Miko Korhonen

Improving Product Lifecycle Management Through Lessons-to-Learn Culture

- Case Global Consumer Electronics Company

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Abstract

Author	Miko Korhonen
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New product launches in handheld consumer electronics market have recently attracted a significant amount of attention in the market place. At the same time economies rising from the recession enable the manufacturing companies to ramp up their production due to the rising demand. However, the elevation of manufactured volumes is somewhat constrained due to limited supply in certain components, since suppliers were forced to lower their capacity in the downturn to recession. The situation is made even more strenuous in certain markets by the booming demand and tough competition. To fulfill the demand and match the competition companies have to make most from the available supply as efficiently as possible.

In a manufacturing company the pressure mounts up especially in the ramp-up phase of manufacturing, when production is still striving for the target yield and volume levels. The longer the time-to-market, time-to-volume and time-to-yield the more the company loses profits.

The goal of this study was to identify how product lifecycle management can be improved by applying principles of a learning culture. The effects of early product stages and processes to production ramp-ups were identified and the study perspectives used in literature for examining ramp-ups were described. The importance of learning is also legitimized with the support of literature.

Furthermore, practical product ramp-up issues were illustrated in a descriptive case study that focused on a company that operates in the fierce market landscape of consumer electronics. Based on the literature studies and numerous interviews in the case company a set of processes and tools were created to enable and support product ramp-up learning in the case company.

In addition, a study was made based on 26 production ramp-ups that were reported and analyzed by utilizing the created tools and processes. On the basis of the conclusions, recommendations were made to the case company on how to improve ways of working when operating with ramp-up products with different focus, customers and technology, how to improve control of key elements and how important simple problem solving is in a company that is facing high levels of complexity. The given recommendations should illustrate to the case company what to take into consideration when managing future production ramp-ups from product lifecycle management point of view.

Keywords	learning culture, logistics, production ramp-up

Tekijä(t) Otsikko Sivumäärä Aika	Miko Korhonen Tuotteiden elinkaaren hallinnan kehittäminen oppimiskulttuurin avulla – Case Globaali kuluttajaelektroniikkayritys 68 sivua + 3 liitettä
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Uudet tuotejulkaisut kuluttajaelektroniikkamarkkinoilla ovat herättäneet runsaasti huomiota viime aikoina. Samalla globaalin talouden noustessa tuotantoyritykset pyrkivät ylösajamaan tuotantoaan kohonneen kysynnän vuoksi. Kuitenkin tuotantovolyymien nostaminen on haasteellista, sillä toimittajat olivat pakotettuja laskemaan kapasiteettiaan taantuman alkaessa. Tilannetta hankaloittaa entisestään eräiden tiettyjen markkinoiden valtava kysyntä ja erittäin tiukka kilpailutilanne. Täyttääkseen kysynnän vaatimukset ja vastatakseen kilpailuun yritysten on tehtävä parhaansa saatavilla olevista materiaaleista niin tehokkaasti kuin mahdollista.

Tuotantoyrityksessä paine korostuu erityisesti tuotannon ylösajovaiheessa, tuotannon edelleen tavoitellessa haluttuja tuotos- ja volyymitasoja. Mitä kauemmin yrityksellä kestää saada tuote markkinoille ja kannattavaksi, sitä enemmän tuotantoyritys menettää voittojaan.

Tämän tutkimuksen tavoitteena on tunnistaa, kuinka tuotteen elinkaaren hallintaa voidaan parantaa soveltamalla oppimiskulttuurin periaatteita. Tutkimuksessa tarkastellaan tuotteen elinkaaren alkuvaiheen prosessien vaikutuksia tuotannon ylösajoon. Lisäksi oppimiskulttuurin tärkeys legitimoidaan tieteellisen kirjallisuuden avulla.

Tutkimuksessa myös havainnollistetaan käytännön tuotannon ylösajo-ongelmia casetutkimuksen avulla. Tutkimuksen caseyritys toimii kilpailuilla kuluttajaelektroniikkamarkkinoilla. Kirjallisuuden ja caseyrityksessä tehtyjen haastatteluiden perusteella luodaan joukko prosesseja ja työkaluja, joilla mahdollistetaan ja tuetaan tuotannon ylösajoa ja siihen liittyvän oppimiskulttuurin luomista ja ylläpitämistä caseyrityksessä.

Luotujen prosessien ja työkalujen avulla kerättiin tietoja ja analysointiin tuotannon ylösajoa 26 tuotteen kohdalla. Kerätystä tiedosta tehtyjen johtopäätösten avulla caseyritykselle annetaan suosituksia, kuinka parantaa työskentelytapoja, kun toimitaan tuotteiden kanssa, joilla on erilaiset resurssit, asiakkaat ja teknologia. Tutkimuksen pohditaan myös kuinka parantaa prosessin avainkohtien hallintaa ja kuinka tärkeää yksinkertainen ongelmanratkaisu on yrityksessä, joka väistämättä joutuu kohtaamaan monimutkaisia haasteita. Annettujen suositusten perusteella caseyritykselle tulisi muodostua kuva huomioitavista asioista käsiteltäessä tulevia tuotannon ylösjoja elinkaaren hallinnan näkökulmasta.

Avainsanat	logistiikka, oppimiskulttuuri, tuotannon ylösajo

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1 Introduction

Product launches are critical to make a product successful. During the launch phase companies need to pay attention to all processes necessary to begin the actual volume production. This includes preparing the manufacturing capability, filling channels, planning and executing marketing activities, preparing support functions and so on.

As a product is launched it may be that product awareness is very low, but as demand starts to increase, also the profits begin to grow. Nowadays, the product lifecycles in the fast paced electronics industries are getting shorter and shorter. This means that the products have less time to earn profits in the marketplace. Therefore, more emphasis is placed on the successful and well-coordinated product launch activities, because the faster the product's time-to-market, the sooner the products also start to generate profit.

In order to manage the tightening global competition, rapid changes in technology, accelerating industry clockspeed, increasing number of product variants, shrinking product lifecycles, limited supply, and price pressures, technology companies need to put more emphasis on managing product launches successfully and timely. Therefore, the focus of this study is to examine product ramp-ups of a global electronics manufacturer that operates in high volume and high clockspeed industry. Furthermore, special attention is paid to how the company could learn from previous product launches and utilize this information internally when preparing for upcoming product ramp-ups.

1.1 Research Problem and Objectives

The focal point of this study is product ramp-ups in an international consumer electronics company. The hightech electronics industry was chosen to be the focus of this study, because industry leans on new product introductions to attract market and customer interest. Due to short product lifecycles characteristic of the market, companies have little time to analyze and learn from their previous successes and failures in product launches. *Therefore, the purpose of this study is to identify how past experiences in product ramp-ups can be best utilized in a fast clockspeed industry.*

The objectives of the study are the following:

- *To identify challenges in product ramp-up planning and management*
- *To recognize the ways of improving performance through learning*
- *To create a tool for describing and analyzing past product ramp-ups and storing gathered information*

The current ramp-up planning culture and ways of working are described in a real world context of a case company, where the tool is to be implemented. The purpose of the tool is to gather the most relevant information and numerical data from the critical parts of product ramp-ups. The tool is expected to be applicable in high volume consumer electronics companies by supporting data storage and analysis related to product launches. Based on the conclusions made in the analysis suggestions on renewed ways of working are made.

1.2 Research Method

The thesis includes a theoretical part based on existing research literature on product processes and product launches. That is followed by an empirical study of a case company. The theoretical section covers topics such as new product development, productizing process, product lifecycle management, lessons-to-learn culture and best practices. The empirical part of the study is performed as a descriptive case study. The study is descriptive, since it illustrates and describes the topic of ramp-up management in its real-life context.

The purpose of the empirical case study is to describe how the case company performs activities related to product launches, and to identify how it could improve its way of working in the case of ramp-up products and provide a tool for helping in the preparation process. This is done by analyzing how product launches are currently handled in the case company including stakeholders, processes, measurement and targets and determining improvement potential based on the literature and empirical experiences.

Qualitative as well as quantitative data is used in the study. Qualitative data regarding the case is collected via interviews of case company employees who work with product launch related issues as well as from the company intranet. Quantitative data is from the case company's information systems and it is described in more detail in the chapter 4, section 4.4.4.

1.3 Limitations of the Study

As mentioned in section 1.2 the study is conducted as a descriptive case study. The scope of the case study is limited to managing of product ramp-up globally in the case company, so the study is limited to the early stages of the product lifecycle and more specifically to the start of mass production. In addition, the period of ramp-ups observed in the study is limited. The ramp-ups analyzed took place between July 2008 and August 2010. This interval was chosen because multiple process changes took place in early 2008 and product launches that happened before that would not be comparable and therefore, were left outside of the study scope.

A single case study such as this typically has limitations of generalizability of conclusions, models or theory developed. However, case studies can actually be generalized to theoretical propositions, but not to populations [Yin 2003]. In this study, a previously developed theory is used as a template with which the empirical results of the case study are compared, so no over-generalization should take place.

With case studies there is also the risk of misjudging a single event or exaggerating easily available data. In order to avoid this problem multiple sources of evidence are used in the study and explicit links are drawn between the data collected and conclusions made based on the data, so a reader can be assured of how recommendations came about.

1.4 Structure of the Study

The first section of the study investigates the basic idea of product processes and stages through different articles. Also product ramp-ups and their performance are studied through literature in this section. The second section focuses to the organizational importance of lessons-to-learn culture in general and to the benefits of implementing it.

After the research literature examination the study concentrates on describing how to plan, build and implement tools and processes for a lessons-to-learn culture, which considers the requirements that have been indicated in the literature. Additionally, the data gathered through the developed tools are presented and conclusions are made

based on the reports gathered. Furthermore, a set of recommendations is given based on the empirical and theoretical research.

1.5 Key Definitions Used in the Study

In the following the most used concepts in the research are described.

Assemble-to-order (ATO)

The trigger to delivery process start is located in assembly face. Placed orders start assemblies for a product.

Balanced Scorecard

A balanced collection of metrics to picture a company's performance, on the basis of which companies can set goals, which are strategically important.

Benchmarking

Benchmarking is a continuous improvement process with which the performance of object is measured and analyzed. The performance is compared to the best corresponding object and the knowledge is used to elevate the performance of internal processes. [Toivanen 2008]

Commercialization

Processes and actions placed to bring new technology to the market. [Simula et al. 2008]

Execution-as-Efficiency

In an organization where execution strives for efficiency leaders provide answers and employees follow strictly these directions. There is no need for individual employees' problem solving and it is not expected. [Edmondson 2008]

Execution-as-Learning

In an organization where execution is learning based, leaders set direction for working and employees discover the answers for problems. Processes are guidelines, which give the possibility to experiment and improve on the basis of available information. [Edmondson 2008]

Industry Clock Speed

Industries and industry segments are characterized by *clockspeed* that gauges the velocity of change in the external environment and sets the pace of their companies' internal operations. [Cohen et al. 1999]

Learning Culture/Organization

Organization with open mind set on problem solving where employees are skilled at creating, acquiring and transferring knowledge, which increases the performance of the organization through holistic and systematical problem solving that is enabled by tolerance and open discussions. [Garvin et al. 2008]

Lessons Learned

Lessons learned are utilized in project way of working as part of the closing stage of projects. A lessons learned event is organized to collect the main issues, challenges and learning points in that specific project. [Larson & Gray 2011] Product from a lessons learned event is a informal of written report for the top management or a presentation of main issues and lesson learned during the project [Cadle & Yeates 2008].

Make-to-Stock (MTS)

Company makes product to stock, which is replenished on the basis of orders. Production is based on stock changes

New Product Development (NPD)

Company creates new products in the company's own research and development department. [Kotler et al. 2001]

Nutcracker Effect

Supply shortage and high demand pressure companies from two sides causing a nutcracker like effect.

Productization

Processes and actions placed to make the product understandable for the organization so that it can be produced (ability-to-make) and sold (ability-to-sell). [Simula et al. 2008]

Product Life Cycle

Product life cycle describes the sales volume as the function of time, and the different stages of product's development: introduction, growth, maturity, decline and deletion that product goes through during its time-in-market.

Product Ramp-up / Launch / Volume Production Start

Production ramp-up is the stage when product starts mass production in an approved production system and the volumes start to gradually increase when production problems are reduced and supply capability is stabilized. [Berg 2007]

Time-to-Market

Time-to-market is the length of the time period between the initial invention of the product and the product launch to the marketplace.

Time-to-Volume

Time-to-volume is the length of the time period between the initial production start and reaching of target production volumes.

Time-to-Yield

Time-to-yield is the length of the time period between the initial production start and reaching of the target production yield.

Ways-of-Working

The roles, responsibilities and processes used in a business organization.

2 Product Processes and Stages

Customers' perception of products and effort needed to create them might be narrow. The customer only sees the finished physical product and marketing related to it and creates his or her own understanding of the product solely based on them. From the product manufacturer point of view, stages and processes a product goes through before it ends up in the customer's hands is significantly more complex. There are multiple different programs and projects that contribute to the product before it can even be handed to the end-user. The contributing interfaces from both upstream and downstream side are described in figure 1. After the product has been introduced to the consumer the product also lives through multiple stages before exiting the market.

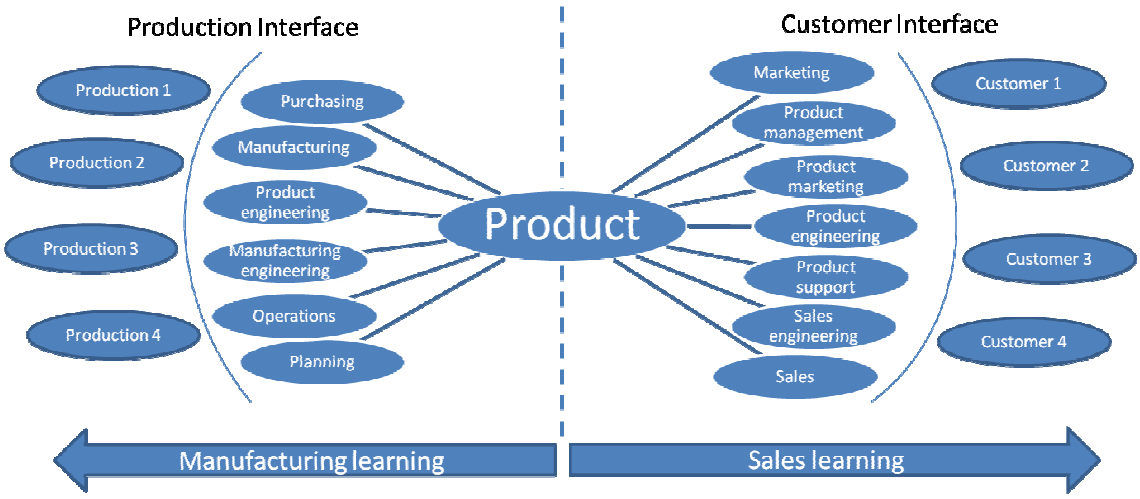

Figure 1. Interfaces to contribute before product launch [Leslie & Holloway 2006]

The different stages and processes of a product can be roughly divided in to three different segments. The first step in creating the product is to identify or generate the need for a product. Based on that, the company has to produce a strategy for the product to satisfy this need. The next step is to create the product physically and immaterially through product development and productization. The third step is then to manage the product through its lifecycle and contribute to it with the help of all the business processes so that the product would be as successful as possible from both the consumer and company perspective. The mentioned steps are illustrated in figure 2.

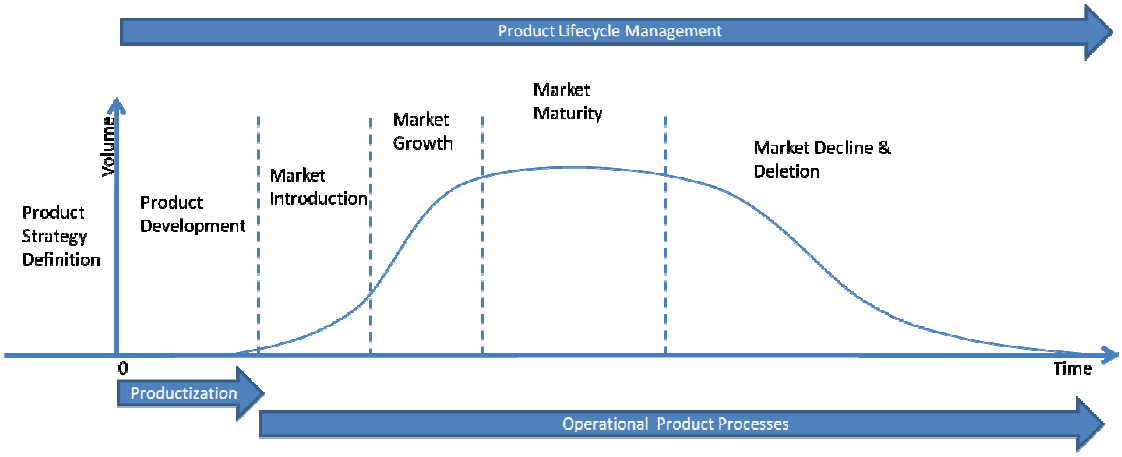

Figure 2. Processes and stages during product lifecycle [Korhonen 2008: 15]

In the following sections 2.1, 2.2 and 2.3 the stages described in the figure 2 are viewed from the perspective of how they affect the production ramp-ups.

2.1 Product Strategy Definition

Essential for a company's existence is to provide value for customers. The only way to deliver the value to a customer is to offer a product in one form or another. A product can be a physical piece of device or an immaterial service. To make the delivery of value possible, the company has to recognize a consumer need and then create something material or immaterial to fulfill that need. The way a company decides to deliver value to a customer and affect the market can be called a product strategy.

In technology industries, such as the mobile industry, the industry's clockspeed sets a challenge for creating a product strategy, because the business environment and landscape is constantly changing [Muneer & Sharma 2008]. In addition, the multiple variables from these changes affect forecasts and plans, so that painting the whole product portfolio is really challenging. Deciding the number of products and variants, and where they are to be distributed, and with what speed requires a significant deal of efforts. The fact that a company has only a limited amount of resources at its disposal does not make the situation any easier.

That is why companies are constantly forced to prioritize between different options and made to decide where to place most of their efforts. The planning in this stage is to contribute to the success and efficiency of the next steps. Muneer and Sharma emphasize in their article "Enterprise Mobile Product Strategy Using Scenario Planning"

[2008], the importance of scenario planning when it comes to product strategies and how important it is to imagine the future before proceeding into it, by evaluating the worst, medium and best cases that the company may face.

These points of product strategy create the initial requirements for manufacturing. This explains the role of product strategy when a product is introduced for mass production. The volumes, variants, distribution, customers and speed are all factors that are defined by the strategy and in that way make a standard for the production ramp-up, which is the focus of this study.

2.2 New Product Development and Productizing Process

If the product strategy gives the guideline where to head productization, new product development (NPD) concretizes the envisioned outcome. Also efficiency of these two often make the time-to-market of the product. If one of the elements does not finish in a desired time period, the launch of the product may be delayed.

So both productization and product development are crucial to the delivery start of a product and they are somewhat overlapping. Two studies "New Product Development: The Performance and Time-to-Market Tradeoff" by Cohen et al. [1996], and "Rethinking the product – from innovative technology to productized offering" by Simula et al. [2008], describe the characteristics of productization and product development in a manner that is suitable for this study.

Cohen et al. [1996] describe the product development in five different steps that produce the final product, which is then introduced to productization and mass manufacturing. Their model describes the following steps:

- Concept generation
- Product design
- Engineering analysis
- Process analysis and design
- Prototype production and testing

Product development traditionally refers to the development of the physical product, but in today's business environment many of the products are more than basic products for a single purpose of use. Especially the company that is focus of this research has strong foothold in the development of software for handheld devices. That is why product development has to have two sides walking hand in hand to produce the wanted outcome, namely the physical product and the software. In the case company the software development department develops a software platform which is then implemented in new products until an enhanced version is available for upcoming products. The software to be implemented determines the requirements for the hardware and on the other hand, the planned hardware sets requirements for the software and in this way the two development parties have to be in close collaboration to deliver combined platform for productization.

After product development round the product skeleton is ready to which the productization starts to add flesh in order to make the product ready commercially. Even after productization takes over the product collaboration with product development still continues. Simula et al. [2008] divide productization into two parts: inbound and outbound productization. The inbound productization is the first step in taking developed skeleton of the product onwards.

In the model of Simula et al. [2008], the inbound productization creates the *ability to make* the product in a bigger scale. This means that the inbound productization has to define the received skeleton in a way that an organization can understand it and start to manufacture it as a product. The inbound productization consists from the following parts:

- Final design specification
- Material selection and sourcing
- Production tool
- Assembly instructions
- Product data management
- Testing process and quality control
- Certification and accreditations

The outbound productization creates the concrete and visible offering to the consumer from the basic platform that the inbound productization has formulated. The outbound productization according to Simula et al. [2008] consists of the following areas of development:

- Branding and naming
- Warranties and technical support
- User guides and documentation
- Advertisements, brochures and white papers
- Customer testimonials
- Contract and/or license terms
- Sales channels and commissions
- Services after sales
- Sales tools and pricelists
- Logistics and packaging

By completing all the named tasks the product gains the ability to sell [Simula et al. 2008]. This section of productization has a key role in today's business environment especially in handheld consumer electronics where the superior technology is not the only aspect that takes one company past others.

The importance of product development and productization cannot be over emphasized, because every mistake and change in these stages and processes has a drastic effect on the performance of the production ramp-up, which is in the limelight of this research. Inbound productization affects especially the physical manufacturing through sourcing, tooling, final design, testing and quality control. On the other hand outbound productization is an increasing priority, because the business environment starts to fill from service providers that offer the product as cloud companies, meaning that the product is not the main reason for the purchase anymore, but services around it that are accessible through the product. That is why the changes, for example, in customer applications can immensely inflict the development of volume manufacturing readiness.

The research by Simula et al. [2008] also makes a difference between commercialization and productization. It points out that commercialization concentrates more on delivering a new technology to the market. In that way commercialization is a wider term focusing on development of the whole technology whereas productization concentrates on delivering one single offering.

2.3 Product Lifecycle Management and Operational Product Processes

A product's presence in the market, time-in-market, can usually be divided into four different stages: introduction/development, growth, maturity and decline, as presented in figure three. These four stages have been introduced in multiple sources, for example, by Theodore Levitt in his article, "Putting the Product Lifecycle in to Work" [1965]. The article describes the strategic decisions that have to be made in different stages of the lifecycle to make a product profitable and successful. These decisions can be called product lifecycle management, which drives the operational processes, such as manufacturing, sales, marketing, logistics and planning to act accordingly.

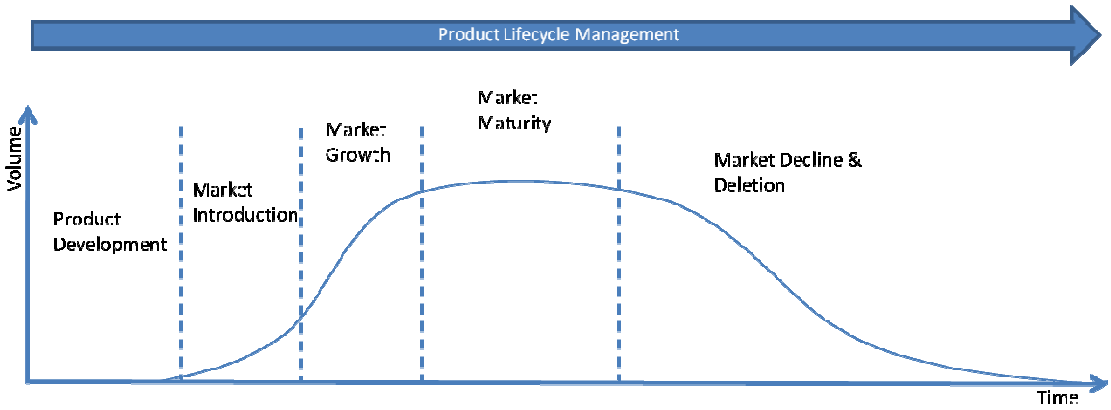

Figure 3. Stages of product lifecycle [Kotler & Armstrong 2001]

In his article Levitt [1965] describes the importance of the concept of product lifecycle and how it should be used as a competitive power. A key factor in his article is the proactive way of anticipating future stages. Early planning, looking ahead, advance thinking, sample planning and acting are the topics that are discussed widely in his text.

Early planning is defined as the promotion of more frequent usage, developing varied usage, finding new users and uses. By looking ahead the company can become aware of competitive and market events and then make noticeable improvements to the short term tactics of the product. When these considerations have been made the company has to also be aware what the impact of one decision has in the following phase. All the effects cannot of course be forecasted and therefore, the company has to act on the basis of conclusions at its disposal, for example, a sample plan, which describes the goal for a product for certain time intervals and therefore, provides a vision where the product should go [Levitt 1965].

Another approach to utilize lifecycle way of thinking is to clarify challenges in the different stages of the lifecycle and that way dodge the problems that Levitt describes. Product sales, profits and requirements will fluctuate in different phases of the product lifecycle and they will set a multitude of challenges to different segments of corporate business. Especially the development of profits with changing demand builds a set of difficulties and challenges. The development of profits during the products lifecycle is described in figure 4.

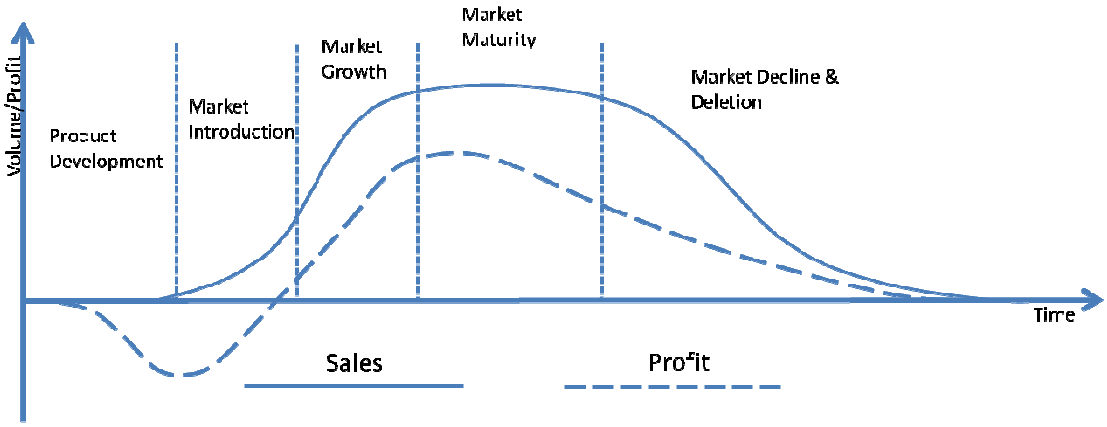

Figure 4. Product profits during product's lifecycle [modified from Korler & Armstrong 2001: 354]

In cases where a new product consists of spear head technology and is a unique product in the market the profits in the market growth phase might be higher due to low competition and willingness of forerunner customers to pay. Whereas when the product is an upgrade or a straight forward successor for the previous product the relative profit difference of growth and maturity stage may be lower to some extent. With products where the relative profit of the growth stage is higher the significance of the efficient production ramp-up increases. The shorter the time-to-market and time-to-volumes are, the more the company can generate profit with the new product. The development of profits is connected to the efficiency of surrounding processes during a product's lifecycle. This is why all the processes of the company have to change their objective with the product when it moves from a stage to another. The challenges with a new product can be described as presented in the table 1.

Table 1. Process focus areas in different stages of product lifecycle [Modified from Kotler & Armstrong 2001: 361; Putkiranta 2010]

New product Lifecycle	Development	Introduction	Growth	Maturity	Decline/ Deletion
Marketing	Efforts on planning the launch.	Lots of efforts to achieve the attention of the market and increase market share.	Efforts continue to increase the awareness of the market. Option to change image.	Efforts focus on maintaining the interest. Altering image not beneficial.	Efforts are transferred to other products.
Sales	Not started.	Slow and low sales. Increasing Profits.	Increasing sales. Option to change price.	Sales peak and market saturation. Altering price not beneficial.	Sales focus on deleting the product with lowest liability.
Manufacturing	Planning and finalization of tooling. Line verification. Prototype development.	Increasing volumes require production ramp-up, efforts on increasing the yield and quality. Small production batches. High production costs.	Production ramp-up with the pace given by demand.	Stabile volumes reached, production performance stabilized. Capacity optimization. Altering quality not beneficial.	Freezing production volumes before hand on the basis of forecasts. Utilization of excess capacity.
Sourcing	Material and supplier selection.	Supplier collaboration, providing visibility to demand.	Supplier volume ramp-up, material shortages force allocations.	Increasing competition generates global shortages.	Active control of liability, inventory exhaustion.
Human resources	Lots of resources before launch to achieve best possible offering.	Marketing and manufacturing focused.	Manufacturing and sourcing focus.	Marketing and financial focus.	Financial focus.
Logistics	Channel and setup planning	Channel fulfillment	Coping with the high growing demand	Maintaining the flow of goods	Utilizing spare capacity

The requirements and challenges in the first three stages, development, introduction and growth, are crucial to this research. After all, the focus of this study is to enhance

product lifecycle management by amplifying and distributing the knowledge of individuals around production ramp-ups in the past. Also the profit aspect arises when trying to improve production ramp-up performance due to speed first and yield first decisions [Terwiesch & Bohn 1998] and a manufacturer also has to evaluate the trade-off between product performance and time-to-market.

2.4 Controllability in Global Manufacturing

In global manufacturing the surrounding external factors of the market space create a multitude of challenges that companies have to cope with. The external factors described in figure five are developed through the sum of actions of multiple players in the market landscape and largely cannot be altered by a single stakeholder. To balance the situation, which external factors develop, companies have to counter act them with actions, called as the internal factors. By identifying the dependencies between challenges created by external factors and the corresponding internal factors to solve the challenges companies can effectively maintain the inflow of profits. [Putkiranta 2007]

Figure 5. Challenges from external factors and corresponding alterable internal factors [Putkiranta 2007]

Demand factors such as delivery time, delivery flexibility, demand forecasts and customer specific product requirements are the main creators of challenges from the downstream. In the upstream challenges originate from material delivery times, availability forecasts and delivery time accuracies. Also several of other external factors such as strikes and competitor pricing develop situations which are challenging for companies. [Putkiranta 2007]

The external factors develop situations and challenges the companies have to cope with. In warehousing supply problems and weak visibility force companies to secure their deliveries with high inventories or act with uncertain supply, which might lead into obstacles later on in the process and in that way create final product shortages. When facing shortages companies have to deal with customers, since the supply is not sufficient. The visibility of supply is not the only challenge when it comes to forecasting. The demand faces similar challenges from the downstream in the form of constant demand changes. In production the forecasting and warehousing challenges may lead into poor capacity usage or on the other hand in capacity shortages. While striving to meet the requirements of the supply and demand production faces problems in lead times and scheduling. The situation burdens the collaboration further between processes. Sales are short of products and the stages of production are functioning with a different pace. These several challenges may create a final situation where operations seem to be uncontrolled. [Putkiranta 2007]

The control can be maintained by identifying the measures that affect the process in a way that is beneficial for the whole organization. The measures can be small adjustments, which may have drastic effects on the total flow of material, capital and information. In sales adjustments can be made to price levels and in marketing the visibility of the product can be adjusted to reach a wanted outcome. With product portfolio the availability of product diversity can be adjusted in the different areas of the market. As part of supply chain management the deliveries can be allocated when the supply is short and strategic decisions are needed to maintain market share. In production adjustments can be made in layouts, batch sizes and capacity levels to reach the desired goals, which satisfy the current need. Human resources are also a part of the controlling parameters that can be adjusted to adapt into the prevailing market space. [Putkiranta 2007]

In this research the challenges faced in the past and the external factors responsible for these challenges are identified by means of a lessons-to-learn culture. Also the corresponding adjusted internal factors are gathered with the same method. Measures are taken to elevate the knowledge of individuals in a working community to increase the performance of production ramp-up management in a specific business unit. To understand the nature of production ramp-ups in general an exploration to literature wield-

ing around the subject is made. The goal of the exploration is to identify the areas, which affect production ramp-ups and how they are examined by different sources. The gained perspective is then utilized to create an effective approach to productions ramp-ups and in that way create structured tools which enable a continuous learning culture in a business function.

2.5 Product Ramp-Ups in Scientific Literature

The performance of a production ramp-up is crucial in industries where product life-cycles are short and industry clockspeed is remarkable. Topics like time-to-volume, time-to-market and product performance with quality play a big role in the demanding environment of handheld consumer electronics. The delay of a launch or low output will cause financial losses to a company in the form of lost profits, because the product starts to sell only when it is in the market. That is why improving production ramp-ups is constantly under focus in companies where the impact of unsuccessful increase of volumes is the greatest. The industry clockspeed plays immense role in the high technology consumer electronics. The external environment sets such a high pace for the internal operations of firms that the development and manufacturing times are significantly shorter [Mendelson & Pillai 1999]. This requires all the time improved operations especially in the beginning of the product lifecycle and more specifically in the production ramp-up.

Product ramp-ups are quite widely studied in the literature and from varied perspectives. One of the key sources to this study has been an article called "What Determines Product Ramp-Up Performance?" [Pufall et al. 2009]. In this study a conceptual model is presented to explore the essential characteristics that affect product ramp-up performance. In their study they introduce a set of studies regarding production ramp-up improvement [Clawson 1985; Langowitz 1987; Clark & Fujimoto 1991; Pisano 1995; Terwiesch & Bohn 1998; Almgren 2000; Kuhn et al. 2002; van der Merwe 2004; Schuh et al. 2005]. From these studies a few are taken into comparison to build a legitimate concept for production ramp-up learning. The comparison studies selected for this research are: Clark & Fujimoto [1991], Kuhn et al. [2002], and Almgren [2000] with Pufall et al. [2009]. In addition to these studies a study by Berg [2007] is introduced in which the effects of supply inadequacy during ramp-up are contemplated. Berg's pers-

pective on examining ramp-ups is also taken into comparison. These five studies are presented in figure 6 and selected to this research because they examined production ramp-ups by dividing the subject in to smaller areas of research. The type of dividing enables examination with which the topic can be studied as thoroughly as possible.

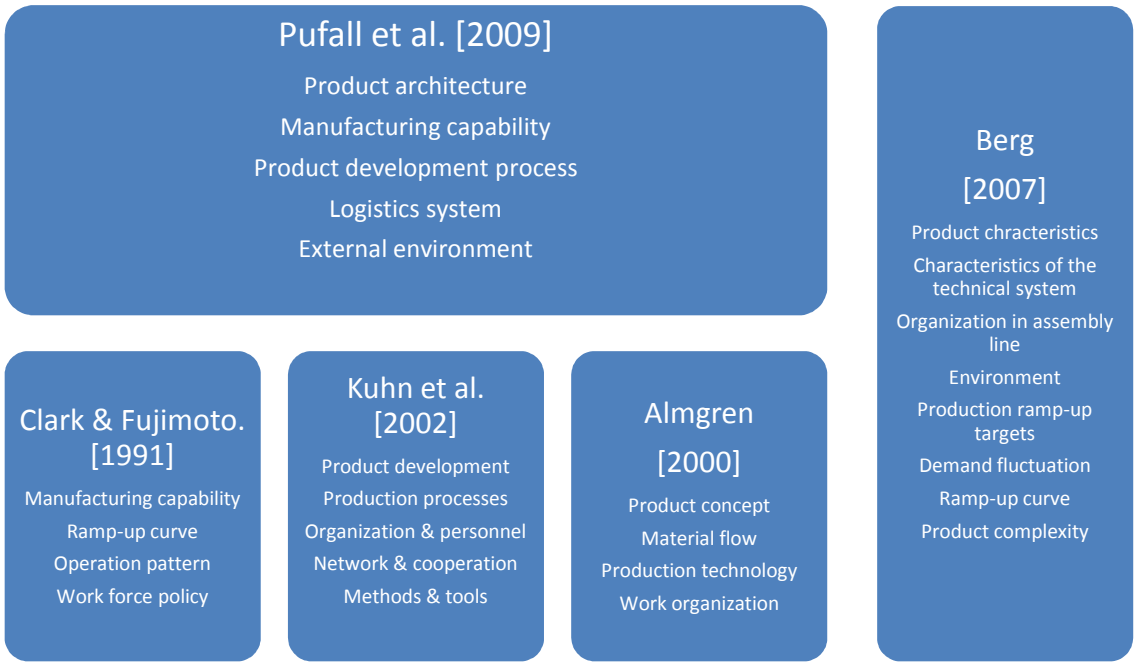

Figure 6. Studies compared in this research

Clark and Fujimoto [1991] divide the production ramp-up into segments such as manufacturing capability, ramp-up curve, operation pattern and work force policy. The manufacturing capability is seen as efficiency of the production process. The ramp-up curve in their study is presented in figure 7.

The three ways of product transitioning possess their own strengths and weaknesses. By shutting the previous product down the new product cannibalization probability is prominently lower. Shorter product transitioning phase on the other hand is significantly riskier since appearing challenges impact directly to the volumes. With the longer transition and ramp-up curve the company might face problems with unsold-goods, cannibalization and focus. Longer transition time also requires more complex scheduling and control, because operations have to concentrate on multiple products. Operation pattern in the study presents the volumes produced in the line whereas the work force policy describes the capability to recruit more human resources. [Fujimoto & Clark 1991]

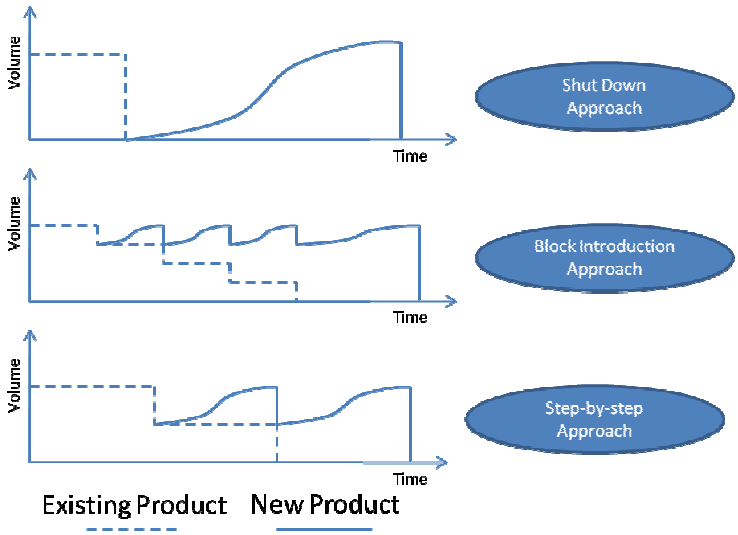

Figure 7. Three ways of product transition/ramp-up [Fujimoto & Clark 1991]

Kuhn et al. [2002] adds a few more areas in their study. They also see the importance of production process and personnel, but from a different angle. In their study production process describes the efficiency and capability of the process and organization and personnel part describes the competence and clearness of roles and responsibilities in the process. Term logistics in their research is a general expression for availability and quality. Networks and cooperation stand for the communication, information flow and visibility in delivering the product. As a final part of the research concept they introduce the expression methods and tools to describe the change and project management skills and practices.

Almgren [2000] follows the same pattern. He describes production, materials management, product and human resources important factors to consider in product ramp-ups. Product is seen as the whole product concept and changes in it affect the ramp-up. Material flow indicates the logistics field of ramp-up by covering the quality, quantity and availability functions. Production technology on the other hand, is the manufacturing capabilities during the ramp-up and working organization presents the competence of the human resources. [Almgren 2000]

Pufall et al. [2009] have based their research partially on these three studies mentioned earlier. Their conceptual model consists of the following: product architecture, manufacturing capability, product development process, logistics system and external environment. Product architecture is divided into complexity and newness. They define

complexity as the number of components and interfaces between components. The product newness on the other hand, is to picture the prior experience and magnitude of technological change in the product. These facts add uncertainty, risk and extra effort to the ramp-up. The product newness can be divided into functional module newness (newness of modular parts), technology newness (newness of the production process and methods) and software newness (newness of critical features). Manufacturing capability refers to the abilities of production.

Pufall et al. [2009] divides the manufacturing capability into growth and steady state capabilities. Growth capabilities stand for the ability to expand the operation and improve the performance of a production line. Steady state capabilities are the abilities and agility to stabilize or change set-up in the manufacturing. The process development stands for the ability to build a process for mass manufacturing. Pufall et al. [2009] divide it into three subareas: process performance, product concept effectiveness and market situation. Process performance stands for the productivity and speed of the development community. Product concept effectiveness stands for the involvement of a customer to the progress. Market situation refers to the external environment factors like market size, growth and competition. In logistics system the research drills down to factors that affect ramp-up performance through logistics. For example, they point out that "geniality" of the product for logistics in means of design and the quantity of logistic facilities in the process associate with improved ramp-up performance.

In the research by Berg [2007] product ramp-up is characterized from eight different perspectives. Product characteristics in his study define the dimensions of the product, for example, weight. Characteristics of the technical system describe the manufacturing process and the quality and quantity of the manufacturing hardware. Organization in the assembly line describes the qualification of the human resources working with the production line. Environment in Berg's study presents supplier base and production ramp-up targets describe the target setting for the ramp-up, for example:

- Total volume: 23000 products
- Tact time: 230 products / day
- Time: four weeks to a reach 85% share of the total volume

Demand fluctuation in his research stands for the order penetration point and how the company is anticipating the development of demand, for example, make-to-stock (MTS) and assemble-to-order (ATO). Ramp-up curve is to describe the length of the ramp-up as described by Clark and Fujimoto [1991]. Product complexity stands for the novelty in the product, describing the age of technology and testing level of the product [Berg 2007]. Also late supplier choices, engineering changes, priority of manufacturability, verification of material supplier capability, supplier collaboration, project cross functionality and time pressure are mentioned in the context of supply affecting to production ramp-up capability. These factors and their connection are described in figure 8 to indicate the reasons for supply availability during a ramp-up.

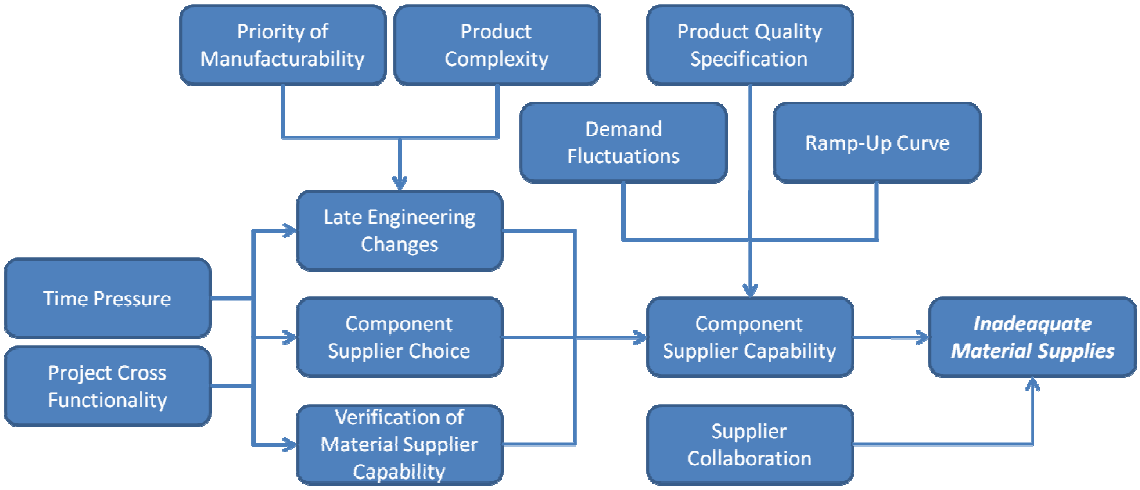

Figure 8. Reasons for supply availability during ramp-up [Berg 2007:5]

As mentioned in this section previously production ramp-ups can be described and measured in multiple ways. That is understandable because all of the studies look at product ramp-ups from different perspectives observing different products in different environments. Table 2 presents the comparison of all the studies mentioned.

Table 2. Ramp-up studies and their perspectives

	Material & Manufacturing Capability	Human Resources & Communication	Product & Product Concept	Customer Environment	Supporting Processes
Pufall et al. [2009]	Manufacturing capability		Product architecture	External environment	NPD process, Logistics
Berg [2007]	Ramp-up targets and curve, production system characteristics, priorities, supplier capabilities,	Organization in assembly, project cross functionality	Characteristics, complexity, engineering changes	Demand fluctuations	
Kuhn et al. [2002]	Production processes, methods and tools	Organization and personnel, network and cooperation			NPD process, logistics
Almgren [2000]	Production technology, material flow	Work organization	Product concept		
Clark & Fujimoto. [1991]	Manufacturing capability, ramp-up curve, operation patterns	Work force policy			

As a conclusion, it can be said that all of the studies mention that factors such as human resources and communication, material and manufacturing capability, supporting processes, customer environment, the product and product concept affect product ramp-up performance. However the main focus is on the manufacturing itself, but it is important to note that the different studies add different features to the examination.

3 Nutcracker Effect Forcing to Improve

In the current global situation, in which the economies around the world are arising from the slump or recession, the supply of multiple electronics components and materials is not building as rapidly as the demand in some markets. The downfall of economy and demand caused many sources of material and manufacturing to decrease capacity.

Now when the demand is rising again the capacities cannot grow in such a fast pace as would be needed, the effect is like a gigantic bullwhip. The bullwhip effect slashes the global marketplace, which causes companies to react accordingly. Companies around the world exhaust their channels to a minimum so that every possible saving can be made. In the upstream this forces suppliers to decrease their capacity and the next challenge they will face is that they are requested to supply with bigger capacity than ever before. Of course the uncertainty which never completely disappeared affects the minds of the suppliers, which further slows the progress. So at the moment the global electronics capacity is somewhat limited. In the mean time the demand is booming for certain components and products, which causes the so called "Nutcracker" effect [Terwiesch & Bohn 1998], and makes the situation worse for some stakeholders.

This forces many of the companies drill into the question of speed first versus yield first. Actually the comparison is easy: both are needed first. Industry clockspeed requires the speed first and global supply situation demands yield first. This is really a situation that needs to be acknowledged. The ones to manage this situation have to dig into their processes, because mistakes are not allowed. One way to speed up to the process efficiency requirements is by improving ramp-up performance. In this research we suggest a way to improve this crucial stage of product lifecycle by learning from the past experiences of individuals in a working community.

Every organization, which utilizes project or program way of working, has to go through all the steps of the same processes multiple times. This frequent repeating of tasks increases the level of skills, but somehow still the organization tends to bump into the same pitfalls from time to time even if everyone in the projects or programs has the mandatory lessons learned sharing at the end. It seems like learnings are gathered and contemplated, but somehow they disappear from the longer term memory

of the organization. That is why the learning should not consist of separate events, but from a continuous and active culture that focuses on contemplating, sharing, combining and discussing issues, which have disturbed or enhanced the ways of working in the past. This way a community is able to improve performance, not by enhancing the discrete segments of scorecards, but the whole picture by elevating their own skills proactively through adopting the knowledge of others.

Companies have an enormous amount of numeric data gathered from the past and it is possible to dig the information years backwards, but then what? One will get to know exactly *what* happened in numbers, but information telling one *how* it happened stays unrevealed. By extracting the tacit knowledge from employees and then sharing it in a structured manner, with the information answering what happened, the individuals can learn and in that way the whole community will learn.

3.1 Lessons Learned as Part of Project Learning

Project way of working is well recognized in the corporate organizations of today. The project way of working can be utilized in multiple areas of operations. The typical characteristics are an established object, defined lifespan, involvement of several corporate departments and professionals, new object of doing and specific requirements in terms of time, costs and performance. [Larson & Gray 2011] Similarly a new product launch in consumer electronics market is done in a project format. Taking a new product to the market is the established object, which is given criteria in terms of volume and time. They describe the lifespan, the beginning and the end of the project. Different processes contribute to the product launch with given time, cost and performance resources during the launch project's lifecycle.

A project's lifecycle can be divided into four stages: defining, planning, executing and closing as described in figure 9. In the defining stage the initial goals and specifications are given to the project. Also the responsibilities and different tasks are clarified in this stage. In the planning stage the means to achieve the goals are clarified in the form of scheduling, budgeting, resourcing, staffing and risk planning. These plans are then implemented in the executing stage. The execution is monitored through status reporting, quality control and forecasting. Most often the produced plans do not cover all needed aspects of the project or a change is required to the plans due to transition in

the desired outcome and that is why importance of change management is recognized during projects. After executing stage the project enters the closing stage. In closing stage customer care is maintained through training and collaboration. In addition, all the documents in the project are transferred and stored. The final decision to release the allocated resources for the project is also done in the closing stage. Finally the project team and stakeholders create an evaluation and a lessons-learned report of the project before it can be terminated. [Larson & Gray 2011]

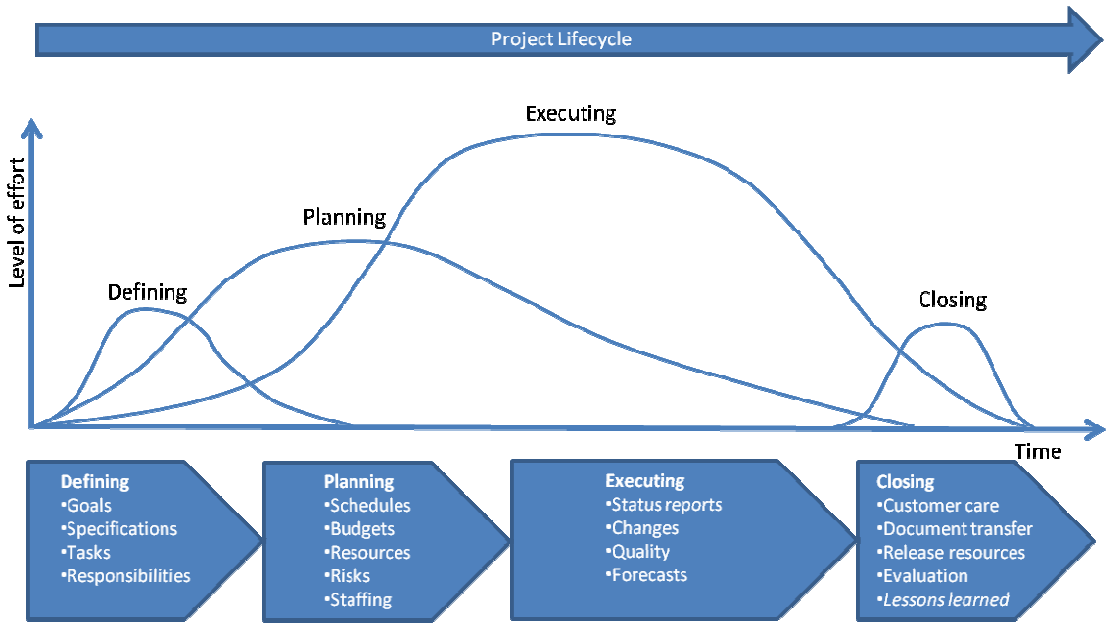

Figure 9. Project lifecycle stages [Larson & Gray 2011:7]

Most often when a project reaches the evaluation and lessons learned stage the allocation of the project team to other projects is initiated. Due to the allocation the focus to these crucial areas of a project lifecycle is significantly lower than in other stages of the project lifecycle. The evaluations, lessons learned and issues during the project are usually gathered and processed in a post- project review. Cadle and Yeates [2008: 108] describe the result from a post-project review as follows:

> The main product of a post-product review is usually some form of written report for senior management plus, perhaps, a presentation of the main issues and lessons learned.

The type of informal reporting with shallow future purposes does not utilize the full potential of project learning in general. When the reports are in an incoherent format

and scattered into multiple locations, the one seeking knowledge from the past is rapidly encumbered by the workload. The aspect of learning is the key especially in high clockspeed industries like consumer electronics where single work assignments are shorter than in industries where the clockspeed is slower. This contributes to the fact that the tacit knowledge gained by individuals perishes faster when employees proceed to new assignments more often.

In project way of working where lessons learned is a part of the closing stage the main learnings and challenges in the project are gathered to elevate knowledge of the specific project team. The utilization of learning can be improved and disappearance of knowledge from a business unit can be reduced by gathering the knowledge for future purposes. By gathering the information in a structured manner and format into a source the knowledge of numerous individuals can be searched and utilized by a single individual. In this way increasing the knowledge of one individual the overall performance of the community can be increased and the total workload can be reduced.

According to Salmi [2009] reduced workload can be achieved especially by increasing the effort in defining and planning stages of the product. By elevating the effort in these two stages the effort needed in the execution stage is reduced as described in figure 10.

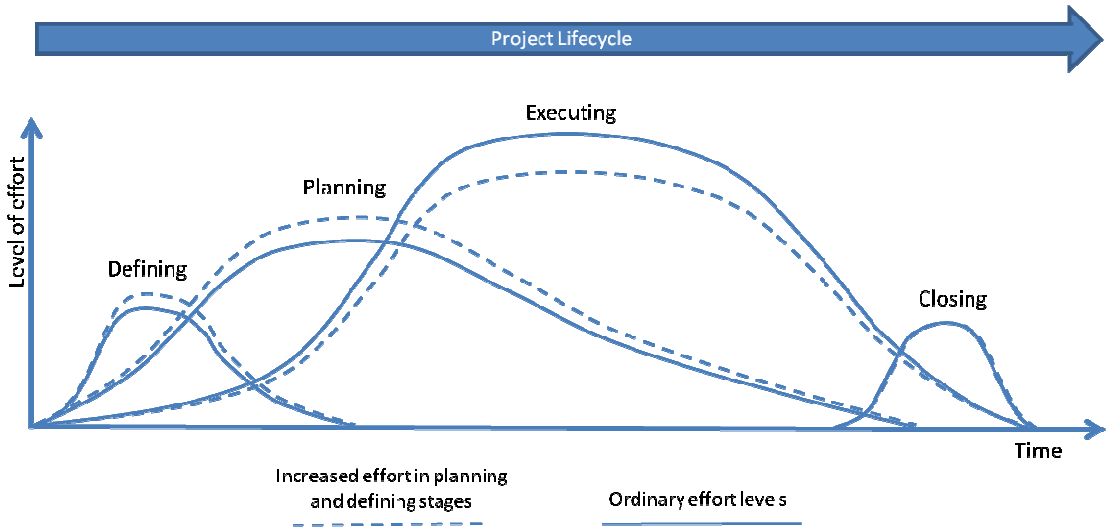

Figure 10. Decreased total workload due to increased effort in the defining and planning stages of the project [Modified from Salmi 2009]

Similarly the same logic could be extended to a situation where a sudden change or challenge during project lifecycle would require planning. In this type of situation the change or challenge should be dealt with elevated care. The planning should aim for longer term benefits instead of hasty and careless resolutions, which could lead into extra workload in the actual execution. By temporarily adding effort into anticipatory planning the savings in the actual execution may be significant in longer term especially when resources are limited.

The learning aspect and sharing lessons learned is important in the project way of working, but also the learning aspect is important in the organization as a whole. In this research the lessons learned concept is elevated to lessons-to-learn to promote the importance of future learning. This is done to make a difference between separate learning events and a continuous learning culture where the gained knowledge would exist even if employees would change. In section 3.2 learning in organizations is described more thoroughly.

3.2 Reflecting on and Learning from Previous Experiences

In the literature learning in organizations and processes has been a considerably discussed subject for quite some time now. In processes, especially in manufacturing, the concepts of learning and experience curves are often referred to. On the other hand in organizations the importance of cultural elements is frequently mentioned when it comes to learning.

Learning curves and experience curves are based on an observation that the needed production effort decreases by 20% when production volumes double [Haverila et al. 2005: 369-371]. The experience curve is a bit broader term than the learning curve taking the previous experience of the operating unit into consideration and not just the learning in the current production program. Both the learning curve and experience curve lead in to a fact that increase of volumes or experience will decrease the level of needed input and elevate the relative quality and quantity of the output. This idea of how accumulated knowledge or experience leads into lower costs and better output, revenue and profits is introduced in figure 11. [Terwiesch & Bohn 1998].

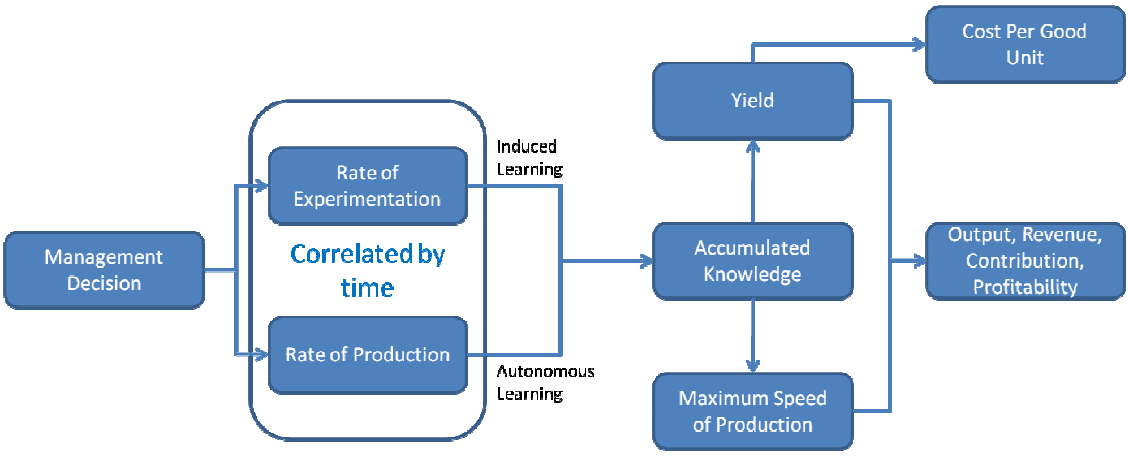

Figure 11. Causes of learning and improvement [Terwiesch & Bohn 1998]

In the concept above two ways of increasing the amount of knowledge are introduced, which elevate the performance of the process. The knowledge in the process can be accumulated by inducing it or by gaining it autonomously through the rate of production [Terwiesch & Bohn 1998]. In this research this same concept works as an example on how the performance of a process can be enhanced by inducing additional learning into the process through community based information sharing and learning.

Organizations frequently find themselves in a pitfall when they think they are perfect and their execution is flawless and there is no way to improve the ways of working. However, organizations may be forced to change their thinking when a competitor drives over them with a superior working culture and execution. It is also possible that unhealthy rivalry arises between employees when everyone in the organization only strives for their own incentives. In addition if the workers happen to be under a huge schedule pressure they will crumble and fail to reach targets and they will never have the time look to back to their mistakes and learn in that way. These are the problems that come from execution where efficiency is the only goal (Execution-as-efficiency) [Edmondson 2008].

The organizations, on the other hand, which are more knowledge-oriented, execute more as learning (execution-as-learning) [Edmondson 2008]. These organizations use the best knowledge available to design guidelines and enable the employees to collaborate by giving the possibility to share knowledge. To get information available these organizations utilizing execution as learning, capture the information during processes to comprehend the current state of various processes. As the most important thing the

organizations keeps this learning going all the time, making the learning business as usual [Edmondson 2008]. Some successful organizations have implemented the execution as learning successfully and reached a stage where learning is fast and also quality of standards is maintained high. The differences in Execution -as-efficiency and learning are described more specifically in figure 12.

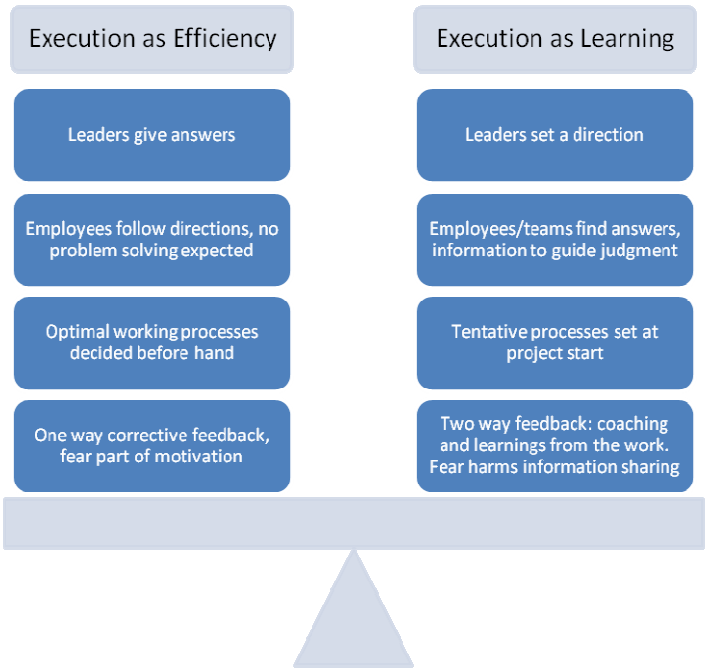

Figure 12. Execution-as-efficiency versus Execution as learning [Edmondson 2008]

To establish this type of culture where learning is fostered through sharing and collaboration the organization has first to build the foundation for it. This type of foundation consist of three parts, namely supportive learning environment, concrete learning processes and practices and leadership that reinforces learning [Garvin et al. 2008], described in figure 13.

A supportive learning environment sets a base for individuals to draw closer to the new way of working. As the first step the psychological safety of the employee has to be ensured. An employee has to feel safe to share ideas and problems. In the environment individuals have to have a right to be different and everyone's ideas have to be welcome and taken into consideration. Also the working cannot be so hectic that the workers cannot stop to contemplate their success of failure [Garvin et al. 2008].

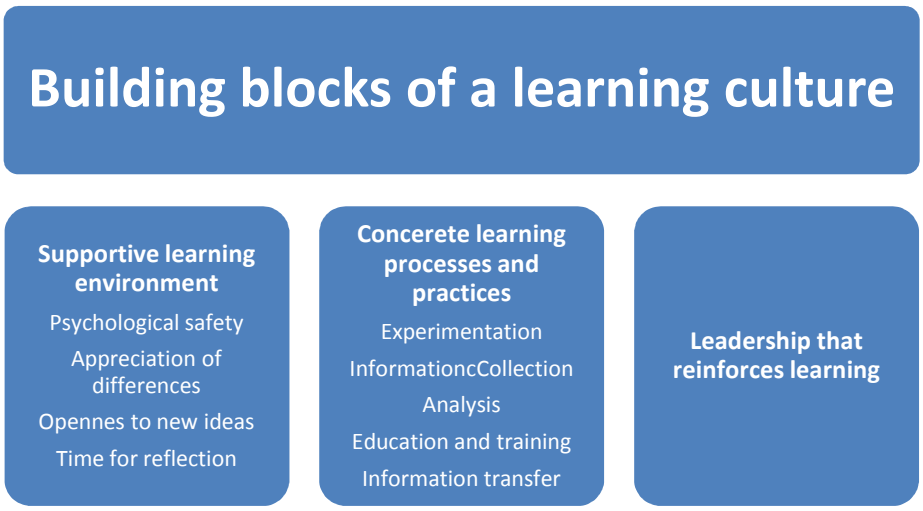

Figure 13. Building blocks for a learning culture [Garvin et al. 2008]

To make active learning possible in the culture the concrete learning processes have to be established. Management has to be ready to experiment new ideas and collect the information from new ways of working and from the old ways of working. The information has to be then analyzed so that continuous improvement is maintained. Through the findings of analysis employees have to be educated and trained, for example by placing the information available or by actively training people. People can then transfer information inside a community and past the boundaries of corporate silos, but to make the obtained knowledge useful they have to have time to contemplate on it [Garvin et al. 2008].

Finally, the most important building block of a learning culture is the leadership. Management has to establish a mindset inside them that they do not give the right answers, but they ask the right questions. In that way they will reinforce the culture through leadership [Garvin et al. 2008]. The employees have to be offered the process guidelines, which to follow and the tools to use, so they can collect the data on which they can reflect [Edmondson 2008]. This way the following is achieved and performance of an organization is improved:

> Fostering an atmosphere in which trust and respect thrive, and flexibility and innovation flourish, pays off in most settings, even the most deadline driven. When managers empower, rather than control; when they ask the right questions, rather than provide the right answers; and when they focus on flexibility, rather than insist on adherence, they move to a higher form of execution. And when people know their ideas are welcome, they will offer innovative ways to lower costs and improve quality – thus laying a more solid foundation for their organization's success. [Edmondson 2008: 67]

To summarize, many companies would benefit from a learning culture. However, it is not enough to establish a purely qualitative culture of learning, but it has to be supported by concrete measurement of performance that can be used to legitimize the efforts made in supportive learning environment, leadership, processes and tools. Ways for measuring and monitoring are described in chapter 3.3.

3.3 Measuring and Monitoring Performance

Measuring and monitoring performance is a common way to increase and accumulate the knowledge from an interesting object [Saari 2004]. In organizations the prevailing assumption is that "what you measure is what you are" and "what you cannot measure you cannot improve." Usually measuring is done with variations of the balanced scorecard introduced first by Robert S. Kaplan and David P. Norton in 1992. Most measurements used today are still financial based, focusing on the cash flow and income statement, but there are also some measurements in the operational level. However they may be less strategic [Toivanen 2008].

Nowadays, the focus should be added also on the operational process performance and not only to the financial output [Varia 2005]. As an example how placing measure in one area leads into benefits later on is indicated in figure 14.

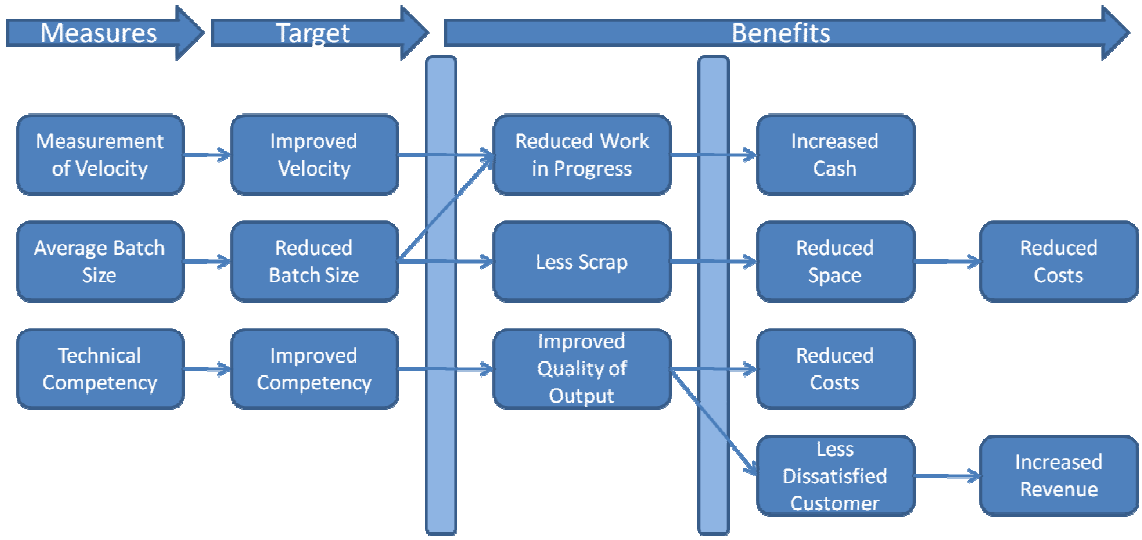

Figure 14. Process and output in measure utilization [Varia 2005]

In its best form a measure gives information about a company in an understandable way [Saari 2005]. By repeating the measuring after certain time intervals, i.e. monitor-

ing, it will describe the progress – positive or negative. This way the top-down communication can more easily indicate what is important for the organization. The simplest way to communicate is to divide the measured performance with the desired performance. This way the relative calculation describes the current state of an organization compared to the objective. In production ramp-ups the idea could be implemented to measure the speed of a ramp-up. By setting a goal, e.g. maximum volumes of the product lifecycle to be reached in six weeks, the calculation would be as presented in figure 15.

$$\frac{\text{Measured Performance}}{\text{Desired Performance}} \rightarrow \frac{\text{Sixth Week Production Volume}}{\text{Product' Lifecycle Maximum Production Volume}} \rightarrow \text{Ramp-up Speed}$$

Figure 15. Example of measuring ramp-up speed

The top-down communication would be: the organization desires to reach the maximum volume in six weeks and the organization should operate accordingly. Of course the measurement does not always tell everything and in some cases the calculations can be misleading. That is why there should be complementary measures. For example, to accompany the measure described figure 15, there should be a complementing measure indicating the time how rapidly the maximum volume was achieved. This way the measurements would provide information about the organization's performance and also communicate the goal from the management.

Ramp-up speed being just an example, there are numerous ways to measure the performance of ramp-ups, for example: operational performance, effective utilization rate, dependability performance and customer perceived quality (presented in appendix A.) [Pufall et al. 2009]. In product launches performance indicators such as on-time-delivery and launch volume are measured. But as described earlier in this research these measurements cannot indicate improvement if the cause for the outcome is not known. This is why the tacit information behind the outcome has to be revealed, which enables path to learning and improvement. One way to explore better practices and improvements is by benchmarking, which is described in more detail in 3.4.

3.4 Benchmarking for Improvement and Best Practices

Benchmarking is a way to search for and develop better ways of working. It works as a continuous and consistent process, which helps organizations to achieve these goals,

improve operations and learn. This type of enhancing is done by comparing to the best available, learning from it and then utilizing the findings to improve one's own behavior and ways of working [Toivanen 2008]. The benchmarking process has been described in multiple sources and in many ways. Figure 16 describes one way to present it.

Figure 16. Benchmarking Process [Toivanen 2008]

The concept of benchmarking in this research is an important topic, because benchmarking can also be internal and in that way learning can happen from others and the collaboration can also be significantly more open. The point of this is research is to partially encourage individuals to utilize this type personal benchmarking to improve their own ways of working and in that way the performance of the whole working community. Internal benchmarking may face the obstacle where no best practices are available, but in those cases nudging forward [Moyer 2009] with small improvements is better than nothing. All the same constant internal communication and collaboration can lead into next practices [Prahalad 2010], which takes the whole company past the competitors.

To summarize, in order to build and foster a learning culture, companies need to make employees feel safe to share their ideas and give time to learn from past experiences. The company needs also to provide tools and guidelines to the employees so that they can collect data and provide it for others. Personal benchmarking should also be encouraged so that employees could improve their own performance as well as that of the whole community.

4 Lessons-to-Learn Culture and Supporting Tools for Product Ramp-Ups

As mentioned in chapter 3, learning in organizations is important to elevate the performance of the working community to a higher level. Environment, practices, processes and leadership have to be modified [Garvin et al. 2008] to suit the new culture where execution is more learning oriented than efficiency oriented. To make this orientation possible employees have to have and know process guidelines and tools with which they can analyze the data and learn upon it by reflecting [Edmondson 2008].

In this chapter the processes and tools that where planned, created and implemented to the working community, in which this research was executed, are described. The current way of working is described. After which the ideology of searching for improved practices is displayed. At the same time considering the requirements, which were laid out in the beginning of the research. When the requirements have been described, the research continues to present the structure of tools, which were created based on the findings from literature review of ramp-ups described earlier. Also a set of interviews were conducted to further outline the needed tools. Finally, the research continues to describe the building of the Lessons-to-Learn Process, PowerPoint Template, Excel Tool and Metrics Generator. In the end implementation of the tools is briefly introduced including the utilization process.

4.1 Product Ramp-up Management in the Case Company

In the case company in which this research was conducted, there are 13 Product Lifecycle Managers (PLCs) who are lead by a Head of Lifecycle Management with the support of two other heads of lifecycle management. The task of these employees is to manage the wide product portfolio availability wise. Once a new product is introduced to the portfolio, it is assigned to a PLC, who is responsible for the product until it has been declared deleted.

In order to familiarize the reader to the new product development (NPD) at the case company the milestones of the development process are displayed in figure 17. This research concentrates on the period between the PD3 and PD4 milestones of the

process, which is the actual production ramp-up. The actual NPD is the period between PD1 and PD2 after which only fine tuning is allowed, because the sourcing and purchase decision are finalized in PD2. The time period between PD2 and PD3 has to be long enough, because the lead times of some components may be considerably long. The steps preceding PD1 are the product concepting and gathering of the project team together with the deciding of the project scope.

Figure 17. Product development process in the case company [Pufall et al. 2009]

In different phases of the product lifecycle the PLC interacts with multiple interfaces. After all they are the ones contributing to a product's success during its whole lifecycle. The interfaces the PLC has to communicate with can be presented as in figure 1. As one can notice the landscape in which the PLC has to cope and constantly learn is quite multifaceted.

During production ramp-up the PLC has to balance and allocate the placed orders between the globally spread sales units according to the availability of the products. Same time the PLC has to function as an information hub towards both upstream and downstream. In upstream the PLC has to contribute in problems solving if the production bumps in to sudden supply allocations and manufacturing problems. In downstream the PLC has to split the limited supply of products to the customer base according to the placed orders by the sales units. In order confirmations the PLC has to also anticipate if certain customers strive for higher volumes than they actually need, when they are trying to ensure a certain portion from the allocation. This way functioning as a specialist between manufacturing and customer end the PLC targets to ensure the planned delivery quantities and timing with optimal profits.

To enhance the management of product lifecycles, a learning culture was seen as a necessity. Some patterns seemed to occur from time to time and taking the global situation into consideration the mistakes from the past could not be tolerated. Launch volume and timing targets were partially missed, because of multiple repeating rea-

sons. In some cases the product was immature when taking it to the production line verification for the first time. In other cases unfamiliar behavior pattern of the customer, which other product lifecycle managers had already experienced, caused a loss of profits. A way to collect, analyze and share the knowledge was needed to improve the ways of working in this community, not only because of the development the single individuals but for the whole community's benefit.

4.2 Lessons-to-Learn Culture and Creating Best Practices

As mentioned earlier, a change was needed to the culture in the working community of the case company. Namely, the knowledge of numerous PLCs had to be utilized to enhance the working culture of the whole team. To achieve these two goals a set of tools were to be created, which would enable storing of verbal and tacit knowledge into one source where the data could be searched with keywords. Also a set of processes were to be planned to enable a continuous lessons-to-learn culture. A guideline for specific metrics was also to be planned to complete and indicate the correlation between learnings and measures that are generated during processes. This way the concepts described by Edmondson [2008] could be fulfilled in terms of processes, tools and leadership.

4.3 Planning the Lessons-to-Learn Tools

To provide the best possible tool to support the needed lessons-to-learn culture the research drilled down to the literature to find the best possible approach, structure and content wise, for the tools. Software resource wise the research was very limited. Merely basic Microsoft tools were available. Also a network drive called "Teamtool" was offered for the storing of the information.

Planning for the lessons-to-learn culture consisted of two areas: the tool planning and process planning. The literature provided support for delivering the possible practices for the community on each area. Learning literature [Edmondson 2008; Garvin et al. 2008] provided views for molding the processes and legitimized the research and the numerous ramp-up and production studies supported the creation of the tools [Pufall et al. 2009; Clark & Fujimoto. 1991; Kuhn et al. 2002; Almgren 2000; Berg 2007].

4.4 Structure and Creation of Lessons-to-Learn Tools

With the support of different sources and with the given resources building of the process and tools was established. Due to the limited resources: time, financial and technological, the target was to create ad hoc tools and processes. Processes and tools were created in a way that they could be developed further into more efficient and sophisticated state when resources would allow the evolution. That is why the approach to the implementation was to be very simple, but still the knowledge from database systems' management would be utilized to enable possible upgrades.

Taking into account the requirements and resources for the study the following tools and processes where created. To enable the whole reporting, a process was created and weaved together with the existing processes to provide a guideline mentioned by Edmondson (2008). For the actual reporting a PowerPoint template was created to provide a location for product specific learnings. To fulfill the requirements such as one source for data and keyword searching an Excel tool was created. The structure of these two tools was created on the basis of literature research, [Pufall et al. 2009; Clark et al. 1991; Kuhn et al. 2002; Almgren 2000; Berg 2007], and interviews [Katama 2010; Palosaari 2010; Yu 2010; Kojo 2010; Chen C. 2010; Chen S. 2010; Garza 2010; Haukilehto 2010; Hu 2010; Mebar 2010; Perälä 2010; Soronen 2010; Suoniemi 2010; Szarka 2010] and the structure depicted in figure 18 was created.

Figure 18. Structure for PowerPoint report template and Excel tool

The findings made in the literature review, some of the company's own metrics and employee interviews, were the main information sources that were utilized when build-

ing this structure. The main branches of the structure were created based on the guideline of academic studies. Although some interviews pointed out that stream way of thinking [Kojo 2010] would more suitable for this purpose it was decided to use upstream and downstream terms instead of material and manufacturing capability and customer environment. The purpose of product definition is to give the grounding organizational information of the product in question whereas the functional characteristics were to describe the product's physical presence. Marketing attributes were aimed to describe the product's targets from marketing perspective. Ideas for the subcategories were gathered from different sources like literature and interviews and presented for the whole community to reach final agreement on them. This way perspective structure for examining product ramp-ups was created for the use of this specific business unit. The structure created for the tools is described in more detail in appendix B.

To enable the requested option of metrics utilization an Excel tool was put together for creating measure graphics from the ramp-up. Also a guideline for utilizing all these tools, a user guide and a process, were created. The chapter 4.4.1 describes the creation and basic functionality of the mentioned tools.

4.4.1 Lessons-to-Learn Reporting Process

The lessons-to-learn process is to give guidelines for an employee when and how to do reporting regarding product ramp-ups. The process is described in figure 19.

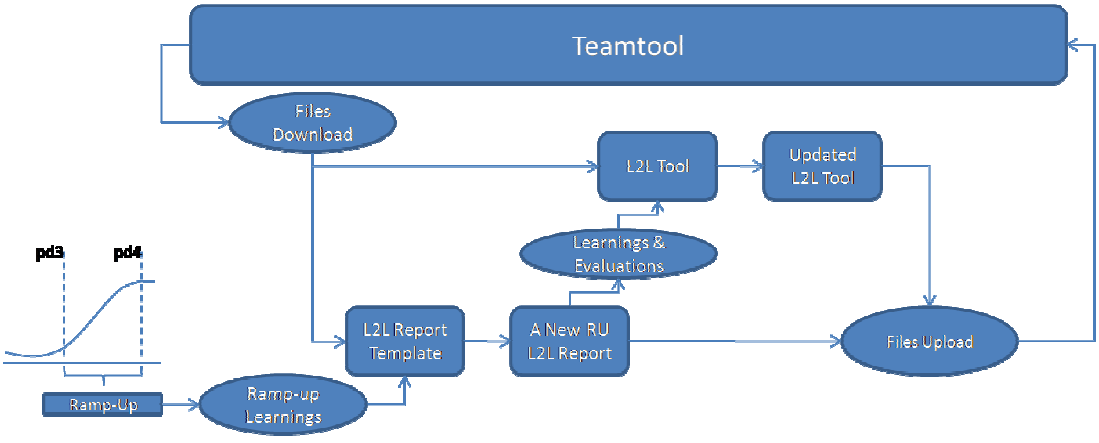

Figure 19. Lessons-to-Learn reporting process

The idea in the reporting is to gather learnings when a product receives the PD4 milestone approval, which is considered to be the end of a production ramp-up. In the gathering of learnings the PLC should utilize the numerous interfaces such as marketing

and product development projects to ensure the best possible quality for the information. Then the PLC should download the PowerPoint template from the common network drive. After downloading, the template should be filled with the learnings. Excel files, PowerPoint files and e-mails could be utilized to summarize the information of the ramp-up into one file.

When the report is ready, the same information should be summarized and transferred to the common Excel file, which is intended to contain records from ramp-ups since July 2008. As part of the Excel tool evaluations, one should also indicate the usefulness of the learnings to new projects**.** The evaluations should be explained by inserting comments including information from the PowerPoint report. This way the one reporting could present his opinion of the information and communicate it to others without having to have separate meetings for that purpose. After the two files are ready they need to be uploaded in the network drive where they are available for everyone in the community.

The reason to separate information sources is to provide a possibility to examine information in two different levels, which is enabled by the common structure. In the Excel tool one can examine all of the ramp-ups in one place with summarized comments and evaluations. If more specific information is needed, one can refer to the complementary PowerPoint report.

4.4.2 Lessons-to-Learn Report Template

The "L2L Report - [Product], [Product Model], [Report Date].pptx" is the actual report where the learnings of the ramp-up should be reported. The report follows a common structure, which should cover all the main areas of a ramp-up. The content of the report also includes a section for the main learnings of the report and a section where the ramp-up specific metrics/graphs may be added. One of the slides of the report would be added with the grounding information of the product.

In the report *the most important errand is to contemplate reasons for the success or for the failure* in different areas of a ramp-up. Only highlighting the success or the failure will not give any value for the report. The value comes from the searching of the cause and effect of certain outcomes.

Highlighting the root cause and the actions to fix a problem are important when speaking of challenges. Also the possible indicators and the outcome are important to emphasize. Of course for the one studying the reports the most important part is to emphasize the actions, good or bad, and to bring out indicators that should be noticed in the future. When reporting from areas of success the most important aspect is to search for the reasons of success. One should try to contemplate what where the reasons for the success and what are the actions that should be possibly replicated to other ramp-ups as best practices. Taking the reader/learner into consideration is the core essence of the whole reporting system. The information should be brought out in a way that it could be understood by the people who would benefit for it.

The content of the report builds up from seven sections: Definition, Upstream, Downstream, Solution, Processes, Additional Information and Other. These sections are then divided into subcategories, which describe the most crucial parts of that specific section. These subcategories work as components to report.

The fourth slide in the template, named "Key Learning Points", is for summarizing the main learnings of the report. The function of this slide is to provide the main information of the report for the examining the learnings.

Key metrics slide is for different graphs and metrics, which are useful when comparing or studying ramp-ups. If one has graphical information of the ramp-up, they should be presented here. By pointing out the impact of experiences to numbers the "How?" and "What?" information is revealed. The learnings that appear on the graphs can be commented in the L2L tool's "Other" section, if they cannot be evaluated in other areas of the tool.

The topics of the report follow the common structure. When filling in the report, it is important that if one does not have anything special to report of in certain sub areas, then short comments on how the process went are totally sufficient. Searching for the cause and the effect in a few critical areas is a significantly more crucial for the relevance of the report.

The one filling in the report has to make the decision to what area the learning is placed. The guideline is to report the information on the subcategory under which the learning has appeared. Of course sometimes it is difficult to decide where the issue

should be reported, but in the case of uncertainty the one making the report must decide where the learning should be placed in the report. The purpose of placing the learning in a subcategory lies in the connection between the reports and excel tool, when a learning is in the report it can then be easily transferred to the excel tool. This way the two layer examination of learnings is implemented the best.

4.4.3 L2L Excel Tool

The Excel L2L tool is meant for searching, pivoting and sorting of data. Each row of the database should contain the main information of a report (one product). The information of a report should be inserted as comments into subcategory specific cells when at the same time doing evaluations of the relevance of the information, as described in figure 20.

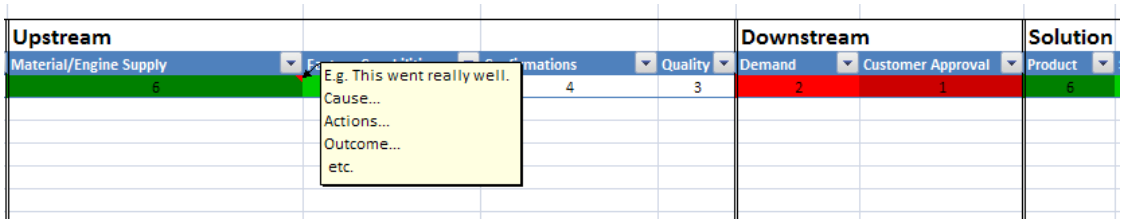

Figure 20. Evaluation and commentary example from the L2L Excel Tool

The relevance of the information in a cell is communicated by evaluating cells in a record on a scale from one to six. The further the evaluation is from the medium of 3.5 the more important the information is, e.g. evaluations one and six are the most relevant. When the learning is due to a negative experience the evaluator should give a score of one and on the other hand, the evaluation of six should be given when the learning comes from a positive experience. The evaluations of two and five follow the same logic, but the educational value of cases in question is not as high, but still the information may be useful for all stakeholders. Evaluations three and four are of low educational value, but they indicate the performance of the sub area in general.

The tool colors all the evaluations in certain spectrum automatically to indicate data. In this way the tool works as a "treasure map", which provides the reader a visual path to useful information. The Excel L2L tool is presented in appendix C.

4.4.4 L2L Graph Generator

When the reports describe "How something happened?" the different metrics and graphics describe "What actually happened". To make it as easy as possible for the one making the reports it was decided that a simple tool would be created to provide a possibility to produce certain measure graphs to support the reporting.

The biggest challenge in building this tool was finding a suitable source from where the information would be downloaded into an Excel based tool, which would function as the user interface for the data. A database containing the needed information was found, which made the tool creation and maintenance less complicated. A set of queries were made into the database. These queries were as follows:

Actual Database Table

- Product family group – Named groups for similar products
  - Returning all the discrete product family groups in the database
- Product name – Names that have been given to products
  - Returning all the discrete product names in the database
- Sales units – Global sales units in the case company
  - Returning all the discrete sales units in the database

Table for plans' clarification

- Plan ID and Year Period Week – Weekly plans are provided with a Plan ID to function as a key attribute in the actual database. In a separate table(Table for plans' clarification) PlanIDs are clarified into a format Year-Period-Week (yyyyPppWww, e.g. 2010P01W01)
  - Returning all discrete PlanIDs' and corresponding date for the information

In the Excel, the user could define the parameters such as the product family group and product to be examined either globally or per sales unit as described in figure 21. In addition to these, the user could choose four different examination periods for the data, so that the actual graphs would indicate the differences in the plans/actual during different examination periods. The one utilizing the graphs could then refer to these differences when reporting and in that way provide the "What?" and "How?" information to the reader.

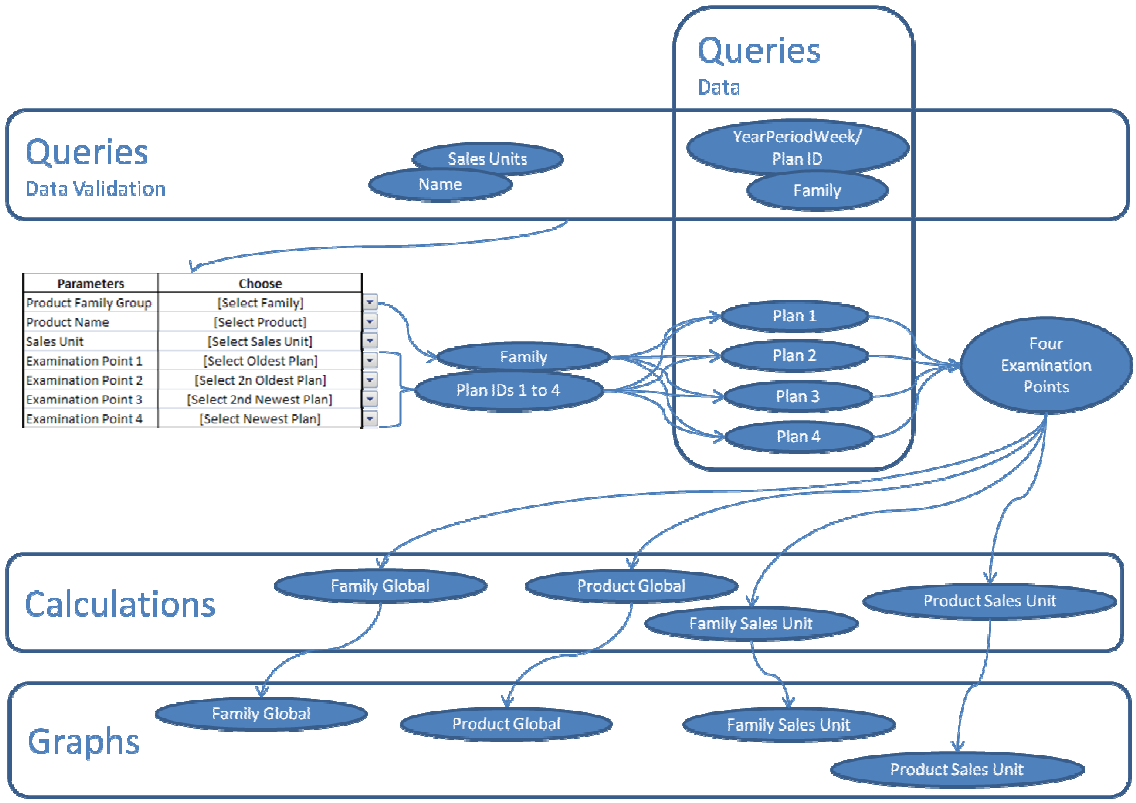

Figure 21. Functioning logic of the graphics generator

On the basis of the Product family group and four examination points, four queries are made into the database. The retrieved data contains information from the product family group in four different observation points. This information could then be modified into a sheet and used for the graphs by using basic Excel functions. All the possible graphs, both periodical and cumulative, that could be extracted from the tool are presented in table 3. In the tool graphs can be made to describe manufacturing and sales development. Also combinations from the two can be displayed in the tool. Sales can be described as sales plans and corresponding confirmed sales plans also latest sales estimates and invoiced quantities can be displayed. Manufacturing development can be displayed with three attributes: sales package, basic device and module manufacturing. Sales package stands for the actual sales pack that can be handed over to a consumer. Basic and module manufacturing describes the device production depending on the modularity of the product.

Table 3. Available metrics in the graphics generator tool

Area of measurement	*Measure*	Global	Sales Unit
Sales	*Plan*	Yes	Yes
	Confirmed plan	Yes	Yes
	Estimate	Yes	Yes
	Invoiced	Yes	Yes
Manufacturing	*Sales package planned capability*	Yes	No
	Sales packages produced	Yes	No
	Basic device planned capability	Yes	No
	Basic devices produced	Yes	No
	Modules' planned capability	Yes	No
	Modules produced	Yes	No
Combinations	*Sales plan Vs. Sales package planned manufacturing capability*	Yes	No
	Sales invoiced Vs. Sales packages produced	Yes	No
	Sales plan Vs. Sales confirmed plan	Yes	Yes
	Sales packages produced vs. Sales invoiced	Yes	No

With these graph combinations the one creating the reports can point out the possible impact of the findings. Figure 22 is an example of the type of graphics that can be displayed. The brown color indicates sales package manufacturing capability or produced quantity and the line graph presents the sales plan or actual volume invoiced. The lighter the color is the older the information is. The darkest color indicates the actual volume produced and invoiced.

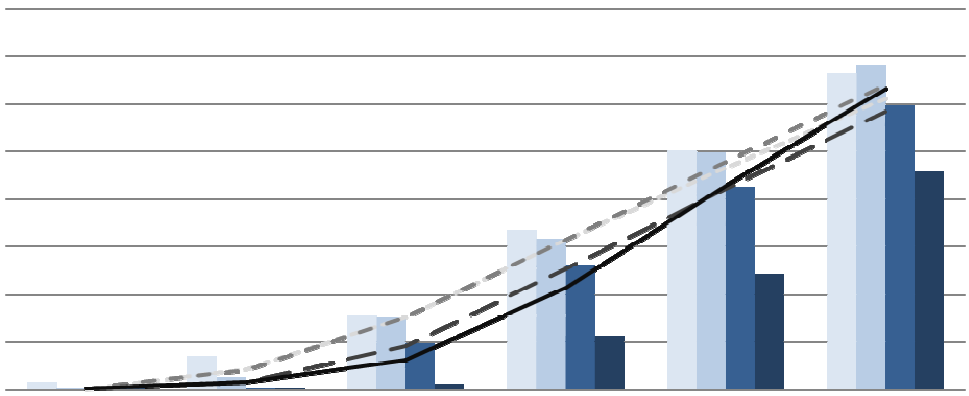

Figure 22. Example graph from the L2L Metrics Generator: Sales package manufacturing capability/Produced (blue shade columns) and Sales Plan/Invoiced (black shade lines) both as cumulative

In this case the actual produced figure did not reach the original plans. The second darkest color indicates the plan before ramp-up and darkest just after it. It is possible to see that the wanted production level was not achieved on time.

When the two types of information the "What?" and "How?", are combined, the community of PLCs can provide vital information to other business units and in that way improve not only their performance, but also the performance of surrounding units.

4.5 Implementation and Utilization of the Created Tools

To make the access to these tools and information they contain as easy as possible they were placed on a common network drive to which the whole team has access. Two new folders were added to this folder, one for the tools in general and another to act as a report database. The report database was only for finished filled reports, so that browsing of existing information could be done with ease. The other folder for tools and guides would work also as a notification area, were change notifications and guides for the tools could be placed.

To make these tools and reports useful they should be utilized in the everyday business of the company. There are at least four means of how to utilize these tools in everyday tasks:

- When a product is assigned to a product lifecycle manager
- When unexpected problems appear
- In general education of the community
- In project risk management

When a product is assigned to a PLC he/she should familiarize him/herself with similar product from the past by searching the tool for useful advice. The other use case would be to use the tools and reports in problem solving during a product's lifecycle, by examining how other PLCs have solved similar problems. The third way to utilize the tools and information is to underline learnings from particularly useful cases to the other individuals in the community, for example, in common meetings, so that the information and its usefulness would be noticed by all of the PLCs. The fourth case would be to utilize the gathered information in projects' risk management. The specialist community of product lifecycle managers should actively work as a contributor community to the marketing and development projects by functioning as interface be-

tween the two. This way the learnings from all marketing, NPD and product lifecycle management could be spread to a bigger working community. The next chapter describes in which milestones of a project the utilization of tools should be done.

4.6 Lessons-to-Learn Sharing Unifying Corporate Silos

When one business unit has information that the other units do not have or at least not so extensively, the information should not be concealed. The information should be actively shared to gain the benefits from the knowledge. For example, it should be utilized as a part of risk management and in other plans of separate units. Since the community holding the information has a wider access to the information, and the ability to allocate useful information for surrounding units.

At the case company there are at least two major projects working on a product: the product development and the marketing project. The available information should be induced to these the two parallel projects, so that wider benefits could be achieved. There are certain milestones in both projects, where the information should be obtained to dodge the pitfalls from the past and to raise conversation between the two projects to improve visibility.

The task of the Product Lifecycle Manager would be to familiarize him/herself with the product when it has been assigned to him/her. The tools should be used in a way that the upcoming project would perform as well as possible and avoid issues that have been faced in the past in other product projects. The L2L Excel tool should be searched with the criteria matching the new product, such as all the functional characteristics, marketing attributes and R&D site. In this way, learnings from the past could be utilized to partially avoid upcoming challenges in areas such as marketing, product development and product lifecycle management.

The two parallel projects, marketing and product development have their own milestones and each one of them requires certain criteria to be achieved. The milestones advance concurrently to some extent, so in that way the information sharing could be done simultaneously when both of the projects need it. There are two steps in both projects in which the sharing would be useful: when the initial plans are being committed to and when the implementation of plans is started. The concurrent milestones

would be in the first stage PD1 in product development and concurrent marketing milestone and in the second stage, PD2 and parallel marketing milestone. By inducing the learnings from the past into the initial plans in the foremost milestones and then revising them later before execution the benefits would be the greatest. Also if problems occurred during later steps the conclusions made earlier could be reviewed for problem solving support.

5 Ramp-Up Lessons-to-Learn Study

A study was conducted based on the initial reports created with the help of the newly created tools and processes. The goal of the study was to establish a picture for the working community of the findings and to demonstrate the usefulness of the tools and processes so that the community could start creating a firm and continuous lessons-to-learn culture by building on these findings and tools available to them.

5.1 Data Sample and Analysis Method

Nine product lifecycle managers reported 26 ramp-ups in total during the review period that form the sample used in the study. From these ramp-ups 22 involved sophisticated handheld computers and 4, traditional less complex devices. The ramp-ups took place between July 1st 2008 and August 26th 2010. The reports and records in the tool were studied from three dimensions as described in figure 23.

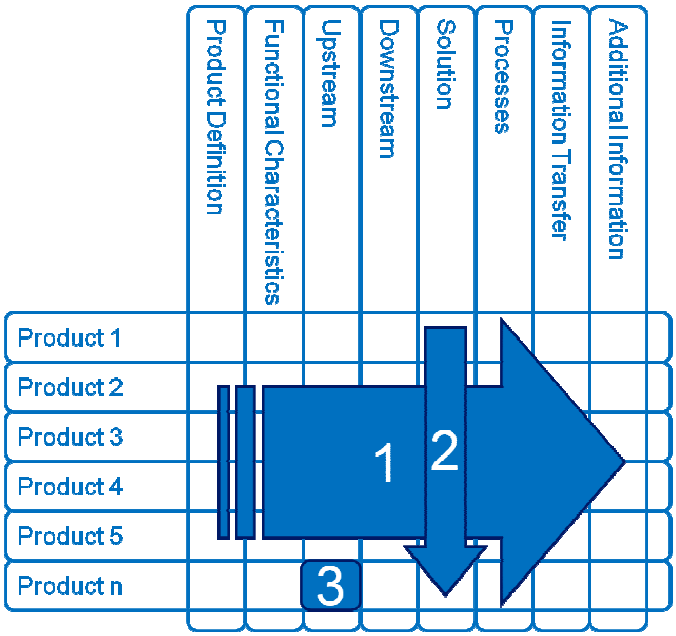

Figure 23. Three examination dimensions: Correlation Observations (1), Repeated Observations (2) and Separate Learnings (3)

First the Excel tool was sorted with different criteria to search for correlation between products with similar characteristics. The second approach of examining the reports was studying the subcategories of the tool separately and in that way finding better ways of working when it comes to certain sub areas of ramp-ups. The third examining

method was to indicate individual useful learnings that should be taken into account in the future. The section 5.2 describes the findings from these three paths of examination: correlation observations, repeated occurrences and separate learnings.

5.2 Study Findings and Recommendations

Using the three examination paths a set of conclusions were made. With correlation observations findings were made about high level divisions, management focus, technology novelty and physical attributes. When observing repeated occurrences problems with sales package variants multitude surfaced and by searching separate learnings at least a couple of useful minor suggestions were discovered.

5.2.1 Correlation Observations

When examining ramp-ups/products through common attributes (see figure 24) findings were made in high level divisions such as traditional devices and sophisticated computers. The marketing classification as the amount of allocated focus seemed to have an impact on the ramp-up performance. Likewise the level of new technology seemed also to have an effect on the ramp-up as indicated in the study by Pufall et al. [2009]. In addition, the physical presence of the product seemed to affect the performance of a ramp-up in certain areas.

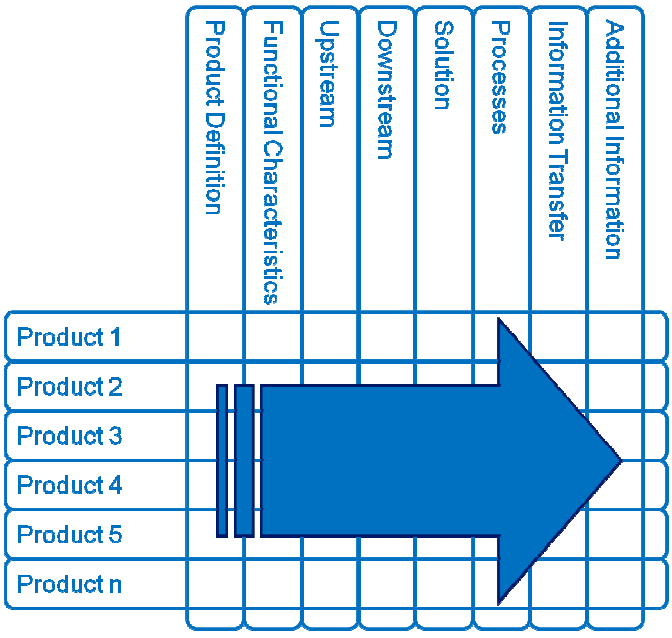

Figure 24. Correlation Observations: comparing products through common attributes

High Level Division Between Traditional Devices and Sophisticated Computers

When observing the products through the sophisticated computers and traditional devices categorization learnings were discovered in manufacturing and in the behavior patterns of certain customers.

In traditional device cases the supply problems and cover quality led to low product engine production output. One solution to this, described in table 4, would be to take the supply perspective as the environment requires it.

Table 4. Issue, implication and solution in traditional devices

	Traditional Devices			
Issue	Supply problems		Cover quality problems	
Implication	Low product engine production output			
Solution	Supply driven actions	Focus on downstream	Gain momentum on program start	Maximize output

Adding more focus to the project start and gaining momentum in that way the final output could be improved. By verifying the supplier capability in the early stages through supplier collaboration, the risk of ending up with supply and quality problems is significantly lower. This way, the time pressure should not be a problem for the supplier, since the requirements are provided earlier. Also the supplier capability verification should be prominently more precise. The capability has to be stated in a way that there is no possibility to end up playing with nonexistent capability when supplier has promised what is not possible.

Gain momentum in program start through intense supplier collaboration and verify the capability to minimize the issues in the manufacturing stage.

In sophisticated computers no umbrella conclusions could be found, but the findings were made regarding the customer-specific product variants (see table 5). When there is a customer specific product the customer's strategy has to be made clear for all of the stakeholders. Some of the customers drive to fill the channel in the ramp-up, which is shown as a high demand. After the delivery channel fulfillment the orders might

drop, which leads into a significant work-in-progress inventory and excess materials if the behavior is not anticipated.

Table 5. Issue, implication and solution in sophisticated computers

	Sophisticated Computers		
Issue	Customer specific variants		
	Sales push for high volumes		
	Inventory risks		
Implication	Volumes drop after channel fulfillment		
	Significant work in progress and inventories		
Solution	Close customer collaboration	Familiarize yourself to customers' strategy	Customer goggles

To avoid this type of problems the case company needs to familiarize itself with the customer's goals. There are two ways of knowing this type of information: either by observing it from the past experiences or by collaborating with the customer. By clarifying the goals with the customer in the beginning the material flow can be evened via increased visibility and in that way the profits may be potentially maximized with minimum risk.

By collaborating with the customer and finding out their goals early the problems from poor visibility can be avoided.

Focus in Marketing Efforts as a Differentiating Factor

In the case company the product marketing projects are categorized in to three tiers. The first tier has the least amount of focus whereas the third is given the majority of available resources. From the study conducted it can be concluded that if a company is forced to prioritize between products, it seems to have effect also on the performance and execution of the production ramp-up.

When a product is being executed with less focus, it becomes apparent that different types of problems appear suddenly (see table 6). Plans seem to be feeble when it comes to demand forecasts and supply planning. Also changes to the offering are

made at the last minute when also local problems complicate the situation even further. Too little focus leads to situation where not enough resources are dedicated to the product. The prioritization is one necessity that cannot be bargained, but the problem solving is one segment that can be affected.

Table 6. Issue, implication and solution in first focus tier products

	First focus tier, low focus products				
Issue	Less focus				
Implication	Late sales package content changes	Capacity or supply allocations	Local flavor	Sudden demand peaks	Plans done with less care
Solution	Two options to solve the situation				
	Anticipatory planning		Rapid performing		
	Add focus Plan Search for latent problems Make decision Execute		Fix problems separately Fire fighting Panicky actions Confusion Patchwork falling apart		

When the challenges appear there are two ways of solving them, anticipatory planning and rapidly performing resort. In rapidly performing problem solving the challenges are judged and solved separately. In anticipatory problem solving resolutions for challenges are planned, latent problems are revealed and a guideline is generated to correct the situation. However, when the problems are fixed separately the situation can end up in firefighting and things are done twice, because the correlation between problems is not clarified. In addition, the multiplied workload may start to create confusion and the outcome resembles a patchwork, which starts to fall apart immediately.

A better way to fix the problem seems to be to add focus temporarily in the form of risk management and contingency planning, and to plan a solution which looks at the possible upcoming problems as a precaution. This way the latent problems get unrevealed and the problem solving becomes more fluent execution vise. The stakeholders know the direction where they are headed and in that way the outcome is more effective and long lasting.

When resources are limited problem solving should aim for more sustainable solutions, so that the workload could be minimized in the longer term.

With products that have a slightly more focus and expectations the demand seemed to be capricious (see table 7). The placed orders can evaporate or there are over expectations regarding the sales. It is also possible that the expectations were too high, but then at the end the demand catches up.

Table 7. Issue, implication and solution in second focus tier products

	Second focus tier products, medium focus product		
Issue	Unpredictable demand		
Implication	Slow growing demand	Softness in the actual demand	Over expectations on the demand
	Sales potential adjustment is placed the present the uncertain		
Solution	Highlight the situation	Seek and anticipate for growth	

In cases when the demand is unpredictable the actual demand is added with sales potential adjustment, which describes the possible demand above sales plans. In these cases the only solution is to underline the situation, that there is possibility to improve, so that the sudden peak will not surprise any stakeholders. Likewise, when the demand seems to be exaggerated, the only way is to provide visibility and distribute the latest information, so that stakeholders can prepare for possible scenarios.

When demand fails to meet expectations, in beneficial or non-beneficial ways, active information sharing reduces unpleasant surprises.

In the case of products that are given the most focus and are aimed to take the brand further, the problems seem to be that the top-down pressure sets such high expectations that the time resources become a constraint (see table 8). This seemed to lead into quality problems, tight software schedules and in that way into schedule delays. Also the plans are set so high demand wise that it can be considered as over hype.

Table 8 Issue, implication and solution in third focus tier products

	Third focus tier, high focus products		
Issue	Top-down pressure		
	Lots of focus		
	High expectations		
Implication	Over hype	Software delays	Quality problems
Solution	Realistic approach		Supply driven actions
	Establish follow-ups		
	Individual diligence		
	Mindset of must-win		

In cases where it is decided that the product has to succeed there is not much that can be done if management pressures drive for certain goals. One way to improve the process from individual's perspective is to be diligent, especially in the project start, and then act as the global supply situation requires. A high yield in all subassemblies would be beneficial, because the constrained situation requires for best possible output, failure units cannot be replaced with new ones. By establishing follow-ups unpleasant surprises can be eliminated and at least anticipated. The fact is that all possible assets have to be used when product is aiming to take the brand further.

Focus on yield, communication and individual diligence is required when supply is constrained and top-down management pressure high.

Effect of Technology Novelty

The study also exhibited that the new product technology has effect on how the ramp-up behaves. In products with new technology, issues with upstream, software and demand seem to appear. The products with technology that has been used before have complications with modifications that seem to pop-up in the later phases of product development.

The problems with demand, software and upstream in new technology appear as slow building orderbook, delays and supply shortages or quality issues (see table 9).

Table 9. Issue, implication and solutions in new technology products

	New technology products				
Issue	Upstream			Software	Demand
Implication	Supply	Mechanics quality	Cover quality	Over optimism	Slow building demand
				Tight schedule	Sales potential adjustment
Solution	Supply driven actions			Realistic approach	Highlight the situation
					Seek and anticipate for growth

In upstream problems like supply of mechanics and covers, the solution would be to follow the guideline set by the global supply situation. Gaining momentum in the project start by collaborating with surrounding elements the probability of succeeding later on is remarkably higher. Problems with software leading to delays and too tight schedules are common, but the only way to avoid surprises is to have follow-ups to constantly paint the readiness of the platform.

Diligence in project start in the form of follow-ups and end to end collaboration is the key to deliver the product with unavoidable challenges.

The products with "old" technology seemed to have one repeating problem: different types of modifications (see table 10). In some cases the tooling in the production was changed or the diverse mix of sales package contents was not in control.

Table 10. Issue, implication and solution in copy technology products

	Copy technology products		
Issue	Modifications left without attention		
Implication	Late tooling changes	Too many sales package combinations	Late sales package changes
Solution	Identify modifications		
	Create specific plans to handle modifications		
	Utilize basic tools to enhance communication		
	Diligence in the program start		

One way of solving these type problems is to identify the changes made to the "new technology product" and create specific plan to handle these changes. The findings should be distributed by using basic tools, such as graphical plans and newsletters, to all stakeholders so that the pitfalls would be recognized by the stakeholders.

Identifying future problems and creating corresponding antidotes early decreases the negative impact when challenges occur.

Acceptance of Physical Product Attributes

When it comes to the physical presence of the product it seems that the user interface has effect on the nature of the ramp-up, as described in table 11. With devices with full QWERTY keyboard as primary user interface the demand seemed to be slow building. In the touch screen devices the hit feature of the market seemed to correlate with good projects' cooperation, communication and performance.

Table 11. Issue, implication and solution with primary user interfaces: QWERTY keyboard (left hand side) and touch screen

<table>
<tr><th></th><th colspan="4">Primary user interface</th></tr>
<tr><td rowspan="2">Issue</td><td>QWERTY keyboard</td><td colspan="3">Touch screen</td></tr>
<tr><td>New type of user interface</td><td colspan="3">Hit feature from the market utilized</td></tr>
<tr><td rowspan="2">Implication</td><td>Slowly growing demand</td><td colspan="3">Good projects' performance</td></tr>
<tr><td>Sales potential adjustment</td><td>Cooperation</td><td>NPD</td><td>Communication</td></tr>
<tr><td rowspan="3">Solution</td><td>Seek and anticipate growth</td><td colspan="3" rowspan="3">Positive mentality and trust on own products</td></tr>
<tr><td>Highlight the situation</td></tr>
<tr><td>New user interface: slowly growing demand?</td></tr>
</table>

In cases where the demand is slowly growing, and where unfamiliar feature is involved, the company needs to rely on the sales potential adjustment that is placed to present the possibility. To make it clear to all stakeholders the information is to be distributed so that the rapid changes will not come as surprise. On the other hand, if the introduced feature is already familiar to the market and successful it seems to have an impact on the projects. There were implications that at least one of the areas: NPD

project, communication project or cooperation had positive comments on performance in products having touch screen as primary user interface. This refers to a possibility that when employees work with a product in which they believe in, it increases the performance of the whole process.

New characteristics have to be sold and marketed internally and externally.

5.2.2 Repeated Occurrences

In repeated occurrences (see figure 25), the research analysis is concentrated on individual segments of the structured tools such as material and engine supply, product or communication. By studying these segments the target was to find areas of ramp-ups that most often have problems and especially similar issues. One area of product ramp-up seemed to have a common and recurring problem, namely the sales packages.

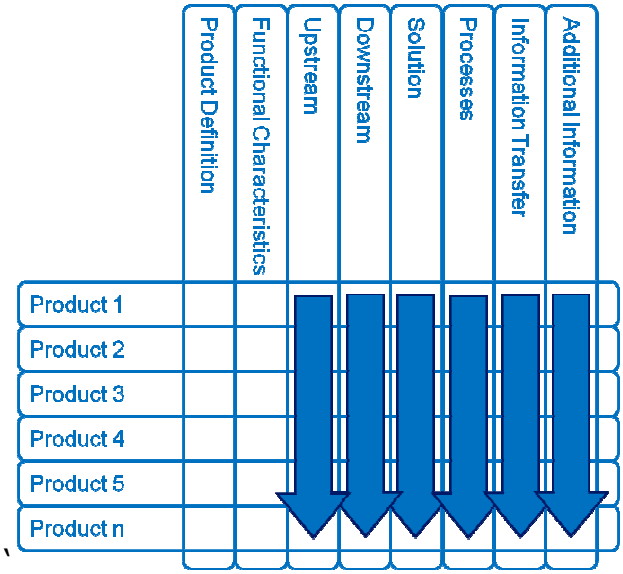

Figure 25. Studying individual segments of product ramp-ups; Repeated Occurrences

Clarifying Sales Package Variant Management

In numerous ramp-ups it seems that sales pack content caused confusion (see table 12). In some cases the content was changed too late in the process, the content was not clear and in some cases there were too many different sales pack options and due to that complexity and unclear priorities caused problems.

Table 12. Issue, implication and solution in Sales Pack Variant Management

	Sales package variant management		
Issue	Sales package content		
Implication	Too many combinations	Unclear priorities	Late changes
Solution	Decide priorities early	Apply focus	
	Basic tools' implementation to enhance communication		
	Preferring quality over quantity		

It seems that the one root cause behind all these problems is the fact that the priorities are not decided early enough or changes are allowed in the last critical steps of the process. To avoid the delays the priorities should be decided early and the deadlines for possible changes should be kept more rigorously. This way the other processes would be forced to execute accordingly and the general process would not be disturbed, because of individual obscurities. Focusing on one plan would make the operating more fluent and possibility for additional variants would be given to following waves of production. By endorsing the communication with basic tools such as graphical plans the unambiguity and intelligibility of communication would increase.

By sequencing the plans with tenable deadlines the control stays throughout the whole process.

5.2.3 Separate Learnings

The goal of studying the separate comments (see figure 26), made by the Product Lifecycle Managers was to find pieces of information, which might be useful for the whole community. At least four separate comments could be pointed out that could directly or indirectly come useful. These learnings concerned product naming, local practices, climate impact and sharp-witted problem solving.

In some cases the name of the product caused problems. If a product is named in one way in one area the use of the same name in other area might cause problems, such as customs clearance problems.

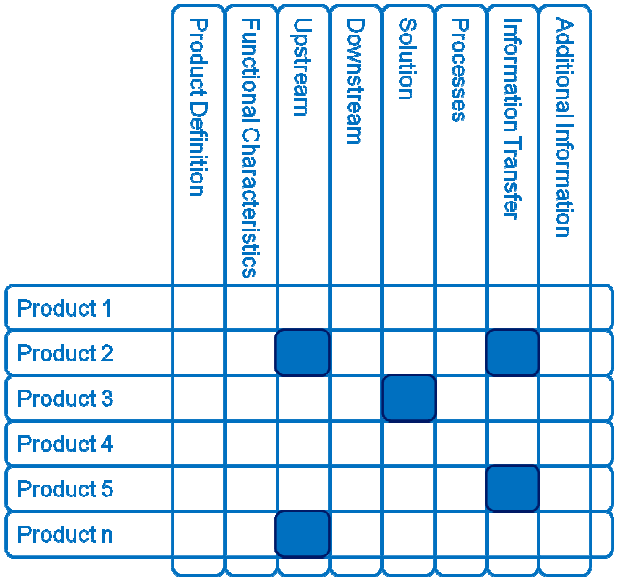

Figure 26. Drilling down to separate comments made by product lifecycle managers; Separate Learnings

The naming problem is also a part of the learning concerning local practices although the local practices and flavors can also affect the product ramp-up process in many other ways. For example, it is wise to schedule the order confirmations of certain customers, so that delays typical to the customer will not hinder the process.

Climate effects also in a way fall into the category of local flavor, but in a totally different way. In some cases the climate difference between the supplier and manufacturing location are so great that it causes problems, strangely even with materials like plastic and metals, which are not so prone to moisture. When this type of problems occur the change into a new supplier may seem unavoidable, but when this type problems have appeared the liabilities from these ineligible components are already a burden. To turn this burden into opportunity certain actions can be done to avoid scrapping of the materials. The two ways of solving the problem are: leveling the climate difference by shipping the materials to other areas or by "tooling" the material so that the problems disappear. For example, components obsolete due to heat and humidity in Central America might be usable in a climate similar to Europe. If the supplier is located in an area where heat and humidity are high and it causes problems the issue can be solved by drying the supplies even if the material usually does not require it. This type of sharp-witted experimenting and problem solving comes often useful when problems seem to be significant, but the actual solution is quite frugal.

The sharp-witted solutions often also come cheaper. Mistake for example in packaging might cause a prominent problem and the solution for it can require a recall for the products. Rather than instantly recalling the products one should search for optional solutions which even might make the situation beneficial.

Clever problem solving and sharp-witted experimenting can help to avoid expensive alternatives.

As a conclusion it can be said that in different types of product ramp-ups the correlative issues that often surface are related to customer focus and technology newness. Additionally, a common nominator for many products is repeated occurrences of issues with control regarding, for example, manageability of sales package variants. Finally, as separate items that the case company should take into account are simplistic ways of problem solving and supporting experimentation.

6 Conclusions

In consumer electronics, the importance of speed and perfection of execution in introducing new attractive products has increased. The most successful offerings have a captivating content delivered in a perfect package quality and reliability wise and on time. The ones falling behind suffer profit losses due to missed launch dates and quality issues. Often these offerings equal in content to the successful ones, but the impressive content gets buried under a mass of numerous interfering matters.

Getting out of the pitfall requires an enormous amount of effort and a shift in the mindset. Once a company looks in the mirror and accepts the problems improvements can be initiated. Focusing to one's way of executing operations plays a key role in improvement efforts, especially in business functions which operate on ensuring the best possible quantity and quality in the correct schedule, and in processes which strive to make the physical delivery.

The current global competitive situation requires companies to have perfected production processes, since certain supplies are in global shortage. These operations are needed for the products that are in high demand or which strategically create the difference in this highly competitive environment. Because of the short supply, operations must work to ensure the highest possible yield. In addition, because of the high demand, in an industry of immense clockspeed, the solutions must be delivered to the market with the shortest feasible time-to-market and time-to-volume in a flawless manner.

When the pressure sways from all sides and the possibilities in downstream and upstream of the supply-chain are limited, one has to make the adjustments internally to cope with the challenging web of constraints.

This research pursued to find ways to improve production ramp-ups. Factors such as time-to-volume, time-to-market, produced quality and gained profit are aimed to be perfected in a company with a world class manufacturing facilities. By establishing a culture of learning into the company's business function with tremendous business impact and amount of gained knowledge the contribution of a group of specialists was aimed to be improved. With the combination of knowledge from all experienced man-

agers the best possible performance of elements surrounding the delivery of individual products can be achieved. By providing the business unit with the tools, processes and education it can start the active utilization of gained knowledge held by numerous specialists in order to improve their ways of working and that of others.

6.1 Key Theoretical Findings

Production ramp-ups are in an essential role in today's consumer electronics market where industry clockspeed forces to perfect the operations. The picture of a product's ramp-up phase starts to develop already in the early stages of the product's existence. The decisions as early as in the product strategy, new product development and productization stage set the difficulty level of the production ramp-up. Product strategy creates the framework for starting product development. New product development generates a product to match these intents, which is then molded suitable for the organization during productization. By making the product both sellable and producible the productization strives to build the product in a way that it can be delivered as efficiently as possible. These steps precede the actual launch after which different functions of the company start to contribute, making the product as successful as possible. As the production volumes gradually increase the progress follows the learning curve supported by the surrounding elements and processes.

By identifying external factors that create challenges and by seeking corresponding internal factors with which the challenges can be resolved the challenging situations during production ramp-ups can be managed. During production ramp-ups the challenges faced should be handled with elevated care. Planning made to solve the faced challenges should aim for longer lasting solutions to prevent increased workload in the later execution.

Most often product launches and corresponding production ramp-ups are executed in a project format, which go through the traditional stages of a project: defining, planning, executing and closing. In the closing stage the final phase is called the lessons learned where the key challenges caused by external factors and corresponding learnings are gathered to be utilized as knowledge in future projects. The gathering of this knowledge is most often extensively casual and in that way the later browsing of this information in an organization is laborious due to incoherent reporting formats and sources

of information. This leads to a situation where one searching for the information is soon encumbered by the workload and once valuable knowledge turns into useless data.

In companies which operate in high clockspeed industries the importance of lessons learned and gathering of the information is even higher. High industry clockspeed shortens the individual work assignments to the extent that the tacit knowledge gained by an individual in an assignment is more likely to perish when employees proceed to new assignments more often. To prevent the knowledge from disappearing, the knowledge of individuals should be gathered in a structured manner and format into a source where the knowledge of numerous individuals can be searched and utilized by a single employee. In this way increasing the knowledge available for one individual the overall performance of the community can be increased and the total workload can be reduced. In this research the lessons learned concept was elevated to lessons-to-learn concept to promote the importance of future learning. This was done to make a difference between separate learning events and a continuous learning culture where gained knowledge would exist even if employees would change.

By inducing this previously gained knowledge and experience by multiple employees into the elements of a production ramp-up, the performance and efficiency of the process can be increased and in that way the yield and profits can also be elevated. The inducible knowledge can be obtained through community based information sharing and learning by creating a learning culture inside a business function with suitable environment, processes, tools and leadership. These tools and guidelines with which to collect and share information provide individuals with the possibility to continuously learn and improve their ways of working with the help of knowledge from colleagues. The open mindset for problem solving, idea sharing and individual differences make employees feel safe which enables employees to move further in execution. By benchmarking others the best practices and next practices can be discovered and funneled to many areas of execution. When employees are not working so hectically and have more time they are able to contemplate, share and experiment new ideas. This way the widening of an individual's skill set increases the problem solving arsenal of the whole community.

By complementing the verbal tacit knowledge with performance measures, direction and tracking possibility should be created for the knowledge existing and improvements made within the organization. Neither measuring nor verbal reporting should be used solely. The combination of numbers and verbal knowledge paint the whole picture from the past to the future. Numbers tell what happened in a certain time period, but the verbal information on experiences has the truth behind the numbers and based on these experiences actions for future to achieve planned goals can be made.

With the combination of active learning and improvement with measures of performance a business unit can actively start to progress. Lack of one removes the foundation from the other. By deciding and partitioning an area to be improved, a solution gathering the numbers and knowledge can be created to elevate the performance of the targeted division, this way a company can separately create performance increasing solutions to areas which are crucial to the company's success.

6.2 Key Empirical Results

The case company of this research manufactures handheld media devices globally in a high clockspeed consumer electronics market. Because of the intensity of the market created by shortening product lifecycles and developing technologies the company has to constantly introduce new products to the market. Based on 17 conducted interviews and numerous company materials reviewed, it became clear that the production ramp-up plays a key role in the current market situation when demand is high, competition tough and supply limited.

The main focus of the research was on supporting the creation of a learning culture for a business unit which is responsible for managing products during their whole lifecycle and in that way to ensure the success of a product in a multifaceted environment. *The absolute main purpose of the learning culture is to combine the information and knowledge of a group of specialists for improved problem solving and processes in every execution.* A set of tools and processes were created and the community was educated to embody the learning culture. The reporting tools were created to follow a common structure to enable a two layer examination of the data: comparing products with summarized data in an Excel tool and drilling down to specific records was enabled through PowerPoint reporting. Reporting tools providing the "How?" knowledge was complemented with a tool for graph creation to enable the use of "What?" information in the reporting. By fusing the mentioned tools to prevailing processes a seed of culture was planted to support risk management, problem solving and daily actions of individuals in the working community.

By utilizing the newly created tools and processes 26 production ramp-ups were reported. On the basis of these reports and records a study was established to provide current state analysis of ramp-up learnings. The records were studied in three ways: correlation observation, repeated occurrences and separate learnings. The findings from the examination are concluded in table 13.

Table 13. Recommendations and conclusions from product ramp-up reports analyzed

Examination	Area	Recommendation
Correlation Observation	Traditional devices	Gain momentum in program start through intense supplier collaboration and verify the capability to minimize the issues in the manufacturing stage.
	Sophisticated computers	By collaborating with the customer and finding out their goals early the problems from poor visibility can be avoided.
	Low Focus Products	When resources are limited problem solving should aim for more sustainable solutions, so that the workload could be minimized in the longer term.
	Medium Focus Products	When demand fails to meet expectations, in beneficial or non-beneficial ways, active information sharing reduces unpleasant surprises.
	High Focus Products	Focus on yield, communication and individual diligence is required when supply is constrained and top-down management pressure high.
	Lead technology Product	Diligence in project start in the form of follow-ups and end to end collaboration is the key to deliver the product with unavoidable challenges.
	Copy Technology Products	Identifying future problems and creating corresponding antidotes early decreases the negative impact when challenges occur.
	Functional Characteristics; UIs	New characteristics have to be sold and marketed internally and externally.
Repeated Occurrences	Sales Package	By sequencing the plans with tenable deadlines the control stays throughout the whole process.
Separate Learnings	Problem Solving	Clever problem solving and sharp-witted experimenting can help to avoid expensive alternatives.

Based on the findings it can be said that the product lifecycle management in the case company should take product division, amount of focus, amount of new technology, functional characteristics of the product, sales package management and every day problem solving into consideration when managing product lifecycles and especially when executing production ramp-ups in a global manufacturing network. In product divisions the upstream and downstream communication should be made transparent by gaining momentum in the program start and by clarifying the goals of the customers. When it comes to administration focus given to the product, the workload optimization and individual diligence should be considered as anticipatory planning and as a

mindset of winning. It should also be noted that functional characteristics affect the internal and external interest of the product. Sales packages' management should be given the proper focus and planning effort to maintain the control of the delivery process. In these mentioned areas the employees should also continue to find optional solutions through clever problems solving when they face challenges.

By utilizing the gathered knowledge provided by the lessons-to-learn the working community of product lifecycle management should continue to develop new ways of working to enable maximizing the sales and profits. The learning culture created should be maintained and the research such as this study should be repeated intermittently to boost the established learning culture, and in that way the established initiative would be maintained. Widely recognized concepts of learning should be exploited in the case company now and in the future. Even if the workload created by the gathering of information feels burdening from time to time, the benefits are for the community's future and not only for the reporting individual.

6.3 Further Projects to be Undertaken in the Case Company

The purpose of this study was to establish a learning culture to support the daily tasks of a working community. Due to the limited resources and experimental nature of the research quite a few possibilities were left for subsequent studies. At least four types of projects could still be implemented in the case company to utilize the power of learning in the case organization, namely the following:

1. Implementing the learning culture to support the whole lifecycle of a product
2. Integrating the tools described in this study
3. Making the tools and prevailing performance measures fully compatible
4. Establishing a similar learning culture at higher level to reduce the amount information sharing obstacles created by corporate silos

For the first topic the crucial part would be to find out if the learning culture was beneficial if it was used on the whole lifecycle of a product. Would the possible output from the reporting input be greater and in that way be useful for the organization or would it be only additional workload for the employees?

The second topic would be based on the same topic as this research, but the scope would be to make the tools of the culture more user-friendly. By combining the tools into one program the use would become easier. But again, it would need to be considered whether the output would be bigger than the input. If the implementation required great amount of resources the project could be seen as a waste of money. Though if it was enabled through witty solutions with basic programs, it would enhance and support the lessons-to-learn culture.

The third subsequent project goal would be to fuse the performance measures of the business unit to the learning tools and culture. By combining the measures with learning reporting, the top management would also have a shortcut view on the plans on how the pitfalls from the past could be avoided.

The fourth research possibility would have the greatest magnitude. Most of the functions at the case company have their own tools for lesson-to-learn reporting, but they all are completely separate. By studying the ways of different corporate silos in learning common benchmarks could be found. In that way all the functions would use similar tools, which again would enable improved visibility when attacking common obstacles and challenges.

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Appendices

6.4 Appendix A. Metrics to determine ramp-up performance

Measure Target	Description
Operational Performance	$$\text{Operational Performance} = \frac{\text{Actuals Invoiced}}{\text{CSVP}}$$ **Actual Invoiced** = Sold quantity over a period of twelve weeks period **CSVP** = (Confirmed Sales Volume Plan) Output quantity confirmed to sales for a period of twelve weeks at the production ramp-up start
Effective Utilization Rate	$$\text{Effective Utilization Rate} = \frac{\text{Actuals Produced}}{\text{MMC}}$$ **Actual Produced** = Production quantity over twelve week period after the production ramp-up start. **MMC** = (Manufacturing and Materials Capability) Reserved and available materials and manufacturing capacity over a twelve week period after production ramp-up start.
Dependability Performance	$$\text{Dependability Performance} = \frac{\frac{\text{Actuals Invoiced}}{\text{USVP(at ramp up start)}}}{\frac{\text{CSVP(12 weeks before estimated ramp up start)}}{\text{USVP(12 weeks before estimated ramp up start)}}}$$ **Actuals Invoiced** = Sold Quantity over a period of twelve weeks **CSVP(12 weeks before estimated ramp-up start)** = (Confirmed Sales Volume Plan) Output quantity confirmed to sales for a period of twelve weeks, agreed twelve weeks before estimated ramp-up start. **USVP(at the ramp-up start)** = (Unconstrained Sales Volume Plan) Sales forecast at the start of production ramp-up **USVP(12 weeks before estimated ramp-up start) =** Sales Forecast, twelve weeks before the estimated production ramp-up start.
Early Batch Failure Rate	$$\text{Early Batch Failure Rate} = \frac{\text{Returned Devices}}{\text{Actual Invoiced}}$$ **Returned Devices** = Returned devices due to quality reasons over a period of twelve weeks. **Actuals Invoiced** = Sold quantity over a period of twelve weeks period

[Pufall et al. 2009]

6.5 Appendix B. Tool structure creation and creation in more detail

To build a set of tools with which a business function can gather data from a subject the structure of the examination has to be valid. The structure for the tools, described in figure 27, was created in this research based on the literature study and interviews to create an approach to production ramp-ups so that all critical aspects of the projects could be defined and described when the reports are produced. In this appendix the creation of the tools' structure is displayed in more detail to present the idea behind all the categories and their subcategories in the picture – "snow flake."

Figure 27. The "Snow Flake", created structure for L2L tools to enable versatile reporting opportunities on production ramp-ups

In the actual report, the topics described in the following chapter: Upstream, Downstream, Solution, Processes, Information Transfer and Additional Information, were added with a precept:

- What was the case?
- What was the cause?
- What actions were made?
- What was the outcome?
- What were the learning points?
- Proposed actions

With these given hints the one filling the templates could make a report sufficient to meeting the requirements of a learning culture. To support spontaneous reporting free

writing was emphasized so that one making the reports could describe, what happened in his or her mind. A Powerpoint slide used by marketing projects to clarify the key aspects of the product can be used to report product definition, marketing attributes and product characteristics sections.

Product Definition

The first branch of the snowflake is the product definition describing the basic information of the product:

- PLCM – Assigned Product Lifecycle Manager who has filed the report
- Report Date – Reporting date which should be close to the actual PD4 Date
- Category – Category describing the high level division of the product: Sophisticated computer or traditional device
- Sub category – Sub category is describing how the products is positioned in the category
- R&D site – Research and development site expresses where the R&D was done
- Product Model – Name used in marketing

These segments give the sorting possibility to examine products in a high level based on their categorization and also to study learnings from a single PLC.

Marketing Attributes

The marketing attributes describe further the goals set for the product marketing wise. Focus describes the tier which is given to the product when it is first introduced to be taken into the market. This way it also describes quite much the resources dedicated to the individual product. Price range is to describe the indicative price at product launch, which helps to examine products inside certain price limits. Weekly target run rate presents the projected sales of the product, which enables the division of the products through volumes.

Functional Characteristics

The functional characteristics describe the attributes in terms of NPD. The options describe the device form factor through a combination of three elements: primary user interface (UI), secondary UI and mechanics. This makes the browsing of the products easier in the Excel tool when options are categorized in three options instead one. When the exterior is described through the previously mentioned three the hardware

content of the product can be described through technology newness and software type. When all these options are combined it offers a broad arsenal to browse the products with common features. The different options possible are described in figure 28.

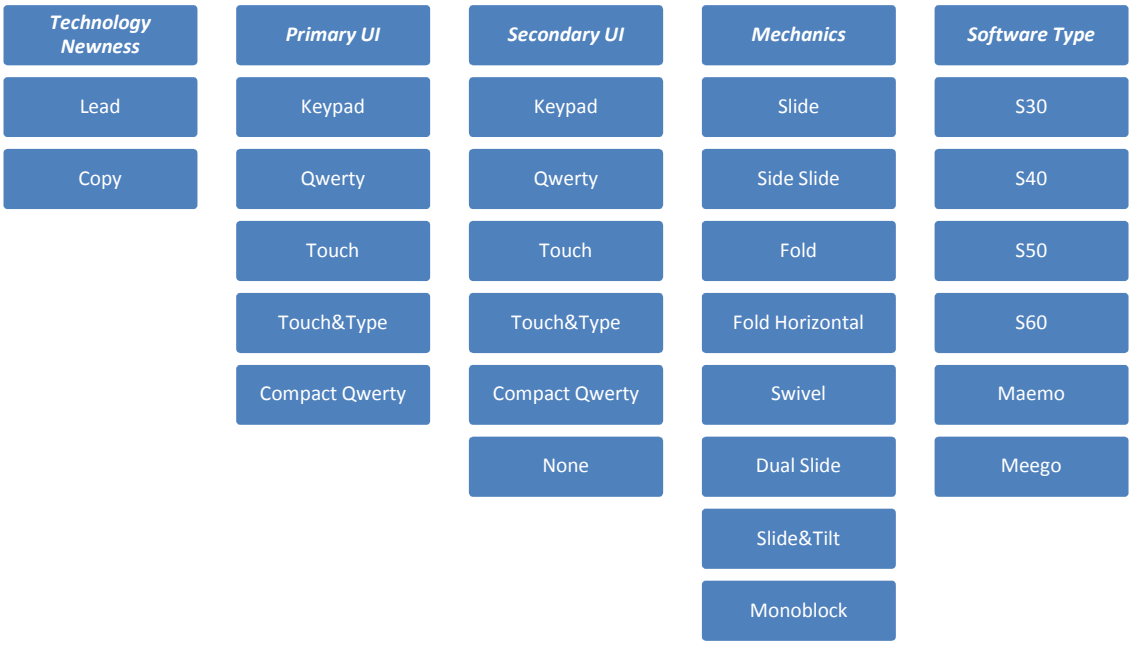


Figure 28. Data validation lists in the L2L tool in functional characteristics branch

With these options the one making or reading the reports can easily give certain criteria to browse and describe products.

Upstream

Upstream is the first actual segment of the report, where interpretation and evaluations should be done. In literature the upstream was described as MMC (Material and Manufacturing Capability)[Pufall et al. 2009], but using the term caused confusion [Kojo 2010] and the term Upstream was chosen to be used instead. The Material and engine supply was chosen to describe the reportable area of supply with a descriptive topic. Under the topic Factory capabilities the product lifecycle managers should on the other hand describe the learnings concerning problems and successes on the production side. Quality was chosen separately because some internal reporting systems used it as a topic. Confirmations on the other hand were needed to describe the crucial task of confirming orders during ramp-up [Xie 2010]. If there were problems allocating

supply to customers or some clever adjustments were made to improve the process the information should be placed under this topic.

Downstream

The downstream includes issues with customer side. Terms demand and external environment were also presented in literature [Pufall et al. 2009], but the use of stream way of thinking was already decided to be used and it also described the topics better. The upstream was divided into demand and customer approval. The two are also used in other reporting programs.

Under the topic demand one making the report could record the crucial learnings concerning demand fluctuations and customer behavior. Customer approval is under the same topic. Issues are described in this section to be with the process in which customer approves the product which they have ordered.

Solution

In literature the product was regarded as the basic product or as the product concept. In this research the product concept was named as solution because it describes the delivery of the offering in a broader way. Under the topic subcategories like Sales package, Core software, Customer software, Variant mix, Product and Services were placed.

The issues and learnings related to the actual device where then to be described in the Product category whereas under the Sale Pack topic the findings concerning the sellable package were to be described. If the mix of products selected for the initial ramp-up was changed or issues popped up during the process they were to be mentioned under the topic Variant mix.

The learnings from software platform are to be reported under the topic Core software whilst the software additions delivered by customer was seen also as an important part since the business is moving all the time to a direction where solutions are build with the help of an ecosystem forming of different parties. If the product was marketed with special services the development of the service delivery capability was to be reported under the topic Services. For example, if the device was marketed with special

navigation system the performance of delivering the car holders would be useful to mention, if the learning could be utilized in the upcoming projects.

Processes

In the processes branch all the key processes supporting the ramp-up were gathered. Logistics was seen useful for the tools after all the research literature showed that logistics system has effect on ramp-up performance. [Pufall et al. 2009] Invoicing was adapted to the structure because early interviews showed that issues with invoicing in some areas appeared constantly. Marketing and NPD projects' performance and functionality was taken into account because they appeared in parallel reporting processes. By adding those into this research and into the reporting system the two would complement each other. The topic Type approval also appeared in the other reporting systems. The problems and learnings concerning the product type approval were to be noted here. For example, if missing documentation for the approval caused delays a notification should be created to this sub area.

Information Transfer

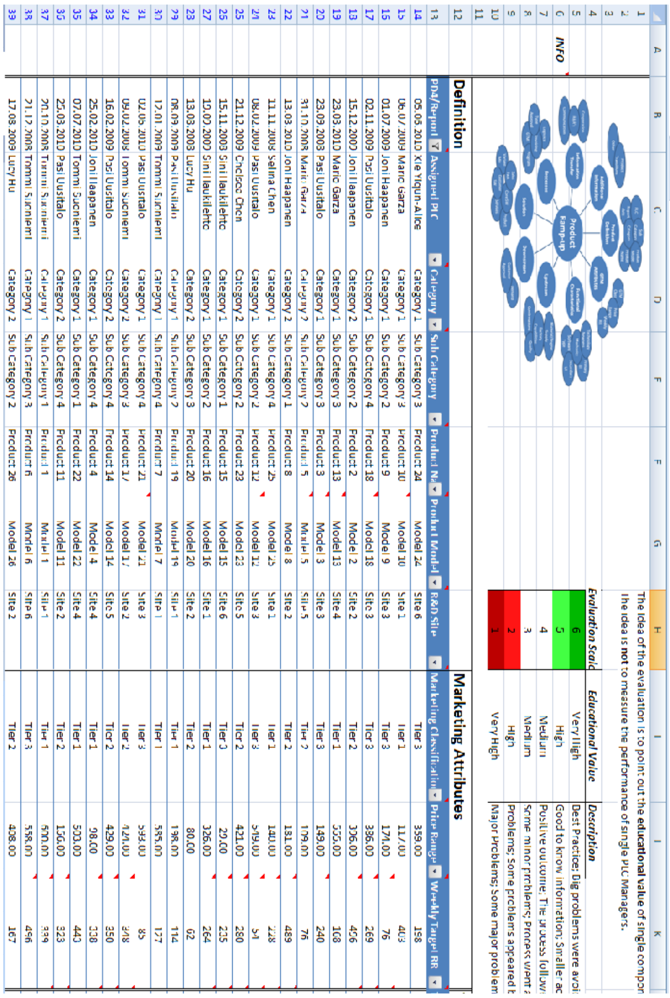
The information transfer section was seen as a must have because other numerous reporting tools could not measure it. By placing communication, cooperation and R&Rs (roles and responsibilities) to the reporting structure numerous potential problems could be pointed out. Learnings especially in this area could improve the visibility of the processes in future and produce new useful ways of working.

Additional Information

In the category: "Additional information" topics:"Other" and "Product transitions" were placed. In the transitions area one making the reports should mention all the issues to be noted concerning the ramp-down of the previous product related to the product to be ramped up. Also transitions inside product family group should be described here. Transitioning is useful to be described in the reporting after all the schedule of the preceding product can have a tremendous impact on the following product to be ramped up. [Yu 2010] The topic "Other" was added because all the previously mentioned topics cannot described all the possible issues and learnings concerning the ramp-up, for

example, natural disaster could be mentioned here if they should be considered in certain times of the year in certain geographical areas.

6.6 Appendix C. Lessons-to-Learn Excel tool



Evaluation Scale	Educational Value	Description
6	Very High	Best Practice; Big problems were avoi
5	High	Good to know information; Smaller ac
4	Medium	Positive outcome; The process follow
3	Medium	Some minor problems; Process went a
2	High	Problems; Some problems appeared b
1	Very High	Major Problems; Some major problem

Definition / **Marketing Attributes**

Row	PD4/Report	Assigned PLC	Category	Sub Category	Product Na	Product Model	R&D Site	Marketing Classification	Price Range	Weekly Target RR
14	05.05.2010	Xie Yiqun-Alice	Category 1	Sub Category 3	Product 24	Model 24	Site 6	Tier 3	359.00	198
15	06.07.2009	Mario Garza	Category 1	Sub Category 3	Product 10	Model 10	Site 1	Tier 1	117.00	403
16	01.07.2009	Joni Haapanen	Category 1	Sub Category 2	Product 9	Model 9	Site 3	Tier 3	174.00	76
17	02.11.2009	Pasi Uusitalo	Category 1	Sub Category 4	Product 18	Model 18	Site 3	Tier 3	336.00	269
18	15.12.2009	Joni Haapanen	Category 2	Sub Category 2	Product 2	Model 2	Site 2	Tier 2	306.00	456
19	23.03.2010	Mario Garza	Category 1	Sub Category 3	Product 13	Model 13	Site 4	Tier 1	555.00	168
20	23.09.2008	Pasi Uusitalo	Category 1	Sub Category 3	Product 3	Model 3	Site 3	Tier 3	149.00	240
21	31.10.2008	Mario Garza	Category 2	Sub Category 2	Product 5	Model 5	Site 5	Tier 2	109.00	76
22	13.03.2010	Joni Haapanen	Category 2	Sub Category 1	Product 8	Model 8	Site 2	Tier 2	131.00	489
23	11.11.2008	Selina Chen	Category 1	Sub Category 4	Product 25	Model 25	Site 1	Tier 1	140.00	228
24	08.02.2009	Pasi Uusitalo	Category 1	Sub Category 2	Product 12	Model 12	Site 3	Tier 3	549.00	54
25	21.12.2009	Chelsea Chen	Category 2	Sub Category 2	Product 23	Model 23	Site 5	Tier 2	421.00	280
26	15.11.2008	Sini Haukilehto	Category 1	Sub Category 1	Product 15	Model 15	Site 6	Tier 3	29.00	235
27	19.09.2009	Sini Haukilehto	Category 1	Sub Category 2	Product 16	Model 16	Site 1	Tier 1	326.00	264
28	13.08.2008	Lucy Hu	Category 2	Sub Category 3	Product 20	Model 20	Site 2	Tier 2	80.00	62
29	08.09.2009	Pasi Uusitalo	Category 1	Sub Category 2	Product 19	Model 19	Site 1	Tier 1	198.00	114
30	12.01.2009	Tommi Suoniemi	Category 1	Sub Category 4	Product 7	Model 7	Site 1	Tier 1	585.00	127
31	02.06.2010	Pasi Uusitalo	Category 1	Sub Category 4	Product 21	Model 21	Site 3	Tier 3	593.00	85
32	09.02.2008	Tommi Suoniemi	Category 2	Sub Category 3	Product 17	Model 17	Site 2	Tier 2	424.00	348
33	16.02.2009	Pasi Uusitalo	Category 2	Sub Category 4	Product 14	Model 14	Site 5	Tier 2	429.00	350
34	25.02.2010	Joni Haapanen	Category 1	Sub Category 4	Product 4	Model 4	Site 4	Tier 1	98.00	338
35	07.07.2010	Tommi Suoniemi	Category 1	Sub Category 1	Product 22	Model 22	Site 4	Tier 1	503.00	443
36	25.03.2010	Pasi Uusitalo	Category 2	Sub Category 4	Product 11	Model 11	Site 2	Tier 2	156.00	323
37	20.10.2008	Tommi Suoniemi	Category 1	Sub Category 1	Product 1	Model 1	Site 1	Tier 1	600.00	339
38	21.12.2008	Tommi Suoniemi	Category 1	Sub Category 3	Product 6	Model 6	Site 6	Tier 3	558.00	496
39	17.08.2009	Lucy Hu	Category 2	Sub Category 2	Product 26	Model 26	Site 2	Tier 2	408.00	167

nents of a ramp-up and in that way share the knowledge around different ramp-ups.

ided with an action or an action had really positive impact on the whole process. These actions are very useful to know for all stakeholders.
ctions improved partially the process. These actions are useful to know.
ed the plans. Add the possible reasons to the outcome.
almost as planned, but a few problems arised. The problems could have possibly been dodged or then not
because of a reason or another. Tell what was the problem, root cause, actions and the outcome. This information is useful for the future.
ns appeared, and really disturbed the process. Mention what was the problem, root cause, action and what was the outcome. Was there any indicators that should noted in the future.

Technology Characteristics					Upstream				Downstream	
Technology	Primary UI	Secondary UI	Mechanics	Software Type	Material/Engine Supply	Factory Capabilities	Confirmations	Quality	Demand	Customer
XXX	XXX	XXX	XXX	Tier 1	5	4	5	3	3	3
XXX	XXX	XXX	XXX	Tier 2	1	2	3	2	3	3
XXX	XXX	XXX	XXX	Tier 1	2	3	2	3	4	4
XXX	XXX	XXX	XXX	Tier 3	4	3	4	3	4	5
XXX	XXX	XXX	XXX	Tier 2	4	4	4	4	4	4
XXX	XXX	XXX	XXX	Tier 3	2	2	2	2	3	3
XXX	XXX	XXX	XXX	Tier 3	3	4	4	2	3	2
XXX	XXX	XXX	XXX	Tier 2	4	2	4	4	4	4
XXX	XXX	XXX	XXX	Tier 3	2	3	2	3	2	4
XXX	XXX	XXX	XXX	Tier 2	3	3	5	4	3	4
XXX	XXX	XXX	XXX	Tier 2	4	5	4	4	4	5
XXX	XXX	XXX	XXX	Tier 3	2	2	4	2	3	4
XXX	XXX	XXX	XXX	Tier 2	3	2	3	3	3	4
XXX	XXX	XXX	XXX	Tier 3	3	4	5	3	4	5
XXX	XXX	XXX	XXX	Tier 2	1	2	3	3	4	4
XXX	XXX	XXX	XXX	Tier 1	4	5	5	3	4	4
XXX	XXX	XXX	XXX	Tier 2	4	4	4	4	2	4
XXX	XXX	XXX	XXX	Tier 3	3	3	4	4	4	5
XXX	XXX	XXX	XXX	Tier 2	4	4	4	4	3	4
XXX	XXX	XXX	XXX	Tier 1	2	2	2	2	3	3
XXX	XXX	XXX	XXX	Tier 1	4	4	4	4	3	4
XXX	XXX	XXX	XXX	Tier 2	4	4	4	4	2	3
XXX	XXX	XXX	XXX	Tier 3	3	4	3	2	4	5
XXX	XXX	XXX	XXX	Tier 1	4	4	4	4	3	4
XXX	XXX	XXX	XXX	Tier 3	4	4	4	3	4	4
XXX	XXX	XXX	XXX	Tier 3	2	4	4	2	4	5

Solution						Processes				
Product	Services	Core SW	Customer	Sales Pack	Variant mix	NPD	Marketing Project	Invoicing	Type Approval	Logistics
3	4	4	4	4	4	3	4	4	4	4
2	3	4	3	4	4	4	3	4	4	3
4	4	3	4	4	4	4	3	4	3	4
4	3	2	2	4	4	4	4	4	3	4
4	4	4	4	4	3	4	4	4	4	4
3	4	1	3	4	4	4	4	4	4	4
5	5	4	4	4	4	2	2	4	4	4
4	4	4	4	3	3	4	4	4	4	4
4	4	3	4	4	4	4	3	3	3	4
4	4	4	3	4	4	4	4	3	4	4
5	3	3	4	5	4	4	3	4	4	4
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4	4	4	4	3	2	4	4	4	3	4
4	4	4	4	4	4	5	4	4	4	4
2	2	4	4	4	4	4	4	4	4	4
4	3	4	5	3	4	4	3	5	4	4
4	4	2	4	4	4	3	4	4	4	4
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4	4	2	3	4	4	4	4	4	4	4
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4	4	4	4	4	3	4	4	3	3	4
4	4	4	4	3	4	4	4	4	4	4
5	4	3	3	3	5	4	4	4	4	2
4	4	4	4	4	3	4	4	4	4	4
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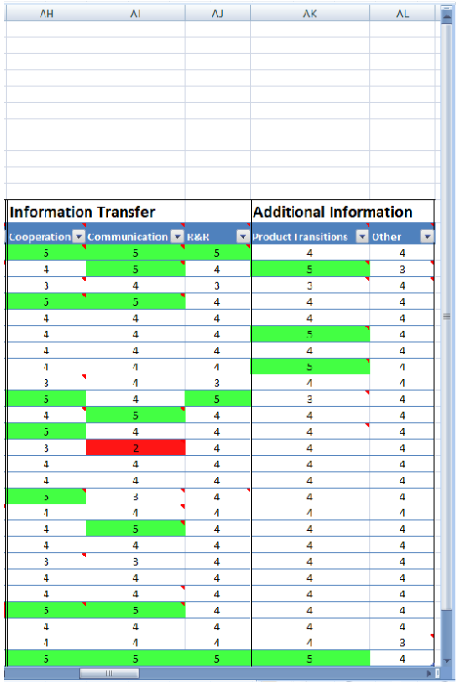
4	2	2	4	5	5	5	4	5	4	4



Information Transfer			Additional Information	
Cooperation	Communication	R&R	Product Transitions	Other
5	5	5	4	4
4	5	4	5	3
3	4	3	3	4
5	5	4	4	4
4	4	4	4	4
4	4	4	5	4
4	4	4	4	4
1	1	1	5	1
3	1	3	1	1
5	4	5	3	4
4	5	4	4	4
5	4	4	4	4
3	2	4	4	4
4	4	4	4	4
4	4	4	4	4
5	5	4	4	4
1	1	1	1	1
4	5	4	4	4
4	4	4	4	4
3	3	4	4	4
4	4	4	4	4
4	4	4	4	4
5	5	4	4	4
4	4	4	4	4
1	1	1	1	3
5	5	5	5	4