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MANAGING RE-USE FOR AGILE NEW PRODUCT DEVELOPMENT

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ABSTRACT

In this paper, a framework is presented for companies to increase their ability to benefit design re-use. The framework describes enabling factors for agility in the new product development and gives answers to following questions: "What aspects need to be managed in order to benefit from re-use?" and "What are the strategic and operative management tasks needed?"

The re-use of product design and process elements is proposed to reduce work effort needed per delivery. We also state the well-managed re-use increases the adaptability of product, new product development process and order-delivery process. This statement is not generally accepted either in research or in industry.

In the previous research, various types of product and process elements were identified. The different elements require different structuring antiques and in this paper, they are superimposed on evolutionary model made by Victor & Boynton. Based on the model, the role of product and process agility is evaluated and the benefit of re-use in partly configurable and in one-of-a-kind products is articulated.

The re-use framework is defined on a detail level to describe the important management aspects. The strategic and operative tasks are then elaborated. Furthermore, this paper discusses how to design reusable elements both as part of the order-delivery process and as a separate development project. The framework leads to a synthesis in which the re-use is described in larger context as part of the strategic company landscape. As a conclusion, the paper highlights the importance of holistic strategy formation, execution and the role of operative management tasks to enable re-use and harvesting the benefits from re-use.

Keywords: Re-use management framework, strategic company landscape, product structuring, process structuring

1 INTRODUCTION

1.1 Terminology

In this paper, the **re-use** is an activity in which variety of elements are used several times. The re-use of components or modules is currently popular task in industry. The elements can be also more abstract and relate to the design and to the order-delivery process.

The word **management** consists of tasks such as identify, analyse, plan, execute and follow up. The word **agile** is in the meaning for company capability to modify its products and modes of operations; the product development process or order-delivery process.

The **new product development** concept is used for all product development activities. When some design work is done and there is some difference compared with previous products, the product is classified as a "new product". The definition covers the variety of structuring tactics currently used in industry such as platform based new product development, modular products etc.

From re-use point of view it is important to consider whether the re-usable design is done as part of the order-delivery process or as a separate development project. When the re-usable design is done as part of the order-delivery process, it is defined as **on-line development**. If the re-usable design is done in a separate project, the development tactics is defined as **off-line development**

1.2 Motivation and previous research

The competition increases globally and more and more high quality products are expected from the company R&D. The shareholders request increasingly better return on R&D investments. This is the key driver to improve the flexibility and extendibility of products and product families and the flexibility of new product development process. This paper is a synthesis of best practices used in industry to survive in the midst of fierce competition. The re-use management is highlighted as solution although in management literature, it is considered as contradiction in terms – how could it be possible to be agile with re-use.

The motivation for this study was to find ways of improving R&D efficiency in delivering complex products. The work effort needed per delivery was identified as the key driver for profitable operations and the target of reducing work effort was planned to achieve by means of design re-use.

Victor et al. [1] presents the mass customisation paradigm as solution for companies that were struggling with low profitability and efficiency. The mass customisation would enable the company to produce efficiently products meeting individual customer needs. It consists of benefit from re-use - the re-use of key parts increases the volumes and reduces the cost of key parts. See figure 1.

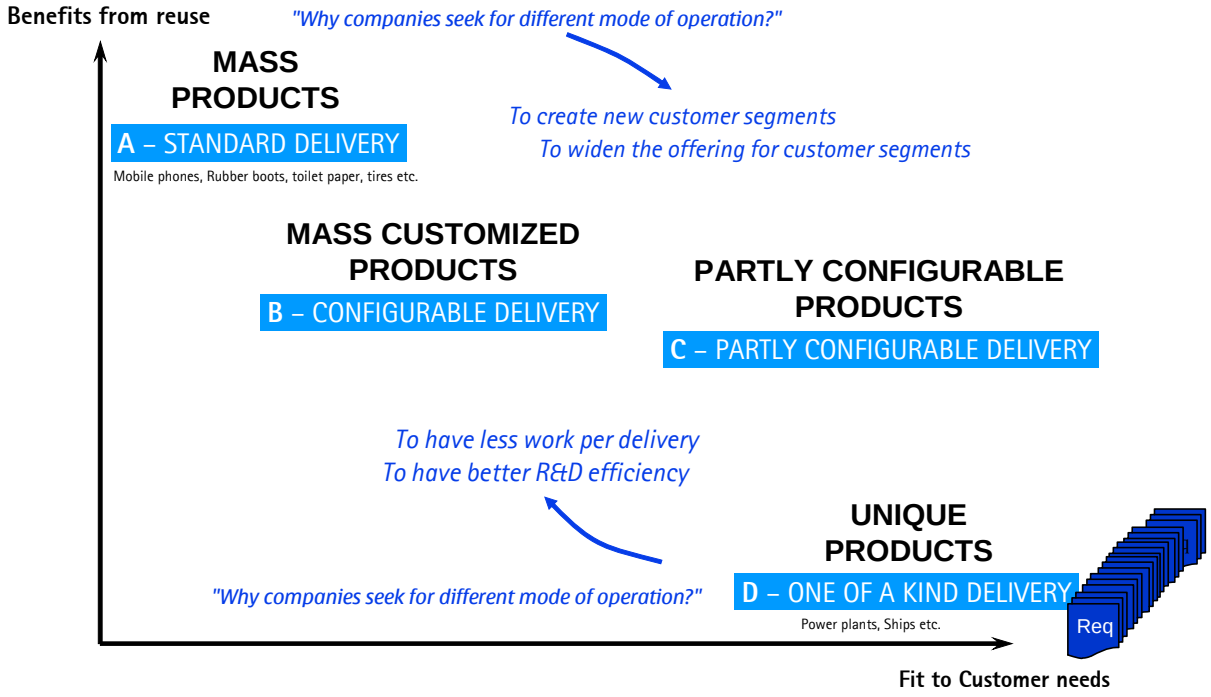

Figure 1.The positioning of mass products and one of kind products. The vertical scale is the amount of products manufactured and the horizontal scale the product capability to meet individual customer needs.

As result of our previous research, the partly configurable product is inserted into the figure. The partly configurable products are situated almost at the same position as the one-of-a-kind products as they meet the customer requirements almost as well. On the benefit dimension, partly configurable products are not as high up as the mass customised products because the unique part in the product does not allow as big benefits as mass-customised products.

This study draws on the Mass Customisation Paradigm by studying products in shipbuilding, telecommunication and heavy machinery industry where similarities were found. The products are complex, having multiple sub-systems and sub-sub-systems with high level of interdependencies. The products are developed to meet customer and internal stakeholder needs very closely.

The main research finding was the product consists of four categories of elements: First: *Standard parts* with no delivery specific design, second: Some *unique parts designed just for that particular delivery*, third: The *configurable parts*. The fourth category is combination of other categories above. The share of each category varies from product to product reflecting the amount of design needed per delivery. The classification is illustrated in figure 2 and described in detail in proceedings of NordDesign 2006 [2].

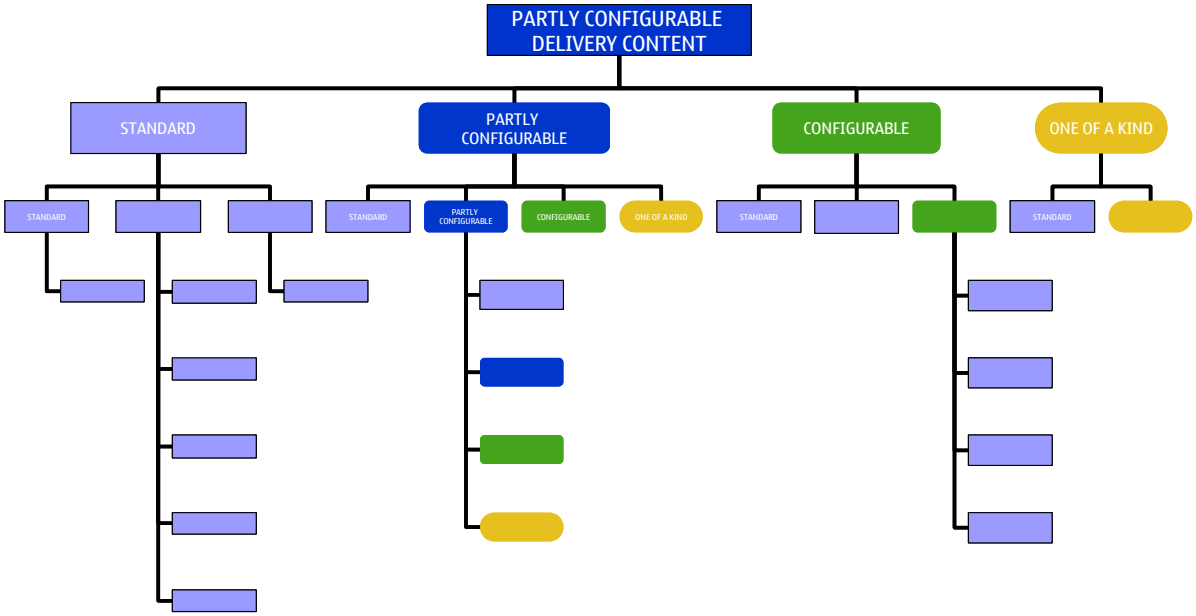

Figure 2. The classification of product internal characteristics. In this example the product type is partly configurable and consists of standard parts, partly configurable parts, configurable parts and one-of-a-kind parts.

The second finding is that the product development process and order-delivery process have different objectives and logic resulting in different types of deliveries. General steps in new product development are as follows: Specify needs - Specify architecture - Specify component - Manufacture component - Integrate components - Verify product - Validate product.

We added the step “Use” between manufacturing and integration because not all parts are created from scratch for the specific delivery as observed previously. With standard deliveries and configurable deliveries the order delivery-process begins from manufacturing or Use and ends up with validation. In the illustration below, steps are from left to right and the each row represents process modules needed for each content type. In general, the thinking is that each process module differs from other process modules because they are for different content type or process step as illustrated in figure 3.

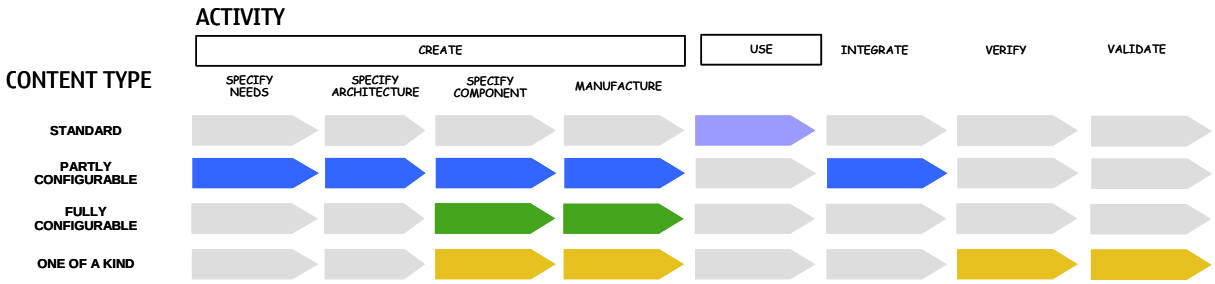

Figure 3.The process chart for different delivery types. The picture indicates process modules needed for design and delivery of partly configurable product. The colors relate to type of element in figure 2.

The product development process starts with "specify needs" work and continues on the same row to architecture specification. At this point there is enough knowledge to continue with parallel processes; component specification for partly configurable, configurable and one-of-a-kind components. The manufacturing follows the same content types and in this case only standard components are re-used – step use in the figure 3. The integration step follows the delivery type and in this case, the verification and validation is done in similar manner as one-of-a-kind product, therefore the steps are according that content type. The figure 3 shows the usage of different process modules and in figure 2 the structure and type of delivery content can be seen.

2 THEORY BASE AND RESEARCH METHODS

The starting point for the research has been the design process proposed by the German school of Design Science [3] and the Theory of technical systems [4]. The System Engineering [5] and the V-model [6] approach has had major impact during the study. The process modelling and modelling of operative mode draws on the business process re-engineering and principles of process management [7, 8]. This paper draws upon various schools of thought, from strategy schools such as positioning school and planning school [9], Systems thinking, product structuring, process management to knowledge management.

The data was gathered using multiple research methods. Ethnography was used in studying the best practices in managing re-use in some companies. The conference papers and results of interviews during 1995-2007 were also used. The practices were benchmarked against state of the art methods described in textbooks in the field of design science. Case studies were made in Finnish SME´s during 1997-1999 [10, 11], in shipbuilding industry 2004-2006, in telecommunications industry during 1999-2007 and in heavy machinery industry in Sweden on 2006.

3 STRUCTURING TACTICS AND DESIGN PARADIGMS

The main finding is that new products are not typically created from scratch. Some re-use takes often place. Another aspect for agility is the concurrent planning of product and design process. This planning enables efficient design of partly configurable products with ease. The key solution for a company is to conclude which product structuring tactics to use and to which parts of the product and the new product development process. The product structuring tactics evolve during time and standardisation, modularisation and configuration were identified as distinct tactics used. In current literature standard elements are often called as modules, platform, common or shared components. The evolution of structuring tactics is further elaborated Lehtonen et al. [12]

The structuring tactics are used in products structuring and the interesting finding was that the same tactics are used also in process structuring. This is one possible cause to the difference of R&D efficiency between different companies. In figure 4 the structuring tactics are superimposed on Design paradigm identified by Victor& al. [1]. A separation is done between product structuring and process structuring because similar structuring tactics are used but the object where to apply the tactics differ.

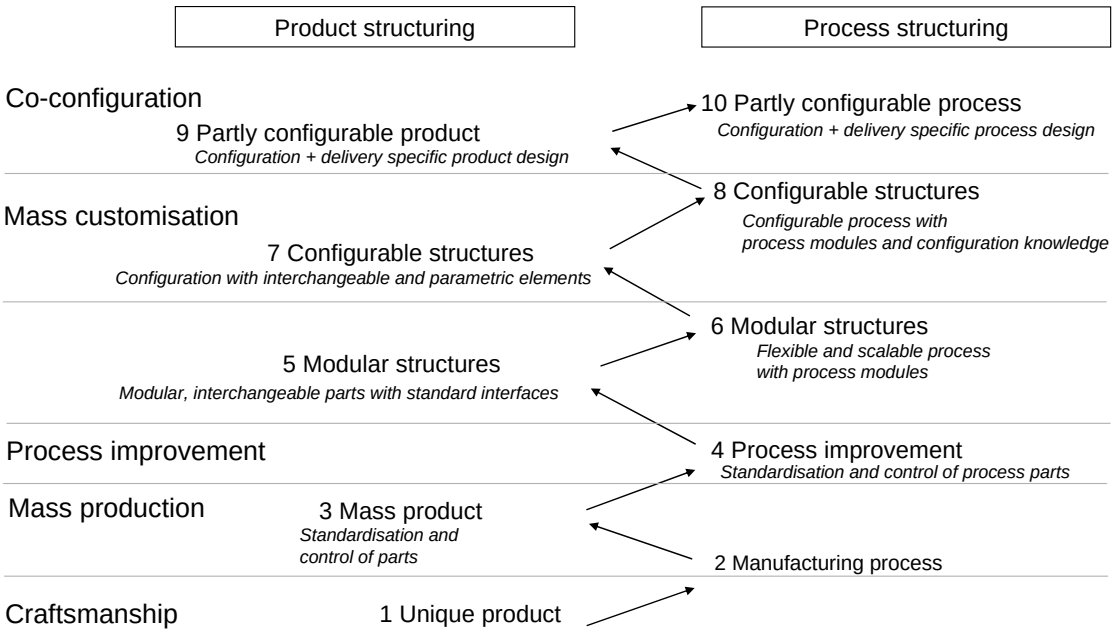

Figure 4. Structuring tactics in relation design paradigms they enable.

The evolutionary path is described starting from unique handcrafted products up to co-configuration with partly configurable products and process. Some companies are competitive by operating with the process improvement paradigm and some companies in another industry need to strive for co-configuration. The path indicates how the enabling capabilities are acquired during time. Some companies may need to start with partly configurable products but they suffer from lack of efficiency because some enabling capabilities do not exist in the company. We measure the efficiency by analyzing work effort needed per delivery. It consists of: 1. work effort used for designing, manufacturing and delivering the product and 2. work effort used for defining and agreeing design and order-delivery process. We observed the latter especially with partly configurable deliveries and one-of-a-kind deliveries and it consists of administrative tasks. The illustration of motivation and benefits of re-use is in figure 5. The streamlining of administrative tasks is not beneficial because of the amount of administrative activities is minimal in mass products and in configurable products.

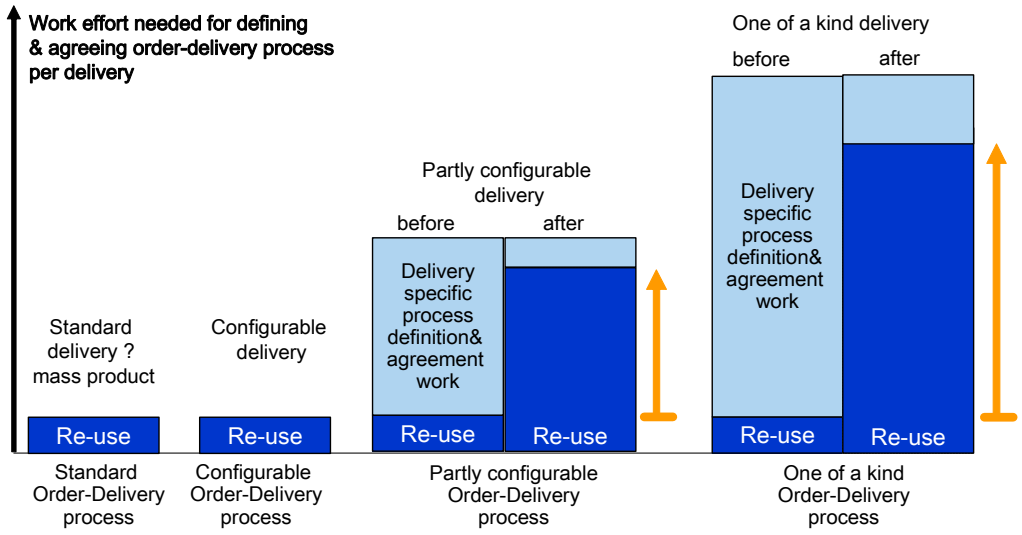

Figure 5. The work effort needed for defining and agreeing design& order-delivery process with partly configurable and one-of-a-kind products. The orange part indicates savings in work efforts situation after managed re-use. The managed re-use also increases agility to adapt products and development process

4 THE FRAMEWORK FOR MANAGING RE-USE

The framework is a synthesis of best practices found in industry, some of the elements are found by avoiding most common pitfalls when doing re-use. It focuses on following questions:

- What aspects need to be managed in order to benefit from re-use?
- What are the strategic and operative management tasks needed?

For the sake of clarity, the framework is divided on: 1. what is managed and 2. how it is managed. The first aims to give answers to the first research question, the latter highlights management tasks addressing the second research question.

4.1 What needs to be managed – the managing of what

The "what" section in the framework contains company-wide scope setting, the objectives for re-use and the management of operative efficiency. The underlying key principle is to make sure the objective and target setting takes place in all levels needed and objectives are set for the key elements enabling efficiency and agility for re-use. The targets need to be set for single development projects to ensure the desired outcome is e.g. standard element or configurable element. The target setting needs to be communicated to individual designers, too. One pitfall is that the designer is not aware of the desired technical element type – should it be configurable or unique?

The company wide scope is discussed by Mayer & Lehnerd [13] where "Power Tower - approach" is presented. In the scoping there is need to consider the maturity of the markets, using the S-curve [14], for example. The maturity dictates mainly what scope for re-use is feasible for the company. The company's strategic intent in the form of desired value chains needs to be taken into account, too. From the value chains, it is possible to derive the scope and nature for reusable elements.

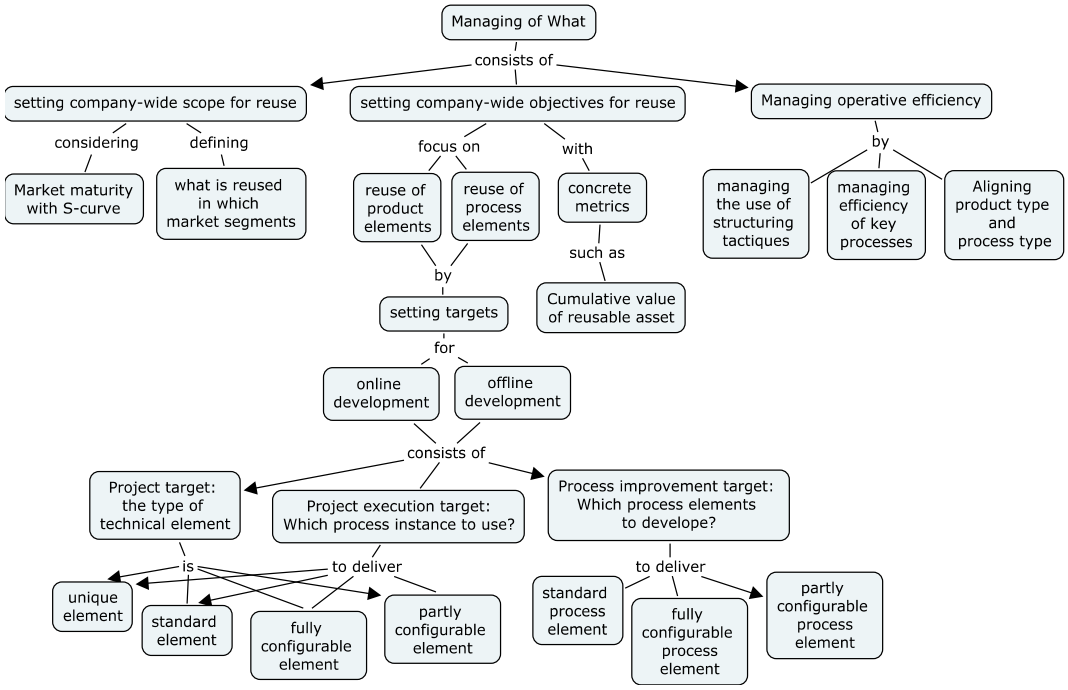

Figure 6. The key areas for managing of "what". The scoping needs to be done carefully and the objective setting needs to be implemented up to designer level. To manage operative efficiency one needs to follow up the use of structuring tactics and actively align the product type and development process type for each project and delivery.

The management of operative efficiency requires the attention of which structuring tactics are used in which elements and what kind of combinations are been proposed. The key processes for delivering products with re-use are [15]: Marketing, Road mapping, Requirement Engineering, Systems Structuring/Architecting, Planning/Re planning, Manufacturing/Design for re-use, Supply /Design by re-use, Integration, Verification, Validation, Delivery, After sales and Administration process.

One best practice with configurable products is the alignment of product type and order-delivery process. The customer was made to choose between alternative options rather than setting requirements for the product. This approach guided towards using existing solutions and did not call any engineering work during the order-delivery process. This is one example how the alignment enabled re-use. If the company would use process adapted for one-of-a-kind products the sales person would end up with detailed requirement specification rather than bill of materials ready to be sent to the production.

4.2 How the management is done – the managing of how

In the framework the "managing of how" is divided into strategic issues and operative issues. This is done to highlight the impact of everyday operative decisions to the strategic objectives of the company. For example, the structuring of product architecture takes place in operative environment as part of the offline or online development. When the design decisions are done on operative level with narrow focus/industry landscape, the product architecture begins to deteriorate losing it's capability to enable company strategic intent in terms of product strategy.

Under the strategic issues, there are Concurrent road mapping, structuring of variety of architectures, organising, financing and collaboration. The concurrent road mapping enables the strategy implementation to foresee the changes needed in projects, technologies, architectures, reusable asset, processes, competences, information systems and legal agreements with key collaborators. The concurrency is vital element because the different roadmaps have many interdependencies. The change in product architecture with new technology has impact on the asset roadmap as well as on the process and competence roadmap.

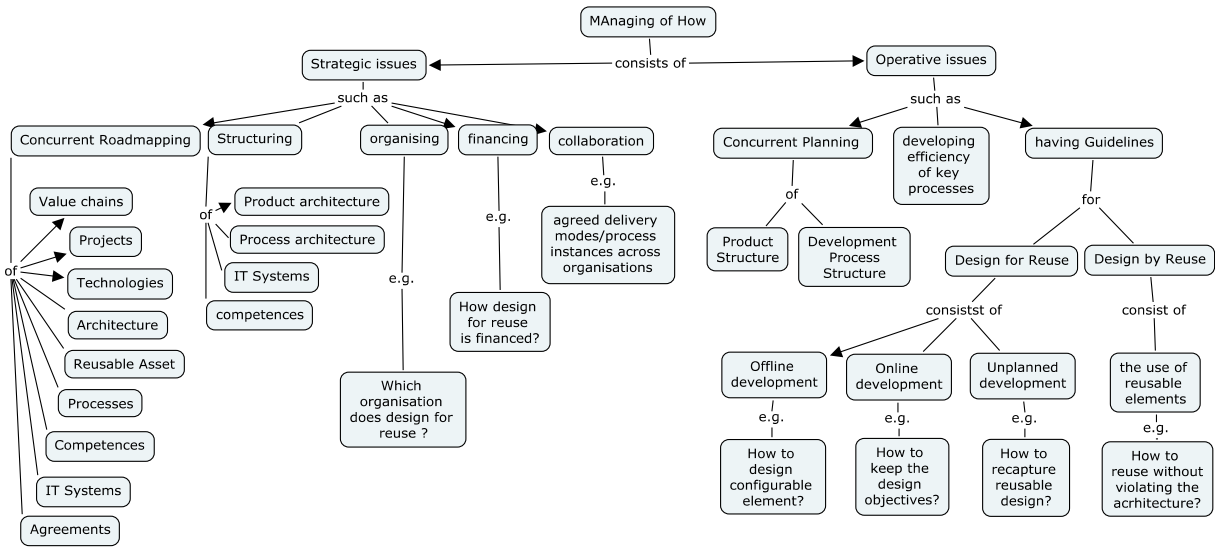

Figure 7. Managing the How issues. Strategic and operative management tasks need to be aligned continuously ensuring strategy implementation.

The operative issues consist of concurrent planning, developing the key processes and having guidelines. The concurrent planning of product structure and development process structure is one of the best practises in industry. It means in practise that when the product is modified in the order-delivery process the development of new product elements is managed by modifying the online development process accordingly. This capability gives agility and efficiency when delivering partly configurable and one-of-a-kind products.

The offline development stands for design for re-use that is done in separate project, not as part of the order-delivery process. The pitfall in industry is the capability of designing configurable elements,

partly due to the lack of suitable development process and explicit management of design activities for desired outcome. Similar pitfall is the mindset that when having enough components or modules you have a module-system or product family. The starting point is to have standardised elements and to have module-system you need to capture and utilise the configuration knowledge ensuring only valid combinations of reusable elements. When this knowledge is not available, the uncontrolled re-use of elements will violate the product architecture having impact on work effort needed per delivery and facilitating the decay of product and asset structures.

One operative challenge is to manage conflicting priorities and interests in the development as part of the order-delivery process. The pitfall is to start the project with intent to deliver reusable elements and then due to the schedule pressure to shift the objective to one-of-a-kind elements. This is according to the schedule-driven order-delivery project but fails to deliver reusable elements.
If the company has metrics for asset development, these pitfalls can be seen on those metrics. The cumulative value of reusable asset can be important and when the project does not deliver reusable elements the projects with design by re-use with those particular elements need to re plan and reschedule having impact on R&D efficiency and company profits. Only the most advanced companies are able to measure the value of reusable asset.

5. SYNTHESIS

The best practices in observed industry use different **structuring tactics** as enabler for agility in modifying their products and development process as part of order-delivery process. The delicate use of different tactics enables efficient re-use. The issue is how the designing for re-use is done and what kind of combination of structuring tactics is used. The most advanced companies define the element type and then use corresponding development process. The actual development process is not run as waterfall model as visualised in figure 3. but more in an iterative manner, considering at the same time the product architecture and the nature of product elements, both existing ones and developed ones.

The pitfall of online development of reusable elements is solved by doing the design for re-use as **offline development** activity. This enables clear target setting and reduced interplay of competing priorities in development. When the capabilities are improved, the companies use online development but with caution because of the challenges describe earlier. One benefit is that the likelihood of the reusable element to cause problems is lower because the development is done as part of the whole, not as a separate project.

Some companies had very practical solution for **concurrent planning of product & order-delivery process**. They selected appropriate process for optimal combinations to adapt for online-offline activities from predetermined process options. The order was classified A-B-C depending work effort needed for modification. The A-type does not require any design activities, the B-type requires configuration task but no design activities and the C-type requires order-specific design.

The benefits of re-use are based heavily on using the existing structures and elements without violating the product architecture. This calls extra focus on **strategic architecting**. With strategic architecting, we want to emphasise the observed need for structuring of architecture with strategic focus in operative execution. The dominance of narrowed down focus and schedule pressure result in decay in product architecture and reduced cumulative value of reusable asset. This is again symptom of mismatch of objectives on different levels.

The root cause is in the manner how objective setting is done and how systematically **objectives are aligned from top-down**, to individual designer and explicit design task for e.g. fully configurable element. In some companies, the re-use and “platforms” were considered self-evident and value adding as such. Although the importance of re-use was understood, there was ambiguity of the scope for re-use. The question stated to the researchers was “Where and how to derive the scope and objectives for re-use?”

Our conclusion is the above-mentioned issues need to be covered in company-wide **Re-use Strategy** that consists of the elements described in the framework and a transition plan describing how the

strategy is to be implemented. The cultural and people related challenges of a transition project is further elaborated in [16]

The question of re-use scope and objectives are very important and the first attempt reasoning where to invest when using platforms was described in reference [17]. The reasoning was derived from the value chains the company wants to make profit. It is possible to analyse from the value chains which part of chain is value adding and according company strategy and what kind of products and services is profitable to offer. Our research concludes with strategic company landscape as **context for re-use and agility** with identified structuring domains. The reusable asset is placed into company-wide context in figure 8. The optimal solution for the company is a balance with all structuring domains and the optimisation task should be done in concurrent manner. This is to say that there is no one places where to start the optimisation. The starting point can be chosen depending on company specific issues.

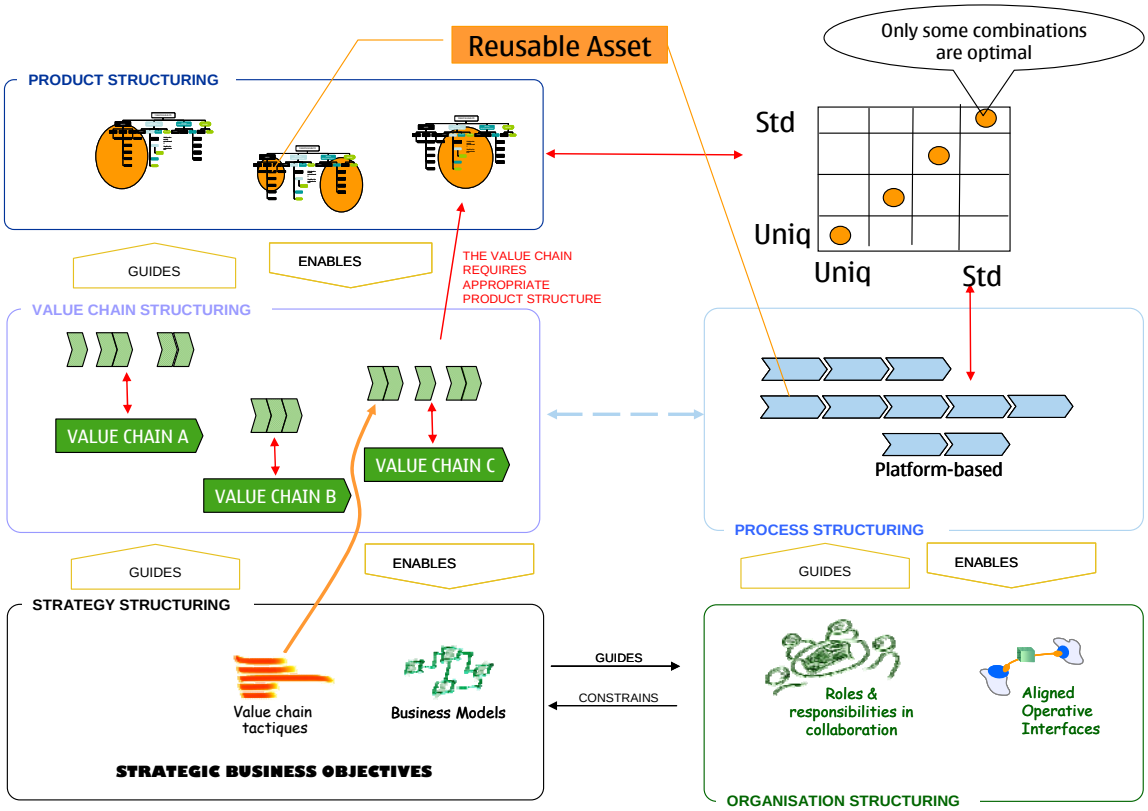

Figure 8. The strategic company landscape as context for re-use and agility. The landscape comprises five different structuring domains and their interactions. This paper focuses on domains of product structuring, process structuring and the dependencies in-between these two domains.

The context figure is synthesis of best practices in industry. The reusable asset is indicated with orange colour. In this example, one company has defined strategic business objectives stating clearly the value chains it will base the future business models. The value chains are selected and company specific contribution is elaborated further in the product structuring and process structuring domain. After careful analysis the company has found out that, it is beneficial to re-use some product elements and some process elements. This thinking pattern with measurable objectives is documented in re-use strategy that serves as a communication tool throughout the company and gives the reasoning for company-wide transition plan.

The re-use management enables R&D operational excellence and flexibility as the standard elements, configurable elements and unique elements are systematically created, used and maintained. The creation requires highly sophisticated process configurations and skilful product structuring capabilities. The main challenge is for the R&D management to be able to manage multiple operational modes for different order-delivery processes simultaneously – as the development of mass product calls for different focus when comparing with configurable or one-of-a-kind projects. The agility in product and process structuring is needed to enable competitiveness and efficiency in co-configuration –paradigm. The structuring tactic matching this paradigm is called Dynamic Modularisation [18]. When the company has the capability and agility it can survive in competition with well-managed re-use that increases the adaptability of product, new product development process and order-delivery process.

One important issue is how to structure products and processes so that they enable company strategy implementation. The re-use needs to be considered against different value chains giving advantage to the particular areas in the value chain.

6. DISCUSSION

The agility is achieved by systematic management of the combinations of products and development processes. The partly configurable products and partly configurable processes are superb tools when key drivers are R&D efficiency and competitive products on the market on time. The benefits are available mainly for companies that deliver partly configurable products and one-of-a-kind products.

There are several attempts in research community to define generic meaning for the term “platform”. Based on our research the research community can add value by describing further how the company can find out the “platform” for them rather than creating generic definition that has room for interpretation. The interpretation creates lot of misunderstanding in company operative work thus causing harm and confusion rather than competitive advantage.

Currently the engineering design and other design schools are emphasising the role of requirements management. At its best, the requirement management can be effective tool but it can guide the development to focus on very tiny issues in new product development. The challenge for the engineering design research community is to visualise the whole company landscape and the role of holistic approach in designing products and facilitating development processes. The context for re-use can be used as a tool highlighting the very crucial role of R&D in company strategy planning and implementation. The question from mindful and alert company management in the future should be “Does our product architecture and operational modes enable our strategic business objectives?”

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