development  
Industrial Manufacturing Company

### Coordination Complexity

Modular design requires a significant restructuring of processes and can increase product development complexity if companies do not assign clear ownership and responsibilities in a well-planned implementation process. Post-implementation, a lack of cross-unit collaboration can cause 1) duplication of processes, 2) inconsistency across product specifications, purchase orders, and manufacturing plans, and 3) incongruous interfaces across business units. If companies do not address these coordination issues, products may suffer from a quality and stability standpoint.



“The main disadvantage is that there is a high cost and major overhaul needed when undertaking modular design. But in the long term, it pays off, allowing you to be quicker in and to the market.”

Vice President, Global Technology  
Appliances Manufacturing Company

### Supplier Risk

Companies that adopt modular design will alter their supplier base and the services needed. When collaborating with new suppliers, companies can experience delays, incorrect specifications, and poor material quality. Also, companies may have to share information and technical expertise to ensure suppliers deliver according to new specifications and cost. A company surrendering too much technical expertise, especially in areas that provide a competitive advantage, may lose technical control to the supplier. (See Alpha<sup>1</sup> solution on page 36.)

### Low Flexibility for Exceptions

To ensure consistency of product lines and reap the rewards of modularity as an organization, companies must sometimes apply modular design to products that

<sup>1</sup> Pseudonym.

would be cheaper to produce through an integrated design. This can reduce margins and decrease competitiveness for certain products. When making these tough modular decisions, companies should leave the final verdict to business units. (See Gamma<sup>1</sup> solution on page 39.)



“You may have to make a few tough calls—some products, which would make more sense if they were left as integrated products, are forced into a modular configuration to fit in with the wider product line redesign.”

Manager, Product Engineering  
Construction Materials Company

### Broad Skills Requirement

Design engineers must have a broad technical understanding across product lines to identify modular components for synergies. This is a departure from more traditional engineering activities, and companies may not capture potential benefits if the design team lacks this broad skill set. (See Gamma solution on page 39.)

### Intellectual Property Risk

Producing discrete modules simplifies the product architecture, enabling competitors to more easily discern technologies employed and mimic modules. To counter this, organizations must increase patent documentation to prevent competitors using key modules in their product architectures.

<sup>1</sup> Pseudonym.



# Application Considerations

OVERVIEW

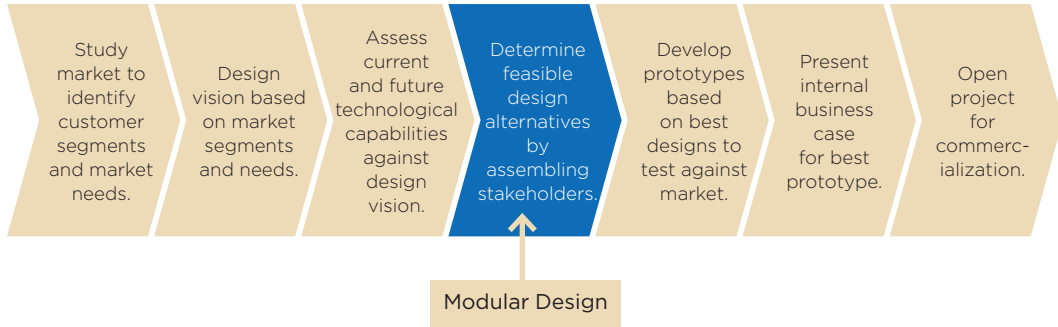
Companies apply modular design in various ways, depending on factors such as industry, brand strategy, organizational structure, product architecture, etc. Independent of these issues, most companies cite very similar screens for deciding when to implement modular design. This section helps companies determine the following:

- I. When in the design process to consider modular alternatives
- II. How to target individual products for modular design
- III. To what extent a design should be made modular
- IV. How modular design manifests itself in different industries

I. WHEN TO INSERT MODULARITY IN THE DESIGN PROCESS

Companies need to explicitly define the particular phase in the development process where they will apply modular design. After assessing the market and technical capabilities and determining a high-level design vision, companies typically consider how to apply modular design in the feasibility stage.

Product Development Process



During the feasibility stage, manufacturing, engineering, project management, and marketing team members meet to discuss various modular alternatives and design possibilities. The outcome of these discussions is a decision on design architecture design parameters. This process ensures that the design can be made modular and can also meet product functionality considerations incorporating both customer and technical considerations. Once designs are approved, companies must assess how the modular design choices will impact supplier relationships: the number of unique suppliers, required supplier technical expertise, and preferred supplier locations. Furthermore, R&D needs to select the right projects for applying modular design.

## II. TARGETING PRODUCTS FOR MODULAR DESIGN

Although companies could potentially design any product modularly, they should be selective in which products to redesign, especially when first piloting modular design. Successful companies initially target products that exhibit the traits described below to more easily benefit from the advantages of modular design:

### Design Architecture

1. *Common Components*—Products that have a high number of components in common with other product lines should be primary modular design targets. Time and cost savings from reuse combined with higher potential product variation possibilities make these products the most beneficial for leveraging modular design.
2. *Platform Infrastructure*—Products that have a platform infrastructure to support various modules (opposed to a wholly integrated design) make interface design a simpler and quicker process.
3. *Non-Client-Facing Modules*—Products that can be redesigned modularly without changing the outward appearance or functionality of the product enable customer perceptions to go unchanged (reducing uncertainty associated with redesign), while the organization can benefit from cost-efficiencies.

### Production Processes

4. *Ability to Leverage Existing Production Processes*—Products produced on similar assembly and production lines that can generate the highest-potential returns through improved utilization of manufacturing capabilities and facilities.

### Demand Considerations

5. *High Volume*—Products manufactured and sold in high volumes will benefit most from modular design through reuse savings. Low-sale volume products typically do not generate enough margin to justify the high initial cost attached to implementing modular design.

## III. DECIDING ON THE DEGREE OF PRODUCT MODULARITY

Many companies strive to make both new and existing product lines as modular as possible to gain the highest degree of cost-efficiencies. But there are many factors executives must consider when deciding on the extent to make any product modular. Besides the obvious requisite focus on technical efficiency and reliability, companies must also focus on the impact on customers and other functions.

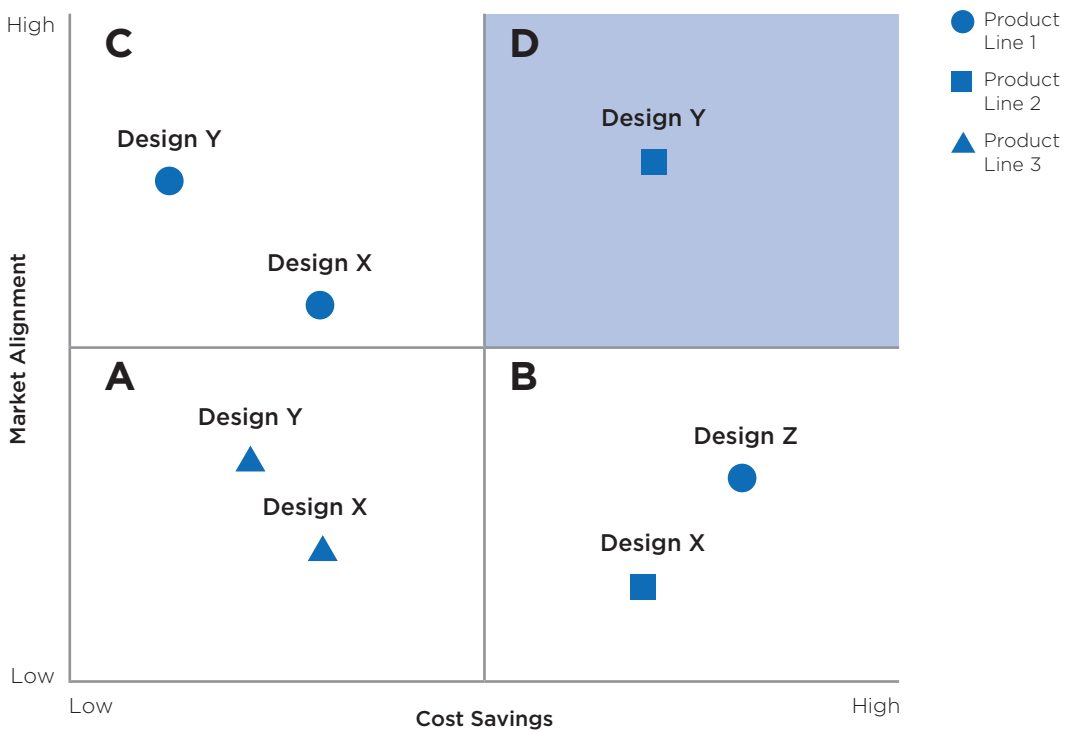
### Customer Impact of Modular Design

Companies can group modules into either client-facing or non-client-facing modules. Client-facing modules are visible to the customer and/or directly contribute to a functionality that satisfies a customer need. Non-client-facing modules provide hidden functionality, where customers do not directly interact with or observe the technology’s functionality.

For non-client-facing modules, companies do not need to limit the degree of modularity, but rather should seek to maximize modular design for cost savings. However, client-facing modules need to align with customer needs and preferences and should not solely be designed for cost-efficiencies.

Companies can modularize a product in different ways depending on the technical capabilities of the company, existing component structure, materials available, know-how, etc. Companies should initially assess which modular design to choose based upon the balance between cost savings and market alignment by overlaying the product lines and modular design options on a matrix as shown below.

Modular Design: Market Alignment Matrix



- A Lower-Left Quadrant:** These product designs should either be revised or discarded. Implementing either of these alternatives may cause harm to the brand image of the organization by not fulfilling customer needs. Plus, the complexity and/or costs associated with these designs typically prevent them from achieving acceptable ROI levels.
- B Lower-Right Quadrant:** These design alternatives benefit from substantial cost savings, but client-facing modules fail to properly align with the market needs, either by not providing functionality expected by customers or visually impairing the perception of the product by customers.
- C Upper-Left Quadrant:** These design alternatives ensure that client-facing modules are market aligned, but do not reap the full potential rewards of modular design. Companies may either explore further potential cost savings or decide that sales forecasts and/or margins are high enough to warrant implementation. Furthermore, some organizations opt for “break-even” or even “loss” design alternatives to benefit from the experience of implementing modular design or because these products support a favorable brand image in the market. Typically, however, companies discard these design options as they do not yield high enough cost savings.
- D Upper-Right Quadrant:** These products and design alternatives successfully balance maximized cost savings with customer expectations. Products and designs in this quadrant should be prioritized for future commercialization.

### Cross-Functional Impact of Modular Design

Different modular designs can have varying consequences for functions across the company. These repercussions play a significant part when deciding on the final modular design. If a company is presented with a number of different designs to modularize a product, it should review the impact each of these design alternatives will have on costs, process efficiency, and risks specific to different departments. The design alternative chosen may not be the most beneficial in terms of cost savings, but one that minimizes risks across the most areas.

Companies should establish mechanisms to ensure that repercussions for “going modular” are fully considered for all stakeholders. To track these risks, some companies establish simple stoplight risk assessments for each design, monitoring potential risk levels by function. Each department determines the acceptable level of risk and tracks parameters. For example, if quality and manufacturing risks reach a certain threshold, it triggers a “red light” status, which forces the company to abandon Design X and consider Design Y that has acceptable risk levels across departments.

#### Cross-Functional Risk Monitoring *Illustrative*

	Quality Risks	Engineering Risks	Procurement Risks	Manufacturing Risks	Marketing Risks	Status
Design X						
Design Y						

#### IV. EXAMINING MODULAR DESIGN IN DIFFERENT INDUSTRIES

A modular strategy provides firms with flexibility, agility, and new design alternatives. However, modularization should be adopted cautiously. The ability of individual companies to capitalize on modular design advantages is often dependent on industry-specific dynamics. Provided below are examples of how companies across various industries have capitalized on modular design.

##### **Automobile Industry<sup>1</sup>**

Modular design helps car manufacturers cut costs and reduce complexity. A good example of this comes from Mercedes-Benz's sports vehicle manufacturing plant in Alabama. The vehicle's design required them to source parts from a large number of external suppliers and manage a vast supply system. Instead of trying to manage this system as a whole, Mercedes-Benz structured the manufacturing process into a number of smaller production modules. They outsourced the production modules to suppliers, who were fully responsible for manufacturing and delivery. For example, the entire driver's cockpit is a separate module produced at a nearby supplier plant, under the complete responsibility of the supplier.

Volkswagen adopted a similar approach for its truck factory in Brazil by making the factory available for use by its suppliers. Suppliers procure their own materials and manpower to create separate modules, while Volkswagen provides the infrastructure and designs the interface between manufacturing units.

##### **High-Technology Industry<sup>2</sup>**

In the high-tech industry, product customization is in high demand. For example, Dell modularizes its product designs and supply chain to ensure high customization for its customers. Customers can choose from a wide array of modules like motherboards, power systems, operating systems, and input devices. The modularity of Dell's PCs helps them deliver against a wide array of customer wants quickly and efficiently. Dell's made-to-order strategy enables the company to be a supplier of choice for its customers.

##### **Software Industry<sup>3</sup>**

Modular software design refers to a design strategy that organizes relatively small routines together to compose a system. With significant modular development, the software industry has rapidly become decentralized, as smaller companies begin to share their technology with outside programmers. For example, Salesforce.com, a fast-growing CRM provider, externally published standards for interconnecting its

<sup>1</sup> Garud, Raghu, Arun Kumaraswamy, and Richard N. Langlois, *Managing In The Modular Age*, Blackwell Publishers Ltd. (2002).

<sup>2</sup> Fine, Charles H., "Are You Modular or Integral? Make Sure Your Supply Chain Knows," *Strategy+Business* (Summer 2005).

<sup>3</sup> Markoff, John, "Sharing Lego blocks: Modular software reshapes the computing landscape," *The New York Times* (5 April 2006).

software. This enabled developers inside and outside the company to add powerful abilities to its core products and create new ones from scratch. The following drive organizations to apply modular software:

- Complex problems can be broken down into simple parts and solved part by part, simplifying project management.
- Developers can reuse software code written modularly as part of other programs, saving time by providing standardization and consistency.

### Construction Industry

Construction firms regularly apply modular techniques, where a building is built in three-dimensional sections (or modules) in an enclosed factory environment.<sup>1</sup> Every modular building starts with a floor plan design. This plan is divided into smaller sections or modules that are constructed separately using existing technologies such as conventional commercial wall, floor, roof, and ceiling materials. To maximize time savings, the site development teams prepare the site and perform any needed on-site construction (a process called concurrent construction). Manufacturers cite the following reasons to apply modular design:<sup>2</sup>

- *Time Savings:* Modular construction allows for building and site work to progress simultaneously, reducing the overall completion schedule by as much as 50%.
- *Weather Autonomy:* Different weather conditions do not affect assembly, which increases work efficiency and avoids damaged building material.
- *Supplier Bargaining Power:* Large-scale manufacturers can effectively bargain with suppliers for discounts on materials.
- *Reduced Complexity:* Reusing the same plans for modules means that the manufacturer has records of the quantity of materials needed for a given job, reducing waste and maximizing the use of purchased material.
- *Environmental Impact:* Modular construction generates less material waste and less site disturbances than comparable site-built structures and is more environmentally friendly.

### Consumer Packaged Goods (CPG) Industry

The CPG industry generally implements modular design to introduce greater customization in their product offerings. For example, Nike uses modular design to empower consumers to choose the component parts, both for aesthetic and functional

<sup>1</sup> "What Is Accelerated Construction?," Comark Building Systems, [www.comarkbuilding.com](http://www.comarkbuilding.com).

<sup>2</sup> "Modular Homes Make Sense," [www.bobvilla.com](http://www.bobvilla.com).

reasons, to compose their own shoes. This enables Nike to serve customers with differing preferences equally well.<sup>1</sup>

Furthermore, Whirlpool employed modular design to produce a new built-in (opposed to stand-alone countertop) microwave oven with two new cooking modes while decreasing costs by 60%. Although the new product line is still evolving, Whirlpool reports initial benefits of reduced prices of purchased components, increased quality, and improved product variation for the new product range.



“The mind-set of modularity allows us to predict the impact of any request for change much more quickly than before. This saves time and energy. In our old, non-modular designs, when someone asked us for a styling or performance change, we had to review the entire design. Now we can easily see which modules are impacted and provide a response much more quickly than before.”

Jorma Mäkilä  
Whirlpool Employee and Owner of the Opera Platform<sup>2</sup>

<sup>1</sup> Sacks, Danielle, “The Fast Company 50,” *Fastcompany.com*, [www.fastcompany.com/fast50\\_09/profile/list/nike](http://www.fastcompany.com/fast50_09/profile/list/nike) (11 February 2009).

<sup>2</sup> “Whirlpool Opera Case Story,” Modular Management AB, [www.modular.se](http://www.modular.se).

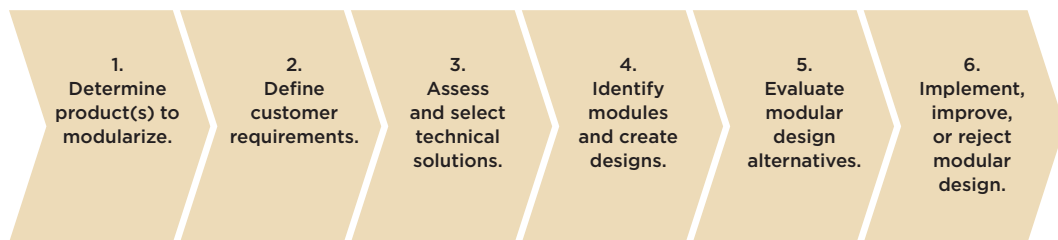


# Implementation Steps and Tips

## OVERVIEW

While the degree to which companies implement modular design varies, the steps taken to implement are fairly typical. This section provides an overview of a typical six-step modular implementation process, highlights some of the common organizational barriers that companies should watch out for, and outlines a few implementation tips from experienced companies.

### I. TYPICAL MODULAR DESIGN IMPLEMENTATION PROCESS STEPS



#### 1. Determine Product(s) to Modularize

Before starting the journey to implement modular design, a cross-functional team, composed of individuals from Marketing and Engineering, initially decides on the extent to which the company will employ modular design. This team will drive the modular design project forward and needs expertise that will reflect the voice of the customer as well as the technical capabilities of the organization.

Some organizations decide to launch a pilot run on a single product to gain experience and demonstrate the success of using modular design with a view to implement this approach incrementally. Other organizations consider all product lines across the company to implement on a large scale. This decision depends upon careful evaluation of the individual risk and reward profiles for each product line.

#### 2. Define Customer Requirements

The second step ensures that designs align with current and future requirements of customers. The cross-functional team, through primary and secondary market research, creates a high-level future product vision and specification requirements. Teams often use various voice-of-customer tools at this stage, such as the quality function deployment (QFD) matrix, to ensure customer needs are well documented.

### 3. Assess and Select Technical Solutions

Once everyone is aligned on what modular design must achieve from a market standpoint, the cross-functional team explores the viable design alternatives that will meet customer needs and are possible from a technical standpoint. The team should view the product(s) in terms of functional purpose. By breaking down the product(s) into the functions that satisfy distinct customer needs, the team can choose the technical solution that delivers against each function. There may be several technical solutions available, depending on technical capabilities, for any given function. When several technical solutions exist, the team chooses the most applicable solution based on criteria such as production goals, part number count, and material reuse. The outcome of this stage is to create a diagram of a product's functional structure (which satisfies customer needs) and technical solutions (that deliver the required functions).

### 4. Identify Modules and Create Designs<sup>1</sup>

This phase identifies potential modules based on technical solutions. Teams should assess each module by the following criteria:

- Technology evolution
- Reuse possibility
- Potential cost savings
- Supplier and distributor complexity

If a single technical solution scores high against multiple criteria, the team considers the solution a viable candidate to become an independent module. The team then either groups or integrates technical solutions that do not map well against the evaluation criteria in the design. (For more information on evaluation criteria, see Alpha<sup>2</sup> case on page 36). Following this analysis, the team should identify and suggest the most relevant modular concepts for review, pairing them with some rough specifications and structures.

### 5. Evaluate Modular Design Alternatives<sup>1</sup>

For any modular design, the interfaces between modules have a vital influence on the final product's architecture and flexibility. Therefore, it is essential that teams closely examine each interface and its relation to different modules. This examination serves as an indicator of the interfaces that need improvement and guides the modular manufacturing process. Based on the relationship between modules and interfaces, the team organizes assembly lines for optimal efficiency.

<sup>1</sup> "Modular Function Deployment," *Lean Directions*, [www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20060609&1&](http://www.sme.org/cgi-bin/get-newsletter.pl?LEAN&20060609&1&) (9 June 2006).

<sup>2</sup> Pseudonym.

With information on modular designs, interfaces, and assembly orders in hand, the team must assess the full view of effects each modular design alternative carries and create a summary for each alternative. Companies assess each alternative's effect on the overall product using the following parameters:

- Quality
- Variation flexibility
- Lead time
- Development costs
- Development capacity
- Production costs
- Service and upgrade possibilities

## 6. Implement, Improve, or Reject Modular Design

In the final step, the cross-functional team chooses the most promising design alternatives and documents technical information, cost targets, planned development, and other information discovered in the process for each alternative. From here, the team chooses to either implement, improve, or reject the modular concept. The team assembles a business case to present to senior management, which shows that the design alternative can fulfill customer needs, is technologically possible, and can generate tangible benefits. At this step, the team should also reach consensus on the metrics strategy for tracking ongoing performance of modular implementation. (See Assessment section on page 43 for more information on developing a metrics strategy.)

### Pilot Implementation Case Snapshot: ESAB Welding Equipment<sup>1</sup>

#### Company Overview

ESAB manufactures and supplies welding and cutting equipment, welding filler metals, and welding technology. The ESAB group has annual sales of \$1 billion and more than 7,000 employees.

#### High Complexity

To supply local regions with local products, ESAB bought a number of geographically dispersed SMEs. Due to these acquisitions, ESAB faced increased internal complexity, high part numbers, significant indirect costs, and overlapping projects.

#### Implementing Modular Design

To tackle these problems, ESAB ran a pilot project for a new modularized product platform, driven by a cross-functional team, to prove the advantages of modularity. The pilot proved successful with a 40% reduction in part numbers; a 90% decrease in lead-time production; and a 50% increase in product variants. The success encouraged senior management to proceed with implementing modular management across the division.

<sup>1</sup> "ESAB Welding Case Story," Modular Management AB, <http://www.modular.se>.

**Benefits of Modular Design**

Through implementing modular design across the division, ESAB achieved the following:

- 40% reduction in part numbers
- 50% shorter assembly time
- Order-to-delivery lead-time reduction from eight days to one
- 50% reduction in suppliers
- 50% increase in product variants
- 40% reduction in time to market

## II. ORGANIZATIONAL BARRIERS TO IMPLEMENTING MODULAR DESIGN

Companies that implement modular design on a large scale must fundamentally change their product and manufacturing architecture. When considering the potential roadblocks of modular implementation, companies should be aware of a few key organizational barriers.

**Difficulty Achieving Senior Management Buy-In**

To implement modular design, a company requires high initial investment of resources, which requires senior management sign-off. Sign-off proves to be the first barrier many companies encounter as future returns are difficult to guarantee and quantify.

**Resistance from Business Units**

The decision to use modular design at the corporate level may yield overall cost savings and increase product variants. However, particular products may be cheaper to produce using an integrated approach. The corporate center may force business units to employ modular designs for certain products (although more costly to the business unit) for the overall benefit of the company, which can make divisions of the organization resistant to adopt modular design.

**Lack of Knowledge-Sharing Infrastructure**

To enable reuse in modular design, information on different product and manufacturing designs needs to be readily available across the organization. Interoperability and mutual substitution between modules are key success factors for modular design. Without a centralized information-sharing structure, this cannot be done effectively.

**Traditional Innovation Culture**

Companies that have a long history of using an integrated design approach where whitespace innovation and individual ingenuity are praised and protected may find

corporate culture to be a big barrier when implementing modular design. Two ways that organizations can resolve this are by rewarding reuse over design novelty and implementing modular design gradually, allowing changes to slowly take root.

### **Organizational Complexity**

Preparing any company to implement modular design can be difficult. Implementing modular design in a large, complex, and/or highly diversified company heightens the difficulty of coordination. Companies should consider organizational complexity and coordination costs when determining the extent to which modular design will be successful.

## III. IMPLEMENTATION TIPS FROM EXPERIENCED COMPANIES

### **Gain Senior Management Support from the Beginning**

Getting senior management involved with production, engineering, and product design decisions ensures support for the initiative from the decision-making ranks of the company early on. Temporary setbacks and losses can be dealt with in the moment through direct communication with senior stakeholders, instead of creating formal meetings where issues are explained to senior management.

### **Communicate Adoption Benefits**

To gain buy-in, clearly communicate and familiarize the business units of the long-term advantages of modular design in terms of cost savings and increases in efficiency.

### **Create and Promote Modular Design Knowledge Sharing**

To benefit from time savings, create IT systems that enable divisions to access relevant designs from across the organization. Indicate contact details for the lead designer to assist other divisions that may want to employ a particular modular design. Once the infrastructure exists for knowledge sharing, usage must be promoted and embedded in the workflow across the company. For example, in the design phase of any new product, ensure the design team includes a new step of searching internally before creating new designs.

### **Provide Training on Modular Design**

Hold continuous training sessions for staff to inform them of the benefits of modular design, the resources available to them, and how to apply modular design in their particular work streams. Training sessions reinforce the message of modular design and keep the issue top of mind.

### **Limit Implementation Risk While Assessing Benefits**

Focus efforts on implementing modular design as a pilot phase for a specific product to gain experience in modular design and limit risks of redesign. Use the successes of this implementation as a stepping stone to harness buy-in and experience for wider implementation across the company.

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# Case Examples

## OVERVIEW

Executives face an uncertain economic landscape with mounting cost pressures. Against this backdrop, organizations increasingly consider modular design as a solution to achieve cost-efficiencies and ancillary benefits needed for survival. This cost-cutting mind-set may cause companies to neglect consideration of the impact that modular design will have on customer perceptions and its effect on business activities across the entire organization. Furthermore, specialized engineering organizations often lack the cross-functional, cross-product line expertise to fully exploit modular benefits across the entire company.

R&D organizations often fall prey to three key downfalls in implementation:

1. Lack of focus on customer impact
2. Insufficient assessment of cross-functional impact
3. Inability to properly assess the full range of modular possibilities.

The following case examples detail how three pseudonym companies address each of these challenges to successfully implement modular design:

## FEATURED SOLUTIONS



#### Market-Aligned Modular Design

Beta uses direct voice-of-the-customer information to implement a customer-focused modular redesign of a key product line.



#### Cross-Functional Modular Design Scorecard

Alpha implements a product design scorecard to assess the impact of various modular designs on different departments and processes across the organization.



#### Central Product Strategy Team

Gamma establishes a central product strategy team that possesses broad technical skills across product lines to ensure that the full potential of modular design synergies are explored and captured when introducing a new product.

<sup>1</sup> Pseudonym.



# BETA'S MARKET-ALIGNED MODULAR DESIGN

## OVERVIEW

Beta uses direct voice-of-the-customer information to implement a customer-focused modular redesign of a key product line.

## SOLUTION HIGHLIGHTS

**Voice-of-the-Customer Review Sessions**—The Beta engineering team proposes modular design alternatives to marketing and sales teams and customers to balance efficient redesign alternatives with market needs.

## SCENARIO

Faced with a new energy directive, Beta reviews its electrical home appliance product range to ensure compliance and also to assess the possibility of cost reductions from implementing modular design. Throughout the review process, the manager of product engineering solicits feedback from commercial peers and customers to ensure that the newly modular products are not only more efficient, but also in line with customer needs.

**Industry:** Industrial and Consumer Products Manufacturer

**FY2008 Revenue:** US\$1 Billion–\$5 Billion

**FY2008 Employees:** 1,000–5,000

Beta makes air conditioners, humidifiers, gas furnaces, heat pumps, and other products. Beta sells its products through many independent distributors in one main market.

<sup>1</sup> Pseudonym.



Beta follows a three-stage implementation approach for redesigning its electrical home appliance product line around modularity and customer needs:

#### Product Line Redesign Process



### 1. Product Line Review

First, Beta’s engineering team scrutinizes the electrical home appliance product line, breaking each product into subassembly parts. The team categorizes and clusters similar parts to provide full transparency on the various existing components across the multiple products. This analysis reveals that the electrical home appliance product line had 16 different heights, 32 chassis, and more than 200 SKUs. Where possible, the Engineering team identifies areas where SKU rationalization is possible and components can be modularized for reuse.

### 2. Market Alignment Meetings

Next, the engineering team holds a series of meetings with Marketing and Sales to review product redesign proposals, suggesting the business case for optimal cost-efficiencies. With in-depth consumer insight, Marketing and Sales can immediately dismiss alternatives that are misaligned with customer needs at a high level. As a result of these iterative meetings, Beta redesigns product alternatives to meet the dual objectives of Engineering and Marketing and Sales for driving cost-efficiency and maintaining market relevance.



“There is a balance between cost-efficiencies and market needs when considering modular design. We strive to make our designs as modular as possible to drive costs down, but we will always ensure we’re aligned with what the preponderance of our customers want.”

Manager, Product Engineering  
Beta Manufacturing

<sup>1</sup> Pseudonym.



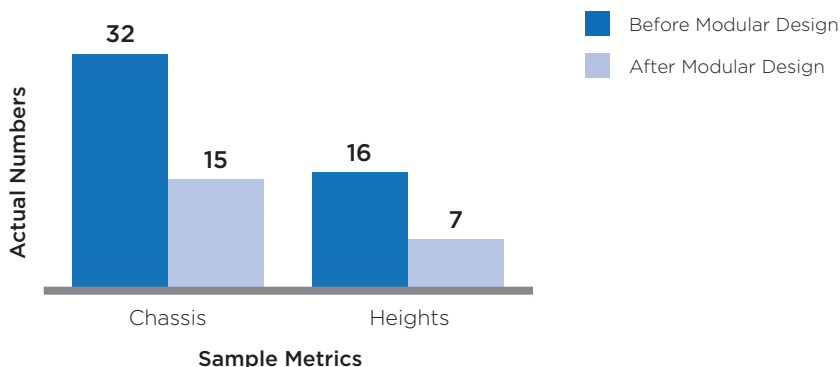
### 3. Customer Review

Once Beta achieves internal agreement on a future vision for its electrical home appliance product line, the team invites key customers to review the suggested changes through rolling one-day sessions. Obtaining direct customer input proves to be a key success factor in ensuring that the new modular product line does not compromise the customer experience.

#### RESULTS

Armed with commercial team feedback and direct customer input, Beta’s engineering team presents the internal business case to senior management to transition the newly designed electrical home appliance line into production. Once the new process is signed off and implemented, Beta reduces the number of chassis and heights by more than 50%.

Impact of Modular Design on Electrical Home Appliance Product Line



Furthermore, Beta’s modular design reduces overall purchased components by 52% and rationalizes production from two factory sites down to one. Beta also reports other ancillary benefits such as increased production efficiency, lower costs, and increased market share.

<sup>1</sup> Pseudonym.



# ALPHA'S CROSS-FUNCTIONAL MODULAR DESIGN SCORECARD

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## OVERVIEW

Alpha Company implements a product design scorecard (that requires input from cross-functional and external stakeholders) to assess the impact of various modular designs on different departments and processes across the organization.

## SOLUTION HIGHLIGHTS

**Cross-Functional Modular Design Scorecard**—Alpha's new product development team creates different modular design alternatives for any new product. These alternatives are tested using a cross-functional scorecard across the organization to decide which designs to implement.

## SCENARIO

Alpha recognizes that the potential efficiencies that can be gained through modular design are usually assessed by a few key technical stakeholders, which provides a limited picture of modular design's total effect on the organization. Major investment decisions cannot be made on such a limited view of potential impact. To address this, Alpha develops a scorecard that solicits feedback from multiple internal and external stakeholders to test the potential future impact of implementing different modular designs across the organization.

**Industry:** Electronics

**FY2008 Revenue:** US\$15 Billion–\$30 Billion

**FY2008 Employees:** 80,000–120,000

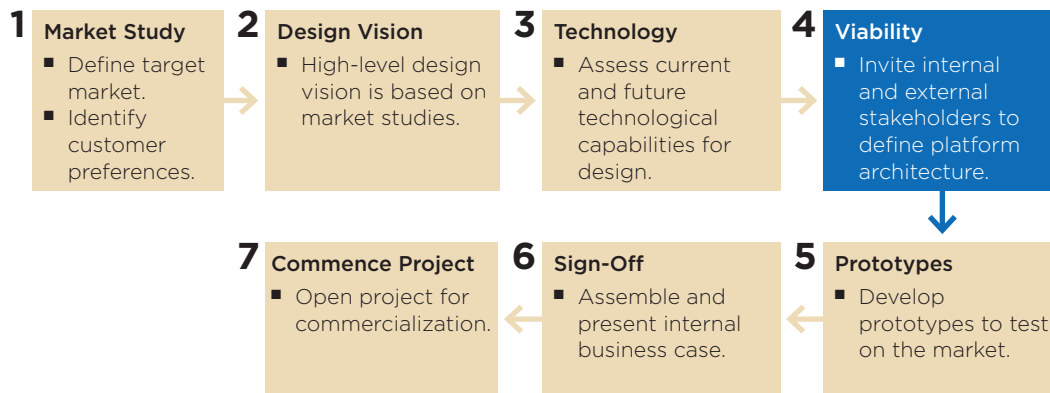
Alpha is a global manufacturer of electrical and distribution equipment. The company has operations in Africa, Asia, Europe, the United States, and the Middle East.

<sup>1</sup> Pseudonym.



Alpha’s New Product Development (NPD) process begins and ends with the customer in mind and considers existing and future technical capabilities to form the design vision of a new product. Alpha considers modular design possibilities in the viability stage of its NPD process. An overview of this process is presented below:

**New Product Development Process**



During the viability stage, the engineering team targets a certain aspect of a product’s design that has the most potential for modularity. The team assembles up to three different modular designs that fulfill the design vision and are feasible from a technological standpoint. The team bases these designs upon the various possible combinations of components, materials, and interfaces.

**Cross-Functional Modular Design Scorecard**

To assess the impact of each design across the organization, the NPD team uses a cross-functional scorecard. This assessment shows which of the modular design layouts will result in the greatest net benefit across the organization.

The NPD team divides the scorecard into specific sections for various departments to fill out. The rationale is that the individual departments have the best insight to assess the impact each design will have on their own business activity and processes. The information is not just gathered internally, but also from external key suppliers. Alpha invites suppliers to meetings to share their perspective and experiences related to the potential advantages and disadvantages associated with each possible design alternative.

<sup>1</sup> Pseudonym.



**Cross-Functional Modular Design Scorecard**  
*Illustrative*

Functional Responsibility	Metrics Impacted by Modular Design	Design A	Design B	Design C
Manufacturing	Cost per production run	✓	✓	✓
	Through rate	✗	✓	✗
Operations and Quality	Defect rate	✓	✓	✓
	Inventory turnover	✗	✓	✓
Procurement	Number of unique components purchased	✓	✓	✗
	Raw materials pricing	✗	✓	✓
R&D	R&D spend as a percentage of sales	✗	✓	✓
	Time to market	✓	✓	✓
Legal and Compliance	Regulation compliance	-	-	✗
	Patent filings	✓	-	✓
Supplier	Distribution efficiency	-	✓	-
	Inventory management	✗	✓	-
	Health risk	-	-	-

Specific sections are sent to different departments across the organization. These departments indicate the impact each modular design will have on a range of department-relevant metrics.

Departments communicate the implication through answering positive, negative, or no change.

**Choosing a Design Alternative**

Once the scorecard is fully populated, the NPD team has a clear and full view along various parameters from across the organization of the benefits and red flags attached to each of the design alternatives. The team chooses the modular design alternative that has the most positive implications across the company (and no major negative implications) to employ in the new product architecture. This tool helps facilitate productive discussions and ensures that all potential risk areas are surfaced when making decisions. Once a design is selected, Alpha develops a prototype and tests it with customers before moving into the commercialization phase.

<sup>1</sup> Pseudonym.

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# GAMMA'S CENTRAL PRODUCT STRATEGY TEAM

## OVERVIEW

Gamma establishes a central product strategy team that possesses broad technical skills across product lines to ensure that the full potential of modular design synergies are explored and captured when introducing a new product.

## SOLUTION HIGHLIGHTS

**Broad-Based Central Product Strategy Team**—Gamma's central team consisting of midlevel managers looks across product lines to capture modular design synergies.

## SCENARIO

While R&D and engineering teams are traditionally composed of individuals with particular niche expertise in their fields, Gamma realizes that this specialization inhibits the ability of individuals to look across product lines to distill modular components. Gamma assembles a central team, from the middle management layer, with a broad technical skill set to understand and explore the full range of modular design possibilities that exist across the company.

**Industry:** Industrial Manufacturing

**FY2008 Revenue:** US\$45 Billion–\$60 Billion

**FY2008 Employees:** 80,000–120,000

Gamma makes construction and mining machinery with diesel and natural gas engines. Gamma has plants worldwide and sells its equipment globally.

<sup>1</sup> Pseudonym.

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Gamma’s middle management layer of the organization sets the product strategy where modular design is initially considered. Product managers, Marketing, Product Development, and Engineering at the corporate center comprise the product strategy team. These individuals have responsibilities and experience across at least two or more product lines. When considering product line strategies, this group meets to discuss market characteristics and the product portfolio mix and also considers opportunities for implementing modular components.

**A View Across Product Lines**

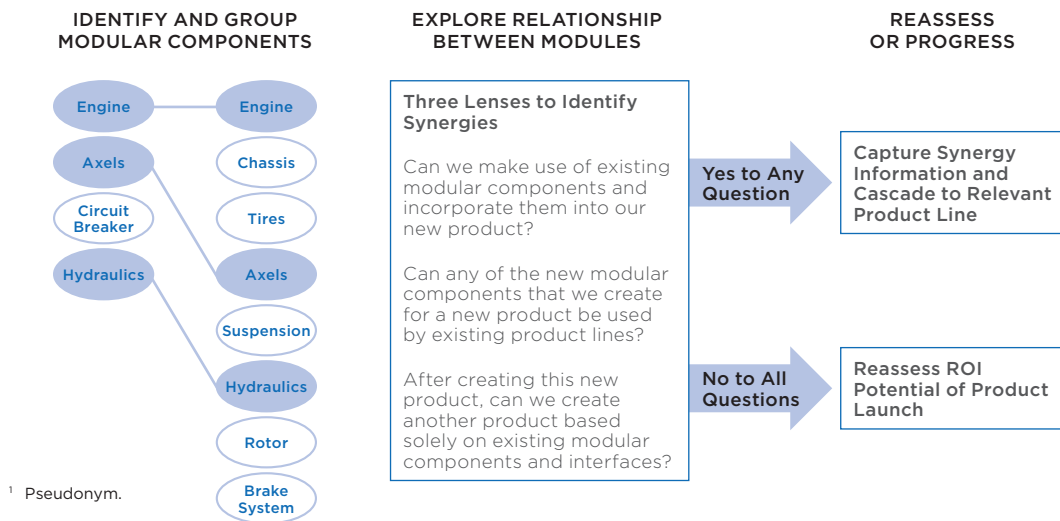
The product strategy team has the visibility and collective expertise to look across multiple projects and product lines to identify optimal cross-business modular components. Modular design synergies can initially be captured through two primary means:

- Reusing existing components and incorporating them into a new product
- Creating new components (created for a new product) and making them available for use by existing product lines

Furthermore, as more modules become available through the introduction of new products, the central team explores the potential of building a product exclusively through different configurations of existing modules.

The illustration below demonstrates the three lenses employed by the team and the process at a high level when considering possible modular design synergies.

**Identifying Modular Synergies**



<sup>1</sup> Pseudonym.



## Decisions at the Business Unit Level

The middle management team cascades the potential opportunities of using modular components to the business units. Manufacturing, Purchasing, Engineering, product managers, and Marketing hold business-level group meetings to design and create possible interfaces. The design decisions are made with the information about potential modular components in hand.

The business units have in-depth understanding of their specific product lines and markets and are held accountable and incentivized on the performance of their products. As such, Gamma empowers the business units to make the ultimate decision whether implementing the suggested modular design synergy proposal is economically sound for their area. If the business unit does not leverage the insight from group level, they pursue a design that will be created and produced within the business unit, as it is more advantageous from their specific standpoint.

## Benefits of Modular Design

Since establishing a product strategy group to identify modular design opportunities, Gamma has experienced a wide variety of benefits, including the following:

- Part number reduction aiding swift inventory management and direct cost-efficiencies
- Supply chain benefits from reducing the number of suppliers, increasing purchase volume, and developing more strategic partnerships
- Manufacturing efficiencies by using shared process planning and standardized assembly
- Product quality improvements from reducing design complexity

<sup>1</sup> Pseudonym.





# Assessing Post-Implementation Performance

Accurately assessing the impact of modular design is pivotal for justifying the high initial implementation costs and maintaining ongoing support for the approach. Many organizations simply track a few cost savings metrics to demonstrate that initial objectives have been achieved, but struggle to establish a metrics strategy that successfully evaluates the broader benefits gained from modular design. To best assess the impact of modular design, companies should follow three basic steps:

1. Establish alignment on what metrics to track.
2. Capture performance on these metrics prior to modular implementation.
3. Evaluate and report metrics post-implementation.

### 1. Aligning on Metrics

The cross-functional team leading the modular design initiative should solicit feedback from different departments to determine the best metrics to track and the best method for quantifying these metrics. To assess enterprise-wide benefits, the team should ask leaders in R&D, Procurement, Manufacturing, Marketing, and Sales to choose two metrics they believe will show the biggest impact of modular design. (See page 46 for a composite table of the most commonly cited metrics.)

### 2. Establishing a Pre-Implementation Benchmark

Once all functions are aligned on the right metrics to track, the lead team must ask individual departments to quantify these metrics for a certain period of time prior to modular implementation—usually for a quarterly, semiannual, or annual period.

### 3. Evaluating Post-Implementation Performance

After the team implements the modular architecture, they compare the compiled pre-implementation to post-implementation performance scores. The modular design team then uses these individual departmental performance scores to supplement the metrics that track the initial goals of modular design. The team creates a composite dashboard and communicates the results to senior management, as well as cascades the success metrics to the rest of the organization to drive further adoption and buy-in.

## Timing of Assessment and Setting Expectations

There is no general consensus on an optimal timeline for capturing performance and reporting the impact of modular design. The timing depends on the extent of redesign, organizational complexity, and average product lifecycle. Timelines will vary significantly from industry to industry—a CPG company’s timeline will differ greatly from an energy company. But regardless of the industry, modular design is a major undertaking for most companies and requires fairly long time horizons to realize benefits. As such, executives need to clearly communicate that early assessments will most likely not capture the full benefits of modular design. If the team does not manage expectations properly, an unfavorable early assessment may lead to premature abandonment of modular design. Teams must set clear expectations when developing a metrics strategy to ensure reporting is not required too early.

### Realizing the Benefits of Modular Design at VBG Limited<sup>1</sup>

#### Company Overview

The VBG Group develops, manufactures, and markets trailer couplings with coupling equipment. VBG is also the distributor of VBG fifth wheel products on the Scandinavian aftermarket.

#### Fragmented Operations

To accommodate a highly variable order flow, VBG maintained high inventory levels to cover order peaks and often employed temporary personnel working overtime. VBG had trouble keeping up with their competitors in offering the newest customer-requested product features, yet struggled with too many unique parts. This led to elevated procurement costs and long lead and set-up times in manufacturing and assembly.

#### Implementing Modular Design

To address these issues, VBG designed a new range of drawbar couplings and decided to reorganize its production system to implement modular design. VBG also ensured that the new modules would fit as spare parts for the older designs.

#### Benefits of Modular Design

The project succeeded in lowering total costs and reducing the number of unique parts and article numbers. The modularization project was one of several projects that contributed to a rise in net profits from 8% to 20% of turnover over a two-year period (1993–95). VBG reported the following specific metrics:

- Reduced number of unique parts contained in fifth wheel product by 42%
- Cut assembly times by 56%
- Reduced number of raw parts for the drawbar coupling product by 48%
- Decreased production lead times from 21 to 3 days through new modular workshop

The considerable reduction in lead times made it possible to deliver to customers in Scandinavia within 24 hours.

<sup>1</sup> “VBG Produkter Case Story,” Modular Management AB, [www.modular.se](http://www.modular.se).

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**Sample Metrics for Evaluating Modular Design**

*Instructions: Distribute to relevant departments. Ask departments to choose two metrics that 1) they believe will show the greatest benefit of modular versus integrated design and 2) can be easily tracked.*

Assessment Areas	Pre-Modular Design	Post-Modular Design
<b>Senior Management</b>		
Cost of Goods Sold		
Return on Capital Employed		
Economic Value Added		
Production Costs		
Direct Costs		
Indirect Costs		
Initial CapEx Needed		
Number of Employees Trained in Modular Design to Date		
<b>Marketing and Sales</b>		
Purchase Experience		
Customer Satisfaction		
Customer Alignment of Brand Perception with Corporate Message		
Share of Wallet		
Switching Costs (Vis-à-Vis Competitors)		
Market Risk		
Reputation Risk		
Total Revenue per Product		
Average Selling Point		
Market Share		
Customer Segments Served		
Sales Volume per Product		
Profit Margins per Product		
Sales Executives' Perception of Complexity of the Sales Process		
<b>Procurement</b>		
Number of Suppliers		
Purchase Volume per Product Category		
"Bulk" Purchase Savings		
Inventory Management Efficiency		
Distribution Efficiency		

<b>Procurement (Continued)</b>		
Number of Strategic Supplier Partnerships		
Number of Unique Purchased Components		
Distribution Risks		
Savings Through Outsourcing		
<b>Manufacturing</b>		
Lead Times		
Cost of Production Runs		
Environmental, Health, and Safety Risk		
Shared Process Planning		
Assembly Line Synergies		
Changeover Costs		
Number of Tools Needed		
<b>Research and Development</b>		
Number of SKUs		
Internal Rate of Component Reuse		
Internal Rate of Design Reuse		
Number of Patents		
Product Reliability		
Cost Savings Attributable to R&D		
Cycle Time for Redesign		
Part Count		
Total R&D Headcount		
Time to Market		
Number of Standardized Platforms		
Number of Systems Needed		
Number of Product Variants		
Development Cost per Project		
Patent Copyright Infringements		

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