

Chapter 8

A Proactive Scaling Platform Design Method Using Modularity for Product Variations

Keith Hirshburg and Zahed Siddique

Abstract To be competitive in the current business environment, a company or engineering firm must be able to produce new products or designs in the marketplace with better quality and greater customization than both their national and international competitors. These business entities must also be able to accomplish this at a more strenuous pace than their competitors to capture the largest market share. In this chapter, a scaling, small product, *proactive platform design method using modularity* (PPM) for product variations is presented to assist the company or firm in achieving the highest competitive result. In Chap. 30, we also present a case study to demonstrate how this method can be effectively instituted in a proactive product design. Even though this method and case study are directed to small product family development, any product family design with commonality can benefit from using these ideas to improve the design process.

8.1 Introduction

To bring a set of products to the market in an intelligent and economical way, a company must use an orderly and defined process to design and manufacture these products. Companies are striving to deliver greater quality, more varieties, faster response, more innovative designs, and lower prices (Bower and Hout 1988; Stalk and Hout 1990). New models are introduced in the market more frequently, while the number of mass-produced models is decreasing (Schile and Goldhar 1989). Although different researchers (Bower and Hout 1988; Hirsch and Thoben 1997; Hollins and Pugh 1990; McDermott and Stock 1994; Wheelwright

K. Hirshburg • Z. Siddique (✉)
School of Aerospace and Mechanical Engineering, University of Oklahoma,
Norman, OK 73019, USA
e-mail: zsiddique@ou.edu

and Clark 1992) have highlighted different reasons for family of products, there is a consensus that for companies to survive in the current global market, they must move towards a platform-based customization or family of products.

Companies are being faced with the challenge of providing as much variety as possible for the market (external) with as little variety as possible between products (internal). One of the key elements in product family is the product platform. "A product platform is a collection of the common elements, especially the underlying core technology, implemented across a range of products" (McGrath 1995). One way to achieve this is by developing the product platform carefully and then using different modules to provide product variety. This approach requires configuration rationalization of the platform and the product family. Configuration design involves determining which modules are in the product, what are the components in the modules, and relationships among the components and modules. A well-defined product platform is required to support family of products. The approach advocated in this chapter, and by many strategic marketing/management researchers and designers/engineers alike, is to design and develop a family of products with as much commonality between products as possible with minimal compromise in quality and performance.

Focusing product strategy at the platform level simplifies the product development process because there are fewer platforms than products and major platform decisions are only made every few years. "A clear platform strategy leverages the resulting products, enabling them to be deployed rapidly and consistently" (McGrath 1995). A platform approach encourages a long-term view of the product strategy. Implementing commonality to develop platforms for a set of similar products requires product configuration reasoning to determine the product platform and then to identify the portfolio associated with the platform.

Review of the traditional individual product engineering design process reveals an insufficiency, that is, the current process does not take into account reusing the design or parts of the design to create other similar products or solutions. Currently in the last few decades, as companies became more competitive, and the markets became more segmented, the product designers need an efficient approach to design a family of products. This method requires a company to design products at a more aggressive pace, provide more variety to customers, while increasing design and manufacturing efficiency and reducing financial burden on the company. Consequently, the overall objective of this chapter is to develop a method for product family design through using a scalable platform and modular product family while using concurrent teamwork, human-involved design negotiation with mathematical optimization, and design for manufacturing. We also investigate changes and extensions to existing individual product design processes to accommodate design of product families.

8.2 Related Work

A product family is a general group of related products that are created off of single or multiple platforms (Simpson et al. 2006). Put another way a product family is an approach “to obtain the biggest set of products through the most standardized set of base components and production processes” (Siddique and Rosen 1999). The product family attempts to fulfill most or all of the customer niches in a certain market(s). Examples of product families range from Black-N-Decker drills to light SUVs made by the automobile manufacturers. Other terms associated with product families are product line and product group. Product family design can be described as “a conceptual structure and overall logical organization” that is used to create a family of products through utilizing commonality achieved from providing a “generic umbrella” to extend product line structure (Jiao et al. 2007).

A product platform can be defined as a set of common components, modules, processes, and assets from which a stream of derivative products can be efficiently developed and launched (Meyer and Lehnerd 1997; Robertson and Ulrich 1998). Extended further the platform can be identified in physical and nonphysical terms, meaning actual knowledge can be considered a platform instead of just designed components. In this chapter a platform will be considered as the common components, modules, and interfaces that are involved in driving the performance of a family.

A proactive platform is a top-down approach, meaning that a company strategically creates a product line “based on a platform and its derivatives” (Simpson et al. 2006). A company performs proactive platform design by designing the platform components from the beginning to work in conjunction with each other that makes a base for the product line. This design would not try to create a platform from existing products or components. An example of a top-down approach is the design of the product family of Walkman, created by Sony Corporation (Sanderson and Uzumeri 1997). A reactive design, the bottom-up approach, is a platform design process where a company takes an existing set of distinct products and tries to consolidate them into using a single set of components (Simpson et al. 2006). Currently, there is a need for a proactive approach to product family design that can utilize tools that have already been developed by researchers.

Modular architecture is a product architecture defined by a one-to-one or one-to-multiple construction of functional elements (Simpson et al. 2006). In product family there are three main types of modularity: functional modularity, technical modularity, and physical modularity. Integral product architecture is defined by having a complex or coupled mapping of functional elements to physical structures or interfaces (Simpson et al. 2006). A scale-based or parametric product family is based on a platform that stretches or shrinks to create different products in the product family. This stretching or shrinking can be a single component of the platform, a few components, or even the entire platform to create the different products of the family. GAM (Lu and Zuhua 2006) is a method for designing a platform through the use of a genetic algorithm to find the components of the platform from a list of design variables.

Design affordance is a design process of allowing and disallowing certain conditions, variables, and aspects, when conducting a design process. Original design of a complex system starts from the view at the system level and then is decomposed in subsystems and finally down to the component level. Design affordance seeks to understand the system as a whole in terms of functions, interactions, reactions, and even emotions. Affordance means “what it provides, offers, or furnishes to a user or to another product” (Maier 2008). The product family is designed by limiting or boosting the affordances. Gonzalez-Zugasti et al. (2000) present a method for designing a product family through the use of an interactive team-based negotiation of components. This method’s inputs are (1) the requirements for the product family, (2) the variables, (3) whether the variables are common, (4) and the interrelationship of the variables. This method computes a platform using basic optimization and then the designer can create variants of this platform to suit the individual product needs. Varieties in many products are based on functionality; hence, an approach is needed that uses modularity as a mean to support family products.

8.3 Proactive Platform Design Method Using Modularity

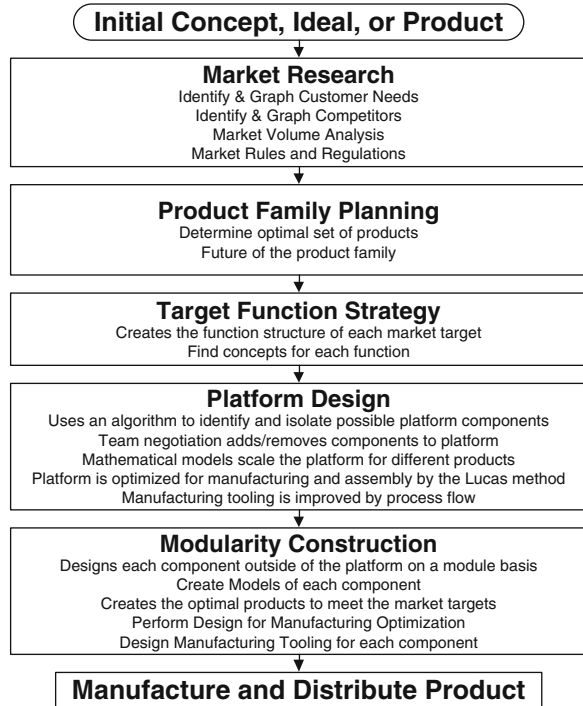
The proposed PPM design method for creating a scaling, small product, and proactive platform, using modularity for product variations, is comprised of five steps to conceive a product family from an initial concept. The steps are (1) market research, (2) product family planning, (3) target function strategy, (4) platform design, and (5) modularity construction. These five phases are shown in Fig. 8.1.

8.3.1 Step 1: Market Research

Market research and analysis for a potential product is necessary for a design team to be aware of all the metrics concerning a product’s performance and the importance of these features to offer an optimized product line to the customers (Stobart 1994). Distributing a product line that fails to meet the customer demands will create a lower than desired sales volume in the present and will also “negatively affect future sales” for the company by damaging the company’s brand name (Stobart 1994). Associated sub-steps are:

Identify customer needs: To be able to determine the customer needs, the design team will need to research the different market segments surrounding the product line’s main purpose or function. The market segment can be designated by viewing existing products that relate to the product line’s base function and determining logically where the product lineup fits. The determination of the market segment can be performed by thinking broadly and working towards a more defined market segment.

Fig. 8.1 Outline of the design method



The result of narrowing down the market segment leads to a more defined set of customer demands, but the consequence to narrowing the market segment will also reduce the sales volume for the product line. A trade-off must be decided between achieving a large amount of total sales and the ability of the products in the product line to fit the needs of a specific set of customers. After narrowing down from a broad market focus, a preliminary main customer segment group should be chosen and the design team should begin accumulating information on the customers of these common segments. This can be accomplished by performing a review of the customers and a review of the competition in these segments. A review of the customers of the market segment is difficult, time-consuming, and statistically non-exact process (Mendenhall and Sincich 2007). To determine the customer needs directly, the team can interview the customers in person or over the phone. A less direct interview can be accomplished through feedback of company's previous products, Internet polls, or email polls. Direct interviews provide less biased information due to people having to put forth less effort and reason to give the company information (Campbell 1974). The direct interview methods usually result in a normal curve for replies if the polls have a large enough population (Mendenhall and Sincich 2007). Less direct feedback methods result in a greater amount of bias. These biases result from the feedback volunteered by customers who appreciate the product in the upper extreme or who dislike the product in the lower extreme.

This indirect feedback method usually results in a reverse normal curve (Mendenhall and Sincich 2007). The indirect feedback method with a large population highlights what features are required in the product family and what features should be left out. The interviewee rates each feature on the interview form with a scale that ranges from the feature that is not important in consideration for buying the product to the feature being extremely influential on the purchase. The information can be organized visually and analyzed to determine the importance of the features. Two graphs should be created, one for the direct interview method and one for the indirect polling method. By overlapping the two graphs, the design features that are most important in the product offerings can be determined by identifying repeated peaks.

Identify competitors: Competitors first need to be identified (Clark and Montgomery 1999) to perform a review of how the competition fulfills the market demand. This can be accomplished by identifying products offered in the market segments and then researching the product features, the quality of the features, how the product performs these features, and how many of these products are purchased. For each product being researched, consumer/user evaluation is gathered using a survey. The consumer/user survey uses four categories to evaluate features:

- Metric A determines if the competitor's product includes the selected feature.
- Metric B describes the quality and durability of the selected feature.
- Metric C is the performance metric and is used to gauge how well the feature performs in the product.
- Metric D is the population metric and is the number of products that are sold per year by the specific competitor.

Metrics A through D are used to calculate the valuation of the feature from the product and are shown in Eq. (8.1).

$$\text{Feature Value} = A_{\text{feature}} * \frac{B_{\text{quality}} - 1}{4} * \frac{C_{\text{performance}} - 1}{4} * D_{\text{amount}} \quad (8.1)$$

After all the competing products in the market have been evaluated, the calculated feature values are compiled to visualize how the competing products match the customer demands, using Eq. (8.2).

$$\text{Total Feature Value (feature}_x) = \sum_{n=1}^i (\text{feature}_x)_i \quad (8.2)$$

Using the compiled scores of the features, the market demands can be compared to the features offered by the competitors. Statistical methods can be applied to gain a more defined edge over the competition in the market segment. After the primary market segments have been researched, the team should decide if reaching market segments outside of the selected ones can benefit revenues, without degrading the product line. These outer market segments might be incorporated into the product line by leveraging a variation of the platform. The outside markets could be

potentially reached by the initial product offering or by a future variation of the platform released at a later date. Investigation into other segments can be accomplished by repeating the same process of research in the main segments.

Market volume analysis: Market volume analysis can be used to determine the number of products needed to meet the customer demands and the number of products currently on the market. Volume analysis should not only cover the total amount of products to be sold but also find the relationship between price and number of units that can be sold at that price. The market volume analysis is used to help decide how many and the price of units for each variation.

Rules and regulation bodies: Along with the laws and regulations involving patents and other information about the designs, there are also laws regulating how these products perform. Each market segment will have sets of regulations that it may have to follow. Some examples of regulatory bodies are the EPA and OSHA, but there are many other agencies and regulations that may need to be researched and followed. All rules and regulations should be researched for each market segment for the product line, before the product is designed. Proactive research in this area will have a large cost reduction, compared to researching retroactively.

8.3.2 Step 2: Product Family Planning

The objective of product family planning is not just to plan an optimal product line for the instance it is released but also to plan out the future offerings, variations, and upgrades to the products, until the next generation of the platform product family can be released. The associated sub-steps are described next.

Optimal set of products: To create an optimal set of products, the team must first convert the product qualitative features of the marketing process into quantitative features the product can be designed from. This is accomplished by converting the generic qualitative feature into a measureable quantitative feature. The conversion can be accomplished by using well-established methods such as quality function deployment. The optimal set of products, also known as the market targets, can be created by using a specific selection of quantitative features needed to create the performance demands of the target. This set of products should fulfill all of the major requirements in the market segments and should be the products the team is attempting to produce in the product family. If the amount of features and details of the features become too complex, the optimal product line can be selected by a genetic optimizing algorithm.

Future of the family: The success of the product family depends on how it is leveraged over time until the next generation of the product family can be designed and manufactured. A large part of the planning for the future is determining the time length between product family generations. This time between generations is dependent upon the market competitor's generational length and the capabilities

of the design team's company. Product life cycles can be as long as 10 years in the example of Sony and its PlayStation systems or as short as a year as is found in some cell phone product families. To find the market average for the product life cycle, the team will need to research when each product of the competitor's was first released and when the product was replaced by the next generation of product. If the product gets replaced by a product, with only a small amount of upgrades, it should not be considered a new generation. After finding the average product life cycle of the competitors, the team should plan on matching this life cycle or even trying for a longer product life cycle. Longer product life cycle usually results in product line generation being more profitable. In certain cases sales will trail off for the longer the cycle because of market saturation or newer models from competitors being available in the market. Falling sales are due to the product line not fulfilling the customer needs as well as the competitor's new products, and this can lead to a damaging of the companies brand name. After the product life cycle has been determined, the product release dates should be decided upon to keep the customer segment interested in the company, to allow for the marketing department to have new products to market, and to provide transition time between the generations. A basic example of a planned time leveraging of a small product family is shown in Fig. 8.2.

8.3.3 Step 3: Function Strategy

The function strategy is the road map for the product family design process and is composed of function structures for each of the products in the family. The first step is to create function structures for each of the market targets to provide an outline of the functions included in each product. A function structure is the mapping of the different flows of material, energy, and information within a design. A full creation of a function structure should be a road map to demonstrate what needs to be designed. Even though it presents what needs to be designed, it does not provide how the product should be designed. For each process defined in the function structure, the process can be extrapolated into a component(s) of the platform or a modular component(s) in the product variants. At this stage, each process should be isolated and named for use in both the platform design process and the non-platform design process.

8.3.4 Step 4: Platform Design

All metrics that can be used to describe the performance of a product family are influenced largely by a base number of components, known as the platform. Choosing an optimal set of components and then optimizing those components need to be accomplished to produce a product line that is successful in the current competitive environment. Sub-steps are:

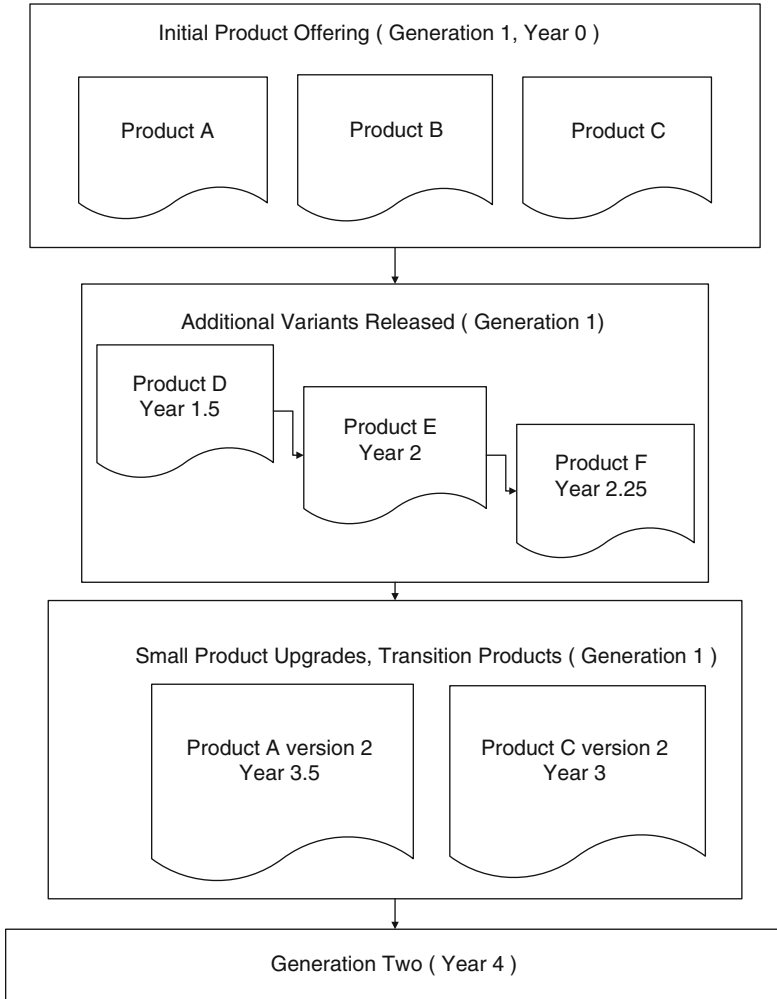


Fig. 8.2 A time-leveraged example of a generic product plan

Determining platform components: To determine platform components, the function structure needs to be broken down for each of the market targets into its components, which are placed in a matrix. This matrix logs the functions in rows and places the details of the function in columns under component name, market target, component function, scalable, standard part, and modifiable. After all these inputs are entered into the matrix, an algorithm (see Fig. 8.3) identifies and isolates all possible platform components. This is accomplished through the use of multiple processes. Components that do not have the flexibility to be modified without adversely affecting the performance of the product are considered nonmodifiable. The first process of the algorithm identifies all components that are nonmodifiable

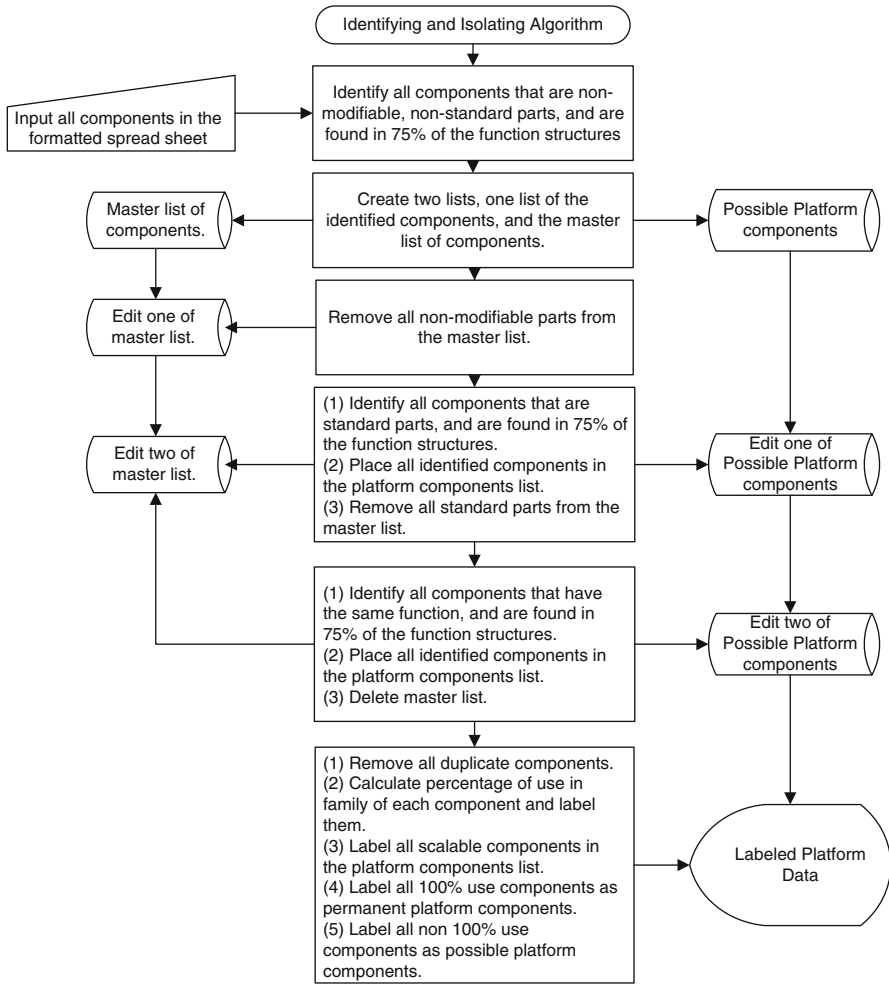


Fig. 8.3 Identifying and isolating algorithm

but found in 75 % (this percentage can be increased or decreased based on the product. A higher percentage will result in lower commonality) of the market targets and places these components into the platform with removing the leftover nonmodifiable components from being considered for the platform. The second process identifies all components that are off-the-shelf/standard parts and are found in 75 % of the market targets and isolates them. The process then places these components into the platform and removes the remaining standard parts from being considered for the platform. The third process identifies all the components that share a function with at least 75 % of the market targets. These identified components are isolated and placed into the platform consideration components

and remove all the function components that did not meet this percentage. The last process evaluates the collection of platform components and removes the duplicates and then calculates the exact percentage use in the targets for each component. After this evaluation, the process tags all components with 100 % use as permanent platform components and labels the rest with a possible platform component tag. Finally the process highlights all scalable components for easy identification.

After the use of the algorithm, the team will need to decide which of the possible platform components should be included in the platform, and this can be done by using a negotiation model. After the algorithm and the team negotiation, the platform components are confirmed and the team can continue to designing, modeling, and optimizing the platform.

Platform design modeling: The platform has been selected and now it needs to be designed and modeled. The platform components should be broken into two categories: components that will be scaled and components that will not be scaled. The design entails creating models using the requirements and functions. In the design of scaled components, the restrictions should be modeled using both the maximum and minimum dimensions required to produce the maximum and minimum performances. These multiple dimensional models are designed so the non-scaled components in platform and the non-platform components can be designed within potential space restrictions. The designers should design the scaled component's CAD models with true flexibility for on-the-fly changes. Non-scaled connections must be designed to remain static during the on-the-fly changes to allow for connectivity in all scales. The static connections to the non-scaled components will allow for modularity in the connections for the non-scaled and the non-platform components.

Platform optimization: Platform optimization is the modifying of the scales, dimensions, and properties of the platform components to achieve the desired performance. The optimization of the scaled platform components can be accomplished using existing optimization approaches to determine the optimal set of scales (Simpson 2004). For the non-scaled components, the use of FEA and CFD analysis should be all that's needed. The designers should repeat platform design modeling and scaling (Fig. 8.4) for different scaling components and modules.

Design for manufacturing improvement on the platform: Improving the platform for manufacturing is important since the platform will be manufactured for each of the products produced. Any waste or underperformance will be repeated many times over, so any improvement found from being thorough in the design and redesign of components for manufacturing is very important. The manufacturability and assemblability of the platform components are improved by following the Lucas method, which is a method based on a difficulty value assessment instead of recording time of assembly as in the Boothroyd and Dewhurst method. The Lucas method assigns values to three processes: functional analysis, feeding analysis, and fitting analysis which leads to an assessment on the assembly of the product. The efficiency of the design is analyzed through functional analysis by providing a

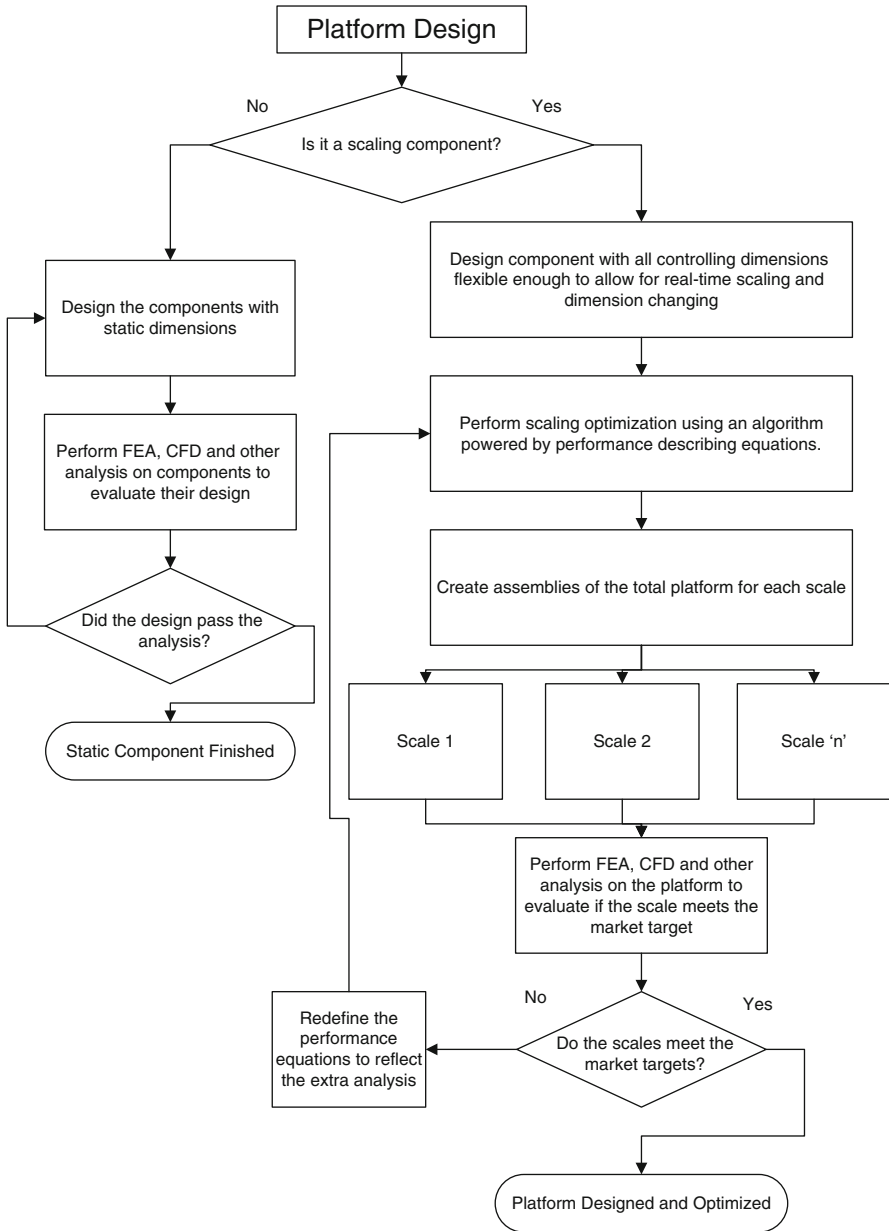


Fig. 8.4 Platform design modeling and scaling flow process

percentage of essential components of the product (parts that are deemed to be essential to the product's function; parts that are not essential to the product's function include fastening and locating). The calculation of functional analysis is shown in Eq. (8.3):

$$\text{Functional Efficiency} = \frac{\sum \text{essential components}}{\sum \text{essential components} + \sum \text{non essential components}} \quad (8.3)$$

The handling of components, during assembly, is analyzed using feeding analysis and is shown in Eq. (8.4). In the feeding analysis, the problems associated with the handling of the part are scored using an appropriate table. For each part, the individual feeding index is scored. Similarly fitting ratio is calculated [Eq. (8.5)].

$$\text{Feeding Ratio} = \frac{\sum \text{Part Feeding Indices}}{\sum \text{essential components}} \quad (8.4)$$

$$\text{Fitting Ratio} = \frac{\sum \text{Part Fitting Indices}}{\sum \text{essential components}} \quad (8.5)$$

The fitting ratio is used to analyze the insertion of the component into the products during assembly. The Lucas manufacturing analysis is an assessment on the complexity and cost of the manufacturing by performing analysis on many different metrics. The manufacturing cost is calculated using Eq. (8.6):

$$\text{Manufacturing Cost Index} = C_C * C_{MP} * C_S * (C_T \text{ or } C_F) * P_C + V * C_{MT} * W_C \quad (8.6)$$

where C_C = complexity factor, C_{MP} = material factor, C_S = minimum section, C_T = tolerance factor, C_F = finish factor, P_C = processing cost, V = volume (cubic millimeters), C_{MT} = material cost, W_C = waste coefficient.

The Lucas method uses seven steps to improve the manufacturability and assembly of the platform. Step one involves the specification of the platform, step two is the design of the platform, step three is the functional analysis, step four is the feeding analysis, step five is the fitting analysis, step six is the assessment of the assembly analyses, and step seven is the assembly analysis.

Manufacturing tooling design: Since the platform is the backbone of the product family, the platform design must incorporate the manufacturing tooling. The platform is the largest contributor to product quality and performance, and it is advisable to have the platform manufactured in-house to have better control over the manufacturing. The only two exceptions to in-house manufacturing of platform components would be fasteners and other off-the-shelf components or with using an experienced partner that is committed to manufacturing the platform to the exact

design specifications. A great reduction in manufacturing time and considerable tooling cost can be achieved by improving the tool passes. A tool pass operation that is not optimized leads to wasted time, incorrect tolerances, and accelerated tool wear. Optimizing a machining operation involves optimizing the machine time and tool wear for volume, surface, and finishing operations.

Dies for injection molding should be designed with easy access to the created part, low amount of lost material in the mold, and proper cooling to allow for repeated moldings and to create parts with near-optimal tolerances to eliminate the need for post-processing. The process for optimizing an injection molding, molding, and forging operation involves six assessments. The six assessments are the following: does the die provide easy access to the part, is excessive material wasted in the die, does the design have proper cooling, can the component be created with better tolerances, and does the part need post-processing?

Nonphysical component platform: The nonphysical component platform is the sharing of guidelines or styling quos throughout the product lineup. A well-defined platform will involve multiple nonphysical platform entities. The nonphysical platforms can be reused in future products for the company to make the design processes easier. The reuse of nonphysical platform can lead to having the products carry a distinct look that adds to the brand identity. A very important non-component platform item is the fasteners. All fasteners should be of the same type, and if at all possible, use the same tool for assembly and reassembly after maintenance or repair work will be more efficient.

8.3.5 Step 5: Modularity Construction

Modularity construction is a phase to design the non-platform components of the product line. The use of modularity in the design of the products leads to the ability to provide product variations of the product line.

Module design of components: Modularity is the one-to-one mapping of the connections used by components in a product. This requires all non-platform components to use modular connections when connecting to the platform and to other components. To allow for greater customization in the design of the product, each component should be designed using only its particular details and not the details of the whole product. The particular details would include the input, output, and behavior of the component instead of the requirements of the entire product. Designing the components to work with a particular interface and a set of low-level details will allow for greater customization and the ability to upgrade single components without being forced to redesign the entire product.

Component design modeling: Component design modeling is a restricted single-product design process. The restrictions on the design process are the behavior of the component from the function structure, the interface of the component, and the

sizing constraints derived from the platform and market research. The specification definition for Ullman's design process would not be the entire product, but the purpose and behavior of the component being designed (Ullman 2002). The customers of the component are all components that will be interfacing with it. The customer requirements of the components are what the component is required to perform and the restrictions on how the component can perform. The competitors of the product are the similar components produced in other company's products. The competitor's should be evaluated for their positives and negatives. The design process of the components of the different product variants is found in Fig. 8.5. The component design process is repeated for each different component in the product line that is not a platform component.

Creating the market targets: With the components designed, the market targets can be created by selecting a scaled platform and adding certain components to produce the necessary performance. If the created product's performance does not match the market targets, the integration of the components needs to be checked for correctness and the underperforming components need to be identified. The underperforming components may need to be redesigned, or it means reaching the market targets is not possible within the product constraints.

Manufacturing improvements for optional components and products: The manufacturability and assembly of the product are improved by following a modified Lucas method that is applied to each component to the product. The Lucas method is modified by performing the Lucas manufacturing analysis after each step of the assembly analyses. The modification of the standard Lucas method disallows an extreme removal of components and lessens the chance of complexity in the components. The modified Lucas approach (Fig. 8.6) validates a component design or forces a component redesign that is optimized for assembly onto the platform or onto other components.

Component manufacturing tooling design: In most cases the small products will be made using multiple materials, with a mix of different components. Some components will be manufactured in-house and some components will be outsourced. For in-house manufactured parts, the tooling design is important to reduce manufacturing waste.

Production volume costing: There are three major factors to the cost of manufacturing the product: labor cost, material cost, and machine cost. Making these factors as cheap as possible will in turn make the product more profitable to produce and cheaper for the consumer to purchase. This is a feedback loop that contributes to the economic success of the product line. To lower the material costs, the manufacturing of the components should be designed to waste as little material as possible and to create as few defects as possible. If the manufacturing facility is located in a cheap area of labor, emphasis should be placed on accuracy and quality of manufacturing instead of automation. If the cost of labor is high, the manufacturing process should include as much automation as possible. The cost of production also includes several types of indirect costs known as overhead.

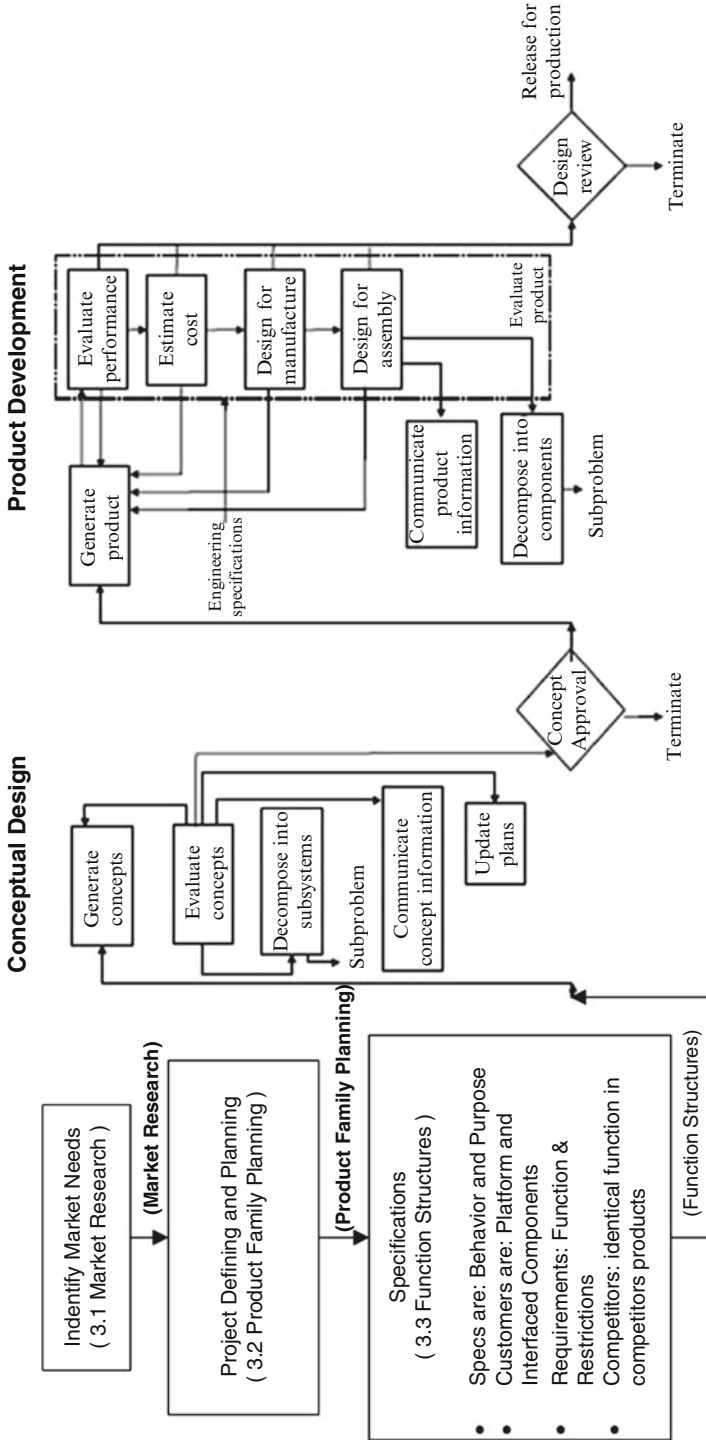


Fig. 8.5 Modified version of Ullman's design process used to create the product components

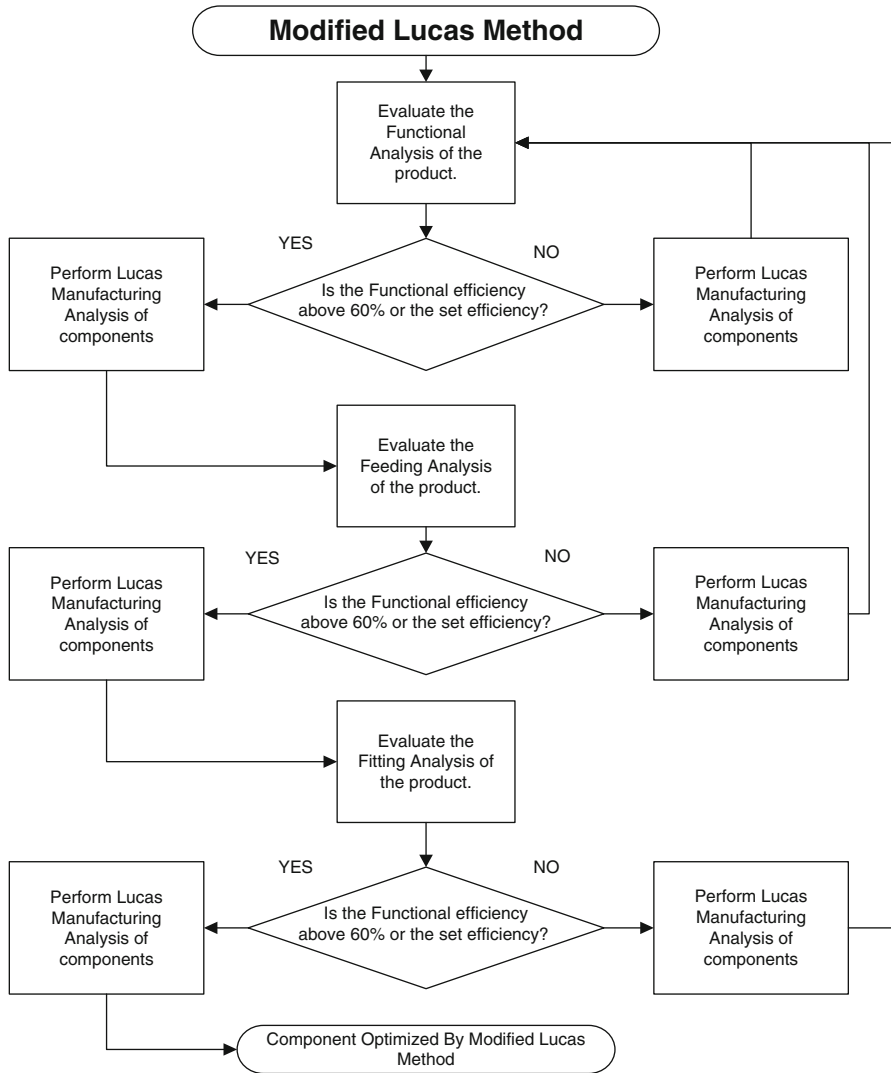


Fig. 8.6 Process flow chart for the modified Lucas method

Examples of overhead include permits, building maintenance, design costs, and marketing costs. Total cost to manufacture a product line is the addition of material cost, labor cost, machine cost, and indirect cost. Total cost to manufacture a product line is:

$$\begin{aligned}
 \text{Total Cost} = & \sum \text{Material Cost} + \sum \text{Labor Cost} + \sum \text{Machine Cost} \\
 & + \sum \text{Indirect Cost}
 \end{aligned}
 \tag{8.7}$$

Cost per product can be calculated as:

$$\text{Cost per Product} = \frac{\sum \text{product}_A}{\sum_{i=0}^n \text{product}_i} * (\text{Total Cost}) \quad (8.8)$$

8.4 Concluding Remarks

The presented design method is for a scaling, small product, proactive platform design, using modularity for product variations. The method begins with performing market research through direct and indirect customer interviews and also through evaluations of current competitor's products. The method then takes the results from the research and provides steps for planning of the whole product generation from initial offerings to variants and finally updates of the products. With the products planned, the method is used to create function structures to describe each of the products and to identify the components needed to create the functions. The method then utilizes an algorithm to identify and isolate components common in all or most of the structures and then uses team negotiation to select and design a platform for driving the entire product family. The method also highlights the Lucas method as an optimizer for both assembly and manufacturing of the platform, suggesting a means for optimizing the manufacturing tooling of the platform. Following the design of the platform, the next step is to design the non-platform components using David Ullman's mechanical design process in a modular mapping to drive variation and ensure ease of integration. Along with the design of the non-platform components, the Lucas method and manufacturing tooling design are used to improve the product. Using the discussed steps, a design team can proactively create a viable and competitive product family offering.

In Chap. 30 a family of landscaping blower vacuums case study is presented using the described design method. The case study provides an example of both direct and indirect interviewing for the market research and an example of a competitor analysis of the market segment using both Stihl and Echo competitors. Furthermore, the case study provides analysis on what the customer base demands and created market targets and product variants to meet these demands. The case study concludes with CAD models provided for the main market target products.

References

- Bower JL, Hout T (1988) Fast cycle capability for competitive power. *Harv Bus Rev* 66:110–118
 Campbell SK (1974) *Flaws and fallacies in statistical thinking*. Prentice Hall, Englewood Cliffs, NJ
 Clark BH, Montgomery DB (1999) Managerial identification of competitors. *J Market* 63:67–83

- Gonzalez-Zugasti JP, Otto KN, Baker JD (2000) A method for architecting product platforms. *Res Eng Des* 12:61–72
- Hirsch B, Thoben KD (1997) Why customer driven manufacturing. In: Wortmann JC, Muntslag DR, Timmermans PJM (eds) *Customer driven manufacturing*. Chapman and Hall, New York, pp 33–44
- Hollins B, Pugh S (1990) *Successful product design*. Butterworths, Boston, MA
- Jiao J, Simpson TW, Siddique Z (2007) Product family design and platform-based product development: a state-of-the-art review. *J Intell Manuf* 18:5–29
- Lu Z, Zuhua J (2006) A genetic algorithm for scale-based product platform planning. In: Jiao L et al (eds) *ICNC. LNCS*, vol 4221. Springer, Berlin, pp 676–685
- McGrath ME (1995) *Product strategy for high- technology companies*. Irwin Professional Publishing, New York
- Maier JR (2008) Rethinking design theory. *Mech Eng* 130:34–37
- McDermott CM, Stock GN (1994) The use of common parts and designs in high-tech industries: a strategic approach. *Prod Inv Manage J* 35:65–68
- Mendenhall W, Sincich T (2007) *Statistics for engineering and the sciences*, 5th edn. Prentice Hall, Upper Saddle River
- Meyer MH, Lehnerd AP (1997) *The power of product platforms: building value and cost leadership*. Free Press, New York
- Robertson D, Ulrich K (1998) Planning for product platforms. *Sloan Manage Rev* 39:19–31
- Sanderson SW, Uzumeri M (1997) *Managing product families*. Irwin, Chicago
- Schile T, Goldhar JD (1989) Product variety and time based manufacturing and business management: achieving competitive advantage through CIM. *Manuf Rev* 2:32–42
- Siddique Z, Rosen DW (1999) Product platform design: a graph grammar approach. In: *ASME design engineering technical conference*. ASME, Las Vegas, NV, pp 1–12
- Simpson TW (2004) Product platform design and customization: status and promise. *Artif Intell Eng Des Anal Manuf* 18:3–20
- Simpson TW, Siddique Z, Jiao J (2006) Platform-based product family development. In *Product platform and product family design methods and applications*. Springer Science, New York, pp 1–15
- Stalk GJ, Hout T (1990) *Competing against time*. Free Press, New York
- Stobart P (1994) *Brand power*. NYU Press, New York
- Ullman DG (2002) *Mechanical design process*. McGraw Hill, Columbus
- Wheelwright SC, Clark KB (1992) *Revolutionizing product development: quantum leaps in speed, efficiency and quality*. Free Press, New York