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Supply chain management in after sales and subcontract manufacturing processes

Case study: Metso Minerals

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ABSTRACT:

Quality of products and services has an important aspect in manufacturing industry. One of the best practices to ensure cost savings in manufacturing industry's total costs without reducing product's or service's quality is achieved by enhancing supply chain management. Supply chain management targets to enhance operations via procurement and logistics actions. Procurement targets to react product's stock out situations as soon as possible and cost effectively when logistics responsibility is to ensure transport and warehousing the goods.

Case company's supply chain management development has become more needed in after sales and subcontract manufacturing processes since work to these areas have been increased due to increase of demand. These two processes are heavily dependent of effective supply chain management. Operative procurement should be able to react increased demand of goods in as proactive as possible when logistics must be able to ensure inventory levels and goods dispatching as proactive as possible, so production and product dispatching doesn't postpone.

This thesis purpose is to recognize problems and development targets case company's after-sales and subcontract manufacturing processes supply chain management area. Thesis' theory is based on literature and topical scientific articles which deals with procurement, logistics and operational excellence. Empirical study is based to theory of these topics which is implemented with interviews and brainstorms with departments that are associated to after sales and subcontract manufacturing processes. From these processes, flowcharts are implemented to represent current statuses of these process. From emergence problems of these processes, these flowcharts are developed such as these should be based on this thesis.

As results of this thesis problems that have occurred from these processes has been mapped and from occurred problems development solutions are presented to case company for free usage and for possible future research. Development solutions included concrete actions, process development ideas, implementation of new IT-systems and enhancing the communication platforms.

KEY WORDS: supply chain management, procurement, logistics, manufacturing industry

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TIIVISTELMÄ:

Tuotteiden ja palveluiden laatu on tärkeässä asemassa valmistavan teollisuuden alalla. Yksi parhaimmista tavoista saavuttaa säästöjä valmistavan teollisuuden kokonaiskustannuksissa, tinkimättä tuotteen laadusta, saadaan muun muassa tehostamalla toimitusketjujen hallintaa. Toimitusketjujen hallinta tähtää ensisijaisesti toiminnan tehostamiseen organisaation oston ja logistiikan alalla. Tässä oston tavoitteena on reagoida tuotteiden puutostiloihin mahdollisimman nopeasti ja kustannustehokkaasti, kun logistiikan tehtävänä on kuljetusten ja varastoinnin järjestäminen.

Kohdeyrityksen toimitusketjujen hallinnan kehitys ovat tulleet ajankohtaiseksi jälkitoimitusten ja alihankintakokoonpanojen lisääntyessä. Nämä kaksi prosessia ovat suoraan hyvin riippuvaisia toimitusketjujen sujuvasta toiminnasta. Operatiivisen oston on kyettävä reagoimaan ostotarpeisiin mahdollisimman ennakoivasti ja oikea-aikaisesti sekä logistiikan on kyettävä täydentämään varastot mahdollisimman ennakoivasti, siten että tuotanto tai tavaranlähetys eivät myöhästy aikataulusta.

Tämä pro-gradu tutkielman tavoitteena on tunnistaa ongelmat ja kehityskohdat kohdeyrityksen jälkitoimitusten ja alihankinta tuotannon toimitusketjun hallinnan saralla. Tutkielman teorian pohjana on käytetty hankinnan, logistiikan ja toimittajien kehitystä tutkivaa kirjallisuutta ja ajankohtaisia artikkeleita. Tämän teorian pohjalta on annettu viitekehys syvempään empiiriseen tutkimukseen, joka on toteutettu kohdeyrityksen jälkitoimitusten ja alihankinta kokoonpanojen prosesseissa olevien osastojen keräämästä ongelmakohdista. Kummastakin prosesseista on tehty prosessikaaviot ilmaisemaan nykyistä tilaa ja ilmenneiden ongelmakohtien pohjalta prosessikaaviot on kehitetty sellaiseksi, kun tämän tutkielman pohjalta näiden prosessien tulisi olla.

Tutkielman lopputuloksena kartoitettiin kummastakin aiheena olleesta prosessista niiden ongelmakohdat ja näiden ongelmakohtien pohjalta esitettiin kehitysehdotukset vapaasti kohdeyrityksen käytettäväksi tai tulevaisuuden jatkotutkimusta varten. Kehitysehdotukset sisälsivät niin konkreettisia toimia, prosessin kehitysideoita, uusien tietojärjestelmien käyttöönottoa sekä kommunikaatioväylien kehittämistä.

AVAINSANAT: toimitusketjun hallinta, hankinta, logistiikka, valmistava teollisuus

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ABBREVATIONS

SCM	Supply Chain Management
SC	Supply Chain
LCS	Life Cycle Services
SRM	Supplier Relationship Management
MES	Manufacturing Execution System
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
JIT	Just-In-Time
MRP	Material Resource Planning
ATP	Available-to-Promise
ATO	Assembly-to-order
MTO	Make-to-order
MTS	Make-to-stock
DC	Distribution Center
CM	Contract Manufacturer
SC	Sub-contractor
SWOT	Strengths-Weaknesses-Opportunities-Threats
OEM	Original Equipment Manufacturer
ETO	Engineered-to-order

1 INTRODUCTION

Quality of product is nowadays one of the most important factors how organizations assure that they stay in their market position and can gain growth. Supply Chain Management (SCM) methods are widely used in companies to ensure that they provide quality products and services with reduced costs in the organization. SCM methods are widely depended on logistics actions and measurement of product quality can be viewed as fewer delayed deliveries, adequate product availability, reduced customer complaints of the product, and product returns. (Biotto, Toni & Nonino 2012: 213–214)

Since we are talking here area of SCM, suppliers present respectively the most important role in it. When organizations aim to be competitive, it is essential that they extend the vision from their own processes to the whole flow of materials and information with the communication of needs from users to included suppliers. This flow of materials and information is called to supply chain (SC) and it is basically formed from: i) a company which manufactures the goods or services for the customers, ii) a set of suppliers of raw materials and components, iii) distributors, and iv) modes of transportation. (Sadler 2007: 1)

Suppliers' caused quality related problems in the organization are taken as an external factor and treats suppliers as random variable for the organization. Since suppliers can be treated as random variable, best decision in SCM is to use differentiation in SC and not just few different suppliers. Since suppliers are from various of sources, deliveries could be made as a whole now or later, only a part is delivered, or only a part is delivered now and rest of it later. (Lee et al. 2013: 582)

Logistics in SC function plays a big part since typically logistics is involved in such actions as order-processing, purchases, inbound transportation, production plans and schedules, inventory management, distribution and delivery transport, warehouse management, and variety of information systems which include customer response management, materials requirements planning and distribution requirements planning. In large organizations, there are use for all previously mentioned actions and then managing different factors of logistics is needed. In this case, where there are many logistics functions in SC, it is favored to organization see this function as a one whole process which is managed from one department with a deep communication with other departments, such as production and marketing. (Sadler 2007: 32–33)

One strategy of ensuring product's quality via using SCM method is providing after-sales service to product. The after-sales business is globally recognized very profitable compared to methodology where organization concentrates only providing product as it is (Rezapour, Allen & Mistree 2016: 409–410). Nowadays customers take, depending of the industry, after-sales service for granted, and that's why providing after-sales service can be viewed as a lifeline for organization (Li, Huang, Cheng, Zheng & Ji 2014: 377).

Organizations which provide after-sales service have forward SC and after-sales SC. Forward SC concentrates in manufacturing the desired products and delivering these products to customers, and after-sales SC concentrates to provide spare parts and products which are agreed between organization and customer. Forward SC's requirements are defined by analyzing demand rates of products that organization is providing. After sales SC's requirements are defined by warranty length of the product and just-in-time fulfillment rate of spare parts that are assigned to the product at the warranty time. (Rezapour et al. 2016: 410)

While these two SCs are separate, they are heavily linked to each other and thus everything that affects to one SC is going to affect the other SC as well. As previously mentioned, how these two SC's requirements for spare parts are constructed, warranty time of product is heavily linked to product demand rate. This can be viewed that if demand rate of a product falls radically inside of its warranty length, then demand of spare parts can be higher in after sales SC than it is in forward SC for the same product. As also previously mentioned, after-sales service is, if not demanded, but highly required from the organization's customers. If organization is providing after-sales service it is simultaneously affecting to its product's demand positively. Due to these reasons, it is important that when organization is planning these two SCs, it is done alongside with each other. (Rezapour et al. 2016: 410)

In SCM methods via logistics enhancing the performance of an organization, outsourcing the manufacturing of end-product can be taken also in consideration. Outsourcing manufacturing locally could offer shorter lead-times, better flexibility and improved quality. Outsourcing leads to changes in supply network, when other providers come a part of it and thus it should be taken as a part in the supply chain. The coordination of supply networks comes to big role in this picture when manufacturing moves from organization's facilities to supply chain and outsourcing company's facilities. The coordination problems become harder since there is not just one environment, but also the outsourcing organization's environment must be taken under the consideration. (Fredriksson, Jonsson & Medbo 2010: 313–314)

In this thesis it is taken under investigation how the case company Metso Minerals in Tampere's facilitates can enhance its SCM methods organization's after sales and subcontract manufacturing logistics processes. Previously discussed actions are taken under the investigations and thesis is done as master thesis for company's operations development by providing improvement proposals for management and newly structured process flow-charts for the actions. In the next sub-titles, it is discussed how this thesis is going to be structured, methodology of the research and background information of the company.

1.1 Research methodology and thesis structure

This thesis is constructed by the case study approach, where theory is applied and empirical study is built based on presented theory. This thesis adapts design research structure applied in Rouquet, Goudarzi and Henriquez (2016) article *The company-customer transfer of logistics activities*. As an approach more detailed, theory of SCM context in supply networks, logistics and procurement is studied closely, and via this theoretical frame empirical study is made by observing how process are executed by author and via brainstorming with each department that are included in after-sales and subcontract manufacturing process. Based on author's observed problems and problems that are brought out in brainstorms, development proposals are done for these processes. This thesis is constructed in three different frameworks. These are i) theoretical research where theory frame is constructed, ii) empirical research where brainstorms with departments are done and process maps are constructed and iii) research results and development proposals phase where development for occurred problems are presented for the case company to use. Research design is presented as a Figure 1 down below.

In availability part thesis makes conclusion and proposes newly structured process flowcharts for Metso Minerals to use and gives development proposals for management to enhance after-sales and subcontracted manufacturing processes. In this phase the thesis becomes available for the case company to use and in publication since it is obligatory within all the master thesis in Finland.

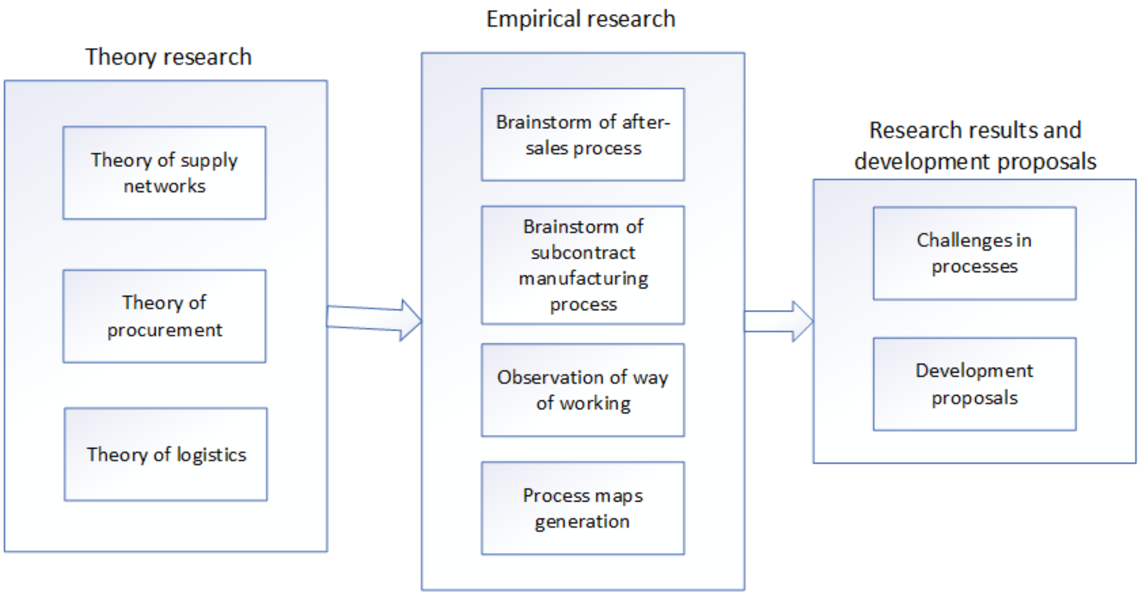

Figure 1. Research design (Rouquet et al. 2016).

For scoping purposes, this thesis has following research questions:

How to enhance after-sales and subcontracted manufacturing processes in the organization?

How to measure after-sales and subcontracted manufacturing processes?

What are suppliers' roles in new processes and how logistics actions are related in this?

This thesis is structured in following way to be continuous and logically advancing:

1. Introduction presents some background information of the subjects related to suppliers, logistics, after-sales process, subcontract manufacturing process. Research plan, methods and research questions are presented. Background information of the case company concludes this chapter.
2. Theory of procurement and logistics in supply networks are discussed. This chapter includes in-depth theory from supply networks, and how procurement and logistics are integrated as a part of supply networks.
3. After-sales process is more theoretically and practically discussed. This part includes scientific best ways how to do after-sales process, introduction how after-sales process is done in the case company, invoicing problems related to after-sales process in case company and proposed development actions related to after-sales process.
4. Subcontract manufacturing process is more theoretically and practically discussed. This chapter includes theoretical discussion of subcontract manufacturing, discussing of case company's subcontract manufacturing process and development process model of case company's subcontract manufacturing,
5. Discussion and conclusion part of thesis summarizes the findings of subjects and gives comparison if the processes are going to better or worse when new processes are applied in after-sales and subcontract manufacturing actions.

1.2 Background information of the company

1.2.1 Metso Corporation

Metso Corporation is one of the world's leading industrial company, and it provides services in mining, aggregates, recycling, oil, pulp, paper and process industries. Company has over 80 service centers and approximately 6 000 services professionals. Organization is listed on the NASDQ Helsinki, with sales number of 2,6 billion in 2016 and employing over 11 000 people in more than 50 countries. (Metso 2017)

As strategy Metso corporation drives customer success. Drivers for this strategy are growth of middle class, natural resources depletion, urbanization, climate change, digitalization and circular economy. Metso's vision is to be globally the best choice for sustainable processing and flow of natural resources, and they list values as: driving customer success, seeking of innovations, performing together, and respecting each other. To succeed in their strategy Metso must be one of the best organizations in providing: customer-centricity, service leadership, technology leadership, supply chain excellence, and people and leadership. (Metso 2017)

1.2.2 Metso Aggregates

Metso Aggregates concentrates to supply energy-efficient mobile and stationary rock crushing plants, screens, feeders and conveyors for its customers. This includes expert and maintenance services as well. Metso provides life cycle services (LCS) for its aggregate products. This includes offerings to targets maintenance, SCM and process improvement initiatives. LCS aggregates six goals are: safety usage, lower sustainable costs, producing quality output, improve reliability, highest possible resource efficiency and lower financial risks. Providing LCS service, Metso promises do deliver global expertise, a world class distribution network, certified technicians and high-quality wear and spare parts. (Metso 2017)

As end-products, variety of different types of products are offered to satisfy end-customers' demands. They are more detailed discussed down below.

Lokotrack Mobile

Lokotrack mobiles provide movable i) ten different jaw crushers, ii) eight different impactor plants, iii) seven different cone crushing plants, iv) two different vertical shaft impact (VSI) crushing plants, v) six different mobile screens and vi) three different mobile conveyors. In addition to these Lokotrack Mobile provides ICr wireless information and control system and metrics remote monitoring products to these mobile aggregates. There is variety of different types of products, since they are designed to be fitted from urban environment to extreme conditions. For example, Lokotrack Urban crushing plant keeps its noise in 85 decibels, and world's largest mobile jaw crusher Lokotrack LT200E is designed to operate as low degree as -40^{o}C and with the winds of up to 30 m/s. (Metso 2017)

Crushers

In crushers, Metso provides i) four different jaw crushers, ii) four different impact crushers, iii) seven different cone crushers, iv) three possibilities to VSI crushers, v) two different high-pressure grinding rolls and vi) one primary gyratory crusher. In addition, there is possibility to connect the crusher with automation appliance, where user operates with crusher remotely from computer. Crushers are highly modifiable depending on customers' desires. (Metso 2017)

NW Rapid crushing and screening plant

Metso's one of the newest innovations is NW Rapid crushing and screening plant. These products are less than 12 hours' set-up plants at the location it is desired. Plants are available for basic crusher plant, jaw crusher plant, impact crusher plant, two different crushing and screening plants and sand manufacturing plant. These set-up plants are transported in three containers and they are highly productive. Plants are designed for smaller volume production, since high movability the plant must be able to ship in country in containers and transported by trucks after job is done at location. (Metso 2017)

2 PROCUREMENT AND LOGISTICS IN SUPPLY NETWORK

Optimizing supply chain is one of the most important actions on supplier's relationship management (SRM). (Sharif, Alshawi, Kamal, Eldabi & Mazhar 2013: 963) SRM is process which is used for managing all the contacts between an organization and its' supplier. SRM process includes setting up, developing, stabilizing and obtaining relationship with in-supplier, as well projecting out-suppliers. (Tseng 2014: 40)

Successful SRM process provides framework for organization to develop and maintain relationship with its' suppliers. Increased competitive pressure, consideration of risks and sustainability, cost efficiency and growing need developing relationship with suppliers are the reasons why SRM is a critical business process. SRM aims to share more information between supplier and purchaser which leads to better integration between supplier and organization. High level of integration between supplier and organization leads to better overall performance in organization. Integration should not be with every supplier in the organization, especially in large organization, but this deep integration should be made with a few key suppliers and keep it traditional buyer relationship with the others. These key suppliers are a crucial part of SRM process' and that way also the whole organization business mission. (Lambert & Schwieterman 2012: 337–338)

2.1 Supply network structures

Disruptions in supply chain have very harmful effects in the organization's overall performance. It is studied, that by announcing disruptions in supply chain, organizations lose average 20% of stock return within six months. For example, tsunami disaster in 2011 caused so enormous disruptions within Japanese suppliers for Toyota, that the organization had to shut down some of its North American facilities six months after the disaster. Natural disasters are hard to forecast, and even the largest and well-managed companies such as Toyota cannot fully be prepared to them. Tsunami disaster revealed also that supply disruptions can't be prevent by doing right things in organization's own facilities, but it requires concentration in organization's overall supply network since disruptions in supply chain usually are caused from supply network rather than organization's internal facilities. (Kim, Chen & Linderman 2015)

Supply network is a total amount of supply chains linked to all the products and services that are provided to customers from the organization (Sadler 2007: 8). Organizations can achieve more efficient inventory management, enhanced product quality, improved delivery performance, decrease in SC disruptions and better overall profitability from creating or reevaluating their supply networks. Supply networks can also work as source of innovations, for example CEO of company P&G stated in year 2002 that 50% of all technologies they acquire are coming outside of the organization (such as suppliers, consumers and universities). (Bellamy, Ghosh & Hora 2014)

Despite literature indicates that supply chains should be viewed as networks they also indicate that networking supply chains leads to more complexity in supply chain management. When supply networks are too large and complex, it increases the chances to disruptions within supply chain management (Gravey, Carnovale & Yeniyurt 2015). As it was indicated in the previous paragraph, one of the supply network's objective is to decrease disruptions in supply chain management. Since complexity and not clear supply network structure can cause disruptions, structures and frameworks for supply network are essential.

Supply network is throughout changing and dynamic system. Order quantities, delivery times and production dates as given examples are all affecting to network, and due to their characteristics, they are all changing constantly. Changing environment and growing trend of outsourcing activities has resulted to uncertainty in supply network. Uncertainty results to more anticipate and control suppliers actions, demands and delivery times from suppliers. This increases complexity and alternative models in supply network structures. (Safaei & Thoben 2014)

Relationship between procurement organization and supplier is traditionally seen as linear and dualistic process rather than network (Bellamy et al. 2014). In Figure 2 basic linear supply chain is presented and it consists supplier's supplier (for example raw-material supplier), supplier (component supplier), manufacturer (organization), inventory (organization's warehouse facilities), dealer and customer. For products to have a trigger to move in supply chain physically, it requires information flow which is presented below in the figure. Generally physical movement of the product goes from left to right (from supplier to customer), when information flows from right to left (from customer to supplier). (Sadler 2007: 6–7)

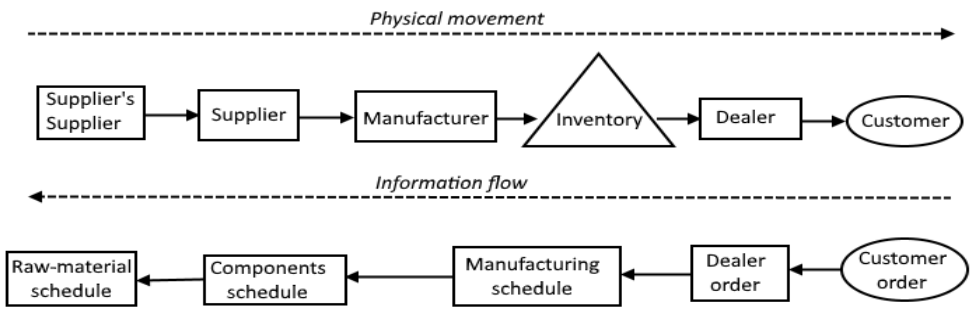

Figure 2: Linear supply chain process (Sadler 2012: 7)

Since supply chain environment is usually complex and full of variable actors, supply chain should be viewed as a network rather than linear model. Supply chain as a network takes all companies in the supply network under consideration and concentrates on the structural elements of the organization and its supply chain partners. More profoundly supply network consists all actors in the supply chain including manufacturers, customers, suppliers, third party service providers and alliance partners. (Bellamy et al. 2014)

Sadler (2007: 10–12) represents two differential structures for supply networks. First of them is called The Double-Bell model (Figure 3), which presents the physical process in supply network. The Double-Bell model is constructed of i) left-hand bell, which gathers all the suppliers of raw-materials and components, ii) central ellipse, which represents the manufacturing process from raw-materials and components to end-products and iii) right-hand bell, which represents the distribution of goods to end-customers. In the structure, ovals at left-hand represents suppliers, rectangle is distribution center for suppliers, central ellipse represents the factory and rectangles several processes, right-hand triangles represent distribution stores and ovals end-customers.

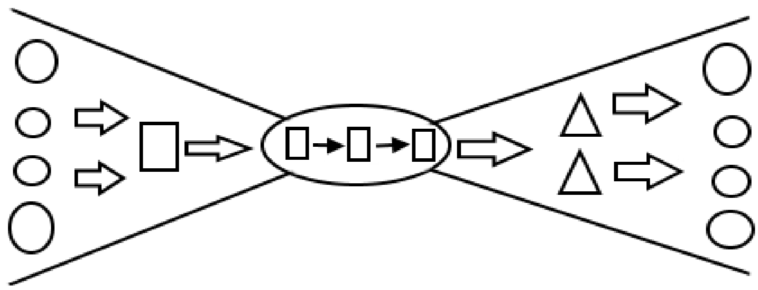

Figure 3: The Double-Bell supply network structure (Sadler 2007: 10)

Another model (Figure 4) which was presented in the literature, is structured based on flow of products and materials, flow of information and time which is passed to fulfil customer's demand. Comparing this supply network structure to the Double-Bell supply network, it also takes elapsed time and effect of information flow under consideration in addition to the physical movement of materials and components. In this structure, all actors such as suppliers, manufacturers and customers are heavily linked to each other and manufacturing organization which produces products to end-customer is on the center of the process. The right side of the process, where customer is located, presents the demand as information flow to the organization which results to system take over. After suppliers have received information flow from organization, which has received it from the customer, this supply network structure acts same way as the Double-Bell supply network does by physically moving the product from upstream supplier all the way to the downstream customer. This supply network structure needs in-depth supply chain management and it requires strategic decision-making, uses balanced inventories as a last resort and system integration. (Sadler 2007: 11)

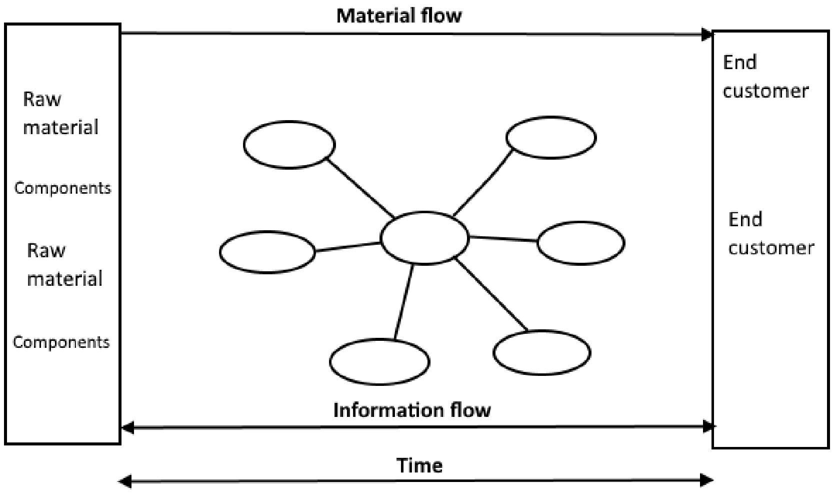

Figure 4: Supply network structure (Sadler 2007: 12)

2.2 **Procurement in Supply Network**

Decision between procurement or in-house manufacturing and supplier management is one of the most researched areas of organization theory. Studies have indicated that procurement actions are strongly correlated to organization's business strategy since it includes handling of procurement department and supplier relationships, strategic direction at the business level and their affect directly to organization's performance. These two actions are affecting to organization's financial performance, so management should pay attention to procurement department and suppliers management intensively. (Bag 2012: 27–28)

Concept of procurement evolves the term purchasing in making its activities more strategic and process-orientated which includes locations of supply sources, forms of materials that are transported to the organization, timetable for purchasing, price determination and quality control. Constantly developing environment of procurement makes some of the purchasing activities, that were before in procurement team's main responsibility, distinguished or automated. (Grant, Lambert, Stock & Ellram 2006: 96) For example: the rise of IT technologies has made it possible that needs of materials can be directed straight to suppliers from production department using Manufacturing Execution Systems (MES) or Electronic Data Interchange (EDI). (Sadler 2007: 36)

Procurement has an important role in value creating process for owners, which can be viewed as a main objective for any business. Procurement and organization's final customer are generally seen as separate functions in the organization. However, high quality and reliably functioning products on-time with valid costs are directly affecting to customer's satisfaction and those attributes are strongly correlated to procurement actions made in the organization. For example, if supplier constantly delivers products late to organization, it directly affects to availability of the end-product from the organization which either results late deliveries or increased warehousing costs of keeping higher stock level. Due to these reasons, it is highly recommended that purchasers know exactly what organization's customers want so they can do right decisions in case of selecting suppliers and making procurement actions. (Grant et al. 2006: 97)

Procurement is the first action which is taken in provision process. Provision process combines processes of procurement, manufacturing, dispatching and serving (Figure 5). In procurement process under consideration are following requirements: i) appointed number of suppliers which are capable of providing desired components or raw-materials, ii) make orders of purchase to appointed suppliers who deliver wanted quantity of material to manufacturing process, iii) receiving the order (on time) and iv) evaluation of the suppliers that quality requirements are met (no significant delays, quantity of materials are right on delivery). Usually organizations negotiate annual contracts with suppliers and procurement department gives information to suppliers from material needs every day. (Sadler 2007: 35–36)

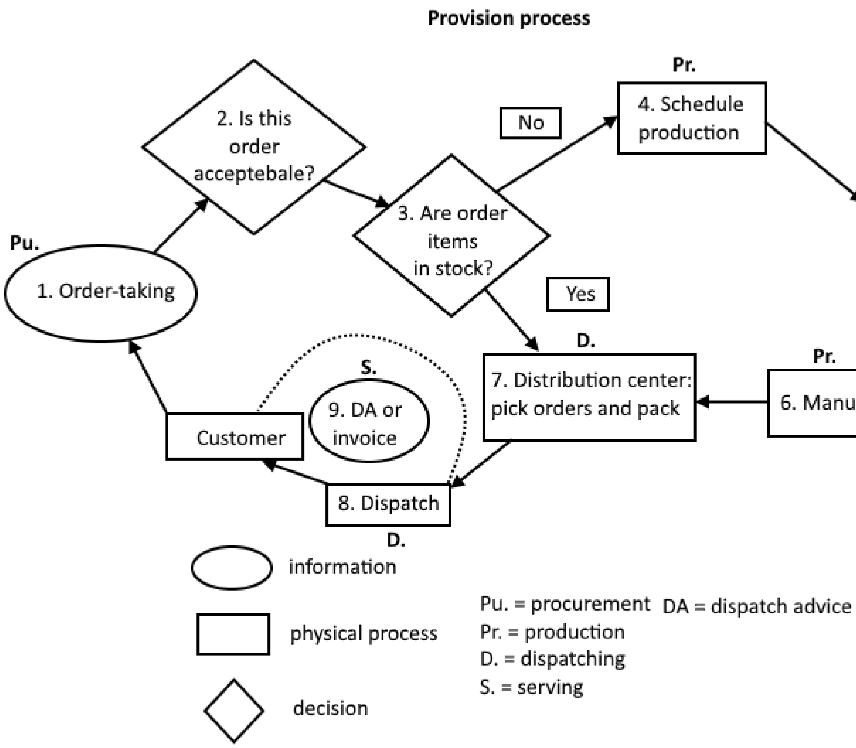

Figure 5: Provision process (Sadler 2007: 130)

2.2.1 E-procurement

Organization, which relies on producing goods aiming to grow its' profitability, is heavily depended on purchasing goods and services. Procurement is nowadays increasingly done by using e-procurement channels which is consequence of growth of Internet and associated technologies in everyday life. It is indicated that e-procurement is essential for optimizing supply chain which is the main purpose of the supplier relationship management (SRM). The growth of Internet and associated technologies have led in variety of communication platforms which has resulted more functional activity between purchaser and supplier. E-procurement channels have made it possible to immediate operational benefits that lead to more efficient and effective purchasing, enhanced information sharing between supplier and purchaser, better relationship between supplier and purchaser, and better possibilities in exploring and developing relationship with new suppliers. Despite evolved possibilities in e-procurement have resulted to previously mentioned benefits, face-to-face communication is recognized crucial in any business-to-business actions and it is very important in SRM as well. (Sharif et al. 2013: 963)

E-procurement's impact on strategic sourcing and firm performance is studied, and according to research made by Kim, Suresh and Kocabasoglu-Hillmer (2015), strategic sourcing has positive impacts on firms financial, operational and supply chain performances. Strategic sourcing is strong positive correlated to e-procurement usage, so when other performs well or bad so does the other. In addition, research's results indicate that e-procurement is affecting in positive manner to organization's performance when markets are more competitive, there are more turbulence in the market and the size of the organization, where larger organization indicates to need more of e-procurement.

According to research done by Chang, Tsai and Hsu (2013), e-procurement can be divided into dimensions of e-sourcing, e-negotiation, e-evaluation and e-design. From e-sourcing organization can enhance the information flow between the organization and supplier, relationship with these two are influenced by e-negotiation actions, e-evaluation develops supply chain integration, and e-design is mainly for designing platforms and environment for the whole e-procurement system. E-procurement is not hence a one system but combination of several sub-systems. Platforms where e-procurement (e-design) is executed can be for example e-MRO or web-based enterprise resource planning (ERP) (Grant et al. 2006: 116). In case company and in this thesis e-procurement is done mainly using SAP enterprise resource planning (ERP) system and manufacturing execution system (MES) platform.

2.2.2 Procurement process (in SAP ERP system)

Procurement process is basically four stage process, where i) warehouse creates purchase requisition, ii) purchasing department creates and sends purchase order, iii) warehouse receives materials and iv) accounting receives invoice and sends payment to suppliers. In bigger organization, it would be sensible to do deeper and much profound process than previously presented four stage process. (Magal & Word 2012: 102)

Basic procurement process is presented in Figure 6 using Simha R. Magal's and Jefery Word's book *Integrated business processes with ERP systems* as a reference. In this model of procurement process starts as a trigger from some other process. For example, production cannot start in two weeks if the organization does not have required component in required quantity. This requirement converts in ERP system as purchase requisition, where purchaser selects a supplier from internal or external supplier. If supplier is external, process could include proposal requests and quotations, when if supplier is internal organization uses a stock transport order, which differs from procurement process and thus is not described more in this section. When proposal requests and quotations are received from the supplier, purchaser evaluates them and selects vendor and makes purchase order. After that, vendor delivers wanted goods to the organization with invoice. After the organization has verified the invoice (all that was required are arrived), it completes the process as a payment to vendor. (Magal & Word 2012: 102–103)

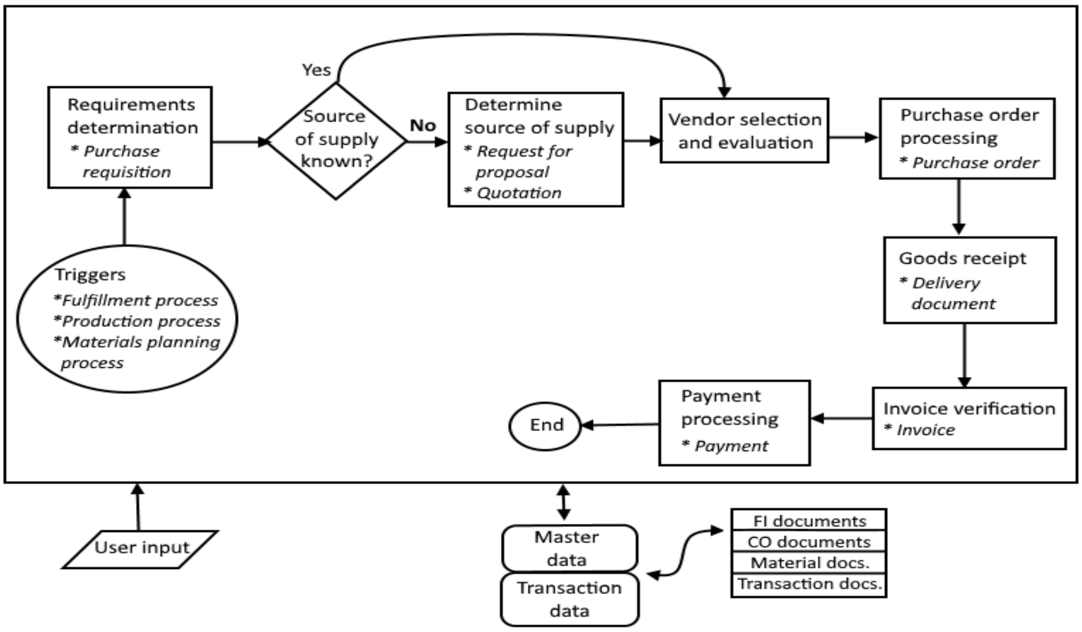

Figure 6: Procurement process in SAP ERP-system (Magal & Word 2012: 102)

Procurement process includes also data as form of master data, transactional data, organizational data and user input. As an output from this procurement process, process makes updates to master data and new transaction data. For every purchase order, procurement process of new financial accounting, controlling, materials, and transaction documents are made or updated. (Magal & Word 2012: 103)

2.3 **Logistics in supply network**

Time used in production and transportation phases of goods are usually only a half of the complete time what it takes from raw materials to become the end-product. Other half of this time are tied up in the logistics actions of the supply chain. Logistics ensures two flows of supply chain, information and material flow, where material flow is physical goods movement and information flow is gathering data from end-customers throughout back to suppliers and supply data to retailer that material flow can be managed thoughtfully. These flows are the corner stones for supply chain management which includes managing the whole process in raw-material supply, manufacturing, packaging and delivery to end-customer. (Harrison, van Hoek & Skipworth 2014: 4–7)

In manufacturing environment, logistics can be divided in three different phases: *inbound logistics, internal logistics* and *outbound logistics.* Inbound logistics considers all suppliers which are producing components and materials for focal manufacturer. Internal logistics considers all logistics actions which are happening inside the focal manufacturer such as shelving, collecting and delivering materials to assemblers. Outbound logistics considers actions, where end-product or materials are transported from focal manufacturer to end-customer or other manufacturer such as subcontractor. Aim for supply chain management is to combine these three logistics levels into one entity with minimal waste and precise outcome for satisfying the end-customer. Material flows from supplier to focal manufacturer are upstream, from where it flows to downstream to end-customer. (Harrison et al 2014: 10–11)

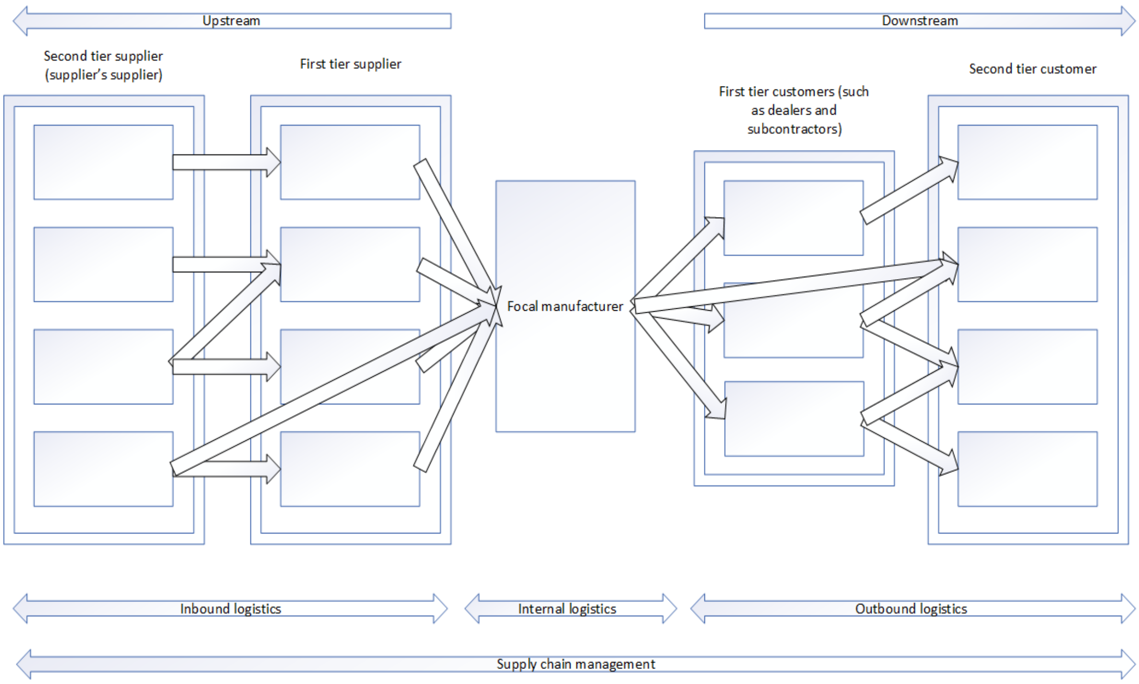

Figure 7: Supply network (Harrison et al 2014)

Optimizing focal manufacturer's component warehousing, which is internal logistics, focal manufacturer usually needs to gather data from following areas: facility and warehousing locations and capabilities, forecasts of customer demands, inventory levels and transportation channel capacities. Optimization is usually made towards cost-minimization reasons and they are done in achieving revenues and market shares and identifying bottlenecks in logistics process for investments in new facilities and increasing the warehousing capacity. (Ivanov, Pavlov & Sokolov 2014)

2.3.1 Just-in-time in logistics

Just-in-time (JIT) process aims to operate the way that goods are produced and delivered in time that they are sold. In JIT logistics process, trigger for supply chain logistics process starts at the time when sold goods are confirmed by the customer. JIT process is directed in *pull* or *push* scheduling. Pull scheduling indicates that materials are needed when market signals for them, or in other words, when a sell is made for the customer. Push scheduling indicates that materials are needed when resources are available for processing. (Harrison et al. 2014: 224–225)

JIT process should be material resource planning (MRP) directed. MRP is constructed in answering questions *how many* and *when* for directing materials straight to manufacturing of end-products. MRP is implemented in ERP system (such as SAP). Usually MRP are constructed in the way that it links downstream materials to manufacturing and upstream materials to supply for customers. Usually MRP follows push scheduling aspects in logistics and assumes that production is done as it has been planned in the system. Since MRP is very good planning but not controlling system, it needs humane control interface. (Harrison et al. 2014: 230–231) Supplier selection is a key factor in supply chain cost reduction. According to mathematical model study of Ghasimi, Ramli and Saibani (2018) JIT deliveries can be used as criterion in selecting suppliers in addition to manufacturing costs and quality.

2.3.2 Lean and agile supply chain

Lean thinking was introduced in western world in 1990's but has its roots in previously discussed JIT production from 1950's and 1960's. Lean aims to cut all unnecessary waste in production from overproduction, waiting, transporting, inappropriate processing, unnecessary inventory, unnecessary motions and defects. In other words, lean thinking aims to erase all waste in the organization and supply chain. Lean thinking is made on five principles, where the four principles are aimed fulfilling the fifth one, *seeking perfection.* First principle is to *specifying value,* second to *identify the value stream,* third *create product flow* and fourth *supply chain should be pull scheduled*. (Harrison et al. 2014: 255–257)

Agile supply chain is constructed in organizing logistics in customer's demand factors. When in typical supply network supply routes are going throughout the focal manufacturer, agile supply chain aims to move supply chain direct from suppliers to end-customer. Agile supply chain is customer centered and is best suited for organizations that are offering products to end-customers with varying needs. Compared to lean production, agile supply should be considered for more variable products with bigger margins and in markets where demand forecasting is less predictable. When lean thinking aims in logistics cut down waste to minimal, agile supply chain's logistics focus lays on high responsiveness to customers and markets. (Harrison et al. 2014: 262–264)

In certain cases, organization offers both, highly predictable demand and high variety products, such as the case company of this study. Supply chain management can be then combination of lean and agile thinking. Agile supply chain is costing more, so the organization, which is combining lean and agile, should do it carefully. Harrison et al. (2014) presents three different hybrids of lean and agile. First approach is Pareto 80:20 analysis, where lean approach is used for 80 per cent of sales and remaining 20 per cent is done via agile approach. Second approach is called decoupling point, where lean is used in product's manufacturing all the way when the product is in its generic form. After that point (decoupling point) when production is more specified agile approach should be used. Third approach is to separate easily forecasting demand to make with lean approach and demand which is under the uncertainty is approached with agile approach. (Harrison et al 2014: 290–291)

3 AFTER-SALES SERVICE FOR ASSEMBLE-TO-ORDER PRODUCT

As it was previously indicated in chapter 2, customer satisfaction of product can be achieved by actions that aim to simultaneously supply chain's optimization. Customer satisfaction can be obtained by making delivering process for customer in timely and reliable way. Supply chain optimization with customer satisfaction in central attention, can be achieved by using available-to-promise (ATP) theorem, which takes in attention all the available resources and production capabilities (for example capacity and lead time) which are straight linked to performance of supply chain. In other words, comparison to traditional order fulfilment, ATP promises to deliver customer product reflecting it to the organization own capabilities. Capabilities are combination of how much materials (components and sub-products) the organization has in its inventory, how much time it takes to purchase missing materials and in production. Traditional order fulfilment accepts order as it is and takes previously mentioned variables into the account after responding to the order. In comparison to traditional model when the organization is using ATP procedure, it reduces the risk in the actual order fulfillment, reduces inventory level obtained and stabilizes value attributes that are linked from the order to the organizations result, such as profit from the order, customer valuation and long-term business interest. (Chen & Dong 2014)

This chapter concentrates in after sales service process for assemble-to-order (ATO) product. Chapter is constructed that it deals with characteristics of product and production, provided service and its process. After sales order fulfilment is one of the problems under the case company, since postponements to these orders are common and it is indicated that different departments that are responsible of after sales service order fulfilment (logistics, order handling, packaging department and production planning) don't communicate efficiently. ATO production is taken under consideration since products that case company produce are made via assembling components and materials rather than making them from raw-materials. For ATO production to be efficient, component inventory level to be precise is essential and since after sales service is done for these products and service can partly be successful into available components level, ATO production is dealt in this chapter as well. The case company operates order fulfillment using ATP procedure in its order fulfillment decisions, so this point of view is implemented throughout in this chapter.

3.1 Assemble-To-Order production and after-sales service

Assemble-to-order (ATO) production system is optimally used in mass-customized products. In the organization, that produces products using ATO-system, its manufacturing facilities keep inventory of components and materials on module level and starts production when order comes to realization in the organization. Modules are assembled in forehand and when production gets triggered from order handling it is done by assembling modules and materials in one complexity. (Chai, Chen & Lo 2013)

ATO production enables much more agile and more efficient production planning than make-to-order (MTO) production system due to its characteristics. This realizes especially in mass customization products, since production planning is made from the order. As it was discussed before, the organization with ATO-system in its production has some already assembled modules in early phases of production (for example, in computer manufacturing industry there are standardized cases for computers), which are not highly modifiable, but the assembled features (such as cooling systems and CPUs for previously assigned computer example) make the end-product customized. (Chai et al. 2013) In comparison to MTO-system, which produces all products as they are desired and ordered from customer, ATO-system shortens response time to customers keeping high level of product variety with reduced inventory levels. ATO-system can be viewed as combination of traditional make-to-stock (MTS) system, which produces end-goods straight to inventory, and MTO-system.

Nowadays customers do not necessarily evaluate products only by price. Since the economic growth across the time has increased welfare to people, customers have increasingly paid attention to nonprice factors. One example is after-sales service to product which is the organization's way to guarantee of product's functionality by providing product supporting during a viable time of product's life cycle. Organizations have three different possibilities in providing the product, which are i) only selling the product by not providing after-sales service, ii) selling the product and providing after-sales service separately, and iii) providing product and after-sales service combined. (Sun, Zhang & Zhou 2016)

Companies globally have recognized potential in providing after-sales services and for example large automotive manufacturers like Toyota and Volkswagen has 4S (sales, spare parts, service and survey) -agreement with their distributors for providing after-sales service to its products. (Li et al. 2014) More generally after-sales service can enhance the organization's sales, profit and revenue numbers (Kurara & Nam 2013).

It is indicated that after-sales services have seven different dimensions which are installation, user training, documentation, maintenance and repair, online support, warranty and upgrades. Companies usually offer combinations of after-sales services from previously mentioned dimensions in reflection of customer's desires. (Szwejczewski, Goffin & Anagnostopoulos 2015)

3.2 After-sales process in case company

In this chapter after-sales process in the case company is taken under deeper analysis. The process is done by co-operation from five different departments in the organization which are department of order-handling, production planning, logistics, procurement and packaging. Process flowchart of after-sales process is presented in Figure 8, where ovals represent information sharing and creation, diamond decision-making and rectangles physical work. This chapter concentrates on what different departments do in after-sales process and what are occurred problems. Data and information for analyzing the process and occurred problems is gathered from brainstorms and meetings where thesis writer has been attended or arranged with representatives from different departments.

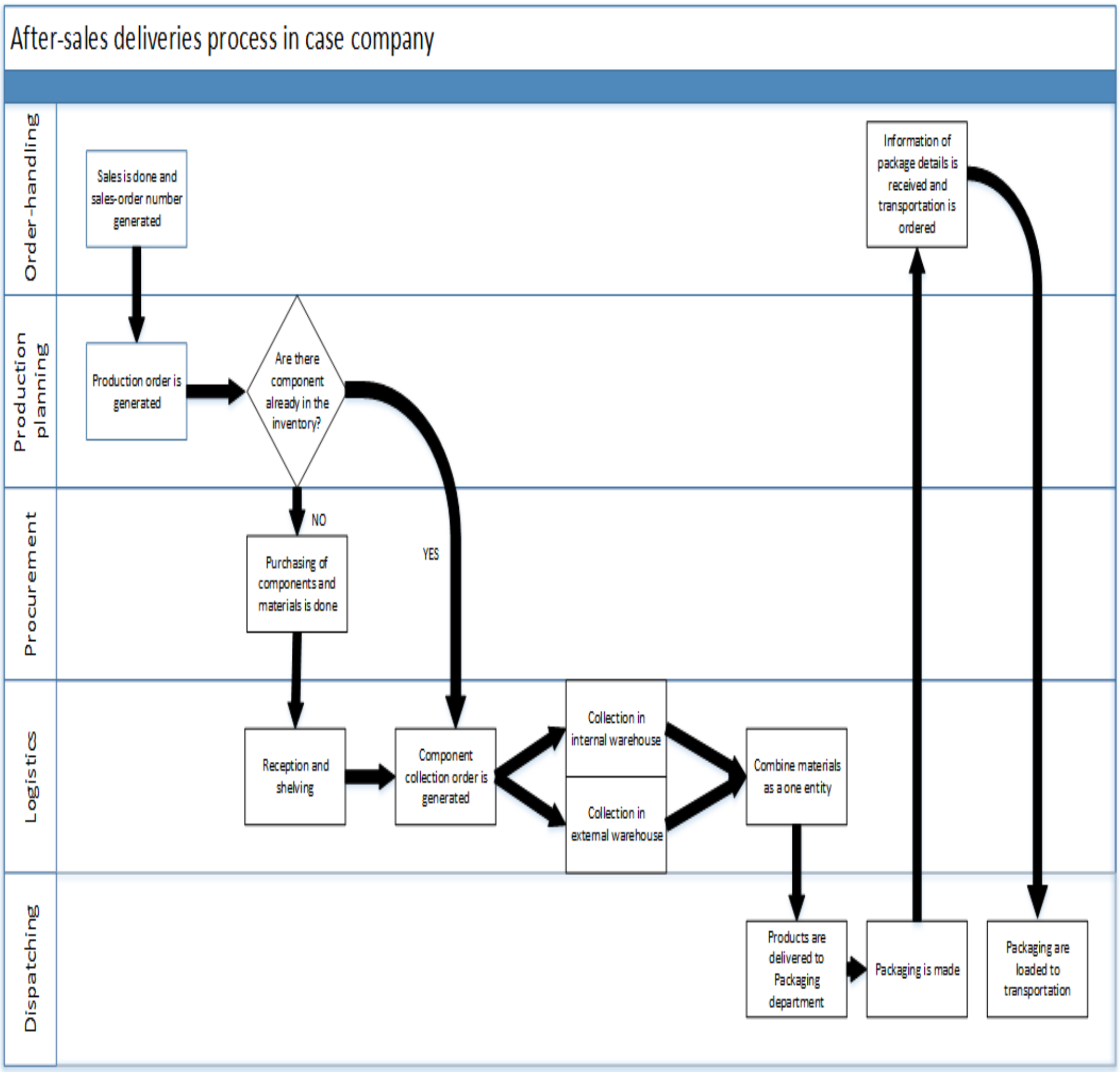

Figure 8: After sales process from order to dispatching

3.2.1 Order-handling

Order-handling department is mainly responsible for generating sales order for the after sales order and ordering transportation for the finished order where all the components are collected and packaged. These are the first and the second to last parts of the after-sales process.

In sales order generation part of the process, after-sales' characteristics is decided, if it is typical after-sales order, warranty order or project order. In this chapter after-sales and warranty orders are dealt more detailed and project orders are taken under consideration when this thesis proceeds to subcontract manufacturing process. In this part of process order-handling department communicates with customer intend for collecting needed information of what customer desires, where the order should be delivered and in which time of delivery. After this order-handling department generates individual sales order number for the after-sales order which contains data of components for this order, requested delivery date and customer details. This sales order number is forwarded to next phase of the process for the production planning department, which generates production order for the sales order.

In the last part of process mode of transportation is decided for the order. For the case company's products, there are three possibilities for transportation which are air cargo, truck cargo or ship cargo. The case company uses truck and ship cargo for sizable orders when smaller orders are transported via air cargo and courier service. This is common way to procedure in area of transportation logistics. If mode of transportation, for example in cases where all modes of transportations are possible, decision of which mode is used is in customer's hands in bigger part-orders and on the order-handling department's hands in other orders. Mode of transportation is triggered to order-handling at the time when packaging department informs size and weight of packed components.

As problems in order-handling department in the case company were listed three different issues. Firstly, information sharing between packaging department and order-handling department, which is done via e-mail, leads sometimes situations where e-mails disappear from order-handling and ready-made packaging could be waiting on the packaging department's floor for weeks before it has been reacted. These situations are common in times when there are temporary employees in order-handling department and contracts with those employees have ended. This is because e-mails via packaging department and order-handling is only allocated to the employee in the order-handling department which is responsible of the order. Second problem is dealing with packaging sizes, which are not known before packaging department has informed them to order-handling department. This is a challenging problem to solve, since after-sales orders usually consist variety of different materials which depend a variety of different variables, so general standardization of packaging isn't a viable solution. Third problem handled with structures of orders which are different from each other (after-sales, warranty and project). Structures differ from each other in SAP ERP-system and this can lead difficulties in learning how to procedure in order-handling for new employees and that way the possibility of human errors increases.

3.2.2 Production planning

Production planning is responsible for generating production order which links to sales order that order-handling department has generated in the first step of after-sales process. Production planning department is responsible for adding materials and components to lists of collection which logistics department execute by receiving and collecting in internal and external warehouses, and checking if materials and components are in the inventory at the time and if not then informing procurement department of purchase requests.

Production planning process starts with the requisition from order-handling department. In this requisition order-handling department finds out if it is possible to get materials and components together for an after-sales order in customer's desired time of delivery. Production planning department executes this requisition by checking inventory levels of materials and components. Checking of materials is done by using SAP ERP-system's inbuild test drive, where time of delivery is feed into the system as an input and system gives list of missing parts for this after-sales order as an output. Based on this output, production planning department communicates with procurement department of possible time of delivery for missing materials and components. After procurement (usually in 24 hours) has answered to production planning department of possible delivery times from component supplier, production planning communicates with order-handling department of delivery times for the completed production order. Based on information of delivery times from suppliers, order-handling communicates with customer of these delivery times and customer either agrees or rejects the deal.

If there are no materials available in manufacturing facilities until requested time of delivery, there are two possibilities to avoid getting materials through procurement. Firstly, it is possible also that after-sales order is delivered without some of the component or material. Then, for example four from five components order are delivered on the time, and fifth one is delivered as after-sales order's after-sales order or customer can seek similar product from another supplier if possible. This procedure is depending if customer desires the delivery to be partially completed on time. Other possibility is to take materials from already allocated production orders which are assembled in the manufacturing facilities. This is only possible if it does not cause postponements in production and new materials can be delivered for production order in the manufacturing facilities on time. If materials and components are in the inventory already, then there are no complications between inventory level and time of delivery is possible in customer's desired delivery time if it is collected by logistics department in given time.

After it is confirmed that there are materials and components available in inventory or customer agrees to postpone desired delivery time until materials are delivered to the organization, production planning does individual production order number for after-sales order. In after-sales orders production order number are generated for collecting and packaging phases of processes. These processes are allocated in SAP ERP-system as work centers, which are for collection MG08, packaging in Lokotrack dispatching department MG10 and packaging in Crusher dispatching department DC01. These work centers are used for allocating material flows from external warehouse to internal warehouse. When printed allocating list of production order indicates that it is directed for work center MG08, it is directed to logistics department of internal and external warehouse. It also creates work queues for dispatching department so when production order for after-sales order is generated, it is directed at the planned delivery date for packaging department to follow-up workload for the day. Work centers are more detailed discussed in packaging department phase of this chapter.

Production order allocates all materials that are numerable to the system, so it takes requirement from inventory to the order. This reserves material for after-sales order so it cannot be used in other production orders. Bulk materials are added like text orders, so they do not affect in the system's inventory levels since bulk materials are not counted in the inventory. Characteristics of bulk materials are discussed more detailed in this chapter's logistics part but in general bulk materials are not counted as a part of inventory since they are materials that are relatively small and cheap and consumed a lot in production.

3.2.3 Procurement

Procurement department is responsible in inquiring and making purchase orders of materials from suppliers that are required for an after-sales order. In this process procurement's role is to be a link between production planning and logistics and although it has relatively small role in after-sales process, it communicates through with production planning and order-handling departments and acts like an executive actor in this process.

Procurement's role in the process starts with received inquiry from production planning department of possible times of delivery for materials and components that should be purchased for the order. This inquiry is received via e-mail and procurement has 24 hours' response rate to it. After inquiry is received procurement team asks from material supplier in which time it is possible to deliver materials and components to the inventory and informs this delivery time to production planning department which takes information to order-handling as was previously discussed.

After order-handling department has confirmed the after-sales order, production planning department asks procurement to purchase wanted materials and components from the supplier. This purchase is done for purchase requisition, which is generated by production planning department. After this, responsibility moves to supplier which confirms purchase order to procurement department, produces materials and components, and delivers them to the organization. Any aberrations in times of deliveries from supplier, procurement team inform directly to order-handling and production planning departments for them to react for the possible postponements in the order.

3.2.4 Logistics

Logistics department is largely responsible of physical workflow in after-sales process. Logistics department's responsibilities includes reception and shelving purchased materials, allocating lists of collection in internal and external warehouses, collect materials and components in warehouses and delivering all the components in packaging department.

Reception of purchased materials is done either before materials are allocated for after sales production order or when production order is already generated, and materials are needed. In the case company, there are two different types of materials: bulk material and denumerable material. Bulk materials are characterized as small components which are usually ordered in large quantities. Examples of bulk material can be screws, washers and cable clips. In the case company, bulk materials are located where they are needed in the production and the most common bulk materials can be found from several locations. Since these materials cost per unit are very low and quantities are high, inventories of them are not maintained. Order from these materials is triggered by when employee of logistics notices that container of material is reaching a low and label of the material is then delivered to purchaser of bulk material when red colored label is left in shelf to indicate container with the low degree of material (Figure 9). Bulk materials are delivered to container depending on their characteristics. They can be either visually directed (FI09) or done by shelf filling service (FI10). Visually directed materials are delivered to container by employees in the logistics and materials usually come in 10–100 pieces batches from various smaller suppliers. Labels for materials are on the board with purchase order where they can be pick up when materials are received in the organization.

Materials which are filled to containers by shelf filling service are characterized to be small, batches can be up to even 500 pieces for one container and one supplier is responsible of them. The case company has four different shelf filling service contractors which are at the same time suppliers for these materials.

1. Material's identification code
2. Shelf bin (**M**obiles**I**nside**I**-hall-120)
3. Material's name
4. Is it visually directed (FI09) or done by shelf filling service (FI10)
5. Supplier
6. Batch size

Figure 9: Material label for bulk material

All other materials and components are counted in the inventory and they are larger, more expensive and complex materials. Examples of materials that are counted in the inventory are motors, frames, water pumps and bigger units of motor such as gearboxes. These materials are received to manufacturing facilities same way as bulk materials, with purchase order which is linked to SAP ERP-system. The difference between bulk material and inventory-counted item is that SAP ERP-system creates transfer order number for the material which it does not do with bulk material. Transfer order number is used for shelving purposes in reception phase of process, but it has other implications which are discussed furthermore in this chapter. Open transfer order indicates that material is received but not placed on the shelf. When shelving is done open transfer order stays in backlog in ERP-system for investigations such as who has done shelving, where it has been shelved and in which quantities. Example of open transfer order in back log is presented in Figure 10, where green rectangle indicates transfer orders that are completed and red circle open transfer order. Transfer orders that are allocated to shelving process are highlighted.

TO Number / SUB	Item / Plnt	Material / Batch	Created On	S S	Typ	Source Bin / Dest. Bin / Return bin	Source target qty / Dest.target qty / Ret.target qty.	AUn	C	CS / Co
0000370494	0001	MM0250903			902	4501928208	20,00	M	1	
	FI01		18.04.2017		M93	MII-310-04	20,00			
							0,00			
0000371574	0001	MM0250903			902	4501928208	20,00	M	1	
	FI01		19.04.2017		M93	MII-340-03	20,00			
							0,00			
0000399489	0001	MM0250903			M93	MII-340-03	10,00	M	1	
	FI01		18.05.2017		914	1001286718	10,00			
							0,00			
0000399490	0001	MM0250903			M93	MII-340-03	10,00	M	1	
	FI01		18.05.2017		914	1001286718	10,00			
							0,00			
0000629338	0001	MM0250903			902	4502084507	50,00	M	1	
	FI01		17.11.2017		M93	MII-310-04	50,00			
							0,00			

Figure 10: SAP ERP-view of open transfer order

Logistics generate delivery orders including picking lists which allocate materials to after-sales orders. Materials for after-sales orders are either located in internal (manufacturing facilities) or external warehouse. Content of after-sales order is deciding how material delivery orders are done. If after-sales order is including materials which are including countable materials in inventory, order picking lists are printed automatically by SAP ERP-system in internal and external warehouse at the day which is scheduled by production planning for collection. However, usually after-sales order include materials which are complex of other materials. These materials are called 'phantom materials', and these are not coming from a supplier to manufacturing facilities but are combination of countable materials and bulk materials which need collection in internal and external warehouse. If after-sales order needs phantom material, automatically printed list of collection includes only countable materials, but doesn't include bulk materials. Here logistics responsible should print list from bulk materials from production order and locate shelf positions from internal warehouse. Locating shelf positions is possible via excel sheet of bulk materials. In after-sales order cases where production order is not done and delivery is straight done by sales order, direction of picking lists are made manually by responsible logistics worker. Direction of materials collection lists are done by generating delivery order from sales order which generates transfer orders for materials that are needed for after sales order. Logistics responsible employee checks, whether the materials are in internal or external warehouse and directs delivery request there. When delivery order is done, ERP-system prints picking list to located warehouse and logistics responsible employee communicates via e-mail details from delivery order to external warehouse if that is needed.

When delivery orders are allocated to internal and external facilities, physical collection of materials can be done. Collection is done based on SAP ERP-system's automatically produced lists of collection and manually printed delivery order component list. Automatically printed list contains information of which material should be collected, from which shelf bin position and in which quantities when manually printed lists of collection need user to check bin positions. After lists of collection are printed from the system, collection in internal and external warehouses can be started. Countable materials are picked for after-sales order by using production order number using transaction LM01 in SAP ERP-system. This transaction has same view in SAP ERP-system both in computer and in handheld device. Collection is done via handheld machine in real time. Collection process in both internal and external warehouses are following the same routine. In external warehouse, where production order collections are made for entire manufacturing facilities (including production of end-product in various work lines) and work assignments usually include collection of materials (approximately ten full truck loads per day) using LM01 via computer based on markings in collection lists would be viable solution. Using handheld device could be more effective way to operate in internal warehouse where work tasks are more profoundly assigned, for example in logistics department there are two to three assigned workers in after-sales process, and operating area is large since external warehouse includes only the warehouse when internal warehouse covers the whole manufacturing facilities which is relatively large area. Bulk materials collection is done from bin positions that are in the internal warehouse near production and assembling lines that tend to use these materials. As it was previously indicated, bulk materials are not counted in inventory since their characteristics (relatively small, cheap and are consumed lot), those materials are not counted to system in after-sales process as well.

When collection is done both in internal and external warehouses, components and materials are combined to same set before they are delivered to packaging department. Components that are located to external warehouse are delivered to internal warehouse where also packaging area is located. Delivery happens with truck cargo which operates between internal and external warehouse approximately ten times in a day. When responsible person receives components and materials from external warehouse, they are checked that they have come in rightful quantities and in good condition. After that, collected materials are combined to same pallet with notification of either production or sales order for packaging department to know which order is in question and have been delivered to packaging department. Last action which logistics do for order is confirmation of delivery in SAP ERP-system.

3.2.5 Packaging

Packaging department is responsible of packaging materials and components that logistics department has delivered and loading these packaging for transportation that order-handling department has ordered. In packaging and transportation loading process, packaging department follows up their work queue to keep up which after-sales orders should be taken care of and communicates with logistics and order-handling departments problems that are related to issues in materials and components that are not delivered and need of transportations.

Packaging process starts with follow-up of work queue which is allocated to packaging processes. In the case company, there are four different dispatching departments from which two are concentrating to after-sales orders packaging and loading. These are

Lokotrack and Crusher dispatch departments. These two dispatch departments use different work queues which are also known as work centers. Work queues are observed from SAP ERP-system via COOIS transaction. Work center for Lokotrack dispatch department is known as MG10 and for Crusher dispatch department as DC01.

When packaging department has checked up what after-sales order is next in the line for packaging, responsible employees locate components and materials from packaging department area which logistics department has delivered. These materials are identified by note, which indicates at least production or sales order number. Materials and components are then packed in appropriate packaging. Packing can take different time depending on characteristics of materials and components that are packed. The simplest packaging could take less than an hour to prepare when the most complex, for example large crusher hammers can take up to two days to prepare since there is the need to build specific cases for them, which hold together all the way from dispatching center to customer.

When packaging is ready for dispatch, packaging department sends sizes and weights of package to order-handling department. Order handling department makes the decision based on these measurements which mode of transportation is chosen. After transportation is ordered it takes approximately one to two working days for truck cargo to come manufacturing area, where packaging department dispatch packaging for transportation and physical process in manufacturing facilities comes to an end.

3.3 **Problems related to after-sales process**

After-sales service contains many problems. The most common one is that components and products, which are allocated to after-sales delivery, are not ready in promised time of delivery or are delivered as partially completed. Since the main problem is in a general level, it is effect of various causes in the process. Because causes and effects can be identified, the most efficient way to model problems related to after-sales services is using widely recognized Ishiwaka's model, which is also known as cause and effect diagram. In this thesis' cause and effect diagram causes are related to different problems that are occurred in different departments that are related closely to process (order-handling, logistics, packaging, purchasing and production planning). Problems related to this process are gathered by interviewing employees in departments who are working with after-sales services. In Figure 11 cause and effect diagram is modelled as it is in the case company.

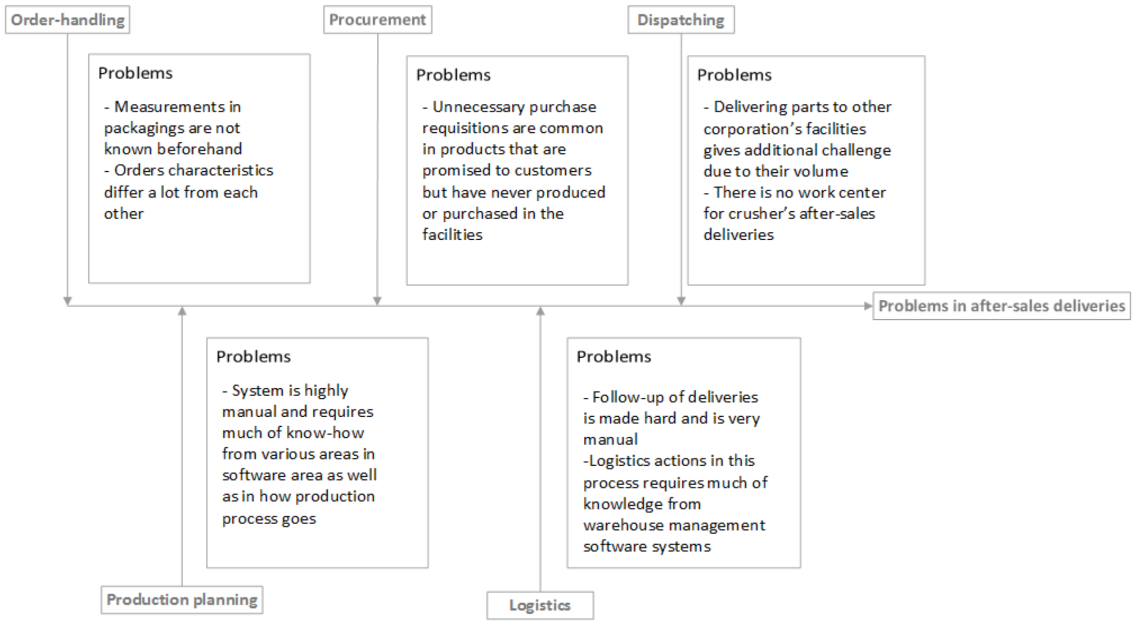

Figure 11: Cause-effect diagram regarding to after-sales deliveries

During interviews with departments it occurred that every department has some problems related to after-sales process. In order-handling problems were closely related on information flow of delivered components and materials and in structures of after-sales orders. In production planning system's complexity and manual way to execute actions in creating materials for delivery is seen as a problem. In addition, production planning in after sales deliveries is just few employees' responsibility, so absence of these employees causes high probability to late response in sales orders and delays in deliveries. In procurement problems were seen in the components which are promised to customer but does not exist in the manufacturing facilities already. In these cases, procurement must extend various materials in one entity. This causes much additional work in procurement and does not provide significant advantage especially if components are delivered inside of corporation, for example in case company's other facilities. In logistics problems are entangled with following-up of deliveries and what should be done in which timetable. At the time, data of deliveries are relatively hard to get from the system and reactions to already late deliveries are common. All the data related in these deliveries are in the SAP ERP-system, but it requires experience of doing deliveries and mistakes from logistics are common. In dispatching problems are seen in the volume of deliveries which have grown exponentially, and this requires more time allocated in packing and dispatching actions. Non-existing work center for crushers after-sales deliveries is seen as problem as well in dispatching area of process. Setting up a work-center would provide better following up platform for crusher's after-sales deliveries.

3.4 Proposed development solutions for after-sales deliveries

As a part of this thesis empirical research and proposed development solution, an author is proposing an Excel-based solution to follow after-sales deliveries. Also, in this chapter propositions for occurred problems that are not dealing with follow-up related problems are presented. These problems are occurred in production-planning, procurement and dispatch department.

3.4.1 Follow-up Excel tool

As problems are highly related to challenges in communications between different departments inside of the process, this study introduces alternative way to affecting these challenges. Excel VBA scripted user form is constructed to answer problems that occurred from discussions with different departments and which are presented in chapter 3.3 (Figure 11). Since it is as an Excel macro-based form, it is highly modifiable and can discuss between programs that are already used in the case company such as Outlook and SAP ERP system and is able to be linked with them. Introduction and explanation of the tool is explained in this chapter, and screenshots of the tool are included in appendix 1.

This Excel user form is made for production planners, packaging department and logistics department to update, and for order-handling and procurement to observe and update in errors. Menu sheet introduces delivery frame, where is option to add after-sales delivery, add delivery to packaging department, add load to transportation, and edit after-sales delivery. Errors frame includes adding and editing errors that are occurred in after-sales delivery.

Using this system starts when production planning department updates the order to the delivery sheet. Updated input includes necessary type of information of the delivery: type of delivery (component order, after-sales or warranty delivery), sales order number, production order number, confirmed delivery date, description of delivery, does it include phantom materials, customer and dispatch department. After the input is in the sheet, logistics department which combines delivery’s components, adds delivery date via user form, which updates input of the date to delivery sheet. When packaging department has packed and dispatched the delivery, they add the date when it was dispatched, and this date is added to delivery sheet as well. Adding delivery and dispatching date is done via navigation frame, where orders can be navigated with previous or next button or searching it via sales order number.

For errors that occur in after-sales deliveries, every department in the process can update any disturbances in their area and how these are affecting to after-sales delivery. There is possibility to add and edit error. Adding error needs information of reporting department, sales order number, notification date, requested correction date, description of error, delay in days, importance (from scale 0-4 where 0 is notification and 4 has very high affect), costs from error and user who has reported the error. Error is then added to error sheet and these errors can be edited if there has been for example typing error with edit function.

In the example that is presented as Appendix 1 of this thesis, logistics user trehalonju adds error in sales order number 303240400 with notification and requested correction date 21.2.2019. Component MM****** has fall from forklift and it has resulted component's permanent damage. New component is collected from the warehouse and component's cost price 80 euros is added as a cost of this error. Importance for this is marked as moderate (scale 2). As manager of logistics has observed this error, trehalonju is asked to edit importance of this error to high (scale 3) which is done in error's edit mode.

3.4.2 Evaluations of component deliveries to organization's other facilities

As it was mentioned previously in this chapter (see Figure 11), after-sales and component deliveries are challenging for packaging department for their volume and for procurement department due to their characteristics to include sometimes materials that are not ever used in Tampere´s facilities before. Due to these reasons, order-handling should concentrate what materials they are promising to send, especially to other organization's facilities. Some of orders can include small fasteners and such like bulk materials, which should be easier to get from nearby supplier in organization other facility than send them from Tampere facility.

For example, one component order in the case company orders to Tampere facility to send 20 pieces of rubber O-rings for Metso's China's facility. China's facility is in Tianjin, which is China's third largest city by population. O-rings typical net price in Finland is under 10 euros and they are delivered as sets. Summed up the price of purchase order, delivery from supplier to Tampere's facility, warehousing the under 10 euros component, use component delivery process employees (production planning, sales-order, logistics, procurement and packaging), sending these components all the way from Tampere to Tianjin (6415 kilometers) is relatively more expensive and ecologically more harmful than making a supply route between O-ring supplier and Tianjin's factory.

This study makes hypothetical calculation of costs that are lost in unnecessary deliveries. In one-month time, case company's Tampere facility is sending approximately four deliveries that are cost priced very low in such as bulk material. Suggestive value of one delivery is net price of component (10 euros), warehousing cost (10 euros), employee hours spent (one hour per department, 25 euros times five is 125 euros) and transportation (50 euros). To sum these costs these deliveries are costing 780 euros in a month, which in a year time will cost 9 360 euros to the organization. These values are calculated on hypothetically, so costs for the organization can vary. Exact costs for these deliveries are not used for calculations.

As a suggestion, this study proposes that every time components that are net priced under 10 euros are enquired from organization's internal facility, previously calculated 9 360 euros are kept as a limiting value. If supplier who can supply under that value in a year is found near these facilities, these supply routes should then be established.

3.4.3 Proposed process-model for component deliveries evaluation

Decision-making in which components are worthy to deliver from Tampere's facilities to other Metso factories should be divided between sourcing and supply chain team which are responsible of after-sales deliveries and Metso Distribution Center is responsible of component deliveries company's internal deliveries. Challenges using Metso Distribution Center (DC) as an integrated supply chain department are i) information sharing between Metso Minerals and Metso DC and ii) factory has the better knowledge of assembling components than DC. In proposed process-model, decision making should be interacted between order-handling and supply chain management executives. Order-handling should interact with supply chain management executives of small components which are low-cost to produce, but high-cost to deliver. If component delivery is made to other factory inside the organization, the picking of material should be done from Metso DC warehouse and packaging department which is responsible of this should be decided from crusher or track dispatching center. Process flow-chart down below is this thesis' proposal for component delivery evaluation process.

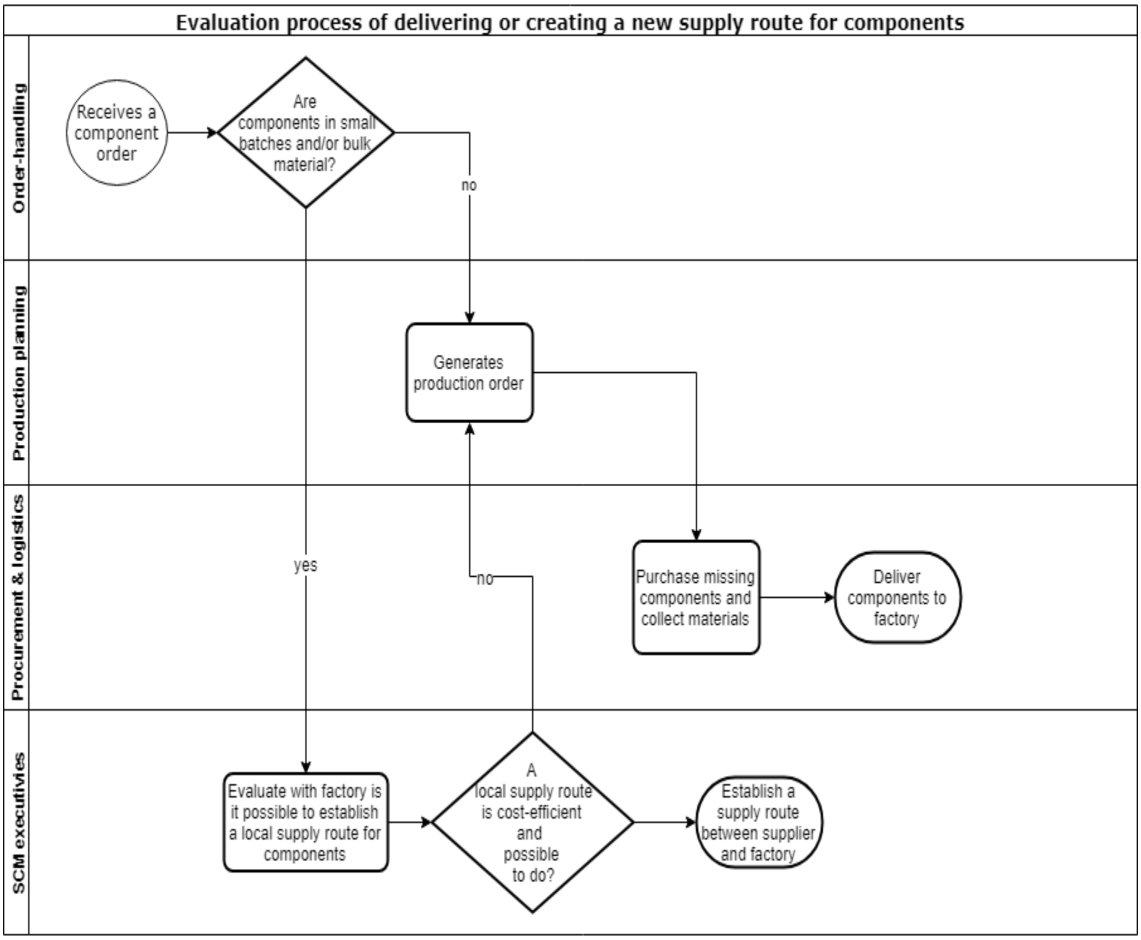

Figure 12: Evaluation process of component deliveries

4 SUBCONTRACT MANUFACTURING PROCESS

Using subcontractors in manufacturing has increased over the years in manufacturing industry. According to Brewer, Ashenbaum and Carter (2013) subcontract manufacturing are used in over half in the organizations in computer, communications, automotive, medical, and industrial control equipment industries.

There are plenty of reasons why using subcontractors are widely recognized as a competitive advantage in organizations. Mainly the reasons are related in answering technological change, willingness not to invest in manufacturing capacity, booming market and increase in demand, and increased competition. When manufacturing facilities capacity is not sufficient for answering demand, organization seeks ways to add capacity to desired level by using sub-contractors. In this situation when more capacity than costs reduction related issues are the motivation to outsource production, it can be viewed as resource-based view from organization. Contract manufacturers (CM) can offer better resources and capabilities to manufacture original equipment manufacturers´ (OEM) products and this way be as a competitive advantage for OEMs. When co-operation with CMs has developed in time, CMs can be utilized in various operational areas in addition to assembling services, such as new product development, spare parts procurement, warehousing, and distribution. (Brewer, Ashenbaum & Carter 2013)

There were a couple drivers which made the case company outsource some of its production to subcontractors. Firstly, the case company did a relatively large investment, which was new production line in case company's facilities, and which was taken into the use in the beginning of 2018. This new production line was intended to produce 6 regular machines per week instead of previous 5. In the mid-year 2018 production line's capacity was around 4–5 machines per week so investment didn't produce expected capacity increase. Secondly, demand of case company's products was higher than ever before and even if new production line would have been successfully implemented, even that could not cover the capacity which was needed in answering increased demand.

This increase of demand is shown in year 2017 financial statement, where revenue of case company increased from 2016 to 2017 over 100 million euros and value of received orders increased just under 200 million euros (Metso annual report 2019).

In this chapter, case company's decision to move manufacturing of certain end products to CM's are reviewed, process from past to present is discussed and development choices to this process model are presented. All statements of CMs are result of this research and they are constructed by analyses and opinions gathered throughout of this process mapping phase.

4.1 Subcontractors

The case company started using subcontractors in some of their Track (T) and Screen (ST) production in autumn 2017 and in Crusher (C) production in autumn 2018. There are four different sub-contractors which are presented in down below:

Subcontractor 1 in Pirkanmaa area, central-Finland

Subcontractor 1 is a workshop located in northern Pirkanmaa area in Finland. This subcontractor produces machinery components for marine and offshore industry. Subcontracting services are offered in welding, assembling, heavy machinery and surface finishing area. This subcontractor is producing three different Track machines and one type of crusher for the case company. Track machines are presented in this thesis as T1, T2 and T3 versions and Crusher is named as C1.

Subcontractor 2 in western coast area of Finland

Subcontractor 2 is medium sized machinery workshop located in south-western coast area in Finland. This subcontractor's expertise is in metal welding industry and sub-contract services in machinery, marine, chemistry, metal, and concrete industries.

Subcontractor is producing two different T machines for the case company. These machines are T4 and T5.

Subcontractor 3 in Harjumaa, Estonia

Subcontractor 3 is Estonian based organization which is specialized in packaging solutions. In addition to this, subcontractor offers transportation, warehousing and, since 2013, machinery assembly services. As subcontractor for case company co-operates with large industrial building and assembling Estonian based organization. This subcontractor is producing different mobile screens (ST) for the case company. SC3 produced five different ST machines and in the late of 2018 it was decided that all mobile screen production from case company's facilities are moved to this subcontractor since their competence producing these machines.

Subcontractor 4 in Pirkanmaa Finland

Subcontractor 4 is combination of three differential production unit. Subcontractor 4 is specialized offering solutions in heavy machinery, metal industry, welding and assembly services. As subcontractor co-operates with supply chain organization. This subcontractor is producing all specialized T machines for the case company which are capacity reasons not possible to produce in the case company's facilities on time for customers. Since specialized and custom machines vary from order to order, production times for these machines are more difficult to define.

	Products	Distance from OEM
SC1	T1, T2, T3	97,9 km
SC2	T4, T5	163 km
SC3	ST1, ST2, ST3, ST4, (ST5)	287 km
SC4	specialized Ts	10 km

Table 1: Subcontractor's general information

4.1.1 SWOT-analysis

As a part of introduction and mapping subcontractors, SWOT-analysis of these four firms is made. SWOT-analysis values are based on benchmarking between study's author and OEM's global product manager.

Strengths	Weaknesses
Opprtunities	Threats

Table 2: SWOT

Subcontractor 1

SC1's strengths as subcontractor are that it has a solid financial base, it has capacity area for possible expand of the business, specialized working tools, such as cranes and surface finishing tools are available and on a professional level, employees are highly skilled, and SC1 co-operates closely with area based transportation firm which makes material flow's execution between SC1 and OEM more flexible and easier. As weaknesses SC1 has its procurement team's skills to directly buy components from suppliers to SC1 and software problems related to MES, ERP, and 3D CAD systems. As software problems, MES system which is used in reporting in all inconsistences related to production and logistics is highly problematic with this SC and since SC is a different organization from OEM, ERP-system's linking to OEM is not possible due to legalization. 3D CAD drawings of assembled machines were also hard to get, and often were problematic for SC to get by their own. Licenses of ERP and 3D drawings are mainly the problem for SC1.

As opportunities SC1 has three of them. Firstly, capacity which is widely available in this SC's case can be expanded for other subcontracting services for OEM. Secondly, work force is highly available in this area of Finland and this SC is a large employer in the area. Thirdly, cost-level can still be reduced at their assembling services and owner base of the SC is highly committed in achieving this. As a threat SC1 has recession, which can shrink demand levels for OEM's end-products and that way reduce production in OEM and higher the costs at this SC.

solid financial standing, production capacities, tools and equipment, employees highly skilled, transportation firm	procurement team's capability, software problems
area of expansion, work force's availability, commitment in cost-level reduction	recession

Table 3: SC1's SWOT

Subcontractor 2

SC2's strengths as subcontractor are that it has highly skilled management, procurement and production teams, it has a long supplier-relationship with OEM and it achieves production target work hours. Weaknesses for this SC is their location which is not on any main routes in Finland, its area to expand is limited which gives not much room to expand assembling services, work force is hard to recruit for SC due to their location and software applications are not working properly.

As opportunities, SC2 can start assembling smaller components that are at the time done in OEM's facility. A location can be also an opportunity for this SC, since their location is near of harbor area of south-western coast of Finland, which would enable that end-products that SC2 are producing can be straightly shipped to the end-customer from there. New production line and actions inside OEMs manufacturing facilities can be seen as threat for SC. New production line was designed to produce T4 and T5 machines, and if this production line starts to operate it designated capacity, it reduces these machines manufacturing in SCs facilities. Recession is threat in SC's situation as well, since SCs are the first place where production is cut if demand decreases. At the area where SC2 is operating also is many other possibilities, especially in marine area of business, so SC2 can decide to retreat from providing assembling service for OEM.

organization skills, long and profitable history with OEM, production target hours are met	location, limited production capacity, work force hard to get, software
start of doing component assembly from OEM, location near harbor area	new product line capacity increases, recession, SC2's decision of retreating

Table 3: SC2's SWOT

Subcontractor 3

SC3's strengths as subcontractor are big production and warehousing capacity, location in Estonia, which is near OEM's suppliers, management is committed of achieving needed production level and work force is cheaper than in Finland. As weaknesses, this SC has ability not to forecast material shortages and inadequate procurement team. As it was previously mentioned, whole mobile screen production was decided to transfer as it whole to SC3's facilities. In early 2019 this SC still needs materials and components from OEM which should outsource purchased in this production volume due to the fact it ties up working force in OEM's facility. Also, software applications are not on adequate level between SC3 and OEM as well, for example problems in using MES are common.

As opportunities, this SC can be viewed more part of supply chain than outsourced manufacturing facility. Since production is decided to move to this SC it enlarges possibilities for OEM as well. If production rate (which was largest in 2018 from four SCs) keeps increasing in 2019, OEM should consider takeover in this SC. This would make easier for OEM to have all functions implemented in SC (which would be in this case subsidiary) and opens OEM to have manufacturing facility in southern Gulf of Finland area, which would provide better logistics implementations to central Europe area. SC's area of expand is an opportunity as well. As threat can be seen a recession and if OEM decides to cancel production transfer from OEM's facilities to SC's facilities. These threats can be seen minor scale threats, since there are no signs that it is in OEM's interest to withdraw transfer of production, and if whole mobile screen production is at SC's facilities, wrong decision would be at recession to transfer production from SC to OEM again. As external threat, this SC's facilities are only on rent, so lessor's unpredictable actions can be seen as threat. Also, other companies can execute takeover to SC3, so that can be seen external threat as well.

warehousing, location, committed management, labor costs	ability not to forecast material shortages, inadequate outsourced procurement, software
part of supply chain, OEM's takeover of SC, area to expand the business	(OEM's withdrawal, recession), lessor's actions, other organization's takeover

Table 4: SC3's SWOT

Subcontractor 4

SC4's strength as a subcontractor is their location at Tampere, which is at the same industry area where case company's external warehouse is located as well. This area is approximately 10 kilometers from OEM's facilities and transportation volumes between external warehouse and OEM's facilities are great. SC4 production employee's skills are at good level in SC4. As weaknesses, this SC doesn't have outsourced procurement at all due to their lack of solidity, weak management skills, no warehousing capacity or clear way to be sure where materials are, and no manufacturing enterprise system (MES) connection. Because of the weaknesses, manufacturing in this SC's location is challenging and usually this SC can produce 2 machines in month at the most.

As opportunity, SC has some area to expand their business. This would enable better warehousing and, in best case scenario, expansion of their production capacity. As threats, this SC is on the brink of not producing anymore OEM's products when it's recession, or capacity in OEM's facilities are upscaled. In addition, lack of solidity in finances can be damaging for OEM, in case of SC4's bankruptcy. To prevent these threats to happen, SC should really concentrate in their weaknesses and if not converting them as strengths or at least erase them.

location, transportation, employee skills	outsourced procurement, warehousing capacity, no MES connection
areas to expand their business	recession, lack of solidity in finances

Table 5: SC4's SWOT

4.2 Contract manufacturing process

4.2.1 Process in general level

Contract manufacturing process can be seen as bigger entity from previously in chapter 3 discussed after-sales delivery process. When after-sales delivery process has five different departments included which are order-handling, production planning, procurement, logistics and packaging departments. Sub-contract manufacturing process includes more departments in the process. After all, after-sales are basically dealing with components or materials which are sent to customer, when sub-contract manufacturing includes production of the end-product which is then delivered to customer. In addition to previously mentioned five departments, sub-contract manufacturing process includes sales organization, product planning, OEM's administrative department, OEM's production, OEM's quality department, SC's administrative department, SC's production and transportation companies.

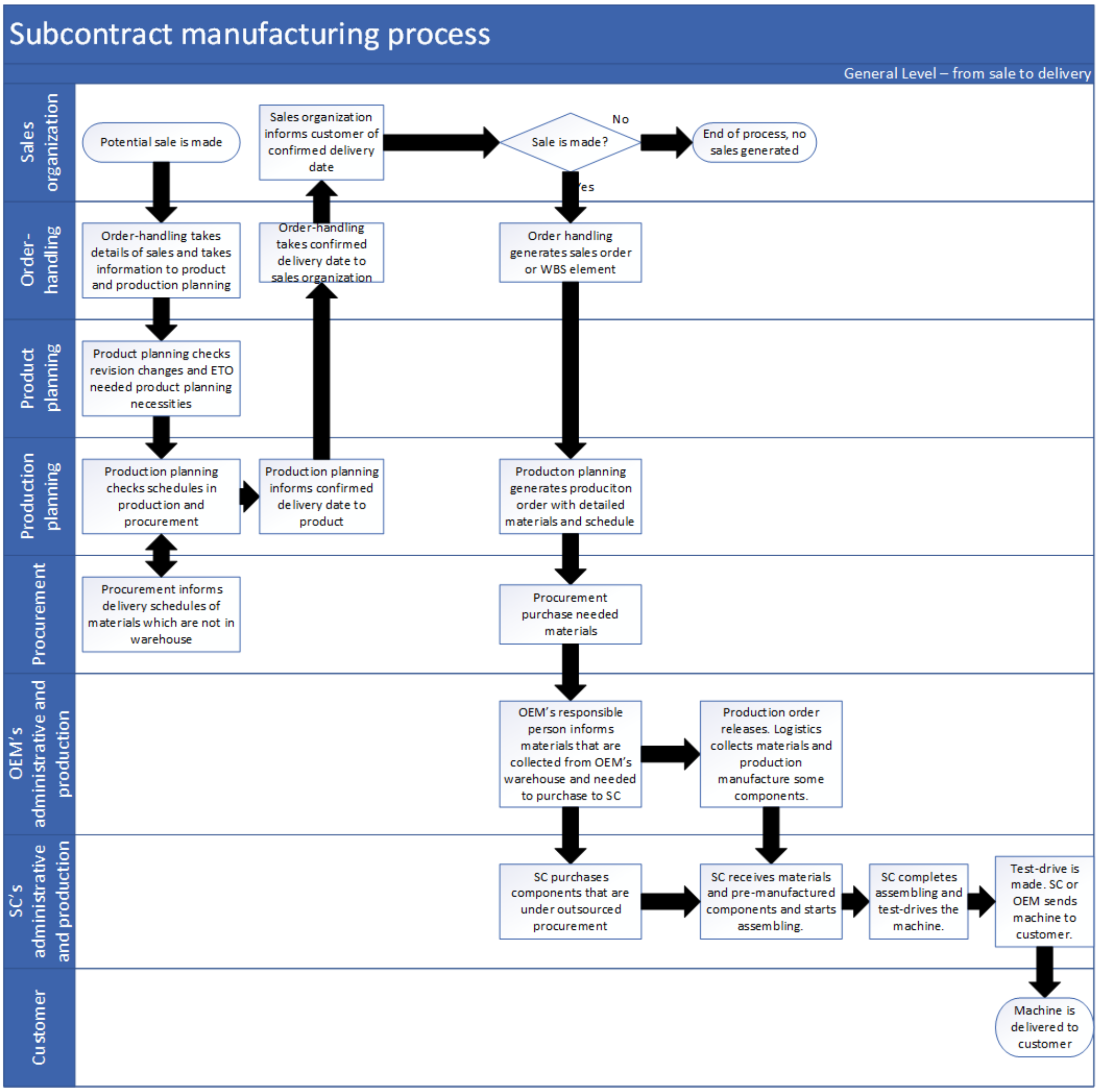

Figure 13: Subcontract manufacturing process from sales to machine delivery

Sales organization

Sales organization's objective in this process is to sell the machine to customer and to operate as a link between customer and operative department of OEM. Sales organization determinates the needed machine based on customer's desires and offers customer the machine solution which is the best alternative for them (for example, is high volume stock machine enough or does the machine need specifications). Sales organization gives all the information from customer to order-handling department which then gives back information to sales organization of possible delivery date of enquired machine. Sales organization negotiates with given information the deal of machine with the customer. When deal is made, and production of machine starts, sales organization keeps customer informed of machine's manufacturing situation and informs customer of possible changes in schedules.

Order-handling

Order-handling department's objective in this process is to operate as a link between sales organization and OEM's administrative and production departments. First step for order-handling is to take details of potential sales and take them to product and production planning departments. After product and production departments have done their part of planning and manufacturing capacities, they give time schedule and estimated cost calculations to order-handling, which prepares machine's confirmed delivery date and cost calculations to sales organization.

Third part of this process for order-handling department is to generate sales order, serial-number and WBS-element for the machine in SAP ERP-system. These numbers channel machine in the ERP-system so different departments are knowing which components are allocated for which machines. As last part of process for order-handling is to book transportation for the machine to the customer.

Product and production planning

Product planning operates in this process depending on which type of machine is in question. If the sold machine is assembly-to-order (ATO) machine, product planning is included in the process usually with revision updates. These machines are common machines which are usually not too much specialized, so all product planning is included in revision updates. If the machine is engineered-to-order (ETO) machine, then product planning is included more in the process than it is with typical ATO machines. In ETO machines, which are more specialized machines to customer's purposes, product planning needs to draw pictures of components and sometimes create completely new assembling entities. In ETO machines product planning is taken in the account as more time-consuming and cost creating factor than in ATO machines.

Production planning department's objective in this process is to act as a linking enabler between everything that is decided in machine's production to be done and operative supply chain departments. First step to production planning is to check material and production availability of OEM's and SC's warehouse and facilities. Production planning then takes these schedules as a one entity and makes as an output a delivery date for order-handling department which can be seen as a capability of manufacturing. Next step to production planning is to generate production order of machine to SAP ERP-system, which includes components, work stages, schedules and all needed data such as machines serial number, sales order, WBS-element and delivery date. Since changes are possible to make to the machine in components and schedules during the production, production planning department orchestrates every stage in production and is constantly responsible that all the information is reached by responsible departments in the process. For example, if customer wants different type of crusher on Track machine what was decided before (and the change is still possible to make), it is production planning's responsibility to inform this change of need to OEM's or SC's production department and, if needed, to procurement and logistics department as well.

Procurement and logistics

Procurement's first step in this process comes, when production planning makes a request of materials that are needed to be purchased for assembling the machine. In this phase, procurement drives the data of missing parts to SAP and gives delivery dates of components to production planning, so production planning can construct schedules of production. Next phase to procurement is to purchase the needed materials for the machine. Needed materials come as a purchase plans to SAP ERP-system, and material's responsible person realizes this purchase plan as an actual purchase order. Procurement is included in the process whole the way when changes are made to the machine structures and if there is something wrong in component deliveries.

Logistics department's responsibility is to ensure that materials are delivered from OEM's warehouse to SC's manufacturing facilities. Logistics must be sure that right components are delivered on-time to SC's manufacturing facility. Logistics also works with the whole process from start of machine's production to end of machine's production ensuring the material flow. In generally speaking logistics department ensures materials to SC's manufacturing and reacts to material shortages from SC's manufacturing facilities.

OEM's administrative and production departments

OEM's administrative and production departments are here combined as a one entity. Administrative department includes production and project managers. Production department includes all production and component's quality departments. Project manager's responsibility in subcontract manufacturing process is to ensure, that all functions in the process are working well and they make decisions how process is lead. Production managers are responsible of OEM's production's capabilities and they ensure that production that are made in OEM's facilities, are made correctly and on-time. Production department's tasks in this process is to manufacture some sub-assemblies which are decided to keep in-house manufactured. These components are engine modules (for all SCs), hydraulic modules (for all SCs, expect SC3) and part assemblies, such as water pumps and valve groups (for all SCs expect SC3).

SC's administrative and production departments

As well as OEM's administrative and production departments, those two departments are here combined as one entity at the SC's as well in this process. SC's administrative department includes sales managers, facility managers and other administrative employees. Their responsibility is to keep OEM's parties informed of realized assembling schedules, realized costs, and production's down hours and reasons to them. SC's production department's responsibility is to assembly the machine in given schedule and inform OEM's logistics of missing materials and OEM's production department of production and quality issues by using manufacturing execution system (MES), Outlook or other decided information sharing channels.

4.2.2 Process from production order generation to finished product

As this study concentrates in supply chain management and logistics actions in given processes, general level process is cut down in the more specified process. This process starts from where production order is generated ending where machine is ready in for transportation to the customer.

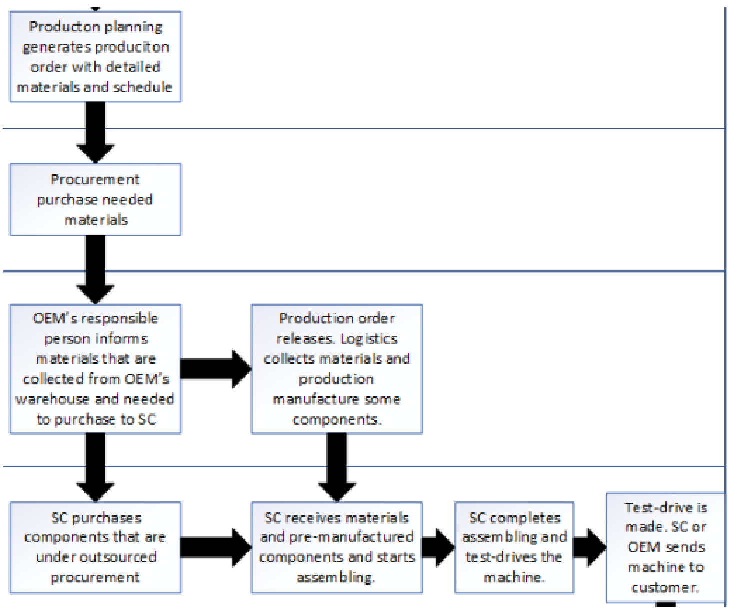

Figure 14: Subcontract manufacturing process from production order to dispatching

Since previously made process is only general level insight of this process, more specifies process flowchart is constructed here. This process flowchart includes OEM's administrative departments, OEM's production, OEM's procurement, OEM's quality, logistics, SC's administrative departments, SC's procurement, SC's warehousing and SC's production.

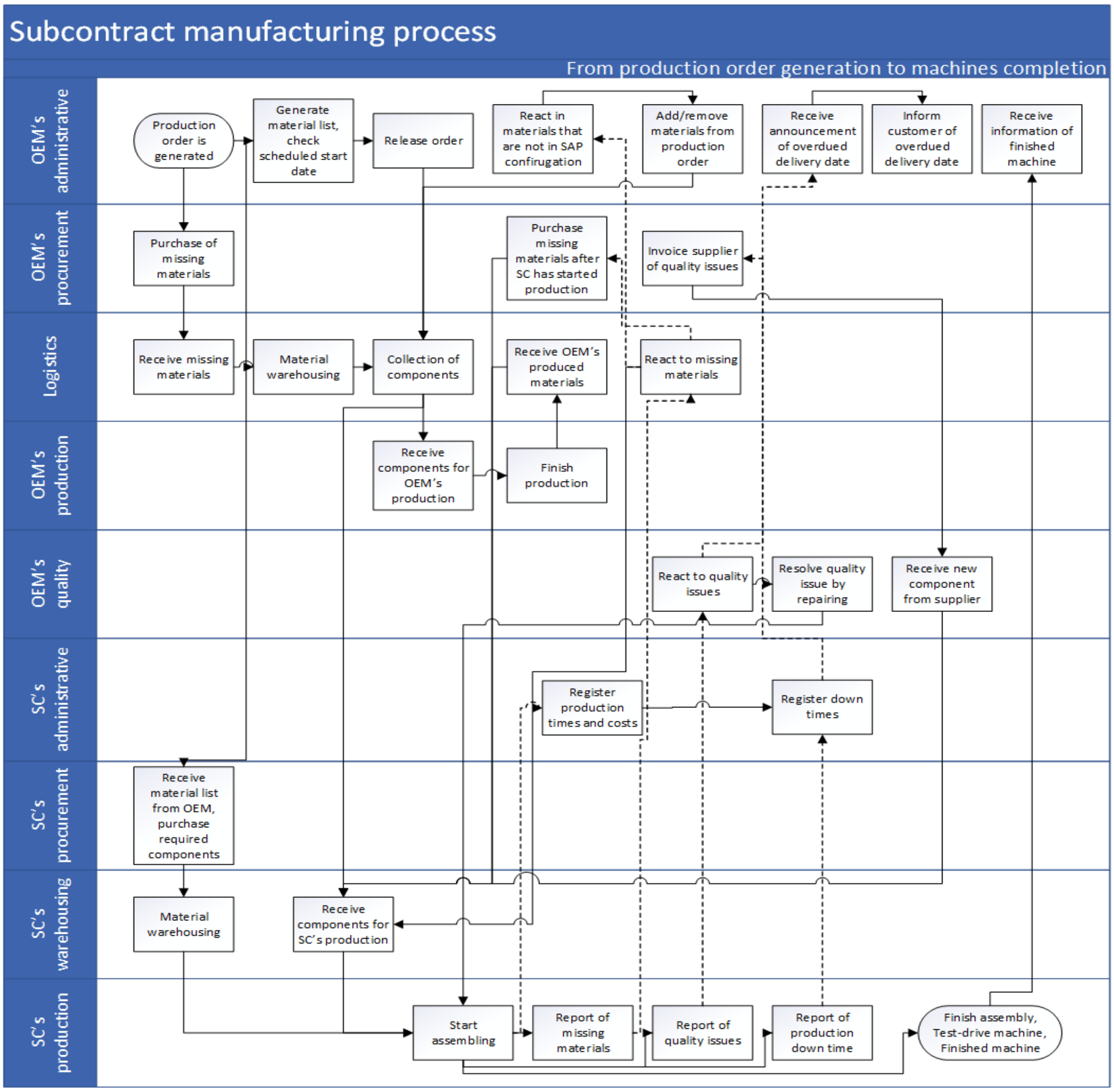

Figure 15: Contract manufacturing process from production order to dispatch more detailed

Instead of presenting what each department is responsible to do in this process, the process map is explained by following paths from start function all the way to the end function. These paths can be divided in three categories which are before production order release, after production order release and during production categories. Release in this environment means SAP ERP action, where orders are released in need to production order realize from plan to execution. In other words, before production order is released, no actions are made for production order, even if scheduled date has been past.

Before production order release

The process begins when production planning generates the production order. In this phase, production order gets unique order number and it contains serial number of machine and sales order, WBS-element, and all the components and materials that are needed in assembling the machine. Production order is at this point in CRTD status and production and product planning can highly modify the order, especially if the scheduled start day is way ahead. After production order is generated, it gives procurement a task to purchase all needed parts from suppliers. Suppliers then deliver needed parts to OEM's warehouse where they are stored to wait for the release. If materials come from supplier after the release, then they are stored and picked up right away or delivered straight to SC's warehouse from the supplier.

After production order is generated, administrative department in OEM's facilities does material list from production order. This list is taken from SAP and converted as an Excel spreadsheet. This spreadsheet contains all components which are allocated to different activities such as material collection, hydraulic module assembling, and so on. This list is then passed from OEM to SC's warehousing and procurement. SC's warehousing department uses this list to check that every material that are allocated to production order has arrived.

SC's procurement uses previously mentioned spreadsheet to purchase all the components that are agreed to SC's procurement to purchase. These materials are generally bulk materials, that are time consuming for logistics to collect, increases error's probability in the material flow, and stock-out situations in OEM's premises. It is widely agreed that SC’s procurement should purchase at least hydraulic connectors, screws, bolts, washers, clamps, fasteners, nuts, and hose connectors straight delivery from suppliers. These materials are relatively easy to get from a few different bulk material suppliers. Getting almost all the bulk materials straight delivered from suppliers decreases the change of material shortages and probability of production down time.

After production order release

This chain of actions category starts, when administrative people in OEM releases the production order in SAP. This release is done by administrative person from production planning or logistics department. Release results in SAP ERP system to create every component, expect not inventoried bulk material, transfer order from OEM’s facility to production order (to SC’s warehouse, SC’s production and OEM’s production). Collection of materials is done from OEM’s facilities and OEM’s external warehouses by logistics department. When collected materials arrive to SC’s production, they are stored in warehouse or delivered straightly to assembling area, depending on at which stage production is going. Collection of materials are also done for OEM’s production.

As it was previously said, even SC manufactures OEM’s machine, some of production in this process is done at OEM’s facilities. These sub-assemblies that OEM produces for SC are engine module, hydraulic module, and part assemblies. Collection of these materials are done from OEM’s external warehouse and OEM’s facilities by production employees (bulk materials) and logistics. After production of these materials are done, they are picked up by internal logistics and sent to SC’s facilities.

SC’s production

SC’s production starts of chain of actions, which requires from OEM and SC to start, upkeep and finish the production. At the start of production, SC should have great deal of the components and materials to start with. Usually material flow continues from OEM's warehouse to SC's warehouse after production start day, for example engine modules are usually needed at the end of production, so engine modules can be sometimes simultaneously at production in OEM's premises during SC's machine production.

However, SC frequently needs back-up support from OEM's logistics, production planning and quality department in production phase. SC usually has other components missing in the start of production process, so OEM's logistics must update where materials are going and why they are not at SC's facility yet. After assembling starts at SC's facility, they update three different reports for OEM: reports of missing parts, quality issues and production down time.

Report of missing parts comes for logistics department to be taken care of. There are generally four types of reasons why missing part haven't come from OEM's facility to SC's facility. Firstly, missing part have not been collected yet, and it is still on logistics collection things to-do list. In these situations, which mostly happen with bulk materials, missing components are collected and sent with the next available transport to SC. Second reason is that component or material has collected according to SAP data but has been lost for one reason or another. At this point, SC's and OEM's warehouses are checked for possible inventory errors, and if material is after the second check-up still missing, missing material is inventoried down and sent to SC's facility. This happens usually to small components and reasons to them appear is that components have been sent to wrong SC, they are with other machines components, or they are components that are not included with sub-assemblies that OEM's production has manufactured. Third reason is that components have been out of stock and they have not been arrived from OEM's suppliers yet. At this situation, if possible, OEM's procurement has been asked to make delivery from supplier straight to SC's facility. Fourth reason is that component is not in the machine's configuration, and thus why they haven't been collected since there has not been transfer order of component. In these situations, production planning department checks if machine really needs the component in its information.

If not, SC is reported why component is not needed in machine and production goes on. If it does, production planning adds component to machine's configuration and either logistics collects component to SC or procurement purchases component if it is not in stock.

Report of quality issues refers to faulty components. Faulty in these situations can be caused by transportation, it has been faulty component from supplier, or it has been broken during assembly. If component has damaged because of transportation, SC try to fix it in its facility by welding and painting it. If it is not fixable, then logistics sends new material to SC's facility and faulty material is either taken back to OEM for quality team to closer investigation or inventoried down and disposed. If component has been faulty since it has come from supplier, then quality department takes matter to procurement's knowledge which audits supplier for bad quality. Supplier then sends new corresponding component to OEM or SC, depending if OEM has substitutive component in its warehouse. If component is damaged during the assembly, damaged component is sent back to OEM's quality department and substitutive component is sent to SC. OEM's quality department investigates can damaged component be repaired and makes decision of repairing or disposal based on the outcome.

Report of production down time is updated when machine's production is interrupted so that assembling work stops due to that reason. SC's administrative department reports machine's production time in two different categories, production time and production down time. Production down time is time which is not included in production. If production down time grows too much, it can result that SC gives warning of overdue production and delivery date of the machine to OEM's administrative department. This results to make the machine, which is in the brink of overdue, to be the highest priority in whole OEM's associated departments. If correction is not made in time, warning becomes reality and then OEM's order-handling gives information of overdue to sales organization, which passes the information to the customer. Overdues in production usually comes when many previous steps have gone wrong or a great interruption comes out near the machine's finishing date. More of wrong actions in steps and great interruptions are discussed in next chapter 4.3.

4.3 Challenges in the process

From the beginning of the subcontract manufacturing process the case company as OEM and four different SCs have had many problems regarding to material and service flow. These problems can be categorized in four different subcategories: absence of organizational structure in subcontract manufacturing process, inadequate logistics workforce, personalization of work tasks and not standardized way to procedure with SCs.

Absence of organizational structure

The most general problem of the subcontract manufacturing process is that there is not clear organizational structure. It was not until late 2018, when subcontract manufacturing got it responsible manager, almost year after the first machine was assembled in SC's facilities. Absence of organizational structure has resulted that not everyone included the process are known where to inform if problem occur. This problem is the root cause for presented problems, which deals with inadequate logistics work force and personalization of work tasks.

Inadequate logistics workforce

As it can be seen in process flow chart, logistics department has an essential part in process. Logistics department has a lot of responsibilities to process to succeed, when it comes to receiving purchased components, warehousing the components in rightful place, collecting components, and reacting to missing components from SC. When the department has that essential part in succeeding process, it should be obvious that department is concentrated more carefully.

From all logistics work force two employees are responsible of logistics actions regarding to subcontract manufacturing. These employees are subcontract manufacturing coordinator and logistics worker, where coordinator's main duty is making component lists for SCs and OEM, attend to meetings with SCs, react to missing materials and develop the logistics procedures, and logistics worker's main tasks are collection of large and small materials from OEM's facilities, load transportation trucks, order transportation and react to missing materials. When there are only two employees, both need to know how to manage each other's job as well in case of another's absence or unbearable workload. Unbearable workload can be seen late collections which can result to overdue manufacturing. For example, collection of bulk materials is very time-consuming activity, and it requires up to two workdays to complete depending on which SCs machine is in process.

In addition to that these two employees work at the same place, OEM's facility, what leaves OEM's external warehouse without SC manufacturing's materials responsible person. Almost every component, expect the biggest volume ones such as conveyors, crushers, and some of screens, are stored in this warehouse. When missing materials are rooted to be collected from the external warehouse, it is almost impossible for the two employees in OEM's facility to tell why collected material from there is missing.

Personalization of work tasks

Personalization of work tasks relates highly on absence of organizational structure. In the case company's situation personalization appears that almost every work task has one employee who does it well and others might not be familiar enough to know how the employee is doing so efficiently that work task. One hand, this is clear way to work for every association in SC and OEM. If there is a problem in certain area, there is always an employee who to turn to. On the other hand, it is very hazardous to trust issues on one person, especially if issues are large or unbearable. This is because, one person's capacity to do work tasks is limited and they can be undone or postponed if this person is absence of work or loaded with other just as important tasks. In other words, tasks should be able to do in, if not as precisely as they are done by its responsible employee, so them must be able to be performed inside the responsible department.

Not standardized way to procedure with SCs

Since there is no standardized way to procedure with different SCs, it has resulted that the process contains unnecessary work. This is due to fact that configurations of production orders are usually done by same manner how they are done at OEM's facility. Unnecessary work is done because of two reasons. Production planning department does not do SC production orders in machine production different way and that is why configurations of machines are not specified in any SC's manufactured machines. When production order to machine production is done in same manner for SC than it is done to OEM, it causes that collection of some materials in external warehouse is directed to OEM's packing department. After OEM's packing department receives these materials, they make a request to OEM's SC manufacturing process logistics employees, to resend these materials to SC. Unnecessary work comes when materials are needlessly taken to OEM's facility since they are needed to SC production. When it comes to configuration specification, there is none of that in track machines. This usually results that missing materials are asked from SC to OEM, since all materials are allocated only for one stage in production order. If there are six stages in manufacturing the machine, this does not affect in collection of materials. All the materials are collected in the same stage.

4.4 **Development of process**

For occurring challenges, this thesis represents development solutions. There is one solution which can affect to personalization of work tasks, one for absence of organization structure and inadequate logistics work force and two solutions for not standardized way to procedure with SCs.

Organizational structure

Personalization of work tasks and inadequate logistics work force are both consequences of lacking in organizational structure, which should have been built for SC manufacturing process. This study represents two alternative organizational structures, which would clarify process to all associated departments. Logistics structure is presented more detailed.

In the first presented organizational structure there are five needed departments: logistics, procurement, subcontract manufacturing, production and planning. Production includes quality department and planning is combination of production and product planning departments. In this organizational structure, subcontract manufacturing manager makes enquires to other departments managers of policies how subcontract manufacturing process are done. For example, if subcontract manufacturing process needs to concentrate more in logistics, subcontract manufacturing manager makes request to logistics manager of more resources to be aligned to logistics actions that are needed in subcontract manufacturing process.

Subcontractors direct all issues to subcontract manufacturing coordinator. SC manufacturing coordinator directs then all issues to responsible departments. For example, if materials are late or not found, coordinator forwards this problem to logistics and cooperates with them to solve issues regarding to subcontract manufacturing. This one coordinator organizational structure is presented as a figure below.

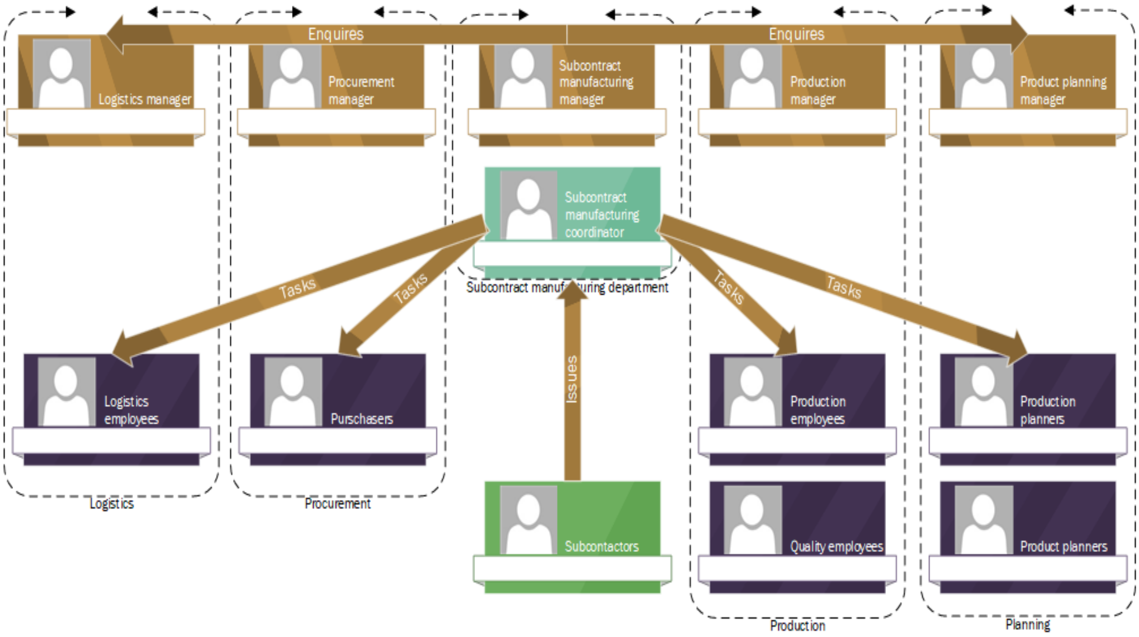

Figure 17: Proposed organizational structure with one coordinator

Another organizational structure is operating the same way than previously presented but instead of structure where one coordinator delegates the tasks to each department, there are two coordinators to delegate these issues. One which is specialized to supply chain actions such as logistics and procurement and the other which is specialized to manufacturing actions such as production and planning. This would be more effective way, but it would require a will from the organization to hire two people for subcontract manufacturing and willingness to invest in SC manufacturing.

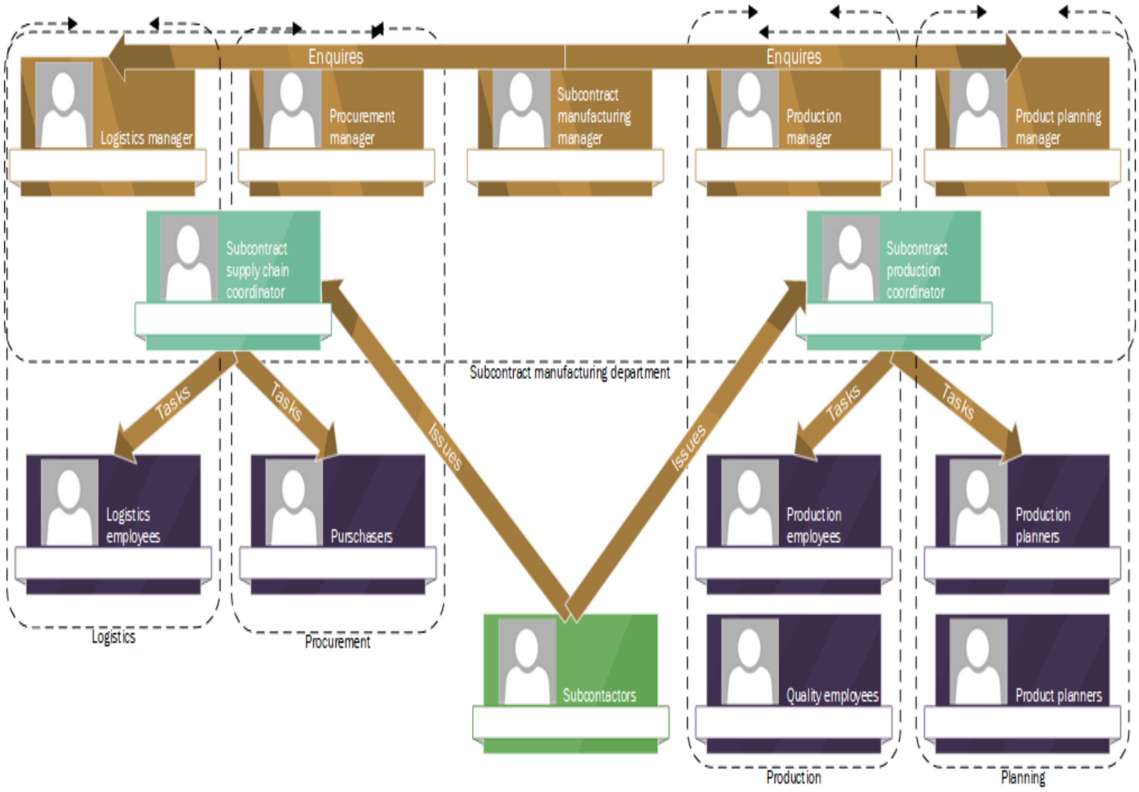

Figure 18: Proposed organizational structure with supply chain and production coordinator

As a part of these organizational structures, logistics structure for subcontract manufacturing is presented. Two to three employees in OEM's facility and one responsible person in external warehouse should be enough to cover the work load. One employee is responsible of outbound logistics, which includes ordering transportations and loading components trucks. One to two employees are responsible to collect materials and OEM's pre-manufactured components. Finally one employee should be responsible in external warehouse's outbound materials.

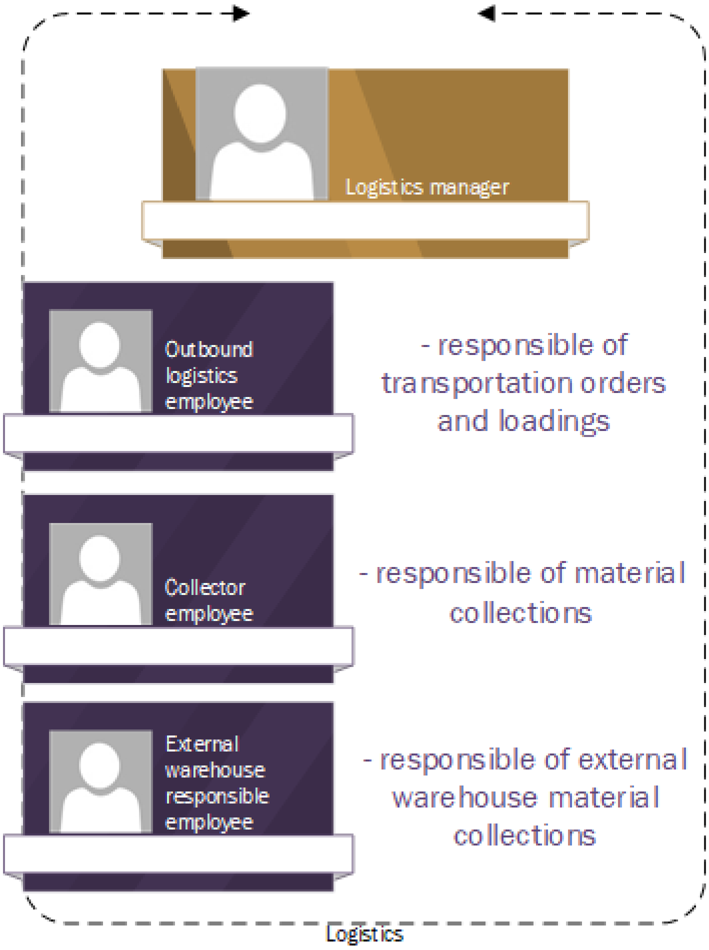

Figure 19: Logistics structure in OEM regarding to SC process

Configurations of machines

Configurations of machines are aimed to prevent unnecessary work occurring. Configuration in subcontract manufacturing machines are done at the present time only for engine modules, pre-manufactured components and crushers. Whole production of the machine is at one collection of components phase, even production is usually phased in six different parts. Figure 20 presents the current situation of materials collection.

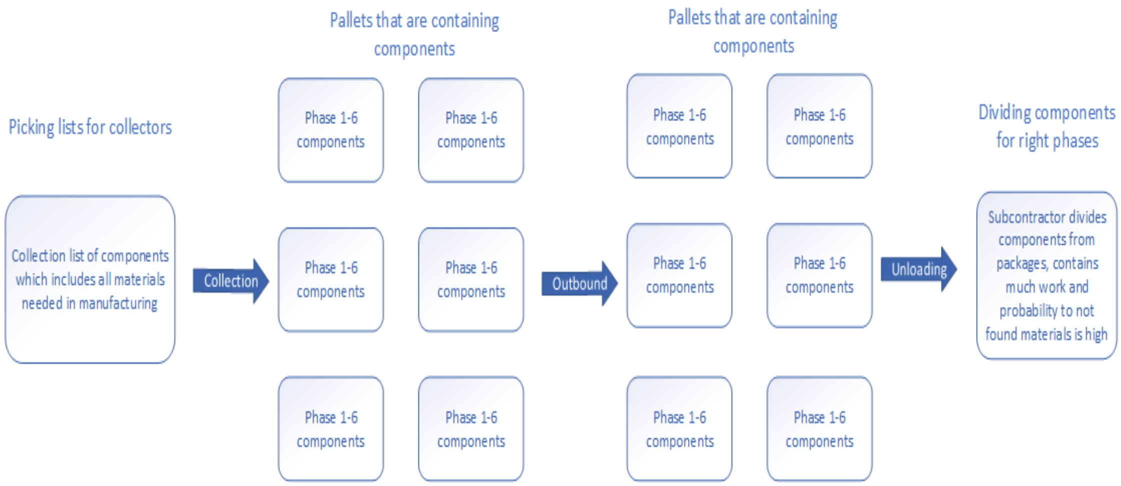

Figure 20: Material collection without configurations in SAP ERP-system

As it is seen in Figure 20, present procedure does much settling work at SC's warehousing. When components are collected randomly, regardless of which phase of assembly they are needed, into the same pallet it is hard to SC's warehouse to be sure all the components have come for each phase. In worst case scenario, some of the components can be still waiting to be outbound to SC in OEM's external warehouse when SC is due to start the production. If there are components waiting in OEM's external warehouse for production's phase one, it can stop the production at the early stages, even all the collection work is done.

If collection is done for chronological order of the assembly, it would reduce material searching work in SC's warehouse and divides the collection load of components in external warehouse, would be done more precise and in right order. Collection in phases would also take as much time as it takes with the present procedure. Figure 21 presents how collection in phases would look like.

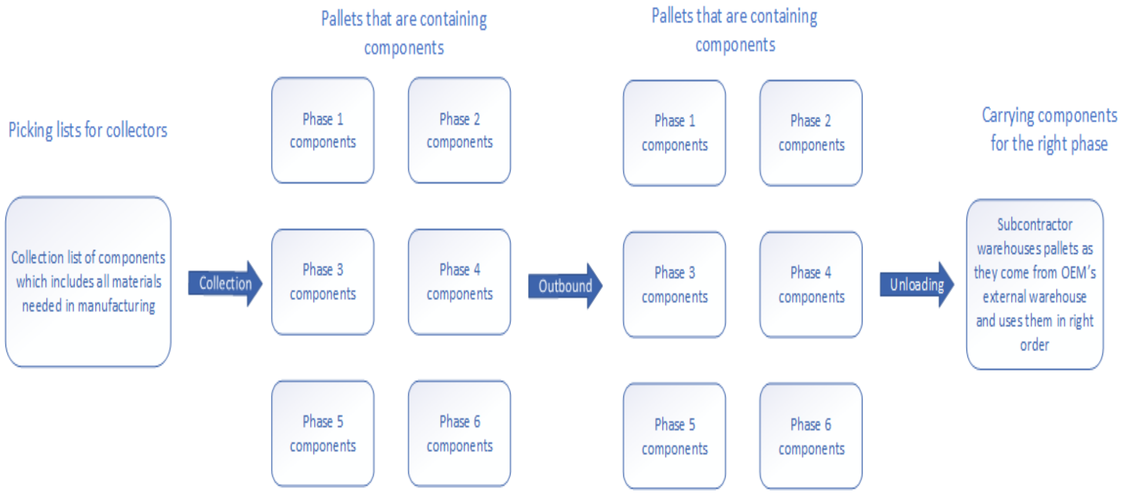

Figure 21: Material collection with configurations in SAP ERP-system

Collection of materials with configured data would not increase workload in external warehouse where collection of materials is done. In SC's warehousing this procedure would massively reduce workload, since there is no need to divide every pallet that comes from OEM's external warehouse and components are more easily to be found. If collection is done in chronological order where phase 1 is collected first and phase 6 collected last, this would also add relevance to collection and outbound logistics. SC receives first needed components firstly and rest of the components in their order. Collection of materials by configurations would generate cost reduction when it comes to material handling in form of fewer lost materials, reduced work hours in component searching, and reduced truck loads.

Developing MES-system

At the time, manufacturing execution system (MES) is used in subcontract manufacturing process to inform all inconveniences from SC production to OEM. Inconveniences are including problems related to quality when material is in bad condition or faulty, logistics when materials are missing, development when components are not properly fitting or any other development needing actions and production when pre-assembled components at OEM or supplier are assembled poorly area. Executives in these areas are responsible to take actions towards to these problems and make corrective actions to prevent them happening again.

MES-application is somewhat troublesome at its present, and that's why it is not even used in two of four subcontractors. These two subcontractors which are using it are also constantly finding problems with it when it comes to usability of MES and keeping OEM on track of problems. For example, if material that is needed in assembly, is not configured in MES, it is not possible to be as missing material. For material handling or quality purposes it is not relevant to have material in MES database, so material codes can be written and then searched from SAP ERP-data at OEM.

Kuvaus	Virhekohde
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Figure 22: MES-application's short of material request

Because of troubles using MES application, subcontractors are contacting OEM departments via phone calls, Whatsapp or e-mail which have been noted as more quicker response time. When these platforms have quicker response time, they do not leave any marks in any database and root-causes why problems are happening from time to time cannot be tracked. Tracking occurring and repetitive problems is key part in making machine assembling cheaper and more efficient.

In this process and at OEM, MES application is provided from company called Citrix. At the time this application is in plans to change and it should have somewhat same possibilities to work with which are provided from smaller company Maistertask. Maistertask has visualized cards, which can be altered depending which work phase they are having. Examples of them are made with some of the machines, and it has been clarifying and more pleasant way of working. Due to legal reasons, it is not upgraded for company's use, but it can give some idea of what would be useful in MES application.

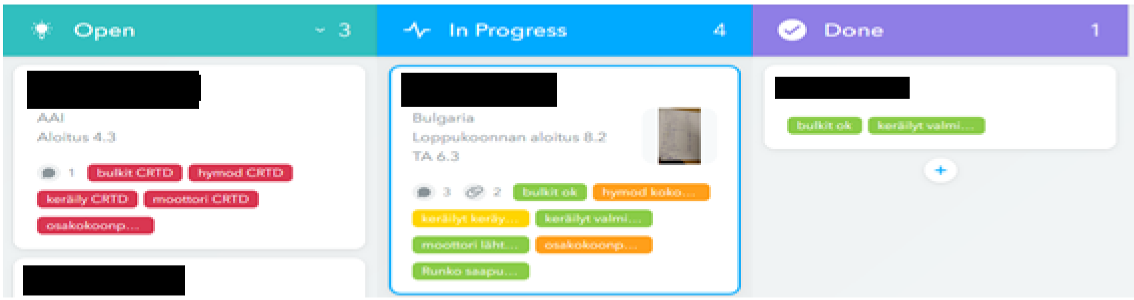


Figure 23: Proposed MES-application in SC process

Outsourced procurement and deliveries from supplier to SC

Outsourced procurement and direct deliveries from suppliers to SC is the most direct way to generate cost reduction in this process. According to Brewer, Ashenbaum and Carter (2013) study of which procurement actions should be outsourced, there are three hypotheses when this was reasonable. These hypotheses are CM's competitive advantage, CM has a more competitive procurement team than OEM, and components are highly commoditized. Hypotheses one and three are taken into account in this study since OEM has the most capable procurement organization in the process.

CM's competitive advantage consists actions that CM are doing more precisely in their facilities than OEM (Brewer et al. 2013). In this process, some of the CMs have capability producing frames for machines, painting and finishing job, and they are located nearer to some key suppliers than OEM. In these cases, CM should purchase all parts and components which they have that advantage.

Procurement of commoditized products usually does not need high skill personnel and are not depending on strong supplier relations (Brewer et al. 2013). This is taken in the account of this thesis since it results in costs reduction in the process. Highly commoditized product in this process are all the bulk materials that are needed in production. Bulk materials include fastening screws, washers, nuts, general hydraulic components, and all the other small components that are easily available from various different suppliers. If SC and OEM does a contract, where SC purchases these materials directly from suppliers and OEM agrees to buy these materials back from supplier it would generate cost reduction in OEM's logistics and SC's warehousing labor costs. Other way, which is still implemented in the one of the SCs, is to collect all these materials from OEM's facilities, bag them in separate plastic bags with information of collected material and send them in one pallet to SC. This is highly time consuming, usually takes physical collection work from 15 to 20 hours and 5 to 10 hours sorting out work from OEM's logistics and SC's warehousing departments per assembled machine. If employee's work hour costs for the organization on the average 20 Euros (Suomen yrittäjät, 2019), for the bulk material collection and sorting out work costs 600 Euros per machine. When there is included material transfer costs and increased risk that some materials are not collected and machine's production stops, there is more to add in these costs.

When it comes to straight deliveries from suppliers to SC, it is due to reason to cut down warehousing costs and possible quality issues that can occur when materials are needlessly warehoused in OEM's facilities before they are resend to SC. Warehousing costs comes especially when produced machine is specialized and materials are bought from suppliers for the first time or quantity of materials in these orders are low. If it is already known that machine is planned to produce in SC, it is not necessary to deliver these materials in OEM warehouse. In addition to increased warehousing costs, warehousing in OEM's facilities increases the probability of components getting external damages such as scratches and even the permanent damages when they are unloaded from the packages in external warehouse. To this happen SC should have enough storage space to cope with incoming components.

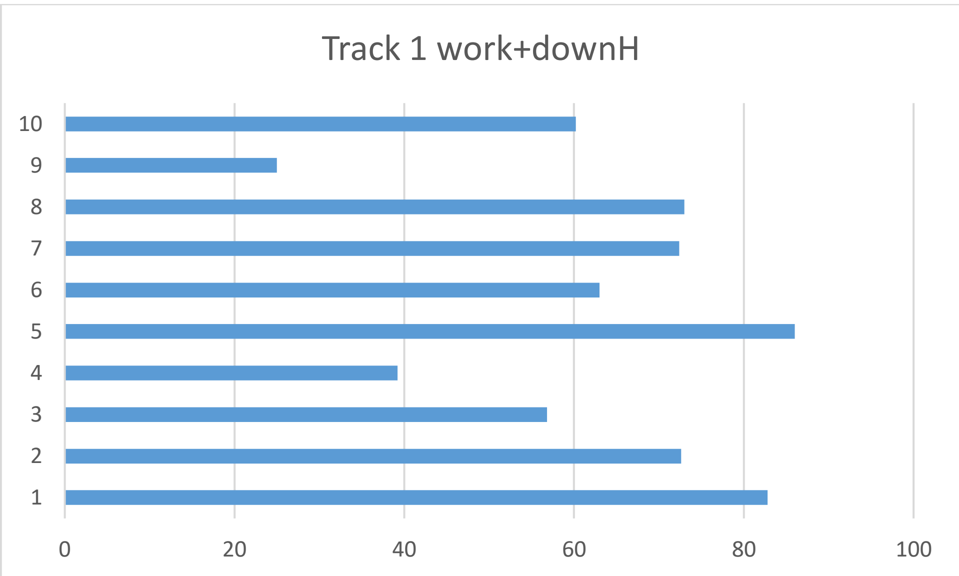
4.5 Work hour development

From the start of subcontract manufacturing process these processes are developed in the way that are previously mentioned. For example, SC's procurement is developed to buy highly commoditized components, straight deliveries from supplier to SC are increased and organizational structure has somewhat developed. For example, there is operational excellence manager in SC manufacturing process and responsible employee for almost every action that are included in SC manufacturing process. This has resulted decrease in work hours and down time hours where down hours are including hours that are directed to machine's assembly hours, but it is the time when employees are not doing work due to material shortages, capacity restriction, or similar problems.

Down below are presented charts for Track 1, Track 2, Track 3, Track 5 and Crusher machines in work hours and in down hours where target hour point is 0. Since production volumes are organizations' internal information, data is gathered from last 10 T1, T2, T5, and last 5 T3 and Crusher machines. Since down and working hours are company's internal information, they are not presented in this thesis as they are in reality but with relative values.

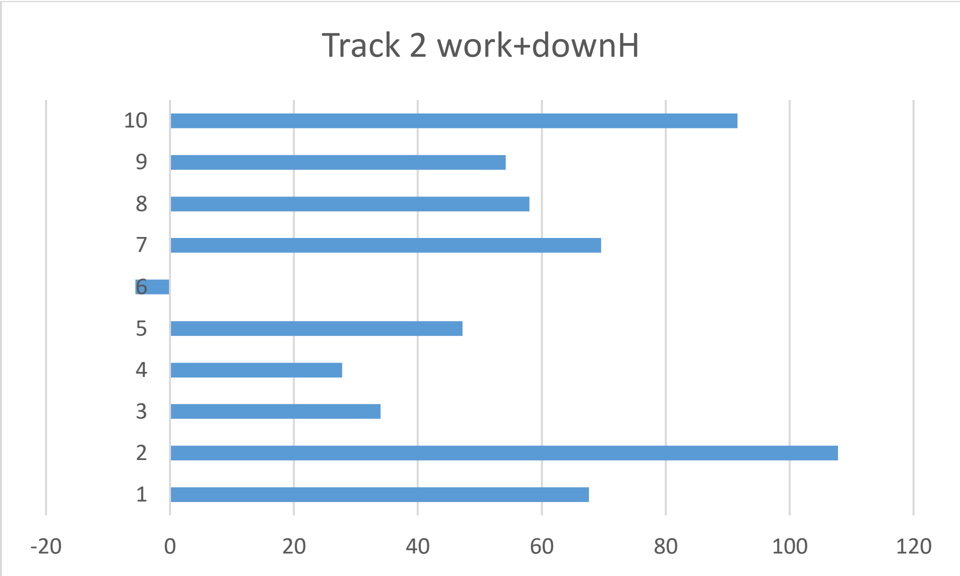
Track 1 work hours

SC1's last produced 10 Track 1 machines are all exceeding target hour point. Down hours have been on the average for these machines 18,6 hours. It is safe to say that SC1 has not been efficient in producing Track 1 machines and from this data, machine 9 is closest to 0-point with value of 25 hours.



Graph 1: Track 1 work and down hours

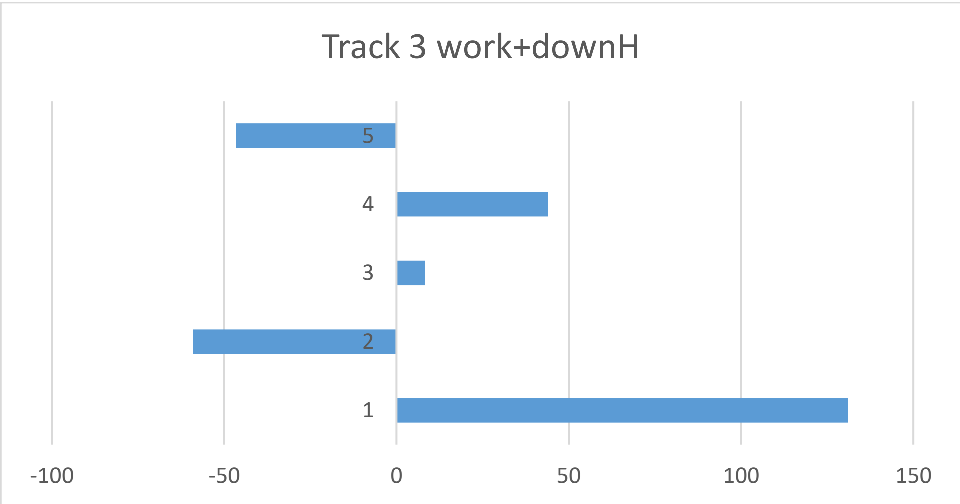
Track 2 work hours



Graph 2: Track 2 work and down hours

From last ten T2 machines only machine number 6 has managed to undercut point zero. Track 2 machines' down hours are around 20–30 per machine now. Last time when missing materials were remarked as significant problem, it was for the machine 2.

Track 3 working hours

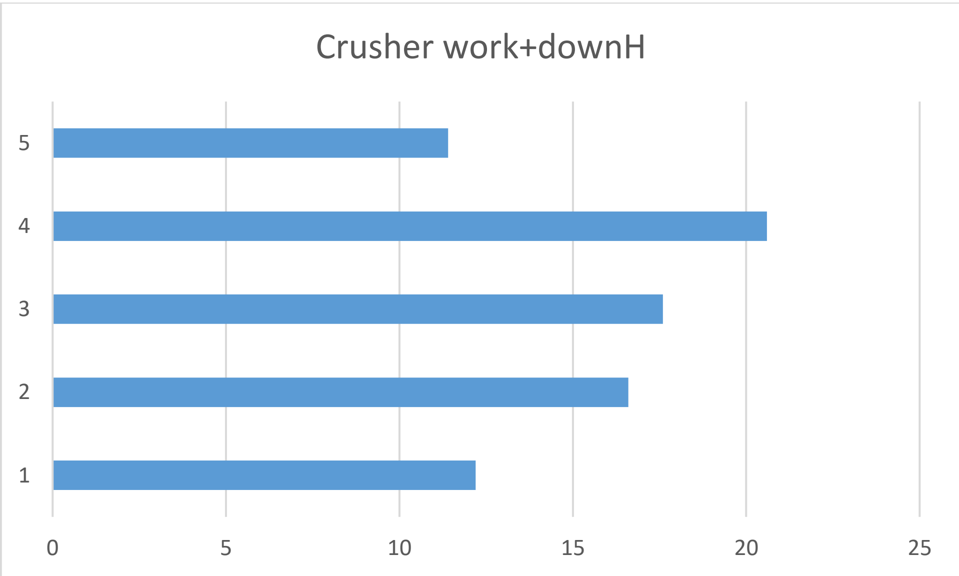


Graph 3: Track 3 work and down hours

From last five Track 3 machines produced by SC1, 'zero point' has been undercut in machine 2 and 5. This indicates that producing Track 3 is the easiest to do for SC1. Track 3's down hours have not developed the same as they have been in Track 1 or Track 2, so down hours have been on the same level from the beginning.

Crusher working hours

Graph 4: Crusher's work and down hours

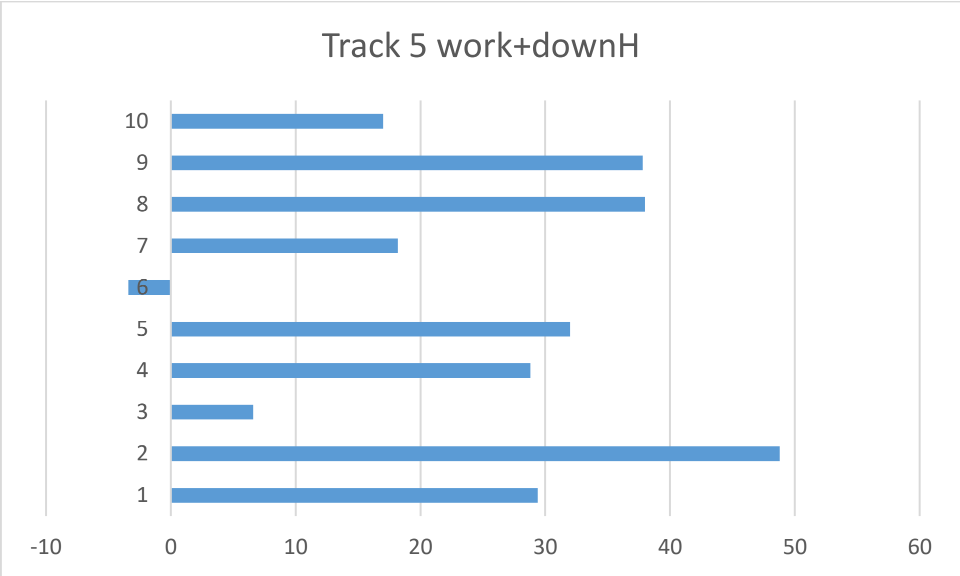


SC1 started assembling OEM's Crushers in late of the year 2018 and development of the SC manufacturing process shows in these work and down hours. Success in Crusher's assembling is an outcome of development in SC manufacturing process. Out-sourced procurement worked properly on these machines, and configurations of crushers makes it easier for SC to direct materials for each phase of assembling (see chapter 4.4 *Configurations of machines*).

SC1 has not however been able to undercut the ‘zero point’ in Crusher assembly, which can indicate inadequate tools and working environment. These are not however logistics or supply chain related problems and thus are not considered of this thesis.

Track 5 working hours

Track 5 is produced by SC2. From last ten Track 5 machines, sixth machine achieved value -3,4 and also third machine achieved close to zero point value 6,6. Compared to SC1 machine production, SC2 Track 5 production has however been more predictable and learning curve of assembling these machines has been better than in SC1 case.



Graph 5: Track 5 work and down hours

5 CONCLUSIONS

This thesis studied after-sales delivery and subcontract manufacturing processes in the case company using supply network, procurement, and logistics as theoretical framework. The case company has large organization's resources available in logistics and procurement actions. This study found some work tasks in the processes which can be eliminated, and that way enhance both processes and generate cost reduction in supply chain management area of these processes.

In after-sales deliveries, findings on uncertainty where deliveries are going at the time and overload of component deliveries to case organization's other locations are major problems. As a part of this study, VB-scripted user form tool in Excel is presented for production planning, logistics and packaging department to follow where every delivery is at the process going, and for every department in the process to add errors that are occurring in the processes. For overloading component deliveries, this study proposes that order-handling department screens deliveries that contains only bulk materials that are low-cost volume components and re-evaluate if they are more efficient to deliver from OEM's facility or provide by establishing supply route.

After-sales deliveries are seen as one entity, which consists every delivery that are done outside the organization's factory's facilities. This entity consists component deliveries inside of the organization, from Tampere's facility to other Metso Corporation factories not depending on where they are located. Since these are bonded as a one entity, it can be seen difficult among the operative employees, that which are needing most of the concentration and which are not. This is very hazardous way of thinking, since if component deliveries inside corporation are treated at the same manner than for example warranty deliveries to customers, it increases the risk that deliveries that are more important in customer satisfaction wise are postponed for the reason that there are too many deliveries to keep eye on at the same time. That is why after-sales deliveries should be divided in two different delivery types which are only delivered to customer, and component deliveries should have their own process, separated of the after-sales deliveries.

Based on findings this thesis´ interviews between associated departments that are handling after-sales and component deliveries, communication of these orders is seen very challenging. For example, importance, desired dispatch date, and status of orders are not clear for associated departments and that leads to postponements in these orders.

As a part of developing the after-sales and component deliveries´ processes this thesis presented user-based system in Microsoft Excel, which would clarify which orders are associated to which order type, what are desired dispatch date, notifications of aberrations dealing with orders and urgencies of orders. This Excel is provided for free usage and editing for Metso Minerals and is seen more of a guideline how communication of orders could be enhanced in the organization.

Findings of this thesis indicated that problems were found in every area of after-sales and components deliveries´ process. Production planning is very much personified for a one employee´s job, even when quantities in after-sales and component deliveries are high. This results in two outcomes. Firstly, since production planning responsible employee is over-whelmed of orders that are needed to be taken care of, human errors are more than likely to occur and motivation in over-whelmed working environment can be challenging. Secondly, when work task is personified in one person, in situations when this employee is absence of work, replacement for this employee is difficult to find. That is why production planning for after-sales and component orders should be either diversified for more than one employee´s responsibility or more work force is needed in production planning. Diversification could be more cost-efficient solution than hiring new employees. When Metso Minerals operates in business area that is very affected of economic cycle, often made changes among employees would awake uncertain atmosphere in the working environment.

Dispatching centres' difficulties in after-sales and component process were dealing highly with communication of the orders and affection of cumulative errors. This is especially seen in the last stages of the process, where dispatching of the goods is. Difficulties of communication is seen when dispatching centres are not sure of which component, after-sales or warranty order is who´s responsibility and which is not. If errors are made in early stages of the process, these errors are difficult to solve in last stages where dispatch should be made and promised dispatch date is dealt with customer. The fact that crusher´s dispatch centre does not have work centre for component orders in SAP ERP-system is a misleading fact for these orders as well. Component orders are included with crusher dispatching, so it makes it difficult for logistics and dispatch centre to follow how urgent these orders are to be dispatched until it is too late.

Subcontract manufacturing process was started in stages with four subcontractors in 2017 and in 2018 a considerable part of Metso Minerals track, mobile screen and crusher machines were made by subcontractors. When economic cycle and demand of these products are down in late of 2019 due to recession period of economic cycle it is logical to assume that production of the machines are not done as much by subcontractors as it was in year 2018. This was not the first and it is safe to indicate that it will not be the last time when subcontractors are needed in machine production. This thesis is also made available for future instances where subcontract manufacturing process can be made without major difficulties in the processes at the early stages.

In subcontract manufacturing process, findings were more complex and inclusive. Subcontract manufacturing process was started from the scratch so problems occurred in organizational structure of the process employees, material flow from OEM to SC in form of configurations, direct deliveries from supplier to SC and out-sourced procurement for bulk components, and every SC has software problems in MES applications. Even it is clearly visible from work hour development, that some major problems and setbacks have been eliminated successfully, there are still set of problems in previously mentioned areas.

One of the biggest challenges in the subcontract manufacturing process is the outsourced procurement for small components made by subcontractors. Since collection of small components are taking so much from work force what is tied in the OEM´s facilities, outsourced procurement would benefit not only OEM but subcontractors as well. This is because subcontractors usually know what their true consumption in small components are and ordering small components straight from supplier would reduce down time which arises when subcontractors wait for these components to be collected and sent from OEM´s facilities. More importantly, OEM is basically ordering small components to match OEM´s capacity of production, so when collection of small components is made from this batch, it grows the risk of stock out situations in OEM´s facility as well. Outsourced procurement for bulk components was partially greatly done for two of four subcontractors, partially done in one subcontractor, and was completely missing in one subcontractor case in the springtime of 2019.

In addition to out-sourced procurement of small components, straight deliveries from supplier to subcontractors would be also an important step to make ensuring quality and delivery capability of the products. In the process, suppliers deliver all products to OEM´s facilities, where they are warehoused until production orders are released by OEM. Then these warehoused goods are packed again and delivered from warehouse to subcontractor. This produces unnecessary work in receiving, packing, re-packing and re-delivering the same product from OEM to SC. This also increases probability in damaging the goods while they are warehoused and re-delivered, which increases down-hours as a rework done by subcontractor.

Another major challenge in subcontract manufacturing process is that manufactured machines do not have structures in ERP-system as they should be. In other words, all the components that are needed in assembly are gathered in one collection phase. This collection phase is sent to subcontractor by whole, not depending on where components are needed in assembling. By arranging machine´s structure to ERP system as by how they are needed in assembling phases would make components available more in JIT-methodology and clarifies components received to subcontractors. It would be clear that first components that arrive to subcontractor are needed first in assembling and thus lack of component in certain assembling phase are easier to notice. This would reduce sorting and investigation work that is currently made when structures are not viable. A good example of effect of structures can be seen in subcontract manufactured crushers, where structures were made as their chronological order, where first needed components are delivered first and so on. Even crushers are simpler and smaller to do than track screens and track crushers, they did not have as much down time because of missing components than previously mentioned machines had.

Another issue arose in communication between subcontractor and OEM. Since communication is executed by e-mail, phone calls and messages with Whatsapp, it doesn´t leave any collectable data of work tasks that are needed to be done by OEM. In this procedure, where work tasks are mainly depending on employees´ memory, risks of human errors occurring are great. There is MES system between subcontractor and OEM but it since it is mainly designed as a communication channel between departments in OEM facilities, it has produced problematic data from subcontractors.

5.1 Managerial implications

First and foremost, the case company should deepen its co-operation with Estonian subcontractor or establish subsidiary in Estonia for track screen production. Since Estonian subcontractor showed such promising results that it was decided that track screens are produced as a whole in there, potential for even better success hides when organization would get their office and ERP system fully implemented in the area where good results are made. At the time Estonian subcontractor has good resources in facilities in form of area to expand, in production employees and in operative employees.

Another important major task that organization should do for enhancing logistics and procurement is to implement JIT in production, not only in subcontract manufacturing process but in OEM subassembly processes as well. This is achieved by establishing clear structures in ERP as they are done in crusher assembling at the time. When components are clearly visible when they are needed and where, by precise scheduling, it would shorten investigating time for missing components, decrease warehousing costs and divide workload for procurement team.

When subcontract manufacturing is up and running as it has been in summer 2018 the clear organizational structure has been somewhat not existent. This has resulted that some work tasks in the whole process is not anyone´s responsibility and thus they are not made correctly, not in time or at worst both. Therefore, there should be a clear management for subcontract machines, that orchestrates the whole process, and coordinators for supply chain and production as well. Organizational structure is presented in this thesis and it provides guideline how this structure could be made. When responsibilities are clearly assigned to employees, situations where work is not done since there are no responsible employee, would not occur so often.

Last implementation that this thesis proposes for the organization in subcontract manufacturing process, is to establish a proper communication channel between subcontractors and OEM. Management should either update current MES system to provide easy usability for subcontractors or investigate other platform possibilities that would provide MES-system with communication channel. This thesis presented Meistertask company´s communication channel, which is for usability purposes better option for subcontractor and OEM subcontract manufacturing employees communication than current Citrix MES system. Market for software systems are this day very broad, so organization's management should do tendering for them and make conclusions, which would provide the best communication channel, not only internally but between external manufacturer and OEM as well.

When it comes to after sales and component deliveries, these processes really need top level supply chain management reviewing and close internal co-operation with other factories about bulk components that are needed. After reviewing is done, supply-routes for critical components should be done for these facilities and other components that are difficult or in some cases impossible to provide locally should be sent as component deliveries from Tampere. However, better resources and information of components are with Metso DC (Distribution Center), so possibility of outsourcing the component deliveries to DC should be highly recommended.

In economical aspect, these changes would provide more agile supply chain in after sales and subcontract manufacturing processes, where money is not made first place by achieving new sales but making sure unnecessary costs are not generated in process phase. These unnecessary costs can be lost in materials, resources, and generated fines for late end-product. Not only if these can be eliminated, product that satisfy customer in addition to its functionality, by previous experiences as well, it also generates more customer satisfaction and potential future sales opportunities are more likely to be realized. Since these numbers are Metso Corporation’s internal knowledge and information, they are not analysed in this thesis, but some guidance can be found from prices of Metso end-products that are quite high. That’s why these cost reduction opportunities should be carefully concentrated.

5.2 Future research

As a result of this thesis, a few future researchable topics could be beneficial for the organization.

First of them handles with procurement actions and direct deliveries. A major part of procurement actions is done by OEM´s procurement team since OEM does have the best resources for purchasing the goods. Procurement should be reviewed in subcontract manufacturing material deliveries and component deliveries. It is time-consuming for many departments in the organization if everything is done in OEM´s facilities, which is mainly responsible of producing the goods in OEM’s facilities. There are couple of options which could be made and first of them is more risky outsourced procurement, where all procurement actions are outsourced to subcontractor´s procurement team. This is riskier option since it enables miss usage of strategic information of prices between OEM and suppliers. On the other hand, out-sourced procurement gives more flexibility to overall process since procurement is done at the same location where goods are produced. Second option is direct deliveries from supplier to subcontractor. This leaves all the procurement actions to OEM but warehousing and logistics part of the process is not done by OEM´s logistics department. Combination of outsourced procurement and direct deliveries would be the ideal situation in subcontract manufacturing process for OEM at the present time, and direct deliveries would enhance component deliveries as well.

Second future research topic would be enhancement of communication channels between OEM and third-party subcontractors, and in internal communication as well. MES system is not made easy for usage for this thesis processes and is constantly problematic to subcontractors to use at the time. New MES system, which would be completely editable by responsible person at subcontractor and in OEM would solve inefficient usage of MES and get crucial information between third party subcontractor and OEM right on time. In component and after sales deliveries, all different departments are way off from each other as well, so internal communication channel, where information of key values of orders, such as quantities, dispatch dates, etc., would be essential to after sales and component deliveries as well. This thesis produced Excel based user-form for this problem and since Excel is already licensed and can easily get data from SAP ERP-system, developing that further and taking it as a part of every day´s working would solve internal communication problems in the process.

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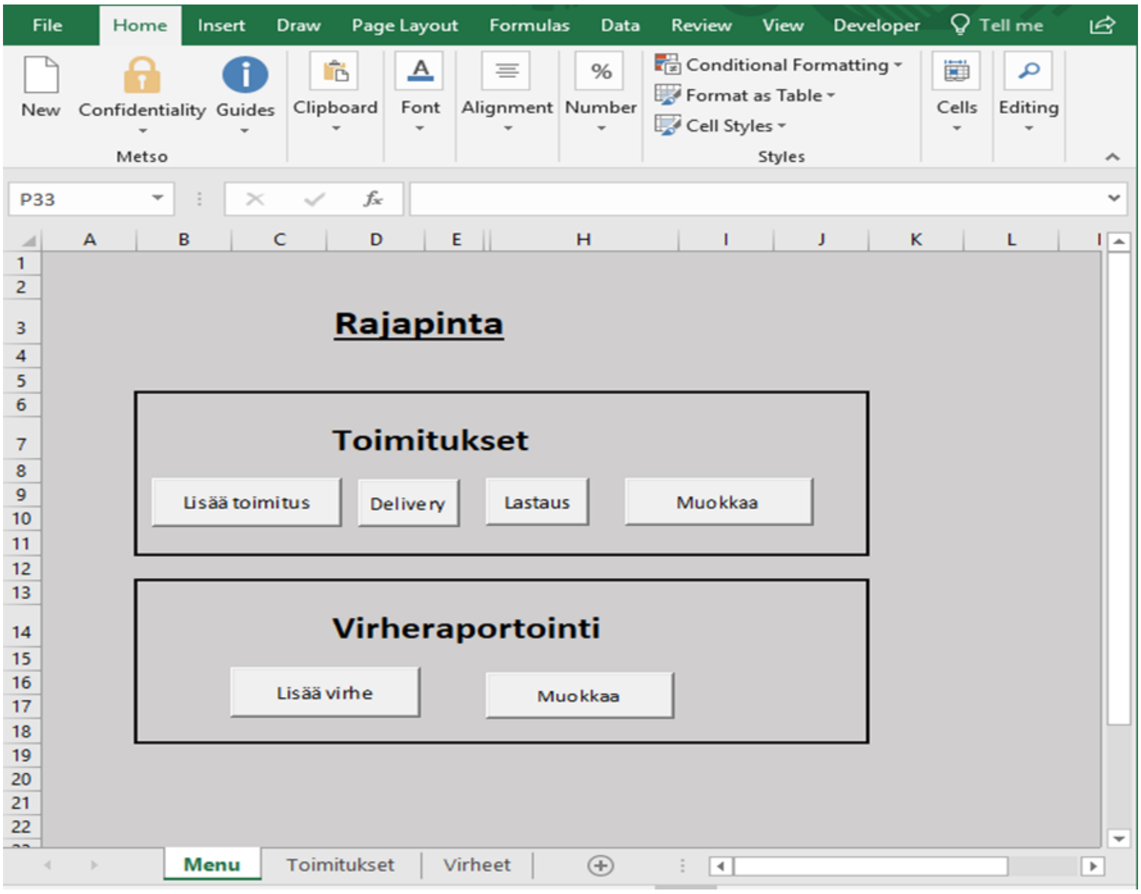
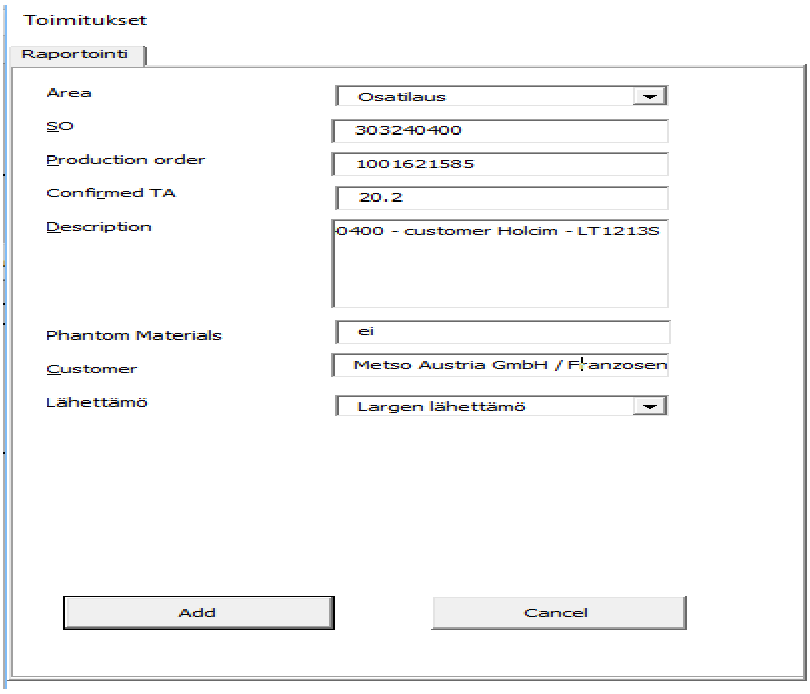
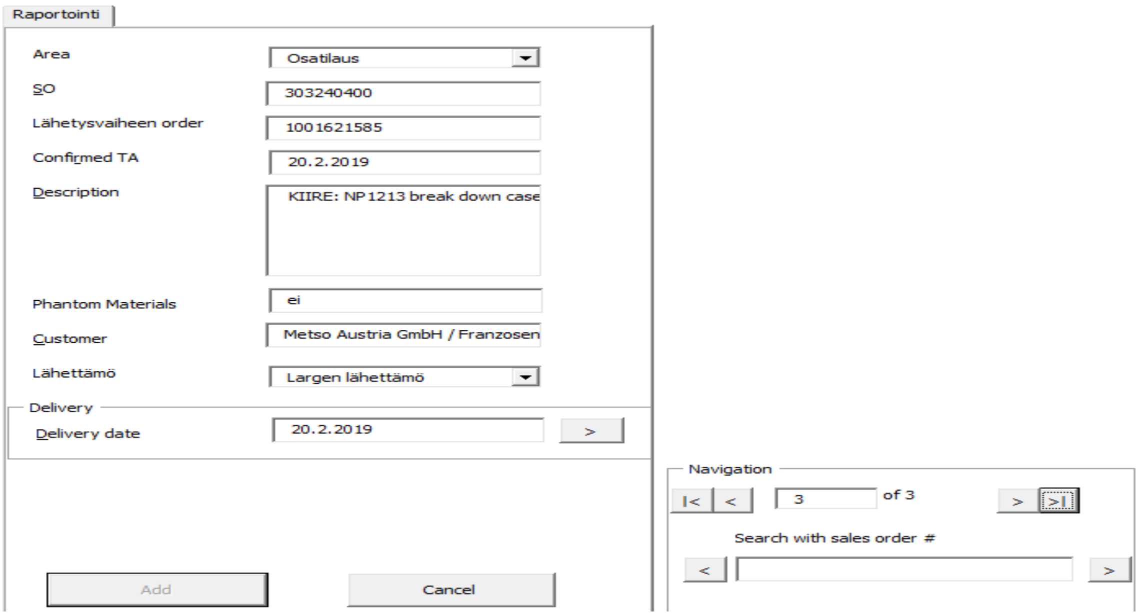
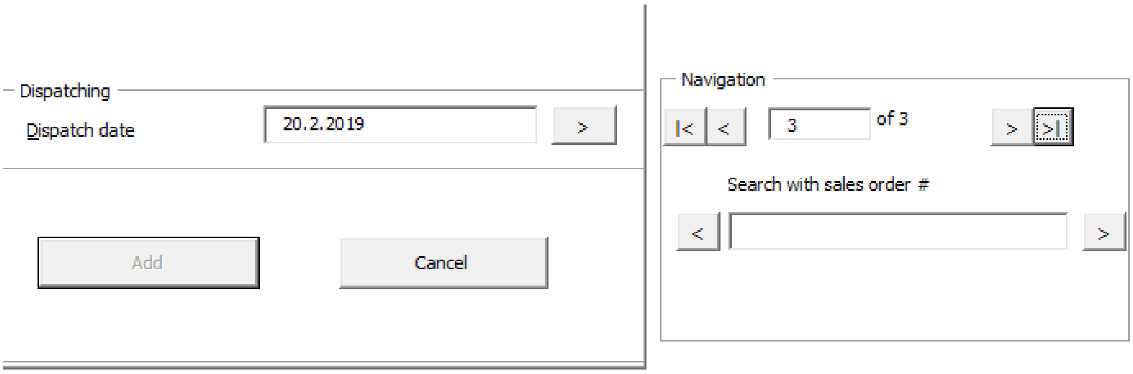
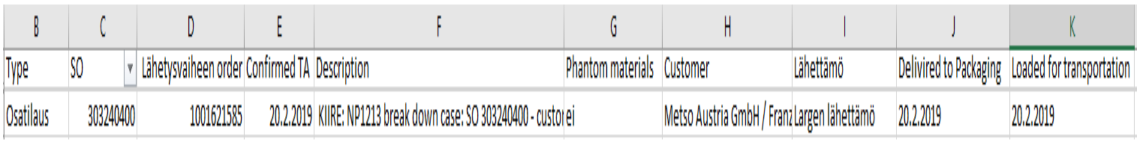
Appendix 1. Excel Userform tool for after-sales and component deliveries



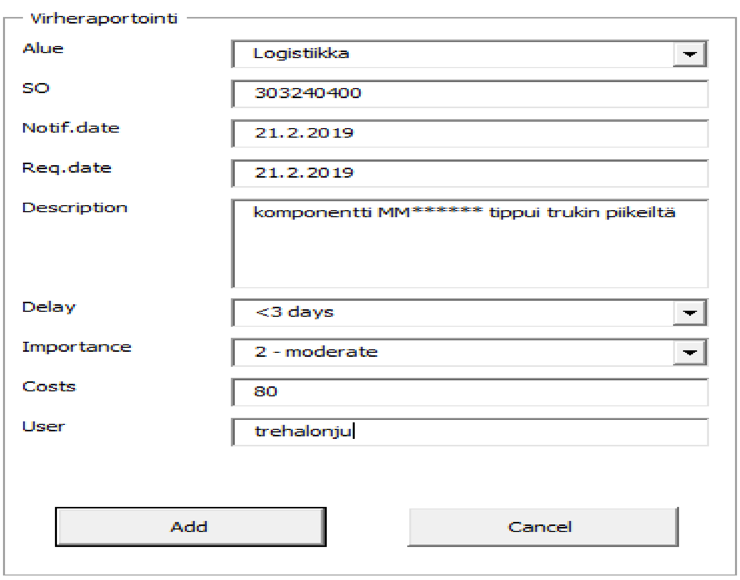




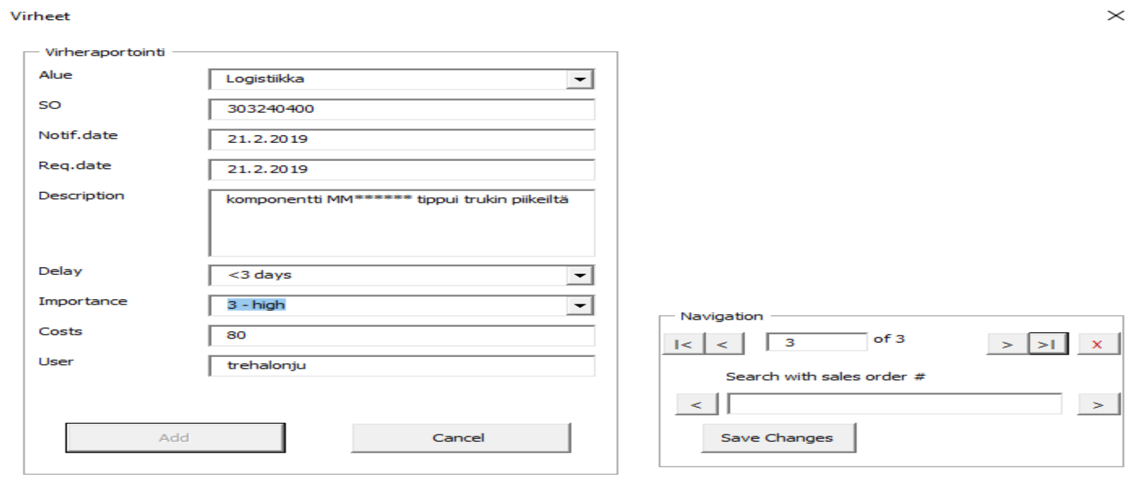




B	C	D	E	F	G	H	I	J	K
Type	SO	Lähetysvaiheen order	Confirmed TA	Description	Phantom materials	Customer	Lähettämö	Delivired to Packaging	Loaded for transportation
Osatilaus	303240400	1001621585	20.2.2019	KIIRE: NP1213 break down case: SO 303240400 - custo	ei	Metso Austria GmbH / Franz	Largen lähettämö	20.2.2019	20.2.2019



B	C	D	E	F	G	H	I	J
Alue	SO	Notif. Date	Req. Date	Description	Delay	Importance	Costs	User
Logistiikka	303240400	21.2.2019	21.2.2019	komponentti MM****** tippui trukin piikeiltä	<3 days	2 - moderate	80,00 €	trehalonju



Alue	SO	Notif. Date	Req. Date	Description	Delay	Importance	Costs	User
Logistiikka	303240400	21.2.2019	21.2.2019	komponentti MM****** tippui trukin piikeiltä	<3 days	3 - high	80,00 €	trehalonju