
Product Portfolio Management Process over Horizontal and Vertical Portfolios

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Abstract: This study aims to extend the product portfolio management (PPM) practices to cover all lifecycle phases and product portfolio layers by the means of comprehensively analysing the current PPM literature and the relevant practices of ten case companies. The principal results of this study include designing ontologies for the potential new business process hierarchy and for new PPM process concept over product lifecycle phases and portfolio layers. The new PPM concept proposal has

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been discussed and validated within a case company focus group to acknowledge the obtained comments. The results of this study can help cross-functional management teams in creating and implementing a process management approach for active PPM practices.

Key words: product portfolio management processes; horizontal and vertical product portfolios; business processes.

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1 Introduction

The performance of a company can be improved by fundamental breakthrough type of development activities based on focused management practices (O'Reilly and Tushman, 2004). The bigger the challenges and changes in the business environment and vision, the more there are needs for major renewal of the processes to achieve breakthrough type of performance improvements (Slack et al., 2012). According to Pinheiro de Lima et al. (2013) companies' performance management should be based on integrated business processes. The foundation for business process management can be seen to consist of the following building blocks: process leadership, process governance, process performance, strategic alignment, people capability, project execution, and technology (Jeston and Nelis, 2008).

The strategic targets of a company should be embedded in all business processes and even acknowledged by each individual employee's performance criteria and operational objectives (Kaplan and Norton, 2001). Business processes can be structured and modelled by multiple ways and methods (Lin et al., 2002). Well described cross functional processes form the base for the common way of activities in the company, connecting the organisation and individual employees as ecosystem to execute the business on targeted performance level on quality, cost and time (Rummler and Brache, 1990).

The process architecture should be supported by the organisational structure by nominating the process managers according to organisational responsibilities (Jeston and Nelis, 2008; Haapasalo et al., 2006). The deficiencies of the functional organisations can be improved by utilising cross functional steering bodies (Sköld and Karlsson, 2013; Pekuri et al., 2011; Poolton and Barclay, 1998; Randall and Ulrich, 2001). In fact, according to Rummler and Brache (1990), business results are achieved via cross functional processes, by the efforts of the individual employees, not by functional organisations.

Through the past decade the product complexity, related manufacturing processes and collaborative product development have increased resulting in challenges in product information management over lifecycle (Assouroko et al., 2014). The need for the alignment between product portfolio management (PPM) and business processes over lifecycle phases has been recognised in the literature on business process management (e.g. Bai and Sarkis, 2012). The systematic use of the process management

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approach is seen as the success factor for managing new product development in an organised manner (Barczak et al., 2009; Hänninen et al., 2013). According to O'Reilly and Tushman (2004), the management of new businesses opportunities and related new products requires different management approach than the more operational management of existing products. The simultaneous development of new platforms and products, and the management of existing products can be organised by focused line organisations, but the organisational structures are often compromises of many different views (O'Reilly and Tushman, 2004; Sosa and Eppinger, 2004). Different types of management structures and cultures impact the utilisation of PPM methods and tools. According to Cooper et al. (1999), the companies classified as benchmarks utilise high quality, realistic, and efficient analysis and decision making methods resulting in excellent business performance. The methods are well understood and fit well to their management and decision making culture. The PPM challenges and preconditions have been evaluated during the PPM research project this article is based on. According to Tolonen et al., (2014), the PPM challenges can be classified into the following five groups: 1) generic, 2) target setting and KPIs, 3) ownership and governance models, 4) processes and methods and 5) data availability.

The systematic and active PPM processes and methods are fundamental preconditions for PPM implementation. This study analyses the existing PPM practices to obtain an understanding on how systematically PPM processes and methods are applied in case companies. In addition, the role of the PPM process in a company's process architecture and its connection to business processes requires clarification. The aim of this study is to analyse and develop PPM processes to address challenges identified in the case companies within two dimensions, over all lifecycle phases (the horizontal view) and product structure levels (the vertical view). The current PPM literature covers well early part of the lifecycle phase but the later phases are left for little attention. Vertically, over the product structure levels, the current literature discusses only the "product" without specifying the product as items on several layers of product structure. Two dimensional way of approaching PPM can provide new contribution both to the current PPM literature and the analysed case companies.

The above described can be condensed into the following research questions (RQ):

- RQ1: What kind of PPM processes and methods can be recognised in the current literature on PPM?
- RQ2: How is PPM applied in case companies as processes and methods
- RQ3: How can the PPM process concept be further developed to cover all lifecycle phases and product structure levels?

This study is constructive in nature. It aims to create processes and some methods for organisations to manage PPM. We analyse case companies'

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challenges the through theoretical frame on qualitative interview, and finally construct a PPM process hierarchy.

2 Literature review

2.1 PPM targets and connection to company strategy

In order to implement the strategy as planned, company's strategic targets need to be described and communicated in a clearly understandable form, such as the mission statement (Williams et al., 2008; King et al., 2010). Mission statement's nine components define the market segments, customers, products, technologies, economic success, competitive advantage, company values, public image and social responsibility and expectations for employees (King et al., 2010). PPM is connected to strategy management and product requirements management to ensure the right decisions for the NPD phase of the product development by analysing the product development project portfolio according to company's strategic objectives: *linking the portfolio to business strategy*, *maximising the value of the portfolio* and *balancing the portfolio* (Cooper et al., 1997; Cooper, 2008; O'Reilly et al., 2004; Weerd et al., 2006). According to Tolonen et al. (2015) the company dashboard, the common strategic KPIs for the company, should include KPIs in PPM and other business processes to ensure their alignment and connection.

According to Cooper et al. (2001), the role of PPM as strategic and high priority activity is seen differently by the key stakeholders within the company due to varying interests for product portfolio development. The highest priority for PPM is given by the top management and by technology managers who view the PPM as a tool that enables strategic decisions for more breakthrough type of product innovations. The least importance and focus to strategic and long term PPM is given by the marketing and sales management who try to fulfil the customer needs as fast as possible, whilst expecting incremental and short term product development activities (Schultz et al., 2013).

Success in business performance can be clearly linked to systematically measured PPM goals and the active usage of the PPM methods and tools (Cooper et al., 1999; Cooper et al., 2004; Barczak et al., 2009; McNally et al., 2012). The benefits of the PPM have been summarised by Cooper et al. (2004): use of a strategic and mission-driven PPM process that are concerned with the entire enterprise as a whole, a single portfolio will elevate the product development project optimisation from the divisional level to the enterprise level for the greater good of the entire organisation as right product development projects will be selected and/or continued sharing the same technical goal, the same budget pool, and the same resource pool. In fact, according to Cooper et al. (2004) the best performing companies have been clearly more active in PPM processes

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and methods resulting in maximised value and strategically aligned product portfolio.

2.2 PPM process, activities and methods

PPM analyses markets, customers, products and technologies in order to make strategic decisions for product portfolio development and renewal (Leffingwell, 2007). According to Ward and Peppard (2002), products should be managed according to their lifecycles and business value. PPM is about periodical and event based portfolio analysis reviews. During holistic periodical PPM reviews the viewpoint is more strategic while event based reviews, for individual products and NPD projects are more tactical (Cooper, 2008).

PPM methods should have a clear and well-defined rules and procedures for prioritisation and selection of NPD projects, resulting in new products that include necessary resource and investment allocations. PPM methods and tools should also be used consistently over the whole product portfolio analysis and all projects/products to enable comparison (Cooper et al., 1999). One concrete outcome of the PPM should be strategic product and release road maps as a high level illustration of ongoing and potential new product development projects (Haapasalo et al., 2006). The simultaneous usage of the multiple PPM methods and tools has been studied including the list of the most common ones such as financial and strategic methods, scoring models and bubble diagrams (Cooper et al., 1999). According to Leffingwell (2007), strategic bucket method can be utilised to divide the strategic product portfolio and use resources and funding, based on four strategic buckets: 1) Investment in existing product offerings, 2) Investment in new products and services, 3) Investment in future, 4) Sunset strategies for existing product offerings. The challenge in the decision making for PPM is the lack of fact based data or systematic PPM processes. The PPM decisions making culture can be more intuitive than objective (Kester et al., 2011).

PPM analysis and decision making requires the existence of product lifecycle information such as product data attributes and dynamic sales and cost figures. The product data attributes are typically managed not only in product data management (PDM) systems but can be spread in many areas and systems such as enterprise resource planning (ERP) systems (Srtiti et al., 2015; Sonzini et al. 2015). Defined product data models, nominated data owners, controlled data quality are the preconditions for companywide master data management (Silvola et al., 2010).

2.3 Synthesis: The current literature on PPM processes and methods

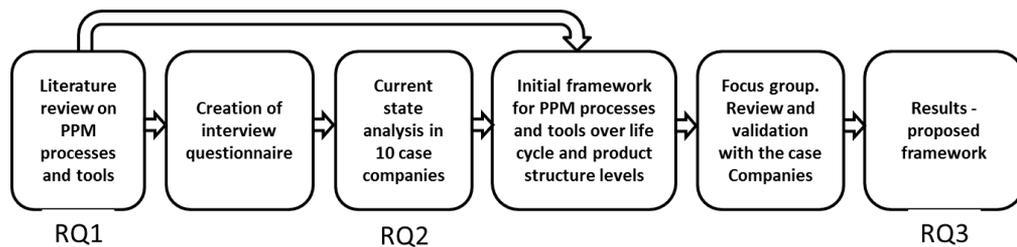
The current literature defines the PPM on a high level as management of “products” and related product development projects by the executive

level cross functional teams focusing mainly on NPD lifecycle phase. The PPM is seen mainly as the management of NPD project portfolio in order to prioritise the investments and resources for the most potential product development projects. As such, the NPD phase and “product level” are very crucial areas of the PPM but the PPM practices in vertical and horizontal dimensions have not been specified adequately. The vertical product portfolio including product families, product configurations, sales items, main assemblies, sub-assemblies and components have been not defined clearly by the current PPM literature leaving room for confusion in terms of what is a “product” and how the product portfolio should be managed over lifecycle phases. The literature leaves fundamental questions open relating to the PPM both over horizontal product portfolio lifecycle phases and vertical product portfolio layers. In addition, the relation and the hierarchy between PPM process and business processes could use more detailed clarification.

3 Research Method

The research process is shown in Figure 1. This multiple case study utilises qualitative and inductive research methods.

Figure 1. The research steps.



Process management concepts were first studied focusing on PPM processes and methods. The analysed literature contained a total of 192 PPM related articles. The literature enabled the creation of the interview questionnaire that was used for analysing the case companies’ current state on PPM processes and methods. The reference list to this article only contains those studies that have the most significance for the analysis. In addition, the questionnaire also covered PPM governance models, and targets and key performance indicators to obtain consistent picture of the PPM practices in case companies. The need for the PPM processes and methods to cover all lifecycle phases and all product structure levels were attempted to clarify by identifying the current PPM literature on processes and methods and by analysing the current challenges and applied practices in the case companies.

The empirical research included current state analysis in ten case companies to clarify the currently used PPM processes and methods

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(Table 1). The questionnaire included 75 questions in total divided to five sub categories including current product portfolio, PPM processes and methods, product management (PM) processes and methods, PPM and PM connection to other business processes, and finally the main PPM challenges. The questionnaire covered four lifecycle phases: new product development, active product sales and delivery, spare part sales and delivery and the product archive phase. For simplicity, later on in this document the phases are referred to as NPD, Maintain, Warranty and Archive. The PPM and PM processes and methods related questions were 32 in total (appendix 1), while 17 questions focused on PPM and PM connection to other business processes. In addition to qualitative information, also quantitative data in relation to business, organisation and product portfolio figures were obtained. In total thirteen face-to-face interview sessions were organised. Each interview session was recorded, extracted and transcribed to enable thorough analyses. During the interviews, the interviewers shared their written notes on a screen to enable the interviewees to verify the results.

After the literature review and empirical analysis the initial concept for new PPM process and related templates were created in order to tackle identified challenges and to extend the PPM practices to all lifecycle phases and product structure levels. The created initial concept was then reviewed and discussed with a focus group, ten case companies, in a common face-to-face seminar. After the review and validation session, the initial concept was further developed to acknowledge the obtained comments.

The analysed ten companies were selected to represent heterogeneous type of business and mix of products such as Solutions, HW, SW, and Service products or only some of them. Also the maturity and the scale of business vary from small fast growing companies to more mature, global companies. In larger companies, the interviews were conducted as several workshops including cross functional groups of managers, while in smaller companies only CEO, R&D, or Product Management type of managers were interviewed.

Table 1. Characteristics of the case companies

C	Portfolio characteristics	Operational maturity	# of interview sessions and informants
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A	Small portfolio of HW products and emerging related service business. Retailers and business customers.	New national rival in mature business	1 session, 1 informant
B	A large portfolio of solutions, HW, SW and services products under strategic renewal. Global business customers.	Experienced global innovator in both mature and new business with strong R&D investments.	4 session, 9 informants
C	Small innovative portfolio of SW products. Consumer customers via business partners	Growing international presence in new growth business	1 session, 2 informants
D	Global portfolio of HW, SW and services products. Business customers.	A global supplier with long history in the business. Both organic growth and by business acquisitions	1 session, 12 informants
E	A new service oriented product portfolio is being established. Regional consumer customers.	New innovator in a growth market	1 session, 3 informants
F	Small portfolio of HW and SW products. Global business customers.	Experienced growing company in mature global business	1 session, 4 informants
G	Medium sized HW product portfolio under strategic renewal. Global, regional and local business customers.	Experienced global leader in declining business, new growth and business potential via portfolio renewal	1 session, 1 informant
H	Attractive traditional HW product portfolio for consumers with new additional services and HW accessory type of products.	Both mature and new innovative HW products with accessories.	1 session, 7 informants
I	Global portfolio of HW, SW, services and solutions. Global, regional and local business customers.	Global supplier in mature business	1 session, 12 informants
J	Global portfolio of HW and services products. Global, regional and local business customers.	Both mature and new innovative HW and services products in mature global business.	1 session, 7 informants

4 Current state analysis of the case companies

4.1 The current state of the case companies in PPM processes and methods

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The trend towards more complex and wider product offering has resulted in accelerated introductions of new products and product variants. More new products are introduced than products are removed from the portfolio. This has led to the explosion of product portfolios in a negative sense when the sales revenues and market shares can no longer be increased accordingly. The trend and its impacts are visible in all the analysed case companies.

The process management practices are familiar for most of the case companies. The business processes such as Marketing and Sales, Product Development, Manufacturing, Logistics, Purchasing and even Service and Care processes have been described and in some cases there are even process managers nominated for these business processes including process targets and key performance indicators. The case companies are customer oriented developing, marketing and selling, manufacturing, delivering and serving their products according to their customer requirements. However, the implementation level of the expected PPM activities and methods vary in the case companies. Only one case company has had a specific PPM team since two years in order to establish systematic PPM practices for the company. The nominated, centralised PPM team still has challenges to get the work and analysis done deeply enough over all lifecycle phases and product structure levels. The co-operation with their line organisations and product development projects need to be enhanced to a more practical level. Six case companies have nominated product managers but only two companies have written job descriptions for them.

There are many strategic and tactical PPM methods available based on the literature but only few of them has been utilised by the case companies. The most common PPM related activities and methods that have been used are the product road maps, financial reporting and NPD process descriptions to guide NPD project planning and execution. Few PPM related activities have been described as a part of NPD or product management processes from the viewpoint of each participating function. In most of the case companies the NPD project evaluations have been executed based on the state gate process approach including related milestone criteria in order to evaluate the readiness of the product development projects. However, the current PPM practices focus more on individual product development projects rather than the holistic product portfolio analysis over the lifecycle and product portfolio layers. The specific and named PPM process, as a higher management level analysis and decision making seems to be missing in all the case companies resulting in lack of knowledge on strategic PPM practices and decisions over horizontal and vertical product portfolios.

Specific PPM targets and key performance indicators (KPIs) have not been defined and implemented. Typically the operational sales and cost follow up is done on monthly basis, in some cases even weekly. Only two

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case companies have the ability to report product level sales, cost and profitability figures. In eight companies the financial reports are just on business unit or business line level only. The most of the strategic PPM type of activities and decisions are related to new product development and ramp up phases. The product lifecycle decisions have been made more intuitively and ad-hoc manner on individual product level rather than based on the systematic analysis of horizontal and vertical portfolios. Only couple of companies have strategic PPM activities for product ramp downs. Typically the new products are opened in parallel with older products increasing the size of the total portfolio. The ramp-down decisions for the existing products in maintain portfolio are mostly related to decreased sales revenue, delivery volumes and the cost and profitability challenges rather than strategic decisions to replace the older products by newer products. During the active sales and delivery lifecycle, the maintain phase, the product related analysis, reporting and decision making occur mainly according to operational business targets and metrics such as sales revenue and delivery volume. In the maintain phase, incremental product modifications are usually triggered by customer requests and cost reduction initiatives.

The customer driven, individual and fast product decisions can lead to increased number of products and costs in the portfolio without the growth of total sales revenue. The lack of systematic and active PPM processes, methods, inadequate PPM targets and KPIs and lack of nominated PPM responsibilities over horizontal and vertical product portfolios are fundamental challenges in the case companies resulting in the unprofitable growth of the product portfolios. The case companies seem to know better which products are more strategic than the others but not the profitability of them over the lifecycle in order to nominate the resources and investments to the most strategic and profitable products. The identified challenges in PPM are not seen to be the lack of overall process management concepts and practices in case companies. The generic process management concepts have not been implemented for PPM due to lack of overall understanding of the PPM as the own focus area for business management.

The results and analysis of the most common PPM practices and methods in case companies are summarised in Table 3.

Table 2. Status of the current PPM processes and methods in case companies

Case	Status of PPM processes	Status of PPM methods
A	<ul style="list-style-type: none">No documented PPM	<ul style="list-style-type: none">Quarterly updated product road map

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	process descriptions available.	<ul style="list-style-type: none"> • Competition analysis • Financial business reports
B	<ul style="list-style-type: none"> • No documented PPM process descriptions available. • PPM types of activities are part of the product creation process in connection with release management, feature screening and program/project milestones. • PPM development and implementation program ongoing 	<ul style="list-style-type: none"> • Yearly updated business strategy • Business unit related product road maps • Portfolio packages (groups of products, technologies and key customers) • Guidelines and criteria for product business cases and decision making • Stage gate type of product creation process descriptions • Financial business reports
C	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • Product road maps • R&D project follow up reports • Financial business reports.
D	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • High level product road map • Financial business reports
E	<ul style="list-style-type: none"> • No documented PPM process descriptions available but the main product management role and targets described. 	<ul style="list-style-type: none"> • Product management bi-weekly meetings started • New product catalogue is being created • Financial business reports
F	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • Yearly updated business strategy • Monthly updated product road map for strategy implementation • Stage gate process under development for NPD • Financial business reports
G	<ul style="list-style-type: none"> • A draft PPM process description is being created and implemented as PPM strategy, vision, and road map 	<ul style="list-style-type: none"> • Yearly updated business strategy • Draft product road map • New individual product initiatives • Monthly R&D project portfolio review for individual products • Stage gate type of product creation process • Strategic bucket method for NPD and incremental development of existing products • List of prioritisation criteria • Module chart for platform and modularisation • A new specific tool for PPM to be studied and evaluated

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		<ul style="list-style-type: none"> Financial business reports
H	<ul style="list-style-type: none"> No documented PPM process descriptions available 	<ul style="list-style-type: none"> Financial business reports Yearly updated business strategy Yearly product master plan for product idea collection Yearly product and technology road maps for product implementation Bi-yearly updated sales manual Stage gate type of product creation process Monthly review and follow up of R&D projects The usage of key resources will be analysed and focused
I	<ul style="list-style-type: none"> No documented PPM process descriptions available 	<ul style="list-style-type: none"> Financial business reports Yearly updated business strategy Annual product portfolio proposals by business units Event based decisions and activities for new products based on customer requests Product road maps Business case templates Stage gate type of product creation process Financial business reports
J	<ul style="list-style-type: none"> No documented PPM process descriptions available 	<ul style="list-style-type: none"> Yearly updated business strategy Product, technology and platform road maps Pre-planned and strict length of product lifecycle Stage gate type of product creation process Financial business reports

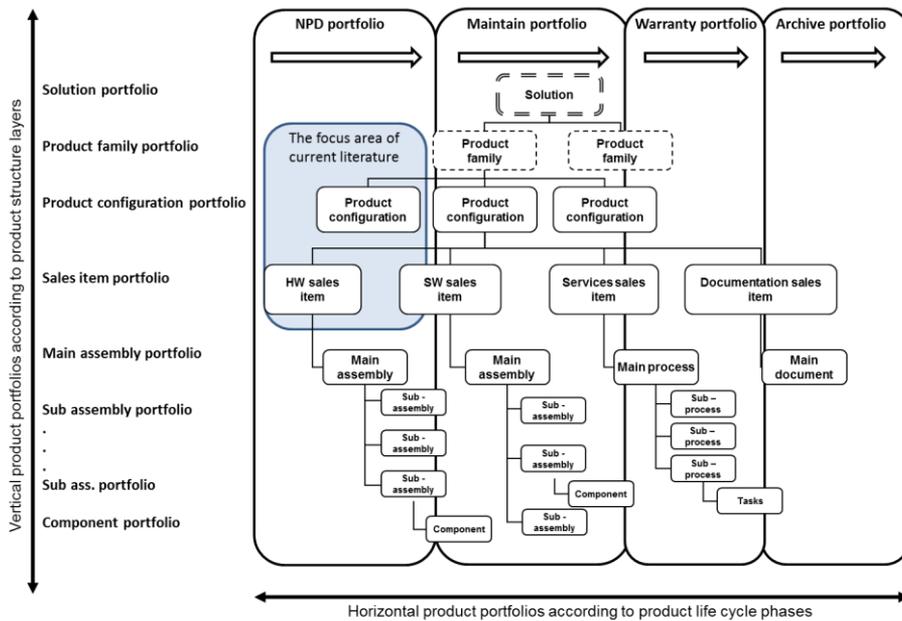
5 Proposal for product portfolio management process over horizontal and vertical portfolios

In order to respond to identified PPM challenges over all sellable and technical items in the case companies a new PPM process based on horizontal and vertical dimensions is proposed. In this study the entire product and product portfolio lifecycle have been split horizontally to four phases of NPD, maintain, warranty and archive. NPD refers to research and development lifecycle phase resulting in new sellable or technical items based on totally new platforms and technologies or the items can be developed based on existing sellable and technical items. The lifecycle of the developed new sellable and technical item always starts from the beginning. The product development activities at the maintain lifecycle phase will not create new sellable items but enhance the competitiveness of existing (old) sellable items based on new or modified internal technical items. At the maintain phase, the sales item codes stay the same for

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customers and version numbering of technical items are used internally to track the technical changes and modifications such as cost reductions in manufacturing process and materials. The lifecycle of the technically modified existing sellable items merely continues forward. Vertically, the sellable items belong to solution, product family, product configuration and sales item portfolios. Non-sellable technical items belong to the main assembly, sub assembly and component portfolios. The horizontal dimension analyses and manages the PPM practices over product portfolio lifecycle phases and the vertical dimension over product portfolio layers, figure 2.

Figure 2. The ontology of proposed horizontal and vertical product portfolios according to lifecycle phases and product structure levels



A new fundamental business process, PPM process, is proposed in process architecture on the level of traditional and well described business processes such as Product Development Marketing and Sales, Deliver, Care and Support processes, figure 3. The new process hierarchy would allow the strategic positioning of PPM as centralised analysis and decision making process over horizontal and vertical portfolios impacting the content of the product portfolio in all business processes. The PPM

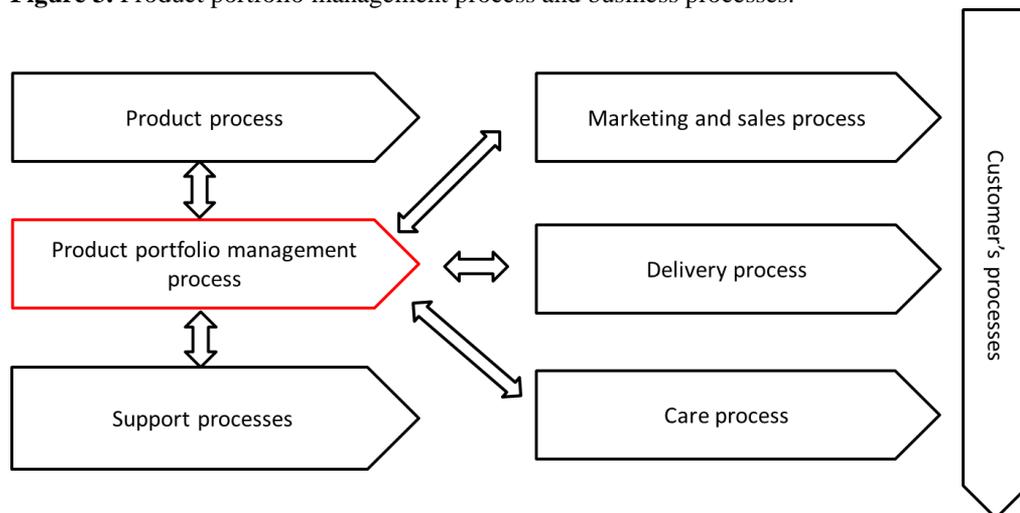
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process would analyse and produce the decisions about *what* kind of products to be developed, marketed, sold, delivered, maintained and finally removed in short and long term according to company strategy. The role of the other business processes will then be more operational and relate to *how* the products are developed, marketed, sold, delivered and cared.

In the proposed process hierarchy the roles of the business processes are

- **Product portfolio management process:** To analyse and decide how to renew the product portfolio over horizontal and vertical portfolios according to strategic PPM targets, KPIs, processes and methods.
- **Product process:** To manage the technology and product development over horizontal and vertical portfolios according to strategic PPM decisions.
- **Marketing and sales process:** To market, sell and contract the products on customer interface according to strategic PPM decisions.
- **Delivery process:** To purchase, manufacture, deliver and invoice the products according to strategic PPM decisions.
- **Care process:** To install, maintain, support and invoice the products according to strategic PPM decisions.
- **Support processes:** To manage investment and resources according to strategic PPM decisions.

Figure 3. Product portfolio management process and business processes.

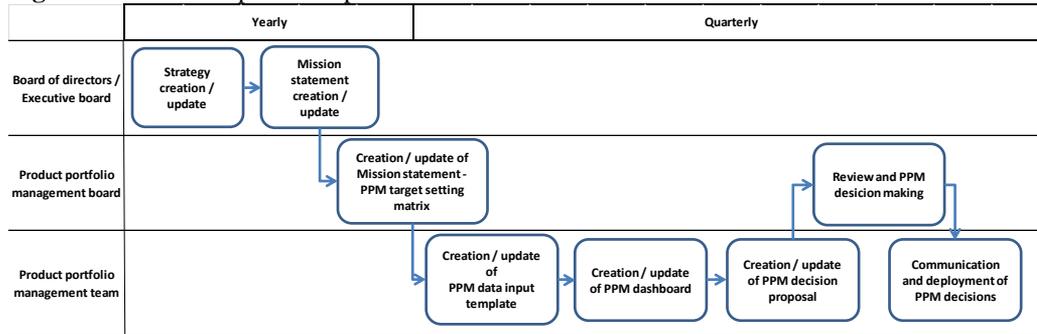


In order to get PPM activities and decision making implemented in case companies the *product portfolio management process chart* including

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related roles, tasks and templates have been developed, figure 4. The activities that follow are very operational in nature and involve collecting product data for the PPM analysis and dashboard template according to horizontal and vertical sub portfolios.

Figure 4. The developed PPM process chart



According to the proposed PPM process chart the first activity would be the creation of the strategy for the company in a form of *mission statement* in co-operation by the executive board and executive team of the company. The mission statement defines nine strategic components from strategic market segments to employee related objectives. As a second step, PPM targets and KPIs will be created in a form of *Mission statement – PPM target setting matrix* by the product portfolio management board (PPMB). The next activity would be the creation of the *PPM data input and analysis template* by the product portfolio management team (PPMT). Based on the data input template *PPM dashboard* could be created by the PPMT for *initial product portfolio decision proposals*. According to developed process PPM process chart, the final product portfolio *review and decision making* would be done by the PPMB. As a last proposed activity, the PPM decisions are proposed to be communicated and deployed by the PPMT in co-operation with operational business process managers within each business process under the supervision of the PPMB. Once the PPM process has been implemented for the first time, product portfolio analysis would need to be done frequently according to business dynamics. The proposed minimum frequency is no longer than one year. The proposed PPM process can also be run on quarterly or even monthly basis in most dynamic business situations. The proposed PPM methods and templates include:

- PPM process chart
- Company strategy in the form of a mission statement
- Mission statement – PPM target setting matrix (appendix 2)
- PPM data input and analysis template (appendix 3)
- PPM dashboard template – PPM KPIs (appendix 4)

The proposed PPM process participants include Board of directors,

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Executive team, PPMB and PPMT. Due to the nature of the PPM, the executive team should act in a role of PPMB. The executive team members are potential representations for key business processes impacted by PPM decisions. The PPMB are proposed to be assisted by the nominated product portfolio manager. The proposed members of the PPMT would be product portfolio manager and the horizontal and vertical sub portfolio owners. Their role is to analyse the product portfolio within horizontal and vertical sub portfolios and prepare the decision proposals according to agreed criteria.

6 Discussions and implications

This article proposes substantial improvements to strategic PPM practices by raising the importance of managerial focus on the PPM concept and the process at the level of other business processes. The role of the proposed new strategic PPM process is to define the strategic PPM targets and KPIs for the operational execution of the other business processes such as product development, marketing and sales, delivery and care processes. The fundamental recommendation is to extend the scope of the PPM horizontally over the lifecycle and vertically over all product structure levels by the idea of horizontal and vertical product portfolios including nominated sub portfolio owners. The horizontal and vertical portfolios widen the strategic and operational analysis and decision making in order to renew and develop the entire product portfolio not only by introducing new items but also by moving the older items further in their lifecycle until the final removal of them. In order to establish the proposed PPM practices in the case companies the PPM process chart has been created including the proposed process participants, tasks and templates.

The managerial implications of the study include the modifications to the process hierarchy and the process governance model. The proposed PPM as a new business process streamlines the role of other business processes to be more operational than strategic by impacting their content. PPM defines what products are developed, marketed, sold, contracted, delivered and cared by the other business processes. The new centralised PPM process for dynamic product portfolio analysis and decision making calls for cross functional managerial work. As noted, PPM impacts the content of all other business processes thus the PPM governance model should include managerial representatives from all of them. The proposed new PPM process requires the nomination of the PPM process owner, key process participants and the process governance model. The proposed *product portfolio management board* (PPMB) has a role to define the PPM targets and KPIs for the product portfolio analysis and decision making and to manage the product portfolio according to company strategy. The strategic execution of PPM requires the existence of a clear company strategy in the form of mission statement. The *mission statement – PPM target setting matrix* has been created for the use of PPMB in order

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to systematically create the PPM targets and KPIs. The developed concept assumes the nominations of *product portfolio manager and horizontal and vertical sub portfolio managers* and the formation of the proposed new *product portfolio management team* (PPMT). The role of the PPMT is to own the PPM concept and related processes and to conduct the operational and active product portfolio analysis and decision proposals for PPMB. The role of the other business processes is to run the product development, marketing and sales, delivery and care processes according to PPM decisions from the product portfolio content viewpoint. The active product portfolio management practices are relevant to any companies trying to renew and manage their product portfolios according to strategic targets increasing focus for investment and resourcing decisions for the most potential, profitable and strategic products. Based on the current state analysis the very principal type of business management question can be highlighted: How long can there be a “black period” in the business management without knowing which customer segments, customers, products and technologies are profitable, +/- profitable and non-profitable? Systematic annual, quarterly, monthly or even weekly PPM practices can provide potential to improve the competitiveness of the company by using agreed PPM processes and methods based on agreed roles of people, in right order, right time and quality.

Ontology is a challenging research field on its own (Milicic et al., 2014). The vertical hierarchy of sellable items has been discussed in PLM and PDM literature (Gomez et al., 2014) and even utilised well in consumer type of business like in automotive industry as configuring rules (Tidstam and Malmqvist, 2015). Also PLM processes and their maturity levels have been studied earlier (Venugopalan et al., 2012). However, this study contributes to the design of ontology by extending the role of the PPM process to cover all product lifecycle phases and product structure levels by introducing the horizontal and vertical sub portfolios and their owners in order to renew and manage the entire product portfolio. The current PPM literature focuses mainly on strategic PPM within NPD phase and without defining the “product” as hierarchy of sellable and technical items. This case study proposes to raise the PPM process to the level of other strategic business processes in process hierarchy. The PPM process is proposed to be developed, described and managed as systematically as any other business process in order to focus on most strategic products in all company business activities. The developed PPM process chart and the analysis and decision making templates provide potential for further development as new functionalities on commercial product lifecycle management and product data management applications. However, only the maturity of implemented new processes will result in expected business benefits and efficiency. In addition, the overall understanding about product lifecycle management and product data management concepts, and relevant processes are the required enablers for further implementation steps for systematic product portfolio management

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processes.

The proposed PPM process concept has been reviewed and discussed within a common work shop with all the case companies. The proposed new concept has been seen to have potential for smaller and larger companies despite the type of company products, such as hardware (HW), software (SW) and service products. The new process hierarchy and the new PPM process concept are being further communicated in the case companies in order to create improvement plans accordingly. The implementation of the proposed PPM processes and methods requires full understanding and commitment by the executive team first. Once they have understood the role of the PPM as centralised analysis and decision making for the product portfolio renewal the commitment by the rest of the organisation working in each business process can be expected. According to case company analysis the proposed PPM implementation over horizontal and vertical portfolios can be expected to take place easier by small and midsize companies due to the size of the product portfolio and the organisation. The bigger the organisation is the more communication, training and change management will be needed to get centralised PPM implemented. Also the analysis of the smaller and technically simpler product portfolios will be easier and the expected changes can be made faster. However, the PPM preconditions are the same and have not been seen differently depending on the size of the company. In case of HW, SW and Services products the model of the commercial product portfolios has been seen as very similar. The differences are mainly on the side of the technical product portfolios. While the HW product is built based on the HW main assemblies, sub-assemblies and components (the bill of material), the SW product consist of SW builds and components (the bill of SW components). Service products are built based on the service processes (the bill of service processes).

7 Conclusion

This case study extends the product portfolio management (PPM) practices to cover horizontally all lifecycle phases and vertically all portfolio layers. The study was realised as comprehensive analysis of the current PPM literature and by analysing ten case companies. The PPM process analysed according to business process management concepts assumes well described, trained and implemented processes with clear process owners, roles, tasks and governance models.

Earlier research on PPM processes is limited focusing horizontally mainly on new product development phase of the lifecycle and vertically “product” level only. The current literature has defined clearly three strategic PPM focus areas such as strategic fit, value maximisation and portfolio balance and the benefits of systematic PPM processes.

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However, PPM over horizontal and vertical portfolios including sub portfolios owners and roles are not widely discussed. Neither have the PPM process positioning been realised in the hierarchy of business processes.

The process management culture has been experienced in all case companies. The examples of this include well described processes in operational purchasing, manufacturing and logistics activities. Typically, also product development practices and responsibilities have been described as a NPD process including product road maps and financial business metrics as the most common PPM methods. However, none of the case companies have described the PPM activities as a separate process chart including relevant targets, metrics, tasks, roles and nominated key players. Some of PPM related tasks are described in product development or product management processes in a fragmented way.

This study proposes a potential *new business process hierarchy* and PPM process positioning on the level of other key business processes such as product development marketing and sales, delivery, care and support processes. The proposed *new PPM process concept* includes *horizontal and vertical product portfolios and related main tasks, analysis and decision making templates*. According to the proposed PPM process, the key roles could include *product portfolio management board, product portfolio management team, and horizontal and vertical sub portfolio owners*. The proposed PPM process consists of key analysis and decision making templates such as developed *mission statement – PPM target setting matrix, PPM analysis template and PPM dashboard template*.

The limitations of this study include the limited number of case companies and the lack of PPM practices in their operations. PPM over horizontal and vertical product portfolios have been seen as the major competence gap in business management and will require further research in order to improve the PPM practices and the maturity level.

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Appendix 1: Questionnaire for product portfolio management current state analysis in case companies

Interview session

- Name of interviewer:
- Date & location:
- Company:
- Name of interviewee(s), current position and experience in the company, what is your relationship to PPM:

1 Current product portfolio

- 1.1 Please describe the product portfolio of the company??
- 1.2 How is product portfolio described, grouped or classified?
 - 1.2.1 New products, existing products, removed products based on lifecycle status?
 - 1.2.2 Based on technology generations?
 - 1.2.3 Based on customer segments?
 - 1.2.4 Based on global and/or regional products?
 - 1.2.5 Based on platform and application products?
 - 1.2.6 Based on product families?
 - 1.2.7 Based on solutions, product families, configurations, sales items, spare parts...?
 - 1.2.8 Something else..?
 - 1.2.9 Mixed / some combinations of above?
- 1.3 What is the size of your company's product portfolio?
 - 1.3.1 as number of solutions?
 - 1.3.2 as number of product families?
 - 1.3.3 as number of configurations?
 - 1.3.4 as number of sales items?
 - 1.3.5 as number of spare parts?
 - 1.3.6 as number of some other type of product categorising in use?
- 1.4 During past years,
 - 1.4.1 How has the number of products belonging to same product family developed?
 - 1.4.2 What have been the root causes of this development?

2 Product portfolio management processes and methods

- 2.1 Are PPM roles, tasks, decisions and milestone criteria described as processes and operational models?

Title

- 2.1.1 If yes, is there a process description available?
- 2.2 What kind of tasks and decisions occur frequently based on "yearly clock" and/or agreed agenda?
 - 2.2.1 Yearly activities?
 - 2.2.2 Quarterly activities?
 - 2.2.3 Monthly activities?
 - 2.2.4 Weekly activities?
- 2.3 What kind of PPM tasks and decisions occur based on product lifecycle phases
 - 2.3.1 within new product development (NPD) phase?
 - 2.3.2 within ramp up phase?
 - 2.3.3 within maintain phase?
 - 2.3.4 within ramp down phase?
 - 2.3.5 within field maintenance / warranty phase?
 - 2.3.6 within removal phase?
- 2.4 What are the main methods utilised in PPM within project/product evaluation, prioritisation and decision making (strategic approaches, diagrams, matrices, financial KPIs, simulations, mathematical methods, etc)?
- 2.5 What kind of communication and change management tasks are there? Done by PPM, do you know by whom?

3 Product management processes and methods

- 3.1 Are product management roles, tasks, decisions and milestone criteria described as processes and operational models?
 - 3.1.1 If yes, is there process a description available?
- 3.2 What kind of product management tasks and decisions occur frequently based on "yearly clock" and/or agreed agenda?
 - 3.2.1 Yearly activities
 - 3.2.2 Quarterly activities
 - 3.2.3 Monthly activities
 - 3.2.4 Weekly activities?
- 3.3 What kind of product management tasks and decisions occur based on product lifecycle phases?
 - 3.3.1 within NPD phase?
 - 3.3.2 within ramp up phase?
 - 3.3.3 within maintain phase?
 - 3.3.4 within ramp down phase?
 - 3.3.5 within field maintenance / warranty phase?
 - 3.3.6 within removal phase?

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- 3.4 What are main methods utilised in product management?
- 3.5 What kind of communication and change management tasks are there? Are these done by product management?

4 Product portfolio management and product management connection to other business processes

- 4.1 Business processes
 - 4.1.1 What kind of business processes are there in your company?
 - 4.1.2 How are business processes structured on main level and sub levels as processes?
 - 4.1.3 What is the process governance model and who are the process owners?
- 4.2 What are company's key performance indicators for the following business processes?
 - 4.2.1 Product process (R&D) KPIs?
 - 4.2.2 Marketing and sales process KPIs?
 - 4.2.3 Delivery process KPIs?
 - 4.2.4 Care process KPIs?
 - 4.2.5 HR processes KPIs?
 - 4.2.6 F&C processes KPIs?
- 4.3 How are PPM and product management KPIs connected to company's business processes and metrics?
 - 4.3.1 Are there shared target setting between business processes? If yes, describe typical shared targets?
 - 4.3.2 Are there shared KPIs and follow up between business processes? If yes, describe typical shared KPIs?
 - 4.3.3 Are there shared bonus pay related targets between business processes? If yes, describe typical shared bonus pay related targets?
- 4.4 Please name process management meetings and possible steering teams in where product portfolio managers and product managers are included?
- 4.5 How do PPM and its decisions affect business in general?
- 4.6 What are the main benefits of PPM to business in general?

5 Main challenges related to product portfolio management

- 5.1 What are the main challenges of PPM concerning product ownership and governance model related issues?
- 5.2 What are the main challenges of PPM concerning product portfolio target setting and measurement related issues?

Title

- 5.3 What are the PPM related main challenges in portfolio management process related issues?
- 5.4 What are the PPM related main challenges in portfolio management methods related issues?
- 5.5 What are the PPM related main challenges in portfolio and product data (and data availability) related issues?
- 5.6 What are the PPM related main challenges in any other area, please name it?
- 5.7 How would you improve your company's PPM?

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Appendix 2: Created mission statement – PPM target setting matrix

	PPM focus areas in target setting and performance management		
9 components of the mission statement	Strategic FIT	Value maximization	Portfolio Balance
1. Market segments	What are strategic B2B and B2C market segments?	What are sales revenues and profits by market segments?	What are low/high risks and short / long term market segments?
2. Customers	Who are strategic customers?	What are sales revenues and profits by customers?	Number of customer? Share of low/high risk and short / long term customers?
3. Products (HW, SW, services, Docs)	What are the strategic core products, supportive products and non strategic products?	Which and how many products make 95% of total sales revenue, delivery volume, cost of goods sold and profit of the company? Which and how many products are profitable, +/- zero and non profitable?	What products are low/high risk, short / long term products?
4. Technology	Which technologies are aligned with company strategy?	Share of sales revenue and profit of the products based on strategically aligned technologies?	Which products are based on future technology, existing dominant technology and old and removing technology?
5. Economic success		Share of sales revenue, GOGS and profit based on strategic products, supportive products, non strategic products? Share of investments (resources and funding) for strategic products, supportive products, non strategic products?	Used investments (resources and funding) for products in low/high risk, short / long term products and within life cycle phases (NPD, use/maintain/field maintenance/obsolescence)
6. Competitive advantage	1) Differentiation 2) Cost competitiveness	1) Higher product prices based on differentiation and product portfolio renewal by new products 2) Cost efficiency based product portfolio renewal by removing non profitable products, by cheaper product design, materials and processes.	Right balance of differentiated, cost optimised products and processes? Righth balance of new products, existing dominant products and removing Products?
7. Values	Global and/or regional product portfolio? What and where are profit/loss accountabilities (customer regions, global head quarter, country offices...), share of project, product and spare part business?		
8. Public image and social responsibility	Strategic sustainability targets and guidelines? Sustainability score card for product design?	Modular product platforms and applications based on renewal materials by own renewal energy power plants?	Share of environmentally sustainable products?
9. Employees	Do employees have skills and competences to create, implement and maintain the products according to market segments, customers, products and technologies?	Share of employees working for profitable, +/- and non profitable markets, customers and products?	Share of employees working for low/high risk, short / long term, new /existing dominant /removing old technology, in NPD, ramp up, use/maintain/ramp down/field maintenance/ obsolescence phases of life cycle?

Figures, images and tables

Figure 1. The research steps.

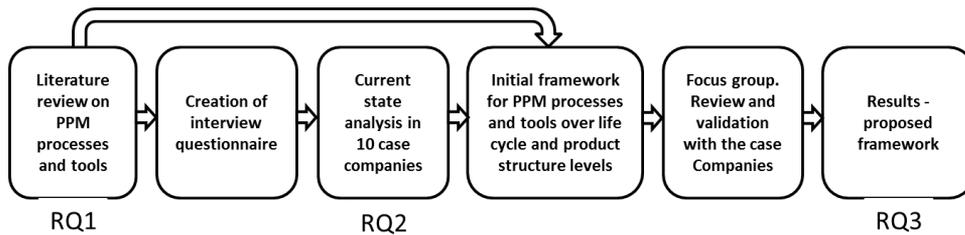


Table 1. Characteristics of the case companies

C	Portfolio characteristics	Operational maturity	# of interview sessions and informants
A	Small portfolio of HW products and emerging related service business. Retailers and business customers.	New national rival in mature business	1 session, 1 informant
B	A large portfolio of solutions, HW, SW and services products under strategic renewal. Global business customers.	Experienced global innovator in both mature and new business with strong R&D investments.	4 session, 9 informants
C	Small innovative portfolio of SW products. Consumer customers via business partners	Growing international presence in new growth business	1 session, 2 informants
D	Global portfolio of HW, SW and services products. Business customers.	A global supplier with long history in the business. Both organic growth and by business acquisitions	1 session, 12 informants
E	A new service oriented product portfolio is being established. Regional consumer customers.	New innovator in a growth market	1 session, 3 informants
F	Small portfolio of HW and SW products. Global business customers.	Experienced growing company in mature global business	1 session, 4 informants
G	Medium sized HW product portfolio under strategic renewal. Global, regional and local business	Experienced global leader in declining business, new growth and business	1 session, 1 informant

<i>Title</i>			
	customers.	potential via portfolio renewal	
H	Attractive traditional HW product portfolio for consumers with new additional services and HW accessory type of products.	Both mature and new innovative HW products with accessories.	1 session, 7 informants
I	Global portfolio of HW, SW, services and solutions. Global, regional and local business customers.	Global supplier in mature business	1 session, 12 informants
J	Global portfolio of HW and services products. Global, regional and local business customers.	Both mature and new innovative HW and services products in mature global business.	1 session, 7 informants

Table 2. Status of the current PPM processes and methods in case companies

Case	Status of PPM processes	Status of PPM methods
A	<ul style="list-style-type: none"> No documented PPM process descriptions available. 	<ul style="list-style-type: none"> Quarterly updated product road map Competition analysis Financial business reports
B	<ul style="list-style-type: none"> No documented PPM process descriptions available. PPM types of activities are part of the product creation process in connection with release management, feature screening and program/project milestones. PPM development and implementation program ongoing 	<ul style="list-style-type: none"> Yearly updated business strategy Business unit related product road maps Portfolio packages (groups of products, technologies and key customers) Guidelines and criteria for product business cases and decision making Stage gate type of product creation process descriptions Financial business reports
C	<ul style="list-style-type: none"> No documented PPM process descriptions available 	<ul style="list-style-type: none"> Product road maps R&D project follow up reports Financial business reports.
D	<ul style="list-style-type: none"> No documented PPM process descriptions available 	<ul style="list-style-type: none"> High level product road map Financial business reports
E	<ul style="list-style-type: none"> No documented PPM process descriptions 	<ul style="list-style-type: none"> Product management bi-weekly meetings started

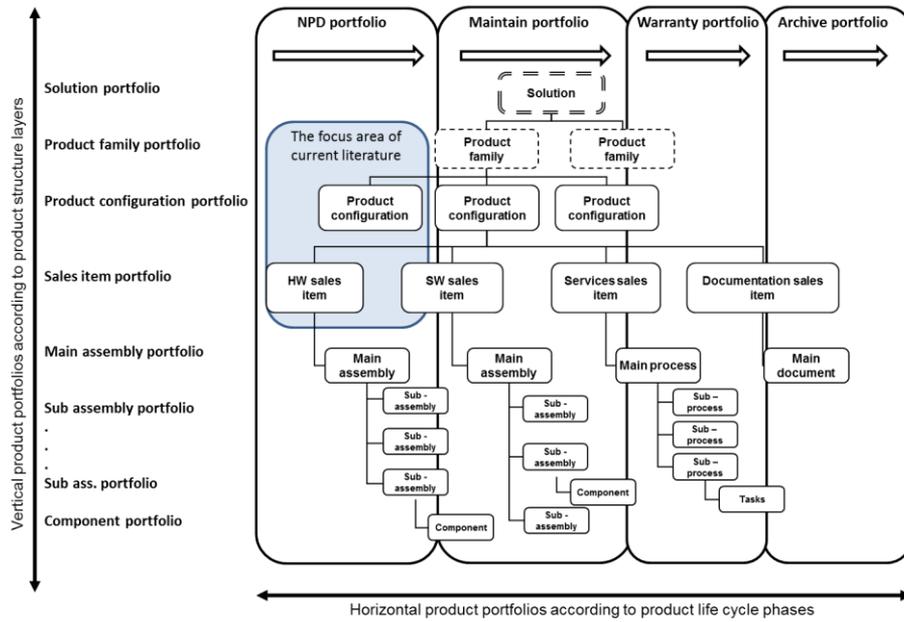
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	available but the main product management role and targets described.	<ul style="list-style-type: none"> • New product catalogue is being created • Financial business reports
F	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • Yearly updated business strategy • Monthly updated product road map for strategy implementation • Stage gate process under development for NPD • Financial business reports
G	<ul style="list-style-type: none"> • A draft PPM process description is being created and implemented as PPM strategy, vision, and road map 	<ul style="list-style-type: none"> • Yearly updated business strategy • Draft product road map • New individual product initiatives • Monthly R&D project portfolio review for individual products • Stage gate type of product creation process • Strategic bucket method for NPD and incremental development of existing products • List of prioritisation criteria • Module chart for platform and modularisation • A new specific tool for PPM to be studied and evaluated • Financial business reports
H	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • Yearly updated business strategy • Yearly product master plan for product idea collection • Yearly product and technology road maps for product implementation • Bi-yearly updated sales manual • Stage gate type of product creation process • Monthly review and follow up of R&D projects • The usage of key resources will be analysed and focused • Financial business reports
I	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • Yearly updated business strategy • Annual product portfolio proposals by business units • Event based decisions and activities for new products based on customer requests • Product road maps • Business case templates • Stage gate type of product creation process • Financial business reports
J	<ul style="list-style-type: none"> • No documented PPM process descriptions available 	<ul style="list-style-type: none"> • Yearly updated business strategy • Product, technology and platform road maps • Pre-planned and strict length of product

Title

- lifecycle
- Stage gate type of product creation process
- Financial business reports

Figure 2. The ontology of proposed horizontal and vertical product portfolios according to lifecycle phases and product structure levels



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Figure 3. Product portfolio management process and business processes.

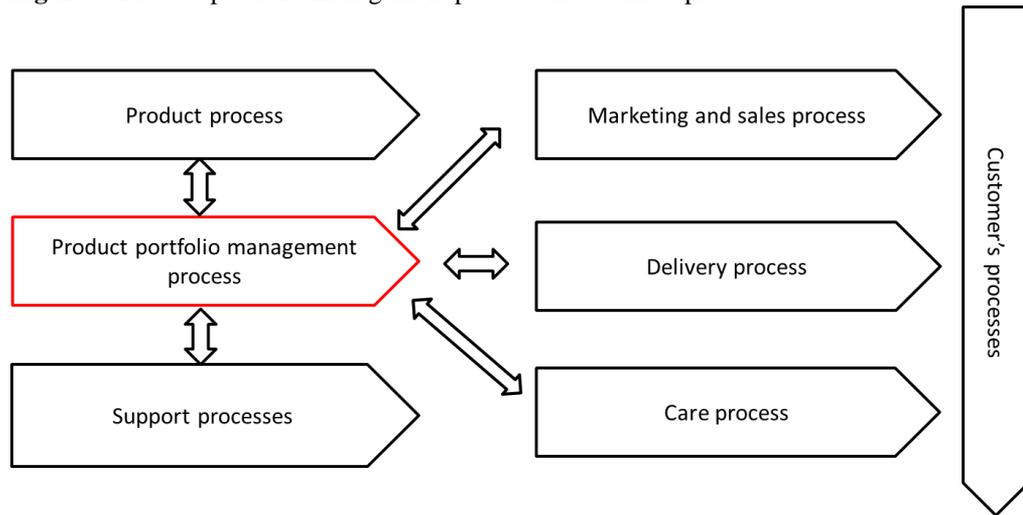


Figure 4. The developed PPM process chart

