

Chapter 4

Modular Function Deployment – Using Module Drivers to Impart Strategies to a Product Architecture

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Abstract Products reflect the needs of many different entities. People such as end-users and re-sellers, regulating bodies of authority, and individuals within manufacturing and engineering provide statements as “voices” that impact the physical structure of a product in different ways. A company establishes a strategy to realize the product that responds to these “voices”. There are various approaches to capturing a singular “voice of x” when realizing a product architecture. Modular Function Deployment differs from other architecture methods by providing a holistic approach to capturing multiple “voices” as a company strategy through the use of Module Drivers. This approach is demonstrated by actual industrial examples that explore the flexibility of Module Drivers applied in the creation of a conceptual modular product architecture.

4.1 Introduction

To compete in today’s global marketplace, many companies are utilizing product families to increase variety, improve customer satisfaction, shorten lead-times, and reduce costs (Simpson et al. 2006).

Product families and synonymously, product platforms and product architectures, are showing themselves to be a tactic of enabling strategic objectives. The industrial community is reporting on the successes achieved through the systematic application of product architecture that support the idea of how useful product

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architectures are for enabling strategic intent. There is a relationship between a product family and the product development. The product development process is the tactical vehicle to convey the business strategy or strategic objectives of improving customer satisfaction, shorten lead-times, and reduce costs through the application of a product family.

Devising a means to model the relationship between the product development process and strategic business objectives would make it easier to explain how industrial companies could benefit from a modular product architecture. Naturally, the model needs to be adaptable not only for different business strategies driven by a product type or industry, but also adaptable to strategies that evolve with product maturity and new market emergence.

Modular Function Deployment (Ericsson and Erixon 1999) is the method Modular Management uses to illustrate the relationship between product architecture and strategic objectives with the use of Module Drivers. Our suggestion is that by using Module Drivers, strategy can be imparted on the product architecture.

In the following sections this topic will be developed. First, a brief study of product platform strategy and its role in the development of product architectures will position the development of our approach. Then a model of how Module Drivers impart strategy is constructed and explained. Based on our extensive database of modular product platforms, the model will be demonstrated using a number of industrial product architecture results. Finally, we will discuss some insights learned from the model's application and directions of continued research.

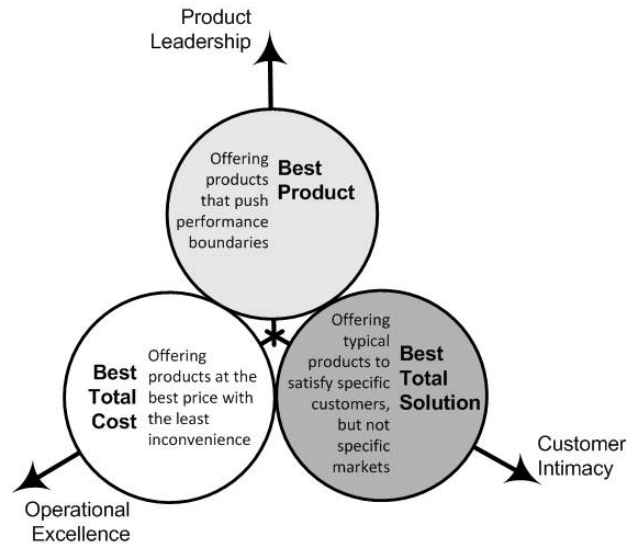
4.2 Background

4.2.1 Strategy and Tactics in Product Development

There is an inherent relationship between strategy and tactics, particularly in Product Development. Where strategy is the idea of an objective that can be realized through the application of a plan, tactics is then the execution and assessment of the outcome of that plan. For example, strategy is found in the idea of selecting between three product development approaches to tactically develop a product platform, as described in (Hölttä and Salonen 2003). However, joining the idea of a strategic objective with the tactical outcome is often inferred, even when the evidence of strategy can be found in the tactical results, like when describing how product platforms are being tactically leveraged by market strategies, from (Marion and Simpson 2006).

However, let us take note of the observation that product platforms and product families are being utilized to realize several business objectives; increase variety,

Fig. 4.1 The value disciplines abstractly represented in a three-dimensional space.



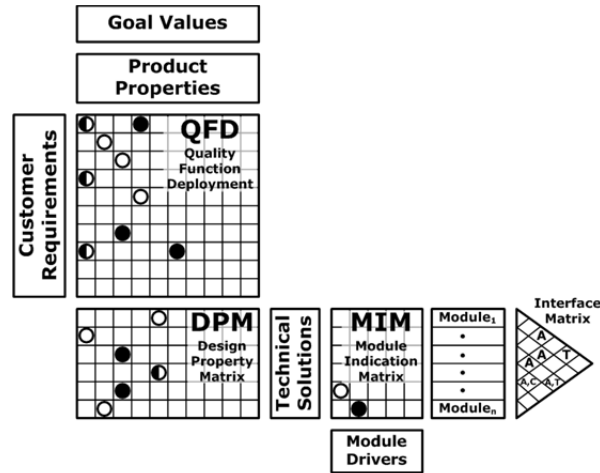
improve customer satisfaction, shorten lead-times, and reduce costs. The strategy of a business is not to realize a product platform; product platforms and product families are a tactical means to operating a business.

When we talk about business strategy we are referring to how businesses are managed (Treacy and Wiersema 1995). For example, a business strategy is based on an idea of what is the company going to promise its customers and then it develops a plan to bring the fulfillment of the promise to the customers, which should be an activity in a product planning process (Bowman 2006). Treacy and Wiersema call the first part of a business strategy the Value Proposition and the second part the Value-Driven Operating Model. These two parts are combined to form the desired way of managing a business, the Value Discipline. There are three Value Disciplines available to a business strategy; Product Leadership, Operational Excellence and Customer Intimacy as shown in Fig. 4.1. Typically, a business will pick one of these value propositions as its main focus and then seek to reach a minimum level with the other two (Nightingale and Srinivasan 2011).

4.2.2 Module as a Tactical Vehicle

In reviewing the literature on product platforms, product families and product architectures, the concept of a module appears regularly as a tactical vehicle in new product development. The concept of a module has been labeled as a “system partition” (Christopher 1964), “structural element” (Baldwin and Clark 2000),

Fig. 4.2 Product Management Map (PMM), where the Module Indication Matrix (MIM) and Module Drivers are the objects of this article.



“chunk” (Ulrich and Eppinger 2008) or “building block” (Vos 2001). Definitions for these concepts typically reference at least one of the following three key conceptual attributes,

- what the module contains; responding to a Voice of Customer perspective that the module will contain a function bearing technical solution that is identified as benefiting the customer,
- what the physical limits of the module are; representing the Voice of Engineering in its need to manufacture modules so that they properly fit together, and
- why the module exists; reflecting the Voice of Business in configuring a product variant using the module.

Modular Function Deployment however promotes a definition of a modular that reflects all three Voices by stating that a module is *a functional building block with specified interfaces, driven by company-specific reasons* (Erixon 1998).

4.2.3 Modular Function Deployment

Since 1996, Modular Management has provided the service of developing modular product architectures using a systematic method called Modular Function Deployment (MFD). At the start of every MFD project a core project team is identified. It is essential for the core team to be cross-functional, which has been clarified by (Kono and Lynn 2007) and (Wheelwright and Clark 1995). Cross-functional teams are comprised of representatives that personify their area of responsibility and experience respectively as the Voice of Customer, Voice of Engineer, and Voice of Business. Collectively these personas are referred to as “Voices of X”, or “VoX”. Cross-functional teams are flexible with a strong project focus.

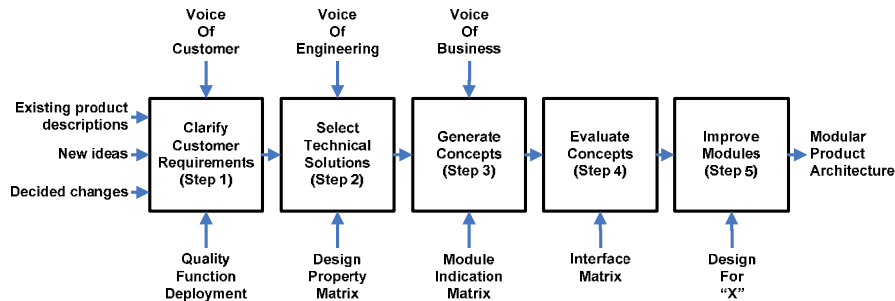


Fig. 4.3 Modular Function Deployment, adapted from (Erixon 1998).

They also bring a breadth of knowledge which can yield an integrated system solution that is not always achievable in functional or departmental teams.

These “Voices of X” are the spoken and unspoken needs, expectations, preferences, and wants of the people who constitute a given entity. Voice of Customer is a key input for product definition and the setting of a product’s value proposition. This voice is typically represented by the sales and/or marketing function. Voice of Engineering collects inputs from engineering, manufacturing, after-market, etc. for the execution of the value driven process to design an appropriate product for the customer. A company’s engineering, research and design, and manufacturing functions define this voice. Voice of Business are shareholders, corporate officers, or others involved in corporate governance who determine which value discipline is crucial to the success of not only the product but the business as a whole. Project manager, platform manager, and product managers represent the Voice of Business for a Modular Function Deployment project.

Modular Function Deployment organizes the product data, information and knowledge gathered by the core team into a collection of matrices known as the Product Management Map (PMM), shown illustrated in Fig. . Each voice is captured in a different matrix to generate the modular product architecture. Iterations are necessary at each step to manage the trade-offs between the different voices.

MFD is composed of five basic steps (Erixon 1998), illustrated in Fig. 4.. The first step is represented in the Quality Function Deployment (QFD) matrix that clarifies the customer requirements (aka customer value statements) by mapping them against the product properties. Product properties are measurable and controllable entities that allow specification of the product demanded by the customer. QFD captures the Voice of Customer and allows it to influence the design of the product at the proper level of abstraction.

The functional requirements of the product are established with the use a form of functional decomposition. Functional decomposition is then utilized to define the technical solutions. Technical solutions are the embodiment of the product properties. If necessary a Pugh process can be used to evaluate and evolve tech-

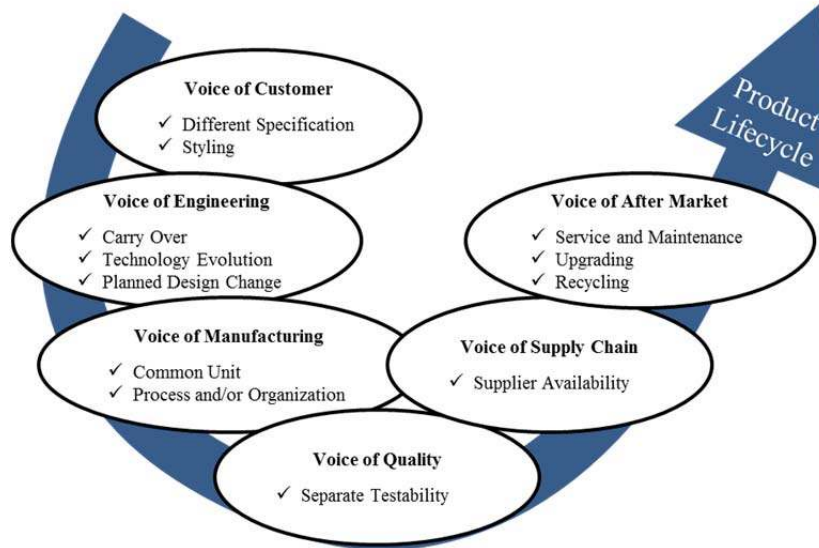


Fig. 4.2 Module drivers positioned along a product lifecycle stream.

nical solutions based on evaluation criteria (i.e. Product Properties) generated in Step 1 of Modular Function Deployment in addition to internal considerations such as part number count and production goals. The results of these decisions are modeled in a Design Property Matrix, first presented in (Nilsson 1998), which documents the relationship between product properties and technical solutions. DPM then becomes the representation of the Voice of Engineering.

Step three highlights a unique attribute of Modular Function Deployment. Unlike other architecting approaches, MFD incorporates a company's strategic intent into the product design. Module Drivers are the mechanism used to indicate the strategic reason a module should be created. There are twelve Module Drivers which cover the entire life cycle of a product. A driver is applied to a technical solution in the Module Indication Matrix (MIM) to impart the strategy the company has for a Technical Solution being the foundation of a Module. Clustering the MIM and DPM, module concepts are generated therefore capturing the Voice of Business.

The module concepts are evaluated in step four by considering how the modules will be physically joined together using standardized module interfaces. Interfaces represent an agreement or contract (Baldwin and Clark 2008) between modules in a product architecture. Evaluation of the interfaces is vital to ensure flexibility of the product assortment as well as allowing for concurrent engineering. The Modular Function Deployment process considers seven basic types of interfaces. An interface can be defined as an attachment, transfer, spatial, com-

mand and control, field, environmental and user. An interface matrix documents the interface type and facilitates the analysis of interfaces.

Finally step 5 improves on the module concept with DFX approaches, for example Design for Manufacturing and Assembly, depending on the company value-driven operating model. Module specifications are written for each module containing market requirements, technical information, and business strategy. MFD is not a replacement for component level design improvements. Detail design of the components encapsulated in a module is still required and guided by the module specifications.

4.2.4 Module Drivers

Early during the development of Modular Function Deployment, research was conducted in industry to determine the heuristics product designers applied when creating modules by contacting a number of companies who promoted their products as modular. The resultant twelve heuristics were reported by (Östgren 1994) and called “Module Drivers”. Module Drivers are found to cover the entire product lifecycle from introduction to growth, maturing, and decline. Module Drivers also cover a wide spectrum of “Voices of X” as the product moves through its lifecycle, as illustrated in Fig. 4.2. This coverage ensures that all stakeholders in the product have a voice as well as a way to document their particular strategic intent. Because Module Drivers are seen as generic heuristics, a project team may introduce new or modified heuristics which are company specific such as financial caps, geographical constraints, governmental regulations, etc.

The “Voice of Customer” reflects the need that a product platform embodies variance. Variation should be contained in as few areas of the product as possible to be managed effectively and minimize disruptions to the whole product when introducing new variants. Delaying variation adaptation as long as possible in the production chain decreases lead times, improves supply chain, and lowers overall costs. Two Module Drivers are available to describe the Voice of Customer variance in the product architecture,

- “Different Specification” is used to impart the strategic need for technical performance variance in the product platform. Language and culture demands can change the label for the concept of the Module Driver to be referred to as “Technical Specification”.
- “Styling” imparts the strategic need for brand driven appearance variance in the product platform.

Concerns with product planning and design are spoken through the “Voice of Engineering”. Engineering addresses the needs to manage modules of the architecture that will or will not change during the platform’s lifetime in addition to modules that will go through a technology shift based on changing customer demands. There are three Module Drivers to address engineering perspectives,

- “Carry Over” imparts strategies of technology re-use across generations of the product platform
- “Technical Evolution” imparts the strategic development of technology driven by external forces outside the company. Language and culture demands can also re-label the concept of this driver as “Technology Push”.
- “Planned Design Changes” imparts company internal strategies to launch new products, meet changing customer requirements, or decrease product costs. An alternative name for the driver is “Planned Development”.

The “Voice of Manufacturing” strives to maintain a consistent, effective and efficient manufacturing process. Two Module Drivers that strengthen this approach are,

- “Common Unit” imparts the strategy that a required function must have the same physical form in principally every product variant
- “Process and/or Organization” imparts the strategy that there is a suitable collection of technology driven work content for a manufacturing cell or work group to support a uniquely efficient process

“Voice of Quality” seeks to improve the manufactured quality of a product. Increasing quality decreases the loss from warranty and product liabilities by decreasing quality feedback time. To address this concern the following Module Drive is applied.

- “Separate Testability” or “Separate Testing” imparts strategies where functions can be tested independently of the product

“Voice of Supply Chain” provides manufacturing with the raw material and components it needs to build the product a customer desires. At times it will be critical for an outside vendor to provide a company with standard modules or black box modules. Black Box modules are modules in which a vendor takes total responsibility in terms of development, manufacture, and quality assurance. Typically vendors of black box modules are specialists in a given technology and a company can leverage this expertise with the use of this Module Driver;

- “Supplier Availability” imparts strategies for outsourcing “black box” technology in a module. Alternatively, this driver is re-labeled as “Strategic Supplier” or “Strategic Supplier Available”.

The addition of non-factory accessories, parts, service or upgrades refers to the “Voice of After-Market”. This stage of the lifecycle occurs once the product has been released to the marketplace. Sometimes these services are offered by the company that manufactures the product and other times these services are made possible by an unrelated entity. The following three Module Drivers support this Voice of X;

- “Service and Maintenance” imparts strategies where service on a product in the field is an important customer value. The driver is also known as Serviceability.
- “Upgrading” imparts strategies that will extend product life or improve product performance

- “Recycling” imparts strategies that enable codes regarding the disposal of hazardous as well as homogenous materials

The concept of a design strategy represented as a Module Driver for selected Product Lifecycles is not limited to just these 12 Module Drivers. Additional drivers can be added to this generic set depending on the industry and product type. An example of the addition of a Module Driver can be found for the medical industry that develops and markets test equipment that is required to certify subsystems with the Food and Drug Administration for products sold in the US market. A product architecture developed for a company in this industry may well use a “Regulations Compliant” Module Driver. A similar Module Driver is also useful in the specialty vehicle industries that develop motor vehicles for over-the-road use in Europe and North America, because road certification is different in Europe contra North America.

4.3 Approach

4.3.1 *Imparting Strategy with Module Drivers*

Module Drivers are the information objects used to bridge the business strategy with the product architecture and often several Module Drivers are applied to indicate several strategic objectives. There are combinations of Module Drivers that are compatible, which allow them to work together to enhance a module’s strategy. For example, two objectives for creating a product platform are to shorten lead times and reduce costs. The compatible pair of Common Unit and Carry Over addresses both of these goals in a single module. By carrying over the module, lead times are reduced since no time is spent on redesigning or updating the module from one product generation to the next. Common Unit modules are typically high volume modules and therefore attain a sourcing discount. Together the drivers create a coherent strategy.

A second compatible set of drivers is Service and Maintenance and Separate Testability. Service and Maintenance modules are structured in such a way when the module stops functioning it can be removed from the product in its entirety and replaced with a fully functional new module. If the module is also Separate Testability, service can be conducted on the dysfunctional module to discover if the module can be repaired. This combination improves customer satisfaction and reduces cost by preventing extended downtimes.

Separate Testability is also compatible with Supplier Availability. Since Supplier Availability modules are black box engineered by the supplier, companies can verify the quality of these modules by testing them prior to assembly. This shortens lead times and reduces costs.

There are also conflicting drivers. These are Module Driver combinations whose strategies are mutually exclusive. Both Technical Evolution and Planned Design Change state that the content of the module will change over time, where the content of Carry Over modules will not change over time. With differing perspectives on time, Technical Evolution and Planned Design Change should not be used in conjunction with Carry Over for any given module.

Styling and Different Specification are drivers which indicate high variance modules. Common Unit on the other hand is a driver for modules where there is no variance. These drivers have conflicting strategies and should not be used in combination with each other.

The last set of conflicting drivers is Technical Evolution and Process and/or Organization. Technical Evolution modules have content that is evolving due to external sources. Process and/or Organization modules reuse a specific manufacturing process. The idea of reuse and change conflict with each other and should not be combined in the same module.

To illustrate the application of Module Drivers, imagine a laptop. A laptop is a collection of modules each with its own strategy. Take the screen for example. Screens are offered in sizes ranging from 12 inches to 17 inches. Each size offers a distinguishable performance to the customer. In contrast to the laptop, an iPad[®] is currently only available in one screen size. The screen, as a module, has therefore been imparted with the Common Unit driver as a business strategy.

Another example of Different Specification is the battery. A battery offered in a laptop can be available in two different performance levels; regular life and extended/heavy duty life. Depending on a consumer's use of the laptop, say someone who travels on a plane regularly, they would buy a battery with extended life so that during a flight they can work for hours without having to recharge. On the other hand, someone who only checks e-mail and surfs the web for an hour or so at night has their needs met with a regular life battery. Therefore battery supports Different Specification to meet the needs of both customers.

Battery packs found in a typical laptop can be replaced in the event the battery will no longer hold a charge. This capability would be imparted by the Service and Maintenance driver for a business strategy. However, consider the current generation of e-readers and tablets. If the battery in these devices no longer charges, the battery in the unit cannot be replaced by the consumer. This reflects a business strategy for the product architecture that does not include Service and Maintenance on the battery.

The laptop and e-readers / tablets use their case as a style design element in the architecture. Apple[®] has trademarked the iPad[®] white case with clean simple lines. It is the look that Apple[®] has become known for. With the introduction of the iPhone, iPads now also come in black. Similarly, laptops allow a customer to purchase a case in any color of the rainbow. This choice is imparted by applying the Styling driver.

The hinge, USB, and power button are all examples of Common Unit and Carry Over. Each of these modules has a single module variant that is used across the

entire platform of laptops. Regardless if laptop has a 15" screen with regular battery life or a 17" screen with extended battery life, the hinge, USB, and power button will always be the same. While the presence of these modules is essential to the function of a laptop, none bring a tremendous amount of value to the customer. And none will be undergoing a technology shift during the lifetime of the platform. Therefore these modules also embody a Carry Over strategy.

Similar to the hinge, USB, and power button a laptops latch is also a Common Unit. It too comes in a single module variant used across all models of the product platform. Unlike the previous modules, the latch is not carried over from one product generation to the next. Instead the latch is part of the style of the laptop case. As industrial engineers update the form of the laptop the latch will change. Therefore the strategy of the latch is Common Unit and Styling.

Laptop microprocessors are a technology that laptop manufacturers typically do not design for themselves. The microprocessor is an example of black box engineering. The laptop manufacturers would be unable to produce the laptop without the microprocessor supplier. This is a strategic relationship between the companies and therefore a Supplier Availability module.

With a limited number of microprocessor manufacturers there is a significant amount of competition to produce the fastest, most reliable microprocessor. Microprocessors are rapidly changing to exceed the expectation of customers. To stay in line with the latest technology laptop companies decide if they want to enable their product architecture to handle these constant changes. If they want to offer their customers the best of what is available from the external sources, the microprocessor will also become a Technical Evolution module.

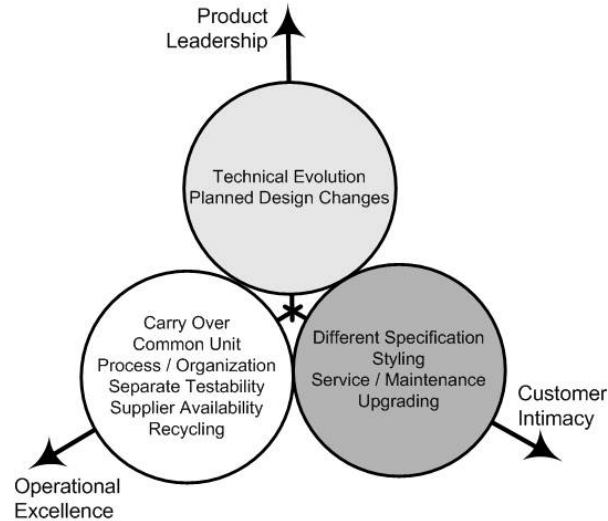
Web-cams are becoming more common in laptops and tablets. For the laptop producer, the web-cam will be a Technical Evolution module. However, within this web-cam there is a chip that is being developed to capture images in ever increasing resolutions. For the chip manufacture this technical solution will be imparted with the driver Planned Design Change.

If a laptop company designs their own hard drives, it may be advantageous for them to increase after-market sales with an Upgrading strategy. Allowing a customer to transition from a 250GB hard drive to a 500GB or even a 1TB hard drive as their storage needs change. The customer will not have to buy a new laptop to gain the extra storage and the company will still maintain the sales revenue by selling the higher capacity hard drive.

Hard drives require a clean room environment during their assembly. Any particles that are introduced may interfere and destroy the operation of the hard drive's intricate componentry. Process and/or Organization would collect the components into a module for an efficient, high quality process.

The final module is the motherboard. This module employs both Separate Testability and Recycling. Motherboards are an expensive and integral component of a laptop. Separate Testability offers quality feedback prior to the assembly of the motherboard to the case. In the event of a quality issue, the impact is contained to the motherboard only. No additional modules will need to be scrapped.

Fig. 4.3 Value disciplines shown with the aligned module drivers.



Motherboards contain materials that require special handling at the end of life of a laptop. The ability to remove the motherboard from the rest of the machine ensures that that module will be disposed of properly. This strategy is enabled by the Recycling driver.

4.3.2 *Aligning Module Drivers to Value Disciplines*

As information objects used to bridge business strategy with a product architecture, the application of Module Drivers impart business strategies that align with the Different Value Disciplines.

Product Leadership companies are creative, commercialize their products quickly, and constantly try to outdo themselves. The value proposition for a product leader is to offer their customers the best product imaginable. The module drivers that substantiate the value proposition are Technical Evolution and Planned Design Change. Product leaders are constantly reinventing themselves. They are not concerned if the changes are external or internal. They will lead the market regardless.

Customer Intimacy companies rely on building customer loyalty. These companies are not directly focused on a product that a market segment wants. Instead they are interested in the product a specific customer wants. The value proposition for Customer Intimacy is selling the best total solution from product to services. Different Specification, Styling, Service and Maintenance, and Upgrading all increase a company's ability to offer the total package to a customer. Different Specification and Styling manage the customer specified variance, where Service /

Maintenance and Upgrading manage the services provided once the customer has purchased the product. These drivers manage the total solution.

Operational Excellence companies are not service or product innovators. They do not build profound relationships with their customers. The value proposition for an operationally excellent organization is to provide their customers the best priced products with the least inconvenience. The module drivers that reinforce the proposition are Carry Over, Common Unit, Process and/or Organization, Separate Testability, Supplier Availability, and Recycling. Each of these drivers' aides a manufacturing company in focusing on streamlining processes, reducing set-up times, and strengthening the supply chain. Reducing the cost of producing a product enables an attractive price point being offered to the customer with superior customer service.

The alignment of the Module Drivers to the Value Disciplines, as discussed, is shown in Fig. 4.3 by treating each Value Discipline as an Eulerian circle. These alignments can be adjusted if the business strategy of company varies from the generic model. An example is found in the Module Driver for Recycling. One business strategy might place the Recycling driver along the Customer Intimacy to impart the idea that the module can be recycled by the end user as part of a "green" strategy. Another business strategy might place the Module Driver along the Operational Excellence to impart the idea of material purity in the module.

4.3.3 Illustrating the Module Driver Profile

During Step 3 of a Module Function Deployment program, a project team completes the Module Indication Matrix by assigning Module Drivers to the Technical Solutions selected to be included in the architecture or platform using a scale of 9, 3, or 1. A score of 9 when applying a Module Driver represents a strong strategic interest, a 3 has a medium level of interest and a 1 has little strategic interest (but there is enough to make a difference). The scoring data is recorded in a database tool called PALMA (Product Architecture Lifecycle Management).

Each application of Modular Function Deployment that results in a module system is captured in a PALMA database that allows the results of the first three steps to be presented as a set of three linked two-dimensional matrices, also called the Product Management Map, shown in Fig. . For this approach we will extract the third matrix for examination, the Module Indication Matrix that illustrates the relationships between the Modules and the Module Drivers.

After discussion with the company, the Module Drivers are sorted into a company specific Value Discipline that follows the general definitions, as illustrated in Fig. 4.3. These same alignments are performed on the Module Drivers in the Module Indication Matrix. Aligning the module drivers to the strategic axes offers a unique ability analyze the Module Driver profile for the product platform and establish the existence of alignment between the corporate strategy i.e. value disci-

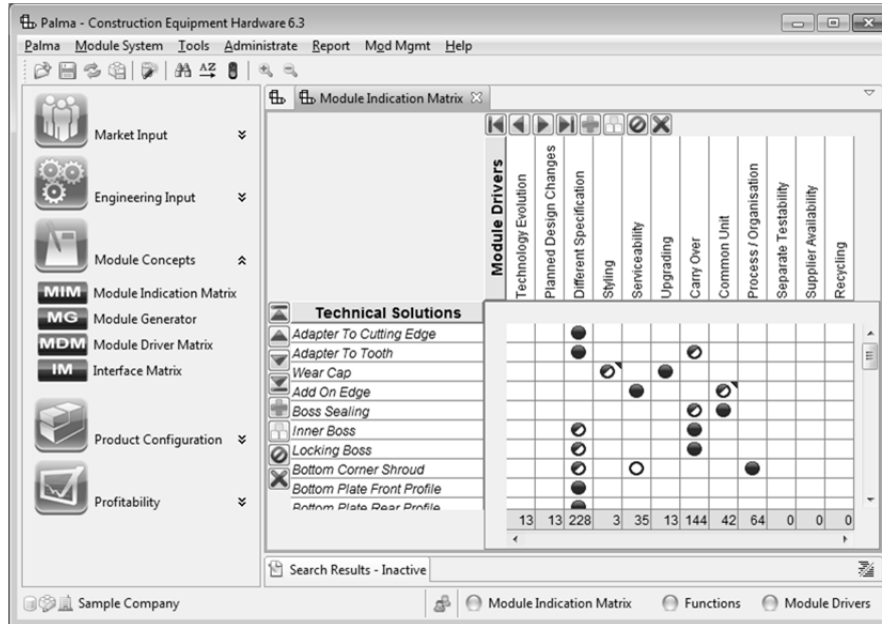


Fig. 4.4 Screenshot of the PALMA application that shows the Module Indication Matrix.

pline and the project team strategy. The Module Driver profile is the unique combination of Module Drivers and can be found on Modules as well as on a whole architecture.

In the first iteration of a Module Indication Matrix it is difficult for the project team to commit to a single driver. Typically different voices are in conflict over the strategic intent of the module. Marketing would prefer to have a module with a high number of variants that change with each product generation, but Manufacturing wants to standardize on a single solution that remains unchanged. In some cases the project team views their corporate strategy differently than upper management. Many engineering teams believe that they are product leaders when in reality the organization has a strong focus on operational excellence. Multiple iterations on the Module Indication Matrix are required to reconcile these conflicts and simplify the strategy.

Allowing only a primary and possibly a secondary strategy reduces the complexity of a module's design and simplifies the module driver profile. Think of it in terms of driving a car; would you want more than one person driving a car? A co-pilot comes in handy but add a backseat driver and the ride can become problematic. As with driving a car, multiple module drivers lead to complications in the management of the architecture. Harmonizing a module's strategy is critical to the longevity and success of the product platform. Module Drivers capture all

Fig. 4.5 Value Discipline spaces in which Module Driver profiles will appear for a module system

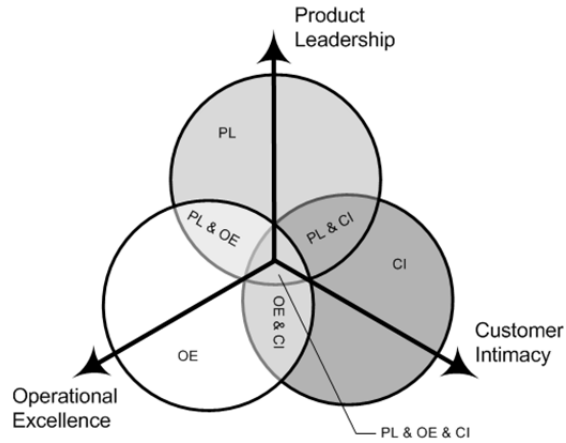
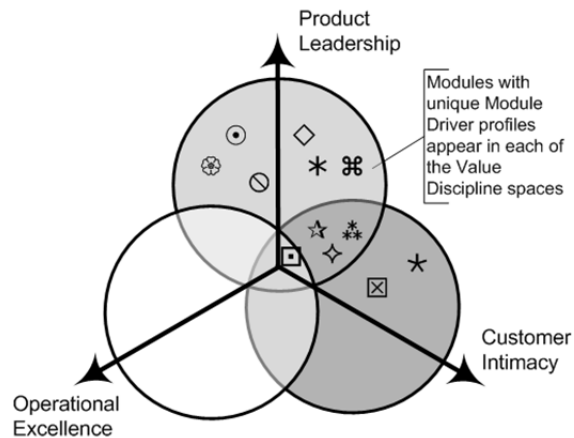


Fig. 4.6 Value Discipline spaces shown with a set of Modules arranged according to their unique Module Driver profiles.



the voices but a decision is needed to indicate which voices are most important to the company as a whole.

Based on the Module Driver profile given for each indicated Module, a count is made of the unique Module Driver profiles for each Value Discipline space and intersection. As shown in Fig. 4.5, there are only seven different spaces in which a unique Module Driver profile will appear. Depending on the application of the Module Drivers to a Module it will appear in one of the seven spaces.

To support communication with the project team, a diagram is created that illustrates where the Modules, having unique Module Driver profiles, appear in the

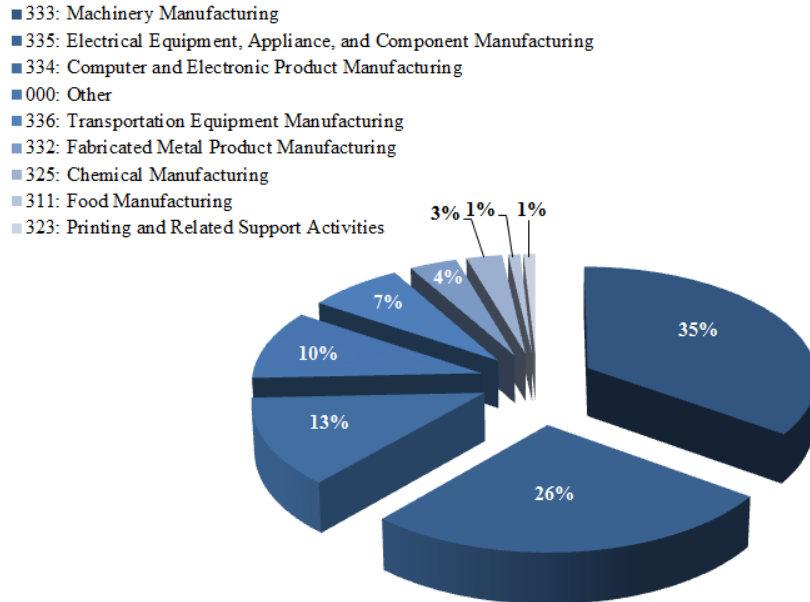


Fig. 4.7 NAICS Distribution of industries that have applied Module Function Deployment.

Value Discipline spaces and intersections. An evaluation of the number of these Modules and the scoring for the Module Driver profiles is performed to qualitatively understand if the stated business strategy is reflected from the distribution shown in the diagram.

An evaluation of the module system shown in Fig. 4.6 would indicate a business strategy strongly aligned with the Product Leadership Value Discipline with a weak alignment to the Customer Intimacy Value Discipline. This would suggest that the product platform will release a steady stream of new product variants, built on an established range of product. A product platform would have to have a very flexible and agile manufacturing process representing very little invested capital, for example a service product.

4.4 Demonstrations

Since 1996 Modular Management has been building a database that contains more than 100 modular product architectures that have applied Modular Function Deployment to develop a modular product platform. The products range from microwaves to motor vehicles.

To sort this list by product types the North American Industry Classification System (NAICS) was used. Expectation was that all Module Function Deployment projects would be for companies classified within the manufacturing sector, however, only 90% of the projects were classified as manufacturing. Looking further, the remaining 10% of companies had a main business practice which lent itself to other NAICS codes but contained a branch dedicated to manufacturing. The distribution of products is shown in Fig. 4.7.

In the following sections four demonstrations of Modular Function Deployment are taken from this database. Each case represents a unique situation that was illustrated using the unique application of Module Drivers to impart a business strategy to the product architecture.

4.4.1 Riding-Machine Platform

The company in this demonstration has for over 50 years had a major focus on the Customer Intimacy Value Discipline with a minor interest in Operational Excellence. The demonstration of Modular Function Deployment for this company represents a whole vehicle platform execution; over two hundred different Technical Solutions were addressed in the integration of 30 different product lines into a single product platform. The thirty different product lines were manufactured on no less than five different production lines in one factory and a minimum of two production lines in separate satellite factory. With the appearance of each new generation of product, a new production line was established to support that product. Furthermore, as each new generation of product was introduced, the previous generation of product was retained, including any related service and support systems. Many of the product variants were further customized after they left their respective production line.

There were two strategic objectives in applying modularity to a new product platform. The first was a technology strategy to reduce engineering effort within individual product lines by eliminating duplicate and competitive Technical Solutions that were used to fulfill the same Customer Value. The outcome expected was not just a reduction in engineering effort but also an increase in product configurability of product variants. The second was a manufacturing strategy to reduce the number of different product lines by establishing a module system that embodied more Customer Value driving variance.

Execution of Step 3 of Modular Function Deployment was performed in two iterations with the first focused on imparting the project team member's current perception of the business strategy to all the Technical Solutions considered for the product platform, the data of which is shown in Fig. 4.10 and then illustrated for evaluation in Fig. 4.8.

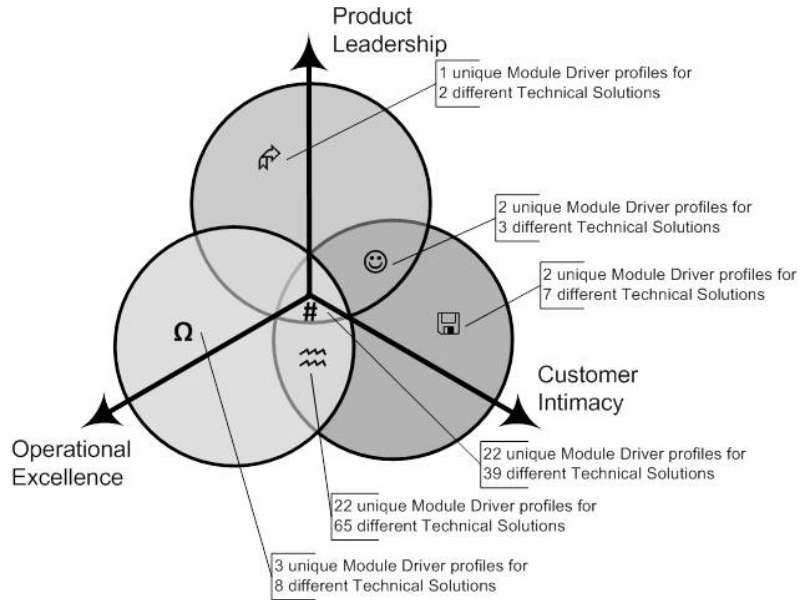


Fig. 4.8 Initial distribution of unique Module Driver profiles across the Value Disciplines for the technical solutions of a riding-machine platform.

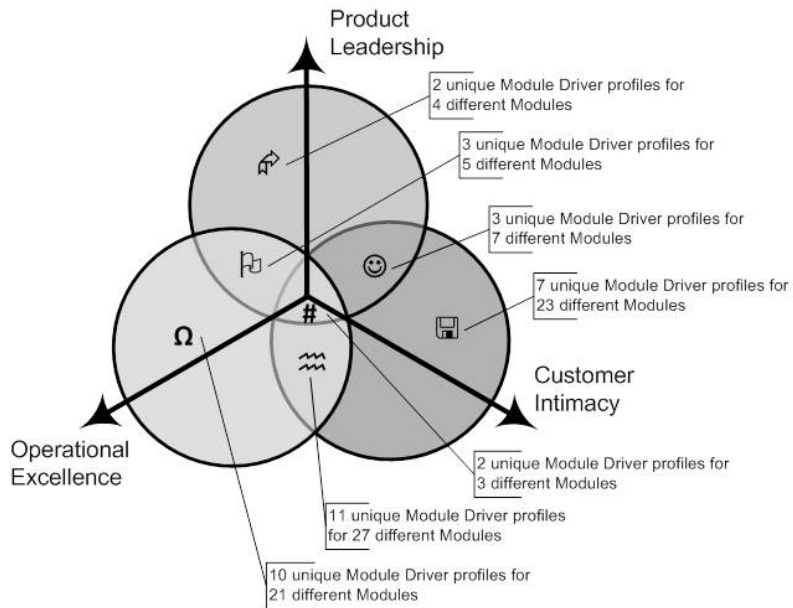


Fig. 4.9 Final distribution of unique Module Driver profiles across the Value Disciplines for the Modules of a riding-machine platform.

Module Driver Combination		Product Leadership	Customer Intimacy					Operational Excellence						
Module Symbol	Number of Modules	Technology Evolution	Planned Design Changes	Different Specification	Styling	Service / Maintenance	Upgrading	Affiliate Ready	Carry Over	Common Unit	Process / Organization	Separate Testability	Supplier Availability	Recycling
⊕	2													
▽	1													
⊠	2													
×	2													
%	1													
S	1													
P	1													
⊕	1													
D	1													
	1													
♣	2													
	10													
#	1													
⊕	2													
⊠	1													
D	6													
%	2													
✍	2													
x	1													
⊕	2													
⊠	3													
+	4													
✓	1													
D	1													
♣	2													
⊠	3													
⊠	4													
+	5													
&	1													
@	5													
?	4													
E	1													
⊕	3													
▽	3													
⊕	2													
?	2													
7	3													
⊕	1													
38	90	49	85	402	0	69	20	113	189	157	181	49	22	0

Fig. 4.11 The Module Indication Matrix showing the initial scoring of Module Drivers for the riding-machine platform Modules.

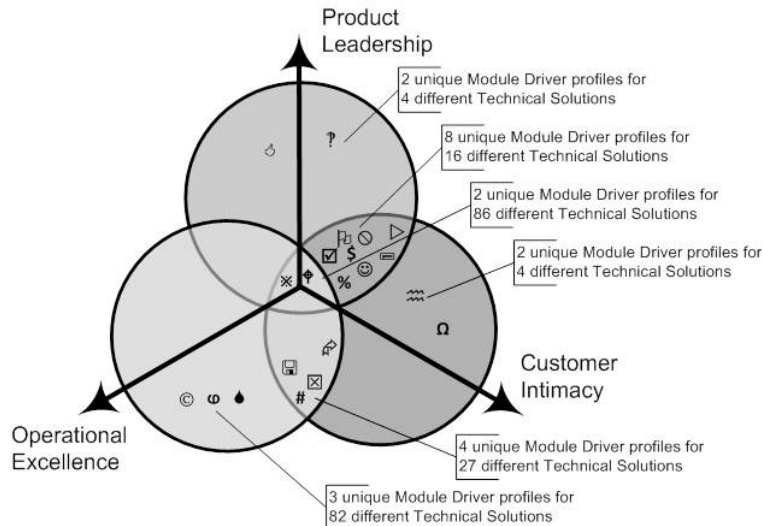


Fig. 4.12 Initial Module Driver profiles for building air conditioning system Technical Solutions.

The second iteration was a review of the results of the first phase, with the added procedural requirement of reducing the number of applied Module Drivers to a maximum of two per Technical Solution and then integrating functionally related Technical Solutions into strategic modules, the data of which is shown in Fig. 4.11 and then illustrated for evaluation in Fig. 4.9. This requirement was driven by the desired alignment of the product architecture to only two Value Disciplines; primary Customer Intimacy and secondary Operational Excellence.

From the results of the first phase, of the 125 different Technical Solutions considered for the product platform, over 100 were identified as belonging to two or more value disciplines, in particular the intersection of Customer Intimacy and Operational Excellence and secondarily with 39 of these Technical Solutions acquiring a Module Driver profile that spanned over all three value disciplines.

This effect of applying the Module Drivers is quite common and reflects the fact that the team members have not negotiated the tactical means of imparting the desired business strategy in a product platform. A resolution is reached by decomposing the Technical Solution into those parts that correspond best to a single value discipline or by aggregating the Technical Solution into a broader function to emphasize the importance of a single value discipline.

The platform resulted in 90 modules with roughly equal numbers on the OE (21), OE+CI (27) and CI (23) value disciplines, which accounts for about 80% of the module system of the product platform. This was a dramatic improvement in understanding the needs of realizing the business strategy; product variance was

Module Driver Combination		Product Leadership			Customer Intimacy			Operational Excellence					
Module Symbol	Number of Modules	Technology Evolution	Planned Design Changes	Different Specification	Styling	Service / Maintenance	Upgrading	Carry Over	Common Unit	Process / Organization	Separate Testability	Supplier Availability	Recycling
⊕	31												
●	47												
⊖	4												
+	2												
⊗	84												
⊠	9												
#	2												
⊞	5												
⊟	11												
⊠	2												
⊡	2												
⊢	1												
⊣	2												
⊤	1												
⊥	1												
⊦	1												
⊧	1												
⊨	1												
⊩	4												
⊪	5												
⊫	3												
⊬	1												
21	219	45	120	197	0	180	15	1149	621	0	0	0	0

Fig. 4.13 Initial Module Driver scoring for building air conditioning system Technical Solutions.

desired but there were still issues in the manufacturing of technology that need to be resolved to improve the performance of the product platform.

4.4.2 Building Air Conditioning System

The products in the building air conditioning system (BACS) market compose a landscape that has changed little over the last 75 years. Technology in the market has remained consistent forcing competitors to find other way to differentiate themselves from each other. As regions of the world are beginning to develop, opportunities for market growth are also developing particularly in the Middle East and Africa.

The project demonstrated here was looking to capture a part of this growing market. An additional challenge posed to the team was global regulations had led to the ban of a domestically used refrigerant. To seize the market opportunity, the BACS company needed to convert their existing product to the new refrigerant in

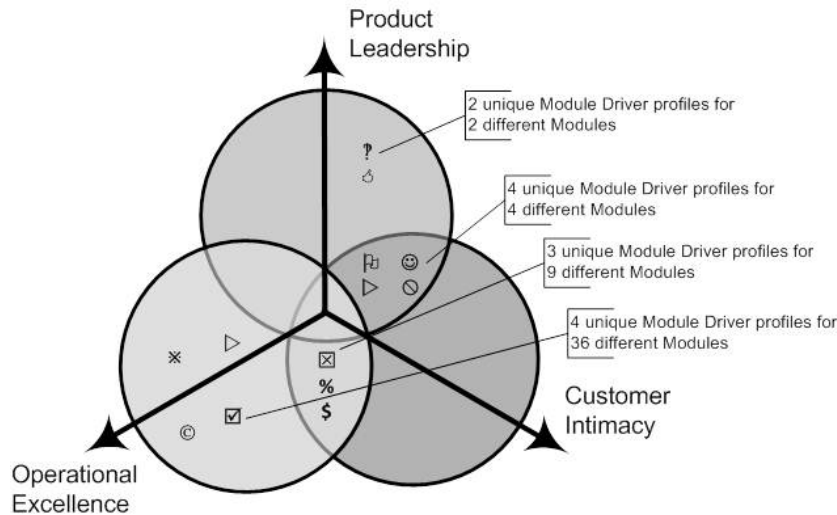


Fig. 4.14 Final distribution of unique Module Driver profiles across the Value Disciplines for the module system of the building air conditioning system.

the shortest amount of time possible. To achieve this goal the platform was going to need to be focused on the value discipline of Operational Excellence.

The first iteration of the platform identified 219 modules with 21 unique Module Driver profiles. 37% of the modules were located wholly in Operational Excellence. 12% appeared in the overlap between Customer Intimacy and Operational Excellence. 2% were entirely Customer Intimacy. 7% showed up as Product Leadership and Customer Intimacy. Another 2% was completely Product Leadership. The remaining 39% appeared at the intersection of all three value disciplines.

To enable the program objective of launching the platform in a truncated lead time, the platform requires a strategy with an emphasis on Operational Excellence. With the initial distribution, there was a large disconnect between business strategy and team strategy. The initial distribution showed 37% of the modules were exclusively Operational Excellence. This was not a high enough percentage to attain the quick product launch requested by management. Management realigned the team and gave them the goal of 80% Operational Excellence.

After the realignment of the team, a second iteration of the MIM was generated. The result was 51 modules with 13 unique profiles. The new distribution had 71% Operational Excellence, 18% Customer Intimacy and Operational Excellence, 8% Product Leadership and Customer Intimacy, and 4% Product Leadership. The updated profiles were closer to the goals outlined by management.

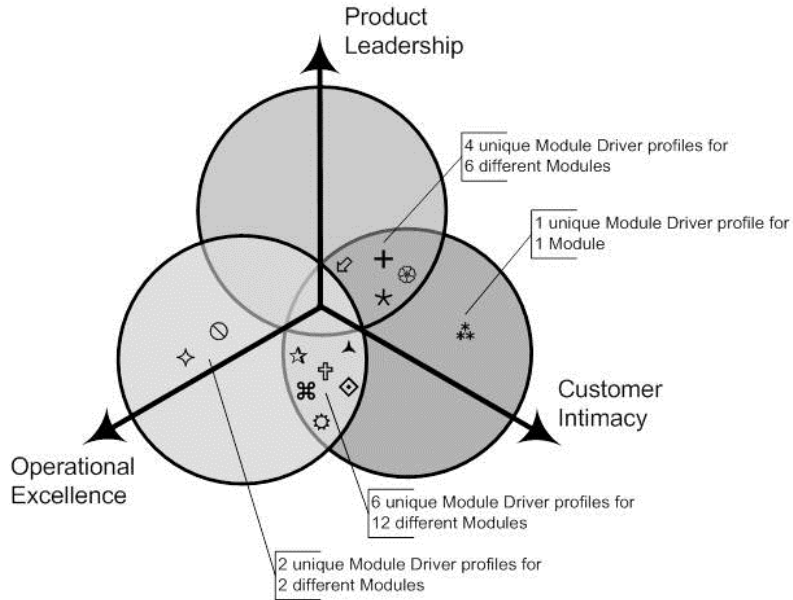


Fig. 4.17 Distribution of unique Module Driver profiles across the Value Disciplines for the module system of a construction equipment accessory.

Module Driver Combination		Product Leadership	Customer Intimacy					Operational Excellence					
Module Symbol	Number of Modules	Technology Evolution	Planned Design Changes	Different Specification	Styling	Service / Maintenance	Upgrading	Carry Over	Common Unit	Process / Organization	Separate Testability	Supplier Availability	Recycling
△	1												
□	1												
○	1												
*	1												
⊙	1												
⊕	5												
◇	1												
⊞	1												
8	12	21	18	12	9	9	12	9	75	0	12	0	21

Fig. 4.18 The Module Indication Matrix showing the scoring of Module Drivers for the Modules of the cell phone.

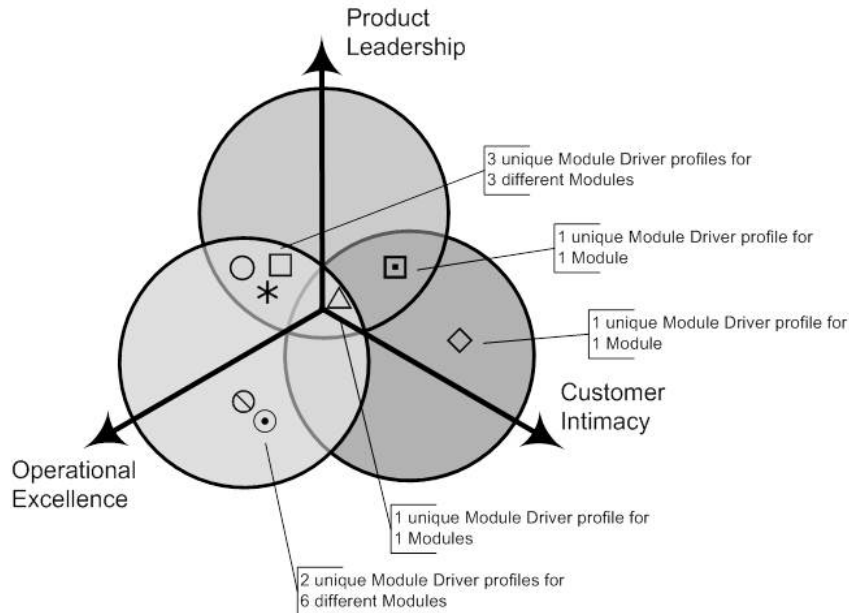


Fig. 4.19: Distribution of unique Module Driver profiles across the Value Disciplines for the module system of a cell phone.

From the distribution of the unique Module Driver profiles shown in Fig. 4.19, the product architecture clearly reflects the manufacturing strategy of the client. Of the 12 modules identified for the platform, 10 of those modules are directly aligned to the Operational Excellence Value Discipline.

All of the Module Drivers, as defined, were utilized and produced eight unique combinations for the 12 different Modules in the platform. Notice that nine of these 10 modules have acquired the Common Unit Module Driver, indicating that these Modules will be used in every product variant configured from the module system. Notice also that four of this set of 12 Operational Excellence Modules is contributing to the Product Leadership Value Discipline; Two Modules driven by Planned Design Changes and two Modules driven by Technology Evolution.

If one should emphasize the importance of responding to the strategy of providing product variance, notice that three of the 12 Modules are aligned with the Customer Intimacy Value Discipline, where only one is clearly aligned with the Module Drivers for Styling plus Upgrading. This is the Module intended to carry the greatest variance in the platform. However there is also performance variance indicated using the Different Specification Module Driver for the two remaining Modules.

4.5 Conclusions

Industrial companies are applying product architectures to realize business objectives. In this chapter the concept of a business strategy represented as a Value Discipline has been integrated with Modular Function Deployment's Module Drivers to show where in a product platform that a project team has imparted the business strategy. Using this approach during the execution of Modular Function Deployment, it has been possible for project teams to discern the strategic intent their decisions have made in selection of Modules by reviewing the distribution over the seven different Value Discipline spaces using the Module Driver profiles.

Sometimes there are often a great number of tough decisions that need to be made by project teams. Ensuring that the team remains focused on a primary and secondary Value Disciplines requires careful review of the application of Module Drivers and iterating on results in order to impart the desired business strategy. This makes the application of Modular Function Deployment a unique approach to the development of a modular product platform; it can be applied to devise module based product architecture (the tactic) and it can be applied to explain the objective of the module based architecture (the strategic).

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