

## IMPLEMENTING A SUCCESSFUL MODULAR DESIGN – PTC'S APPROACH

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### Abstract

This paper outlines PTC's experiences based on the deployment of its Modular Product Architecture Service to companies requiring a modular design process.

The specific focus of this paper is on the critical process to realize a modular design in the Product Lifecycle Management (PLM) system and an efficient implementation approach to ensure rapid adoption and learning of the required roles, responsibilities and methods by the users.

*Keywords: Product Architecture, Modularity, Modular Design, Interface Management, Adoption*

## 1. Introduction

In recent years, companies have made significant investments in optimising product development and manufacturing operating processes in pursuit of economic value. Unfortunately, many of those same companies have missed the opportunity to tune their product's architecture to align to their business objectives. In many cases, their product's architecture has inhibited their ability to execute. In fact, most companies have not made the realization that a product's architecture can determine the fundamental economics of the product as well as company results [1]

Historically, the topic of a modular product architecture has primarily been confined within the walls of engineering. As a result, the architecture of a product most likely evolves into one that best meets the product's design and performance requirements as engineering sees it but fails to meet cost and time to market expectations required by product management or marketing. Where this is most noticeable is in companies that are attempting to address product complexity through product platforms or configure-to-order products.

### 1.1. Product platforms

In an effort to control product costs, product platform initiatives have been introduced as a strategy for cross-product part and process reuse [2].

Platform initiatives however introduce a product management / engineering conflict. The engineering answer to a platform is a family of products that share the majority of their components but as a result, look similar. The product management answer to a platform is a family of products that are completely differentiated from one-another but can generate higher margins.

The struggle as a result of a platform strategy is to find a balance between cost savings, through part and process re-use, and product differentiation. The General Motors example in Figure 1 shows the results of an engineering centric, cost savings platform [3]. VW, on the right [4], has achieved both cost savings through part and process re-use as well as the differentiation between products that are required to generate higher margins. In any case, the architecture of the product must support the desired outcome.

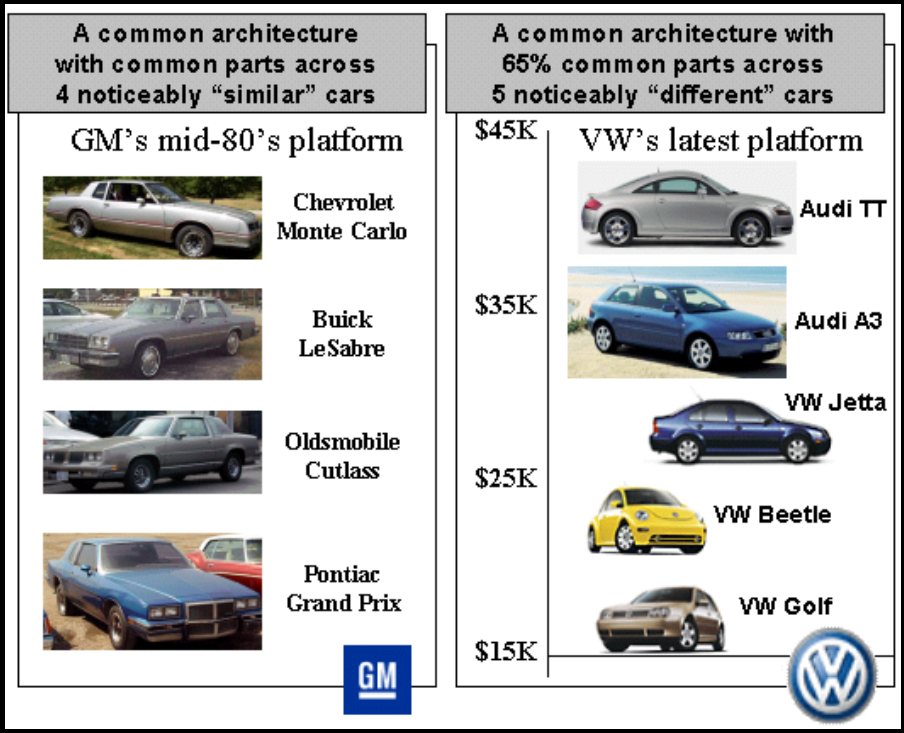


Figure 1 A comparison between GM's mid-80's car platform to VW's latest platform

### 1.2. Configure-to-Order Products

In industries where the customer is demanding options or product variants, configure-to-order products are often introduced. As the number of product variants increases, supporting a configure-to-order product line often calls for an increase in engineering capacity in order to maintain or reduce development times. As a result, these companies start looking into lower cost engineering capacity by leveraging engineering availability distributed throughout the world, both within the corporation and outsourced. This introduces an additional challenge of how to maintain product quality as more engineers become involved in the development process. As with the platform example, the architecture of the product must support demands of a configure-to-order product line.

The overall objective for most discrete manufacturing companies is to produce products that meet market expectations from a performance, price and quality standpoint while minimizing product costs, development costs, and time-to-market. As the product becomes more complex, companies default to making time, cost, and quality trade-offs. Companies with complex products that have been able to implement a modular product architecture have been the most successful in avoiding these trade-offs while maximizing economic value from their products.

### 1.3. Understanding the Impact of a Modular Product Architecture

The architecture of a product is the design or plan in which the components of the product are organized and integrated [5]. A modular product architecture is a logical product structure that defines and controls system (overall product) specifications, module specifications, and module interface specifications [6] based on business requirements (rather than limited to engineering requirements). A well-defined modular architecture considers the performance, price, quality, and quantity expectations of the product as well as the requirement to deliver the product within cost and time-to-market expectations with the expectation that multiple channels and functions may be involved.

A well-defined product architecture plan is a critical early step to both platform-based products and configure-to-order products. However, in many cases, an architectural plan is never developed; therefore the task of component organization and integration is unknowingly left to chance [1].

A massive integration effort at the end of product development resulting in missed delivery dates is a symptom of a poorly planned architecture. Other symptoms include a resistance to increase product options or variability due to cost, a focus on development costs and quality at the expense of product cost and time-to-market, and the inability to maintain product requirements through the product development process.

These symptoms often appear as the design and engineering requirements of product development start to extend from beyond a co-located department to other facilities within the corporation as well as into partner and supplier facilities.

Scania, the Swedish truck maker, has estimated that “Its modular design system was ... the main reason for the company’s profitability” [7] and that “Scania executives believe that this unique design system has enabled the company to achieve higher margins on revenue than any other truck maker in the world” [8]. In Scania’s case, a modular product architecture enabled them to achieve higher margins by focusing on design and part reuse across a platform.

### 1.4. Theoretical foundation and critical issues

The industrial focus on platform issues (as outlined above) has resulted in increased academic focus from both management [9, 10, 11] and design methodology perspectives [12]. However several outstanding issues still remain that impact the ability for companies to successfully *implement* a modular design process resulting in modular product architectures. Specifically

- The activities required to *realize* a defined module architecture by explicit module interfaces. “If the interfaces are crucial, how should then the company manage them”[13]
- The implementation activities required to quickly adopt new approaches and methods [14]

The following sections shall address these two issues as part of the Modular Product Architecture Service developed by PTC.

## 2. PTC’s Modular Product Architecture Implementation Approach

PTC has come in contact with many companies who have recognized the need for a modular product architecture but have not been successful at implementation. Many of these companies have recognized the need after having partnered with enterprise consulting firms to

help them establish corporate direction and product strategy. The need for a modular product architecture is often a recommendation from these partners when there is any hint of product complexity. Unfortunately, in most cases, how to implement a modular architecture was not included with the recommendation. Alternatively clients have half implemented a solution by focusing on the upfront definition activities without addressing the realization activities to ensure a planned modular architecture is developed and maintained. Typical issues have been an over-modularisation thus creating more interfaces than the development organization can create or (more usually) maintain during subsequent face-lift projects.

Our research on the topic of product architecture implementation best practices provided some examples of success with companies like Boeing, Airbus, and Scania, however these companies have invested decades of resources in figuring this out. Additionally, our research has uncovered some academic material that begins to propose an ideal modular product architecture development process, however little work has been done to fully document a milestone and deliverable-based approach to implementing a modular product architecture in a relatively short period of time.

The remainder of this paper describes our approach for implementing a modular product architecture that demarcates explicitly between the required *modularisation implementation process* and our three phase *program* needed to ensure a rapid adoption of the required “new” modularisation approach.

## 2.1. PTC modular product architecture process

The *PTC modular product architecture implementation process* involves three deliverable-based phases: Definition, Realization, and Deployment. Figure 2 shows how these three phases fit within a generic stage gate development process (see for example [15]). Our approach makes the following assumptions:

- Cross-functional involvement occurs throughout the three phases
- An increased upfront focus on system design activities in the product development process
- A commitment is made to assigning ownership and control at the architecture / system level

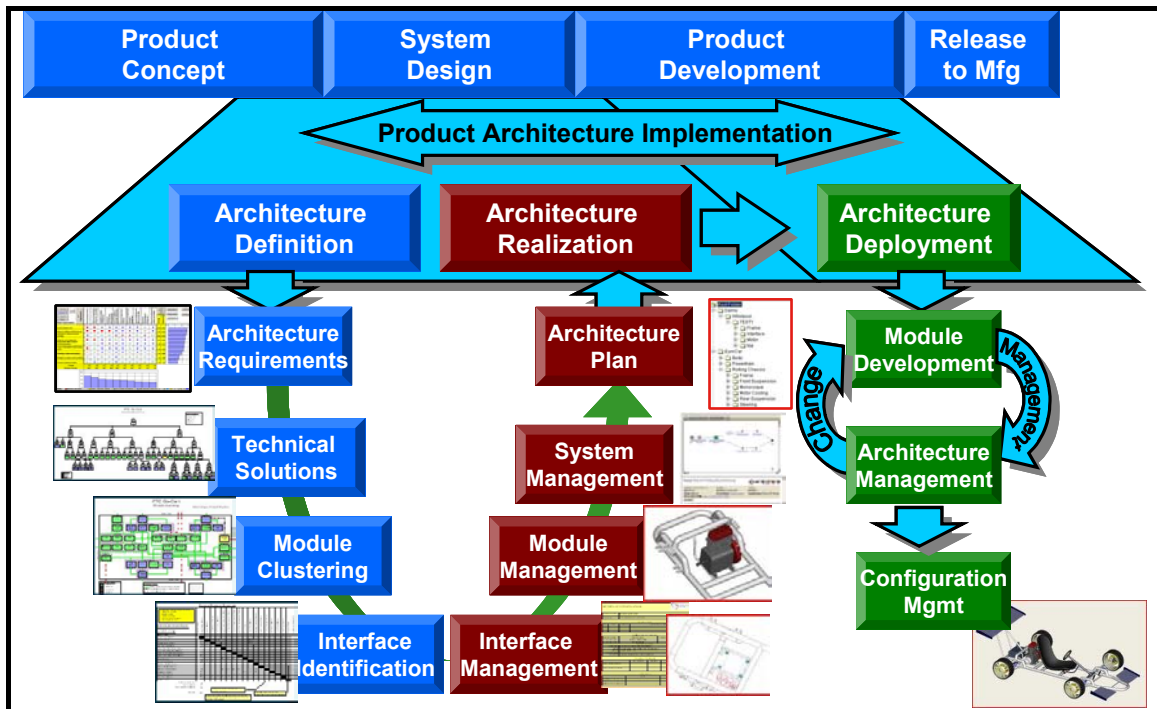


Figure 2 Three phases of a Product Architecture Implementation Process, as they fall within a stage gate product development process, and the expected outcome of each phase.

The definition of the product’s architecture is the most cross-functionally demanding stage of our implementation approach. Input from functions such as marketing, product management, manufacturing, purchasing, suppliers, engineering, finance, and quality is critical to ensuring that the architecture is defined to enable the product to contribute to corporation success. The definition steps are sequential and deliverable-based beginning with architecture requirements. The result of this phase is the explicit definition of the required product architecture (modules and interfaces), forming a new product structure.

The realization of the product architecture focuses on establishing documentation and control procedures essential for the product’s modules to be developed effectively and efficiently. The realization steps include interfacing with the systems and organizations required to support the deployment phase. New roles and responsibilities are required requiring associated processes and mentoring. These steps are not necessarily sequential however the result is an architectural plan that will be the foundation for the detail design of the product.

The deployment steps ensure that the requirements of the architecture are maintained throughout the remainder of the product development activities, primarily detail design. The primary focus is on module development and architecture management, including ownership, change management, configuration management, and control.

### 3. PTC’s Modular Product Architecture Implementation Program

Our approach to enabling clients to rapidly adopt our modular architecture implementation process on a new product includes a four-phase program. This program, outlined in Figure 3, ensures that the modularisation process is first understood, through a business assessment and a management alignment seminar. Phase 2 is a design pilot focused on adopting and adapting the process to the client’s unique product requirements. Phase 3 applies the new modular

product architecture implementation process on a new product program. Finally the value is confirmed and followed up to ensure promised value is actually realized!

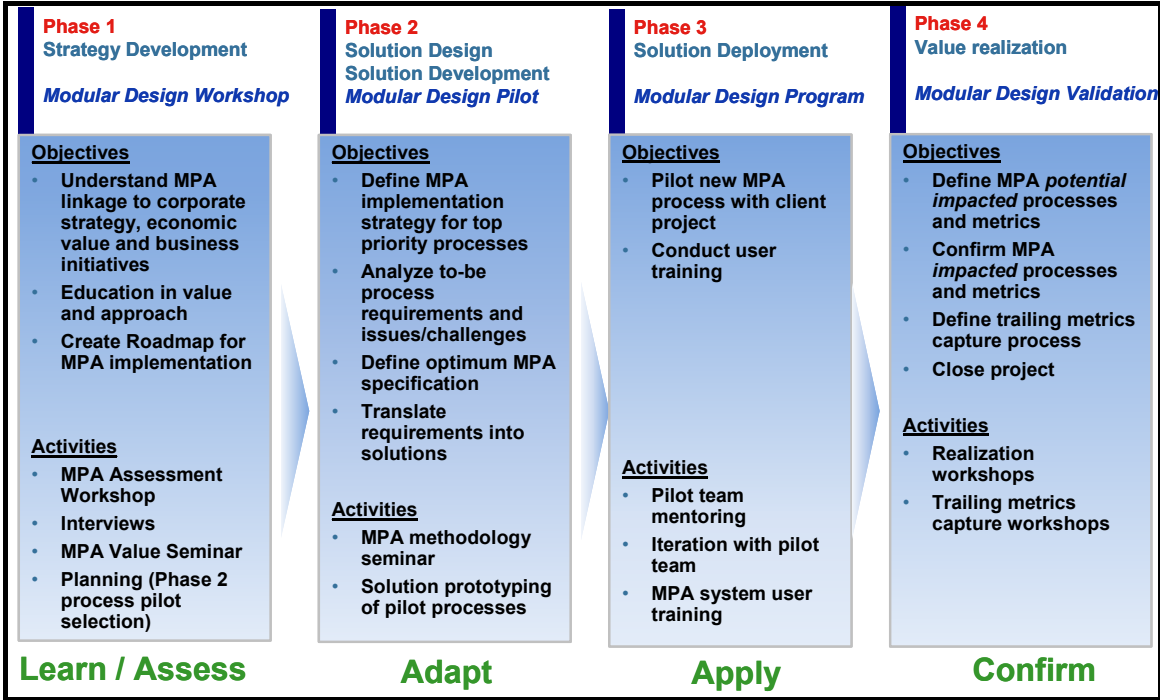


Figure 3 PTC’s four phase program which enables clients to rapidly adopt a Modular Product Architecture Process along with reducing the deployment risk.

#### 4. Critical implementation success factors

Based on past experience the following success criteria have been identified necessary for a successful modular design process implementation

- Value – The effectiveness of the implemented modular design process
- People – The impact to the organization (enterprise wide, not just engineering)
- Process – Impact and change to the existing product development process
- Technology – Requirements on the Product Development System needed to support the product development activities
- Adoption – The realization of the value in a rapid but accepted manner by the users and organization

##### 4.1. Value

The Product architecture must be aligned to and enable the corporate objectives not just engineering requirements. This requires a business strategy analysis to prioritize and clarify business and therefore product development strategies and specific modularization. The Product First Roadmap®[15] is an example of this activity. The main issue is not *if* a company should modularize but *why* a company should modularize its product lines.

## 4.2. People

The product architecture must be defined, realized and deployed by various stakeholder groups during the development process. This requires clear sponsorship to resource, especially for distributed enterprises. This also requires efficient processes due to the costly team based activities needed.

While much focus has been on frontloading the module definition activities, it is our experience that realization and deployment team resourcing is just as important.

In terms of specific roles and responsibilities the organization must demarcate module and interface ownership and a formal architecture manager must have strategic responsibility for interfaces.

## 4.3. Process

We believe that all three processes are required (definition, realization, deployment). While an isolated definition process may be successful for the initial pilot (where there is secured sponsorship and management support) the lack of a realization and deployment process will manifest in increasing downstream facelift project development costs.

## 4.4. Technology (CAD and PDM)

The technology must have the capability (and by implication the associated methods and best practices) in order to

- Create product interfaces – early and easily
- Collaborate product interfaces – within the enterprise for all stakeholders (not just engineering)
- Control product interfaces (interface parts) –must enable clear ownership of modules and interfaces

## 4.5. Adoption

Finally, the new approach must be adapted and embedded into the existing development process, given the large group of target users affected by the process change a phased implementation approach is required involving small steps and reduced risks (employing learn-adapt-apply learning loops)

## 5. Conclusion

In this paper some of the challenges companies face when implementing a platform family of products or a configure-to-order product have been addressed. PTC argues that one of the biggest, but often overlooked challenges to being successful with a platform or configure-to-order product initiative is having a well-defined modular product architecture. We recognize that many enterprise consulting firms make recommendations to their clients to implement a modular product architecture and that academic material has been written on the development process, however, we have found little work relative to a fully documented milestone and deliverable based modular product architecture implementation process which can be accomplished in a relatively short period of time.

Our Modular Product Architecture Implementation Process offers a unique, methodical, deliverable-based process for implementing a modular product architecture in the context of a

product development process. Our process begins with cross-functional input to the definition of the product architecture. Our process includes the realization of an architecture plan, and concludes with steps for deployment of the process on a new product development program. In addition, the process stresses the importance of architecture ownership as well as maintaining system level control in order to ensure that the integrity of the product is maintained during its lifecycle.

For clients that seek our help, our implementation program follows a rapid, workshop-based four-phase approach that enables the client to learn our standard process, test it out on a pilot product deploy it on a new product and validate benefits.

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### **References**

- [1] Reinertsen D.G., Managing the Design Factory. New York: The Free Press, 1997.
- [2] Robertson, D. and Ulrich K., "Planning for Product Platforms," Sloan Management Review, Summer 1998, pp.19-31.
- [3] Ganguli N, Kumaresh T.V. and Satpathy, A., "Detroit's new quality gap," The McKinsey Quarterly, No. 1, 2003.
- [4] Boston Consulting Group Analysis, [www.bcg.com](http://www.bcg.com) 2002.
- [5] Ulrich, K., "The Role of Product Architecture in the Manufacturing Firm," Research Policy, 24 1995 pp.419-440.
- [6] Sanchez, R. and Mahoney, J.T. "Modularity, Flexibility, and Knowledge Management in Product and Organisation Design," Strategic Management Journal, 17, (Winter Special Issue), 1996 pp.63-76.
- [7] Johnson, H.T. and Bröms, A. The Spirit in the Walls A pattern for high performance at Scania Target, Vol. 11, No.3 (May-June, 1995) pp.9-17.
- [8] Johnson, H.T. and Bröms, A. Profit Beyond Measure. London, Nicholas Brealey Publishing 2000 p.139.
- [9] Sundgren N. Product Platform Development – managerial issues in manufacturing firms, Doctoral thesis, Chalmers University of Technology, Göteborg, 1998.
- [10] Sanchez, R. and Mahoney, J.T. Modularity, Flexibility, and Knowledge Management in Product and Organization Design, Strategic Management Journal, Vol. 17, Winter Special Issue, 1996, p.63-76.
- [11] Baldwin, C.Y. and Clark, K.B. "Managing in an Age of Modularity," Harvard Business Review, (September-October), 1997 pp.84-93.
- [12] Blackenfeldt, M. Managing complexity by product modularisation: Balancing aspects of technology and business during the design process, Doctoral thesis, Royal Institute of Technology, Stockholm, 2001.
- [13] Stake R. On conceptual development of modular products: Development of supporting tools. Doctoral thesis, Royal Institute of Technology, Stockholm, 2000 pp.122.
- [14] Senge P. The Dance of Change The Challenges of Sustaining Momentum in Learning Organizations Doubleday New York 1999.



- [15] Ulrich, Karl T and Eppinger, Steven, Product Design and Development, Second Edition. Boston: The McGraw-Hill Companies, Inc., 2000.
- [16] [The Product First Roadmap](#) Parametric Technology Corporation (PTC), 2003.

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