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IDENTIFICATION OF PLATFORM LEVELS IN PRODUCT DEVELOPMENT

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1 Introduction

These years many companies are changing their product development from single to multi product development, meaning that not only one product is developed but product families. There are many reasons for this change, but among the most important ones are reduction of time to market, total cost reduction, ability to launch a wider product portfolio without increasing resources and reduction of complexity within the whole company.

To support the multiple product development process, platform based product development has in many companies such as Philips, VW, Ford etc. proven to be a very effective and efficient tool.

Transforming product development from single to multiple product development is a significant change in product development often involving major changes of product models, procedures and organization. In the area of product models a set of new models has to be introduced, e.g. models of the platform including interfaces are necessary. Procedures change because platform based product development requires a clear distinction between preparation (i.e. development of the platform) and development of individual products (i.e. application of the platform). The organization often has to be changed because the nature of developing platforms and applications are very different. In single product development reuse is often determined by individual designers, in multiple product development reuse is to a large degree a management issue.

It is difficult for a company to switch from single to multiple product development in one step and therefore the objective of this paper is to identify levels of platform based product development. The structure of this paper is as follows. First the applied terminology for platforms will be briefly explained and then characteristics between single and multi product development will be examined. Based on the identification of the above characteristics five platform levels are described.

The research presented in this paper is a result of MSc, Ph.D projects at the Technical University of Denmark and consultancy projects within the organisation of Institute of Product Development. Projects have mainly been carried out in Denmark, Norway, Sweden and Finland.

2 Terminology for platforms

Both in literature and academia there does not exist consensus concerning terminology within the area of platforms. This research is based on Sanchez 1999, Harlou 2005 and Andreasen & Mortensen 1996. In order to succeed with multi product development it seems that two architectures have to match, i.e. a business process architecture and product architecture. In brief, a business process architecture describes how the organisation shall handle the product architecture whereas the product architecture describes how the product assortment or product family is built up.

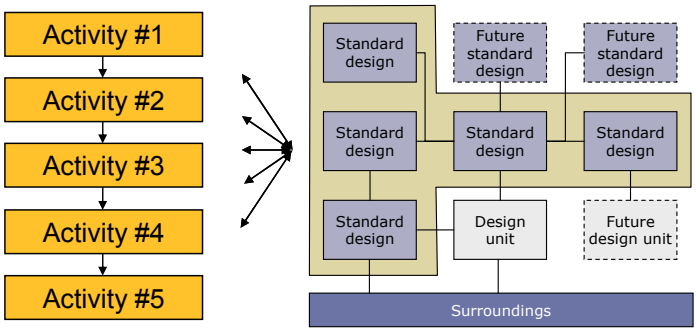


Figure 1. Business process architecture(left) and product architecture (right).

A product architecture consists of design units, standard designs and interfaces, Harlou 2005 which can be of type parts and organs according to Theory of Technical Systems Hubka 1973. The standard designs encapsulate what is reused in several product families, whereas the design units are elements which are not reused. The distinction between standard designs and design units is of importance as their nature is different. Standard designs have to be designed in such a way that they can be used in future products, whereas design units only have the scope of one product. Consequently the application aspects are different for standard designs and design units. A standard design requires a higher degree of documentation, higher degree of maintenance, appointment of responsibility than a design unit, in order to enable ruse in future products.

The term standard design is inspired by Philips Consumer Electronics term for a module that is re-used, Nieuwland 1999. A standard design is design unit, which complies with one or more product families that will be developed over time. Standard designs are about re-using over time, i.e. re-use of physical designs or design principles. A standard design is an encapsulation of software, electronics and/or mechanics to a self-contained functional unit. Examples of standard designs in the audio industry are DVD-drive, hard drive, power supply, FM-tuner, etc. However, such design units are not considered standard designs, unless they comply with the following three rules, Harlou 2005:

Decision of re-use - A design unit is not a standard design until it has been decided that it will be used in more than one product.

Documentation - A standard design has to be documented in such a way that it is possible to implement the standard design for newcomers. This implies that interfaces and design rules for implementing of the standard design have to be documented.

Responsibility - The standard design organization (i.e. standard design manager) has the ownership of the standard design. The standard design manager guides the implementation, design changes of the standard design, etc.

Example: All products in the audio industry have a power supply, but that does not make the power supply a standard design. Neither, if two products use the same power supply. The power supply has to comply with the above rules.

A platform is an instance of an architecture and is a collection of one or more standard designs which exist physically. In our research we have found it purposeful to make clear distinction between architecture and platforms. In brief the architecture describes how products or business processes are built up including the rules for designing within product projects. Architectures do not exist physically but platforms do as a set of standard designs.

Development of the business process and product architecture goes hand in hand. Example: A company has launched a product programme based on a well defined architecture with clear platform elements. This product programme shall be sold by means of a global sales organisation. It is not clear to the sales organisation which variants that are legal combinations within the assortment and how to communicate between the sales organisation and factories. Therefore a significant amount of orders consist of products which is difficult to produce. This means that this company does not achieve expected business benefits. In this case the product architectures were developed but the business process architecture was not taken care of. Later this company has consciously defined the business processes and indicates that they have spent as many resources developing the business process architectures as they did on developing the product architecture.

3 Characteristics of single and multi product development

This section will identify characteristics of single and multi product development based on platforms and architectures. In total 9 different characteristics have been identified. Each of them is shown in table 1 and will be further explained below.

Table 1. Characteristics of single and multi product development

	Single product development	**Multi product development**
Procedure:	Execution	Preparation and execution
Building principle:	Structure	Architecture
Product plan:	Single level	Multi level
Organisation:	Product projects	Architecture, standard design and product project
Business evaluation:	Variable costs/NPV	Total cost/total benefits
Reuse measurement:	None	Platform performance measurement
Building principle responsible:	Project team	Management
Business processes related to building principle:	Loosely defined	Well defined
Formalization of building principle:	Implicit defined	Explicit defined

Procedure: Transforming product development from single to multi product development normally requires, as mentioned earlier, that product development is divided into preparation and execution. In preparation the architectures/platforms are developed and in execution the individual products are developed based on architectures and platforms. This could be seen as a step towards industrialisation of product development.

An important characteristic of industrialising a process is that there exist a clear distinction between preparation and execution. One example is production where there exits clear borderlines between production preparation and production. In the production area this has lead to a quantum leap in performance. Product development is not directly comparable to production but it seems likely that it is also possible to achieve a quantum leap in product development performance by separating preparation and execution.

One of the very difficult aspects is to determine is the borderline between preparation and execution, i.e. how much in terms of architectures, standard design and platforms should be ready before starting product development of individual products. In the companies that we have worked with, the whole spectrum from almost nothing to full specification and physical existence of platforms and standard designs exists. There exist at least three types of borderlines between preparation and execution i.e. degree of readiness. In type 1 there is noting ready and architectures and platforms are developed in parallel with product projects, in type 2 there exist an architecture, but standard designs and platforms do not exist physically. In type 3 there exists specification of architectures and platforms and standard designs exist physically.

Type 1 preparation is often applied by companies that start working with platforms and architectures. If the architecture is not ready when starting product projects it seems difficult to harvest the benefits of architectures and platforms. In one of the companies where the architecture was developed in parallel with the product project, the project director stated. “It is extremely difficult to make decisions in such projects, when I have been travelling for a few days and come back, the project team has decided on new market segments and other interfaces”.

Type 2 preparation is often applied by companies with a development organisation where it is not possible from a resource point of view to make sure that platforms and standard designs exist physically. The persons responsible for the standard designs and platform will in this case participate in the projects and enable the integration of platforms and standard designs into the products.

Type 3 preparation is often applied by large companies developing products where late introduction will have dramatic impact on the business. The rules here is often that product projects are only allowed to utilise platforms and standard designs that exist physically and is full documented and tested. By doing so, the ability to launch on time and budget are increased compared to level 1 and 2.

Building principle: In the Theory of Technical Systems, Hubka 1973 there is a sharp distinction between constitutive and behavioural models. Constitutive models define the artefacts, e.g. that it consists of certain organs and parts whereas behavioural models describe what the artefact does, e.g. provide light, consume electricity.

Theory of technical systems defines structure as "the set of elements in a system and the set of relationships that connect these elements to one another". Structure therefore describes how a single product is built up. In companies structure is described in different ways by e.g. CAD systems, PDM systems, drawings etc.

In order to handle development of product families it is important to describe how a product family or assortment is built up. This phenomenon is named architecture and its elements are described in section 2. The architecture is thus explaining the building principles for a product family or product assortment. If a product has a certain complexity it seems necessary to formalize the descriptions or architectures to ensure that new product are built in accordance with the architecture. Examples shows that some companies have managed to develop a product family with a very good architecture, but because of no documentation and communication of this architecture the following product projects have decided on a new architecture. This means, that it will be very difficult to achieve significant business benefits. Companies normally have little experience with formal descriptions of architectures compared to structures.

For a product assortment to be “good” it has to show certain variety to the market and certain commonality seen from a company point of view, Andreasen et al 1995. Example: Below is shown how a concrete architecture for a washing machine and tumble dryer can be modelled.

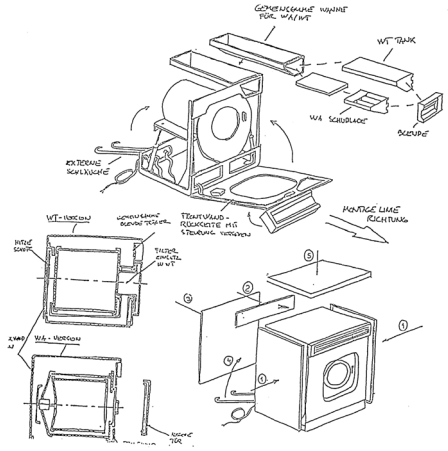


Figure 2. An example of a concrete architecture for a washing machine and tumble dryer, Fabricius 1994

The tumble dryer and the washing machine share a chassis and the drum. Depending on weather a washing machine or a tumble dryer is to be built certain standard designs are mounted on the chassis. Because the chassis, drum and other central standard designs are shared, it is possibly to mount all products on the same assembly line. Many commercial variants can be built up due to standardized interfaces between the design units. This small example shows that there is not necessary a conflict between high degree of variety and high degree of commonality, it is possible to achieve both properties.

There probably exist many types of architectures. In this research three kind of architectures have been identified. They are named core standard design, block standard design and systematic standardization architecture.

Core standard design: In this architecture type the product family is built up with one standard design that is shared in all products. An example could be a welding machine which is built up from a common power unit. This power unit is in itself is a product targeted at the low end

markets. More of these power units can then be combined and thereby large and high end welding machines can be built. Seen from a production and sourcing point of view this enables that the core standard design can be mass produced and thereby having low costs. Seen from a market point of view often the whole range from high end to low end products can be covered. The core standard design is then a product in itself which covers the low end (and often cost sensitive area) and by combining the core standard design with other standard designs, the high end (and often less cost sensitive area) products can be built.

Block standard design: This architecture type consists of "lego" building block which can be combined in many ways. Seen from a production point of view the production volumens of standard designs will be less than the core standard design in the above, but still have interesting properties such as late baptism and low inventory. Seen from a market point of view many variants can be combined. In some cases it lead to products which are not competitive in the low end market, due to high costs.

Systematic standardization: In this architecture, certain standard designs are shared systematically across product families or the assortment. Seen from a market point of view there is often less risk involved compared to the two previous architecture types. Seen from production, high volume benefits are achieved on production of the standard designs but not necessarily on product level.

Product plan: Achieving benefits with multi product development normally requires product planning on several levels. The elements within the architecture and platforms have to be consciously coordinated with product and product projects.

A central aspect of standard designs and architectures is the timing aspect. The definitions emphasize that an architecture not only include one product but a product family or even several product families. The definitions also distinguish between existing and future product, standard designs, and design units. Sony's HandyCam illustrates how elegant new variants of a product family is launched over timer, and how these new variants are build upon the same standard designs. Such a stream of new products has to be carefully planned, in order enable re-use. One way to ease "prediction" of the future is to plan by means of roadmaps. Roadmaps are widely used in the industry. The following describes the concepts of standard designs and architectures from timing point of view. Some of the central points to be able to take decisions about and therefore model are:

Aligning projects – Roadmaps applied for architectures should ensure that features, technologies, standard designs, and products are aligned. Alignment means that the right technology is integrated in a standard design at the right time to ensure that the standard design is ready at the right time for a product. Finally, the product should be launched at the right time with the right features to the market. If alignment is not right the company runs the risk of missing the market.

Opportunities vs. decisions – Experiences from the industry show that R&D organizations how great expectations to which features, technologies, standard designs, and products to launch. Often it is unclear, which of such expectations are opportunities, and which based on actual decisions.

The following presents a modelling formalism planning architectures and standard designs. The modeling formalism is based on tradition roadmaps.

Modelling alignment of features, technologies, standard designs, and products. The starting point for this type of modeling is traditional road mapping as it is known from road mapping of products and technologies. A roadmap describes the life cycle of a given object (e.g. a product). Some of the key time aspects to represent are development start, production start, market introduction, end of sales period, service period, and design updates.

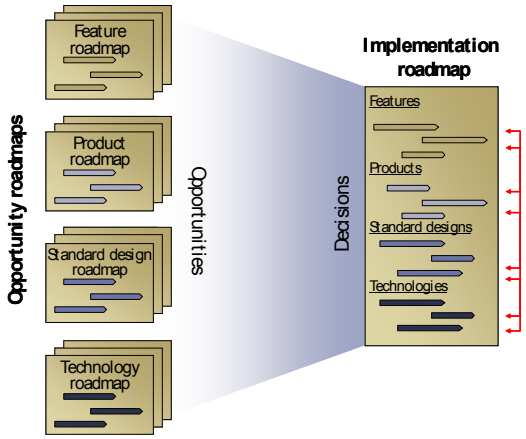


Figure 3. Explicit and aligned roadmaps are fundamental for re-use of standard designs. Such roadmaps should include features, technologies, standard designs, and products, Harlou 2005

When working with roadmaps, it is purposeful to distinguish strictly between opportunities and decisions. Opportunities reflect possible business or technology opportunities that are possible for the company. The decisions reflect which of the opportunities that a given company has decided to implement. Often companies do not distinguish strictly between opportunities and decisions, but it is crucial for a business that the right decision regarding an architecture is taken. In the following the term opportunity roadmap reflects a roadmap that describes opportunities, and the term implementation roadmap reflects a roadmap that describes which opportunities to implement. The term roadmap is used as a common term for both opportunity roadmaps and implementation roadmaps.

There seems to be at least four objects that should be captured in roadmaps: features, products, standard designs, and technologies, Figure 3. Feature roadmaps reflect the key features that should be offered to the marked. These types of roadmaps are especially important for companies that are offering variety of products, which should be able to communicate together or perform functionality jointly. A product roadmap describes the existing products, products under development, and future products. The standard design roadmap is identical to the product roadmap except it represents standard designs. The technology roadmap maps technology projects that investigate and mature technologies, which later will be implemented in products and standard designs.

The feature, product, standard design, and technology opportunity roadmaps can in principle be made independently of each other. This is illustrated with the opportunity roadmaps to the left in Figure 3. However, the implementation roadmaps for features, products, standard designs, and technologies have to be coordinated. The implementation roadmaps have to be coordinated and aligned in such a way that they support and are in agreement with each other, Figure 3. The product roadmap is linked to feature, standard design, and technology roadmaps. The feature roadmap is linked to the standard design roadmap, and the standard design roadmap is again linked to the technology roadmap.

Organization: Implementing architectures and platforms means that product development will take place on different levels. Utilizing the terminology in section 2 means that three levels can be identified. Architecture development will identify the overall way for a product family or assortment to be built up from design units and standard designs. Standard designs development will specify and develop the reusable design units including documentation. Product development will then execute development of individual products based on the architecture and standard designs.

One can argue that only in very large organization it will be possible to make clear separation between the three levels of development. In smaller organizations it is difficult to develop standard designs in such a way that they are ready for implementation. It can be handled by means of a standard design responsible that specifies standard designs and then develop them within the product projects.

Business evaluation: One of the main difficulties in making decisions on architectures and platforms is that often comparison of solutions based on variable costs will show that platform and architecture based solutions are more expensive. The reason for that, is there often will be some "over engineering" of e.g. interfaces. In the projects that have been carried out within this research, there are examples showing that utilizing architectures and platforms does not increase variable costs. The general experience is however that some kind of total costs and total benefits are necessary in order to justify utilization of platforms and architectures.

It is often relatively easy to harvest benefit in one functional area but the total optimization against all functional areas and lifecycles are very difficult. One manager stated that in his company the main effect of platforms has been to move costs from one department to another.

Reuse measurement: In some companies not only the existence architecture and platform application are handled, but also how well this reuse take place. In some companies seniour management evaluate projects against e.g. the professionalism by which design within the framework of architecture and platforms have been carried out. Like any other performance measurement systems, this seem to be away to support learning in projects.

Building principle responsible: Traditionally project teams make decisions concerning the building principle but in multi product development this will be a management decision ensuring that product projects design products within the framework of architecture and platforms.

Business processes related to building principle: Many companies seem to have severe challenges of harvesting the benefits of architectures and platforms. One of the reasons are that deciding and developing the product architecture is only half of the work necessary. Some companies point out that designing the business processes requires as much effort as designing the architectures and platforms. Agreeing on the rules for communication of the product architecture within the organisation is necessary to harvest significant benefits.

Formalization of building principle: In order to communicate the contents of architecture and platforms it seems necessary to document the contents and rules for application of architecture, platforms and standard designs within the product projects. The most common form of documentation of architectures is an architecture diagram as shown in figure 1. For

standard designs, templates describing interfaces, conditions for applications are one way of documentation.

The above characteristics are not necessary complete for describing the transition from single to multi product development, but indicate that it is a major change not only of product development but all functional areas in a company.

4 Platform levels

This section will describe 5 platform levels based on the characteristics defined in section 3. The 5 levels are named:

Level 0: Autonomous projects
Level 1: Informal architecture
Level 2: Management driven reuse of standard designs
Level 3: Explicit architectures – not reuse
Level 4: Continuous application of architecture
Level 5: Architecture based product development with a performance measurement system

Level 0: Autonomous projects: This level applies to companies which run product project almost independently and no formal decisions concerning the architecture have been made. It is largely up to the individual projects to make decisions concerning reuse of subsystems.

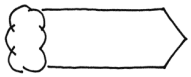
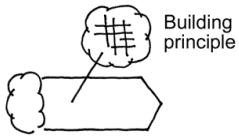
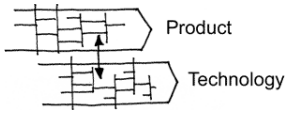
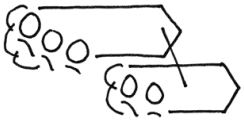
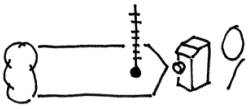
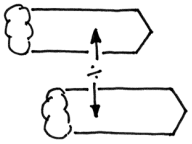
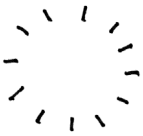
Procedure	**Building principle**	**Product plan**
 Single project approach	 Only single project related	 Maximum two levels of coordination
Organisation	**Business evaluation**	**Re-use measurement**
 Staff has focus on product project	 Focus on variable cost and NPU	 No measurement
Building principle responsible	**Business process**	**Formal. of principle and align.**
 Project related	 Loosely defined and part oriented	 None

Figure 4. Level 0: Autonomous projects

- Procedure: No procedure for development of product families exists.
- Building principle: Each project determines structure individual products within the individual projects.
- Product plan: Product plans exist mainly on product level and technology level.

- Organisation: Product development is organised mainly into product projects.
- Business evaluation: Main decisions parameters are variable costs and net present value
- Reuse measurement: No reuse management system is in place.
- Building principle responsible: The project team members decide on the building principle.
- Business processes related to building principle: No business process related to product family is in place.
- Formalization of building principle: There does not exist any formalization of the building principle.

Level 1: Informal architecture: This level corresponds to companies that have an informal architecture for the product assortment mainly carried by senior designers. In some companies this seems to work well, but as product assortment and organisation grows, it is very difficult to ensure that the assortment will expand in a planned and controlled way. If the senior designers leave the organisation, it will be difficult to maintain the good architecture.

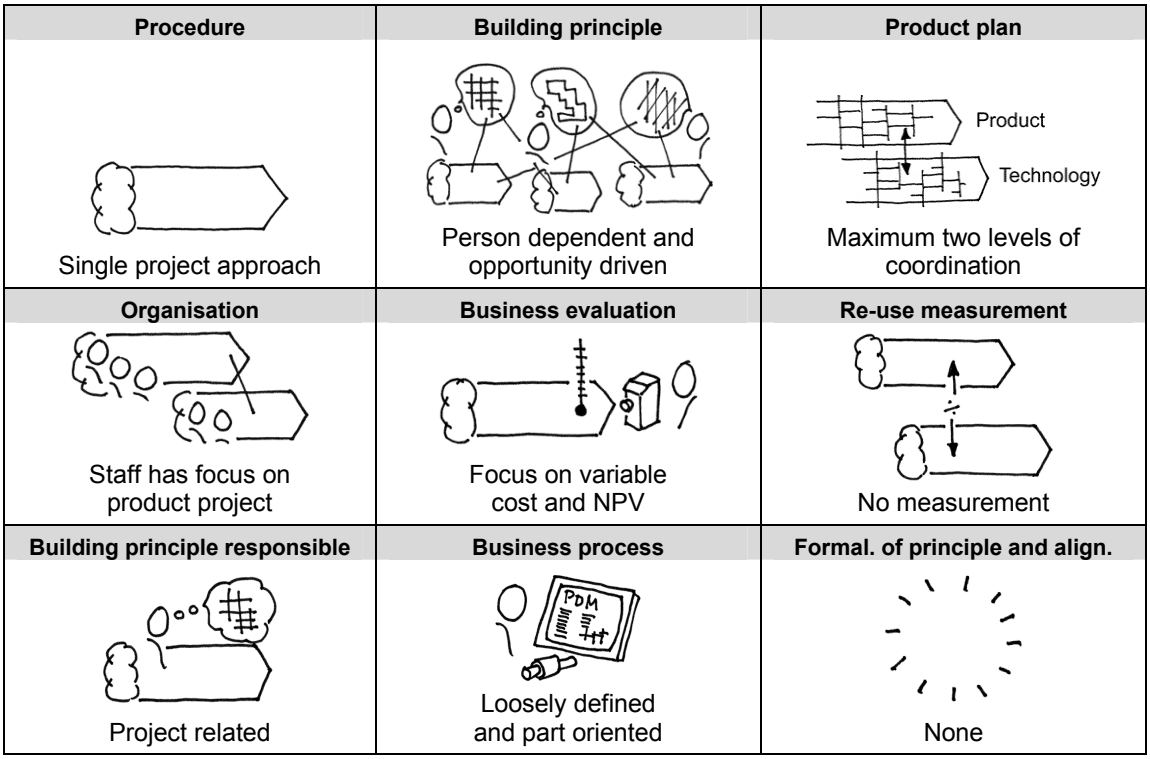


Figure 5. Level 1: Informal architecture

Level 2: Management driven reuse of standard designs: On this level there exists a decision concerning reuse of certain standard designs across product families or the product assortment often driven by management. Projects do not design within the frames of an architecture, but have to utilize available standard designs within the products. The standard designs are pragmatically defined based on what can be reused and the amount of resources that necessary for design and redesign. In some companies this is seen as a first step of proving the architecture thinking on product family or assortment level. This means proving, that the platform and architecture approach is technically feasible and leads to leverage of design resources within product projects.

- Procedure: Design is carried out on standard design and product project level.

- Building principle: Projects make decisions concerning structure of individual products.
- Product plan: Is carried out on technology and product level.
- Organisation: Product development are organised in product projects.
- Business evaluation: The main criteria are variable costs and Net Present Value.
- Reuse measurement: Does not exist.
- Building principle responsible: Individual product projects.
- Business processes related to building principle: Loosely defined.
- Formalization of building principle: Standard designs are documented.

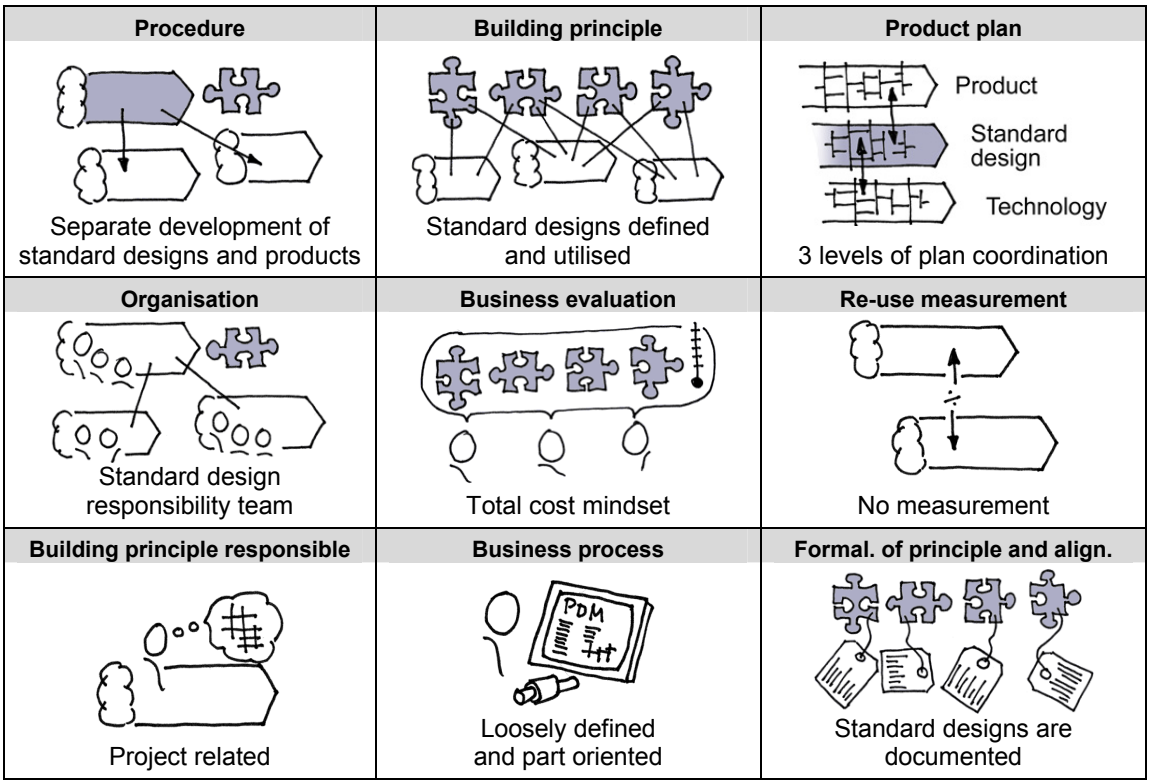


Figure 6. Level 2: Management driven reuse of standard designs

Level 3: Explicit architecture – first generation of products: On this level an architecture which describe the families or assortment and platforms with standard designs are in place, but only first generation of products have been launched. This means that the main benefits have not yet been harvested. The main benefits to be harvested will normally require several generation of products to be derived from the architecture and platforms.

- Procedure: Design is carried out on three levels: architecture, standard design and product level.
- Building principle: Architecture for product families or product assortment.
- Product plan: Carried out on four level: product, architecture, standard design and technology.
- Organisation: There exist three types of projects: product, architecture and standard design projects.
- Business evaluation: A mindset concerning total costs and total benefits exist but actual models are mainly variable costs and net present value focused.
- Reuse measurement: Does not exist.
- Building principle responsible: Management committed architecture.

- Business processes related to building principle: Loosely defined.
- Formalization of building principle: Architectures, standard designs are formally described.

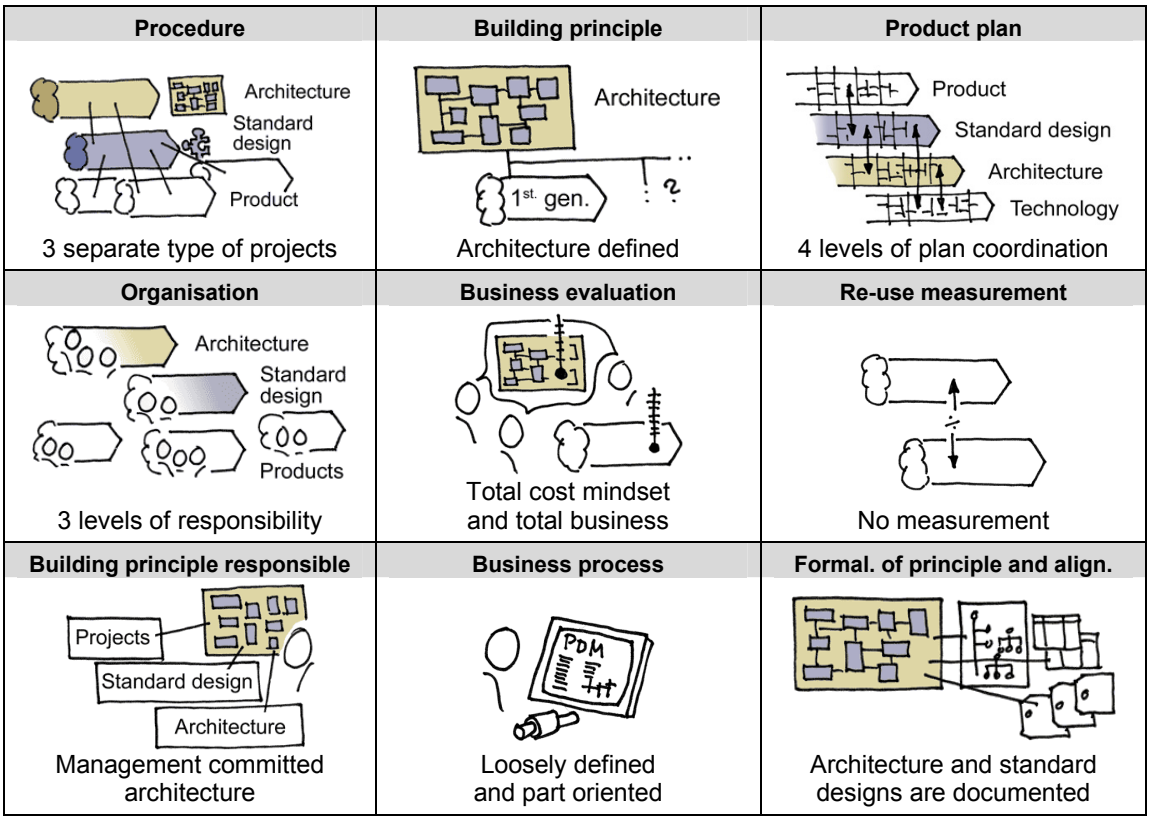


Figure 7. Level 3: Explicit architecture – first generation of products

Level 4: Continuous development based on architecture: This level requires that products are continuous launched based on architectures and platforms. It is mainly at this level that companies utilizing architectures and platforms can recognize improved bottom line effects. In order to prove business benefits total cost and total benefits models are implemented.

- Procedure: Design is carried out on product, architecture and standard design levels.
- Building principle: Architecture for product.
- Product plan: Carried out on product, architecture, standard design and technology level.
- Organisation: Three level of organisation i.e. product, architecture and standard design.
- Business evaluation: Total costs and total benefits models applied.
- Reuse measurement: Not in place.
- Building principle responsible: Management committed architecture.
- Business processes related to building principle: Well defined in such a way that benefits throughout the life cycle of the platform and architecture can be harvested.
- Formalization of building principle: Architecture, standard designs are formally described.

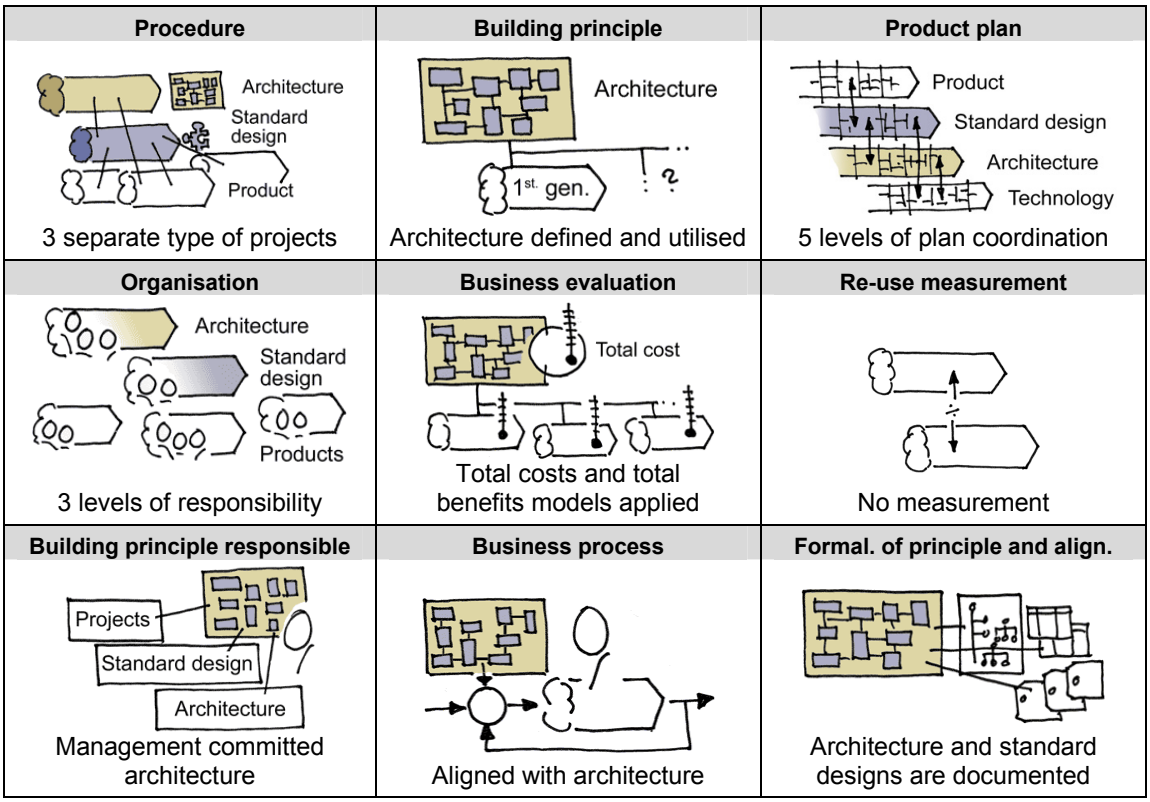


Figure 8. Level 4 Continuous development based on architecture

Level 5: Architecture based product development with a performance measurement system: This level requires an architecture with related business processes in place. In addition to level 4, a reuse measurement system is in place. This means that companies do not only measure that architecture and platforms are utilised but also how effective and efficient this application is. From a formalization point of view, the architecture is defined in IT systems, e.g. PDM and ERP and is under well defined versions and revision control processes.

- Procedure: Design is carried out on product, architecture and standard design levels.
- Building principle: Architecture for product.
- Product plan: Carried out on product, architecture, standard design and technology level.
- Organisation: Three level of organisation i.e. product, architecture and standard design.
- Business evaluation: Total costs and total benefits models applied.
- Reuse measurement: System for measuring efficiency and effectiveness of architectures and platforms in place.
- Building principle responsible: Management committed architecture.
- Business processes related to building principle: Well defined in such a way that benefits throughout the life cycle of the platform and architecture can be harvested.
- Formalization of building principle: Architecture, standard designs are formally described well defined in IT systems.

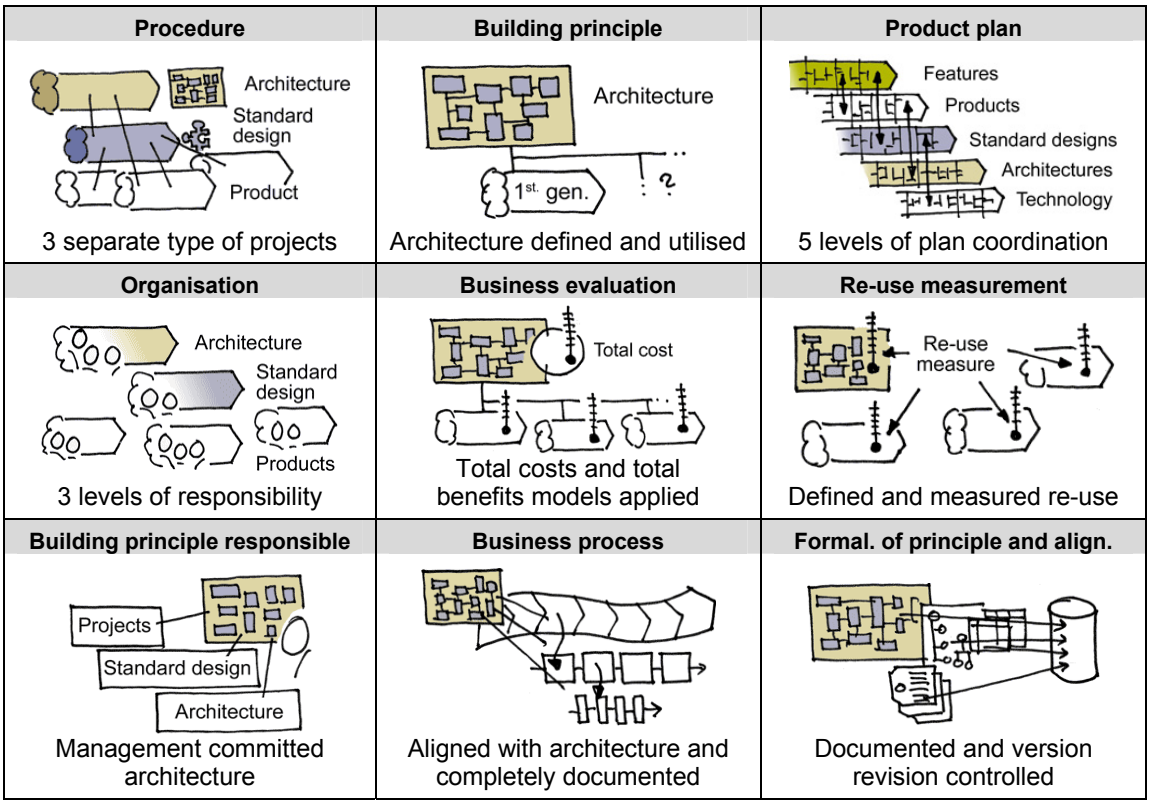


Figure 9. Level 5: Architecture based product development with a performance measurement system Conclusion

5 Conclusions

Experiences in companies have shown that the transition from single to multi product development by means of platforms and architectures is a complex process. One reason for this is that this transition requires fundamental changes of product development. This paper has identified 9 aspects which needs attention. It seems that many companies underestimate the effort to change product development. From the 9 dimensions identified, it is clear that transition from single product development to multi product development can not be taken in one step. This paper presents 5 levels in the transition, where it seems difficult to bypass one level, thus each level represents a natural maturity level.

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