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Enabling Process Improvement Through Production Process Mapping

A Case Study for a Finnish Manufacturing Company

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ABSTRACT:
Many Finnish small and medium sized enterprises (SME's) operate with unmapped, informalized or poorly defined manufacturing processes. Unmapped or unclear production processes with insufficient process transparency can act as a barrier that limits companies' productivity and scalability, and can impede process improvement efforts, such as process automation.

Process mapping is a foundational work for many organizations seeking to build business process management competencies within the organization, and in many cases can serve as basis for future operational improvement efforts, such as implementing lean manufacturing practices or the theory of constraints.

By mapping or formalizing production processes, businesses can increase process transparency and process-based understanding among the workers, facilitate effective communication between management and workers, reinforce process-based thinking and reduce change resistance among workers that can otherwise inhibit or slow down companies' efforts to improve their manufacturing processes and operations. Addressing unmapped manufacturing processes is therefore critical to enable businesses to pursue principles such as lean manufacturing, theory of constraints, continuous improvement, and in general to improve the company's operational efficiency and to strengthen their competitive advantages in the markets.

This study focuses on mapping the production processes for a real Finnish case company that operates in the metal industry. The research was conducted using qualitative research methodology. Semi-structured interviews were used as the primary method of data collection, complemented by observations made during factory tours, and existing documentations provided by the case company.

Team leaders from five different production departments were interviewed at the case company. In addition, the chief of production, and the chief of production planning from the production planning department were also interviewed. Thematic analysis was used to analyze the collected data.

Based on the data analysis, the key process steps, material flows and information flows were identified, and their interrelations were mapped using swim lane diagramming methodology. In addition, process descriptions were prepared for each production department, providing a general description of key process steps, and for the responsibilities of the team leaders and the operators of the departments.

KEYWORDS: Production planning, Production control, Process control, Mapping, Information flows, Manufacturing industry

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TIIVISTELMÄ:
Monet Suomalaiset pienet ja keskisuuret yritykset (pk-yritykset) operoivat kartoittamattomilla, epävirallisilla tai huonosti määritellyillä tuotantoprosesseilla. Kartoittamattomat tai epäselvät tuotantoprosessit, joissa ei ole riittävää läpinäkyvyyttä, voivat toimia esteenä, joka rajoittaa yritysten tuottavuutta ja skaalautuvuutta ja voi hankaloittaa prosessien kehittämistoimia, kuten prosessien automointia.

Prosessien kartoitus on pohjustavaa työtä monille organisaatioille, jotka pyrkivät rakentamaan liiketoimintaprosessien hallinnan osaamista, ja se voi monissa tapauksissa toimia lähtökohtana tuleville toiminnan parantamistoimille, kuten lean-tuotannonkäytäntöjen tai rajoitteiden teorian (Theory of Constraints) soveltamiselle.

Tuotantoprosessien kartoittamisen tai määrittelyn avulla yritykset voivat lisätä prosessien läpinäkyvyyttä ja prosessipohjaista ymmärrystä työntekijöiden keskuudessa, edistää tehokasta viestintää johdon ja työntekijöiden välillä, vahvistaa prosessikeskeistä ajattelua ja vähentää muutosvastarintaa, joka muuten voisi estää tai hidastaa yritysten pyrkimyksiä kehittää tuotantoprosessejaan ja toimintaansa. Kartoittamattomien tuotantoprosessien käsittely on siksi kriittistä, jotta yritykset voivat soveltaa lean-tuotannon, rajoitteiden teorian ja jatkuvan parantamisen periaatteita, sekä yleisesti ottaen parantaa toiminnan tehokkuutta ja vahvistaa kilpailuetujaan markkinoilla.

Tämä tutkimus keskittyy tuotantoprosessien kartoittamiseen Suomalaisessa metalliteollisuudessa toimivassa yrityksessä. Tutkimus toteutettiin käyttämällä laadullista tutkimusmenetelmää. Ensisijaisena tiedonkeruumenetelmänä käytettiin puolistrukturoituja haastatteluja, joita täydensi tehdaskierroksilla tehdyt havainnot sekä yrityksen toimittamat olemassa olevat dokumentit.

Työssä haastateltiin yrityksen viiden eri tuotanto-osaston tiimiesihenkilöitä. Lisäksi haastateltiin tuotantopäällikköä, sekä tuotannonsuunnitteluosaston tuotannon suunnittelupäällikköä. Kerättyjen tietojen analysoinnissa käytettiin temaattisen analyysin menetelmää.

Analyysin perusteella tunnistettiin keskeiset prosessivaiheet, materiaali- ja informaatiovirrat, ja niiden väliset suhteet, ja ne kartoitettiin swim lane-kaaviomenetelmällä. Lisäksi laadittiin prosessikuvaukset kullekin tuotanto-osastolle, joissa esitettiin yleinen kuvaus keskeisistä prosessivaiheista sekä tiimiesihenkilöiden ja osastojen operaattoreiden vastuista.

AVAINSANAT: Production planning, Production control, Process control, Mapping, Information flows, Manufacturing industry

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Abbreviations

APS	Advances Planning & Scheduling
BPM	Business Process Management
DT	Digital Twin
ERP	Enterprize Resource Planning
IoT	Internet of Things

KPI	Key Performance Indicators
LM	Lean Manufacturing
MES	Manufacturing Execution System
OM	Operations Management
QMS	Quality Management System
RFQ	Request for Quotation
RWS	Robotic Work Station
SaaS	Software as a Service
SME	Small and Medium-sized Enterprise
TOC	Theory of Constraints
WMS	Warehouse Management System

1 Introduction

The purpose of this thesis is to map the production processes for a real Finnish case company, for their five production departments involved in the manufacturing of high-quality roof safety products, as well as to write a general level descriptions for the production departments.

Mapping the key process steps and the material flows and information flows between the different stages of the production process is important for the case company in order to formalize the production processes, to introduce process-based thinking to the company and workforce and to strengthen business process management competencies within the company. The process maps and descriptions can help the case company in training new and existing employees, thus introducing process-based thinking into the workforce. Process-based thinking can help workers better identify their roles and responsibilities and to understand the relation between their role and their impact on the other departments and the larger manufacturing operation, which can help reduce unwanted suboptimization inside individual production departments, that can reduce the overall efficiency of the production plant. Furthermore, the process maps can help facilitate mutual understanding of processes, enhancing teamwork, communication and improve issues related to insufficient information flow between different production stages, which can reduce unnecessary idle time and delays. Better process-based understanding can also facilitate and enhance cooperation between the workforce and management, helping to align the two based on common understanding of the production processes. Lastly, the process maps can help management identify areas of improvement for further process development, and the maps can also serve as basis for further, more in-depth and extensive process modeling work.

This work includes mapping the raw material inputs, following the material flow through five different manufacturing departments, mapping the various phases required in each department to transform the raw material inputs into finished manufactured goods, ready to be packed and shipped to the end customer. In addition to the material flow,

key information flows required for smooth manufacturing process and control is mapped as well. Finally, the production planning department and their control philosophy for the manufacturing operation is also mapped.

1.1 Research questions and objectives

As outlined above, the goal of this thesis is to analyze and map the current state of the production processes at the case company. In order to achieve that goal, the following research questions and objectives were formulated to guide the thesis work, data collection and the mapping work of the production processes:

Research Questions:

1. What are the key steps, inputs and outputs in the Case Company's production processes for their roof safety products?
2. What are the key information flows between production process phases in the Case Company's production processes for their roof safety products?

Research Objectives:

1. To document the production process of the Case Company's roof safety products, using swim-lane diagramming methodology.
2. To create descriptions detailing the main steps, inputs, outputs and key information flows between the different stages of the production process.

1.2 Brief case company background

The Case company is a real Finnish company that operates in the metal industry, manufacturing sheet metal and pipe products such as roof safety products. In addition, the

company has other product groups, which will not be mapped in this work. The customers mainly operate in the construction industry. In Finland, the construction industry typically faces reduced outdoor construction activities during the winter season, due to harsher weather conditions. Excavation works are more challenging due to ground freezing and snow accumulation, and pouring concrete foundations can face several temperature related challenges, from cold temperatures effects on the properties of the concrete itself, to equipment malfunctions, such as concrete pump malfunctions in freezing temperatures, as described by KSBR (2025, May 26), a Finnish construction company. Outdoor work is more hazardous due to snow, ice, and reduced daylight hours, and water, condensation and moisture seeping through structures pose challenges and require increased efforts to control and monitor the conditions at construction sites, as explained by YIT (2020, November 11), another Finnish construction company. Thus, winter seasons can typically see a shift toward indoor construction and renovation projects. By contrast, the industry booms during the summer season, driven by longer daylight hours and milder weather conditions more suitable for outdoor construction projects.

As such, seasonal demand fluctuations drive the demand for the case company, and other companies operating in the same industry. Thus, production capacity management and accurate demand forecasting remain one of the critical challenges faced by companies operating in this industry, due to the fluctuating seasonal demand that is common in the industry.

1.3 Structure of the study

The study is structures as follows. Chapter 1 introduces the study, briefly explaining the background, purpose and the motivations behind the study, as well as defining the research questions and objectives guiding the research. In chapter 2, a literature review of theoretical frameworks related to the topic, are covered. Chapter 3 will describe the methodology used in the study and provide justifications for why these methodologies were selected, detailing the data collection methods, the selected data analysis methods,

as well review the validity and reliability of the data collection and analysis methods. Chapter 4 will describe the results and findings from the process mapping work. In chapter 5, the results, comparisons to the theoretical literature and possible future directions for the case company are discussed. Finally, chapter 6 will present final conclusions for the study.

1.4 Limitations

This thesis work was conducted as a case study for a real Finnish case company. Therefore, the results are limited and applicable only to the case study, thus the findings cannot be generalized to other manufacturing companies, although the theories and the methodology is replicable elsewhere.

2 Literature Review

In today's competitive markets, in order for companies to succeed and to remain competitive, continuously searching for ways to improve is crucial to build or maintain competitive advantage in the markets. Manufacturing companies, for example, must continuously search for new ways to develop their processes, how to optimize them further, how to improve their product quality, or how to drive down production costs among other means, in order for them to maintain their competitive advantage in the markets. Operations Management (OM) is a field of study that focuses on studying manufacturing operations, transforming raw material inputs into outputs, and how to manage them effectively. Academics researching OM have developed various theories and frameworks for how to effectively develop, improve, optimize and manage the transformation processes being used in manufacturing operations.

In this chapter, three theoretical frameworks from the field of OM, useful for process development in the manufacturing sector, will be covered. The first section of this chapter will cover Lean Manufacturing (LM) philosophy, the second section will review the Theory of Constraints (TOC), while the last section will cover Business Process Management (BPM). These frameworks were selected due to their connection to process mapping as a prerequisite step, to highlight the possible underlying motivations behind the process mapping work performed for the case company, and to explore possible future actions for process improvement and development that can be pursued at the case company, based on the process mapping work.

2.1 Lean Manufacturing

Lean manufacturing (LM) is a widely applied framework that originated from the Toyota Production System, emphasizing the production of goods just-in-time (JIT), eliminating excessive inventory by focusing on creating production systems that maximize the value added by eliminating waste and delays from processes (Krajewski et al., 2012, p. 297).

Womack & Jones (2003) and Krajewski et al. (2012) both described eight different types of waste, which are critical to reduce in lean manufacturing operations. The eight types of waste that can be eliminated or reduced, outlined in figure 1, includes excessive production and unnecessary or excessive inventory, unnecessary waiting times and movement required in either the production or the logistical processes, over-quality resulting from inappropriate high-precision processing equipment when lower quality would suffice, poor production quality resulting in unnecessary rework, rescheduling and material waste, and underutilization of employees. The lean manufacturing framework includes multiple tools and methodologies, some of which will be covered in the following subchapters, for designing and organizing the manufacturing system in ways that aim to reduce these eight types of waste.

Waste	Definition
1. Overproduction	Manufacturing an item before it is needed, making it difficult to detect defects and creating excessive lead times and inventory.
2. Inappropriate Processing	Using expensive high precision equipment when simpler machines would suffice. It leads to overutilization of expensive capital assets. Investment in smaller flexible equipment, immaculately maintained older machines, and combining process steps where appropriate reduce the waste associated with inappropriate processing.
3. Waiting	Wasteful time incurred when product is not being moved or processed. Long production runs, poor material flows, and processes that are not tightly linked to one another can cause over 90 percent of a product's lead time to be spent waiting.
4. Transportation	Excessive movement and material handling of product between processes, which can cause damage and deterioration of product quality without adding any significant customer value.
5. Motion	Unnecessary effort related to the ergonomics of bending, stretching, reaching, lifting, and walking. Jobs with excessive motion should be redesigned.
6. Inventory	Excess inventory hides problems on the shop floor, consumes space, increases lead times, and inhibits communication. Work-in-process inventory is a direct result of overproduction and waiting.
7. Defects	Quality defects result in rework and scrap, and add wasteful costs to the system in the form of lost capacity, rescheduling effort, increased inspection, and loss of customer good will.
8. Underutilization of Employees	Failure of the firm to learn from and capitalize on its employees' knowledge and creativity impedes long-term efforts to eliminate waste.

Figure 1. Lean Systems - The Eight Types of Waste (Krajewski et al., 2012, p. 297).

Womack & Jones (2003) described the five core principles of lean thinking that are applicable to any business process, not just manufacturing processes:

- The first principle is to define the value produced for the customer. This principle is about identifying what the customer values and focusing on those activities

that create that value, instead of focusing on unnecessary product or service features or process steps that do not increase the actual value for the customer.

- The second principle is to identify or map the value stream, i.e. all the value-adding steps that are required to deliver the product or service to the customer. To identify the value stream, Womack & Jones recommend breaking it into three separate activity streams: the problem-solving stream, which covers design, engineering, and production; the information stream, which covers customer orders flow through production to delivery; and the physical transformation stream, which covers raw materials flow through processes to transformed finished end products.
- The third principle is to make the value flow: this principle is all about ensuring that each value-adding step in the value stream flows from step to step, without interruptions, bottlenecks or other delays, in other words eliminating unnecessary idle-times.
- The fourth principle is to establish pull, i.e. a pull manufacturing system, to produce goods based on customer orders, only when they are needed, thus reducing waste and unnecessary inventory.
- The fifth and final principle is to pursue perfection. This means implementing continuous improvement efforts to constantly evaluate the production process, reiterating the first four principles cyclically to further improve the production operation.

Čiarnienė & Vienažindienė (2012) describes the implementation process for lean systems, as shown in figure 2, which starts from planning and defining what type of change is needed and what are the targeted processes to be changed inside the organization, and securing top management commitment and support to drive the change. Whether the implementation of the plan succeeds is dependent on four success factors. The workers need to be prepared and informed of the change and why it is needed, expectations and roles in the change process need to be set to maintain employee involvement in the change process, and people need to be motivated to maintain morale and to eliminate

change resistance. The methodologies and tools for change need to be implemented, and an environment for change need to be created, including maintaining safe environment and offering support and guidance for the workers during the change.

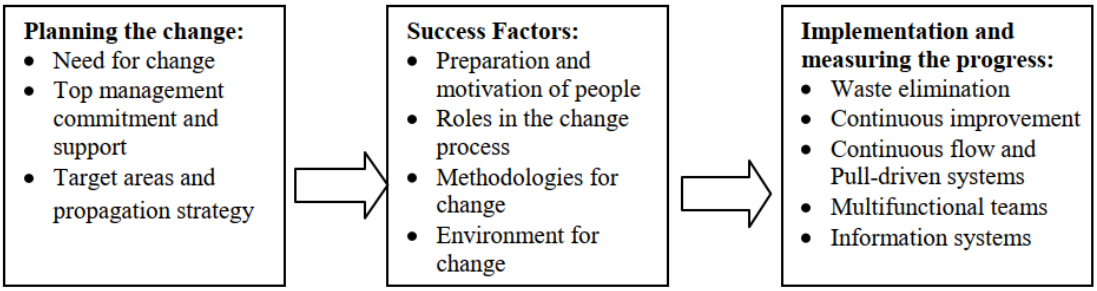

Figure 2. Model of Lean implementation process (Čiarnienė & Vienažindienė, 2012).

2.1.1 Continuous Improvement

Continuous improvement, or Kaizen, as the Japanese call it, is one of the core principles of lean philosophy. Continuous improvement is not just a practice, but rather an organizational culture that is based upon continuously identifying challenges and areas of improvement and solving or improving on them incrementally by various means, such as by for example implementing the lean philosophy, i.e. eliminating and reducing any of the eight types of waste (Krajewski et al., 2012; Imai, 2012).

Slack & Lewis (2017, pp. 233-271) describes continuous improvement as method that seeks to improve performance by small incremental improvement steps. Small improvements, according to the authors, have an advantage over larger improvements in the fact that they can be implemented relatively painlessly. And although the rate of improvement is small by comparison to larger improvements, the momentum for smaller improvements is more easily maintained. Over time (over weeks, months or years) the incremental improvements will accumulate, resulting in a significant increase in performance. Slack & Lewis point out that in operations process development, continuous improvement should be an ongoing, endless cycle of questioning, adjusting and improving

the production processes, and learning how to use the operations resources and processes more efficiently. In order to be able to direct improvement across processes, performance measurements are also required. The momentum of improvement resulting from successful implementation of the continuous improvement philosophy should therefore be reflected in the performance measurements. In other words, performance measurements, i.e. Key Performance Indicators (KPI's) are a useful tool for gauging whether the continuous improvement efforts bear fruit, or not. Figure 3 shows an example of different types of performance measures across the different levels of production operations.

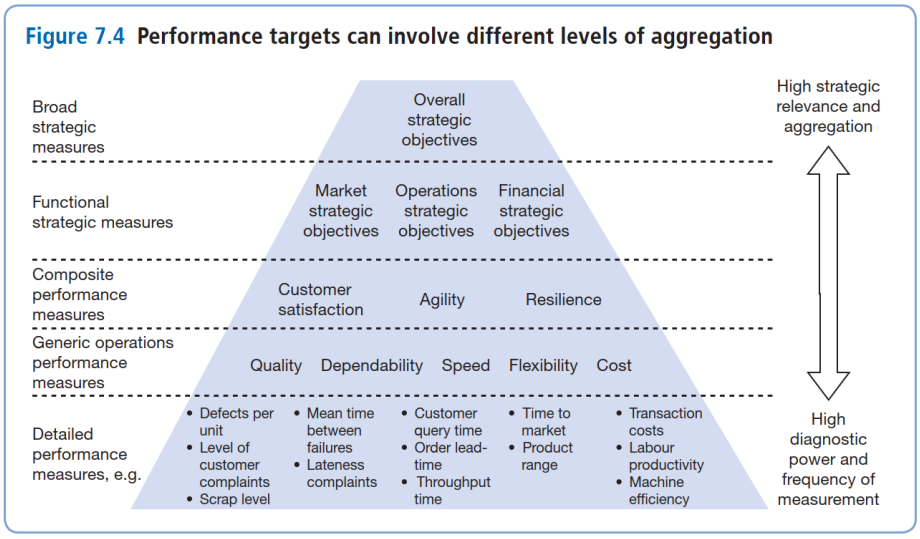

Figure 3. Performance targets across different levels (Slack & Lewis, 2017, p. 242).

2.1.2 Push and Pull Systems

The push and pull systems are alternative methods for controlling workflow in production systems. The pull system is often utilized in lean production systems. Hopp & Spearman (2011) differentiated the two by stating that in a Push system, production works are scheduled in advance into a production plan, while in a pull system, production works are authorized into the production plan. Krajewski et al. (2012) describes that in a pull system, the production flow is activated by actual customer demand, which helps reduce

excessive inventory space requirements, ensuring that goods are produced only when customer demand requires it. The alternative is the push method, which is common in conventional production systems, where production flow is activated in advance of customer demand, based on forecasts. Push systems by comparison often bring increased requirements for inventory storage space, and other related costs for storing the manufactured goods due to production happening in advance of actual demand.

2.1.3 Five-S Methodology

The Five-S is a system of housekeeping at the factory floor, and is related to Kaizen, as described by Imai (2012). Krajewski et al. (2012) describes 5S as a common methodology for reducing waste and errors and removing unnecessary tasks, materials and activities from the production process. The 5S consists of five consecutive steps, as detailed in depth in figure 4. These steps are: Sort, Straighten, Shine, Standardize, and Sustain. With these steps, the aim of the 5S method is to clean and organize the work environment, create standardized practices to sustain the work environment, to improve performance and productivity in the working environment.

5S Term	Definition
1. Sort	Separate needed items from unneeded items (including tools, parts, materials, and paperwork), and discard the unneeded.
2. Straighten	Neatly arrange what is left, with a place for everything and everything in its place. Organize the work area so that it is easy to find what is needed.
3. Shine	Clean and wash the work area and make it shine.
4. Standardize	Establish schedules and methods of performing the cleaning and sorting. Formalize the cleanliness that results from regularly doing the first three S practices so that perpetual cleanliness and a state of readiness are maintained.
5. Sustain	Create discipline to perform the first four S practices, whereby everyone understands, obeys, and practices the rules when in the plant. Implement mechanisms to sustain the gains by involving people and recognizing them through a performance measurement system.

Figure 4. The Five-S steps (Krajewski et al., 2012, p. 303).

The implementation of 5S practices has been linked to multiple benefits, such as enhanced productivity and on-time delivery, improved product quality, better utilization of factory floor space, improved safety in the working environment, and overall lowered operational costs (Krajewski et al., 2012).

2.1.4 Value Stream Mapping

Value Stream Mapping (VSM), according to the Association of Business Process Management Professionals (2013) and Krajewski et al. (2012), is another lean tool that is used to visualize a holistic view of the entire production process, including both material and information flows in the value chain of the production process, spanning from the company's raw materials reception to the final product's delivery to the end customer. Value Stream Maps tend to be quite broad in scope and are helpful for managers in identifying inefficiencies and non-value-adding activities in the process. VSM maps are typically produced separately for each product family.

Value stream mapping usually begins by mapping the current state of the manufacturing process, focusing on one product family at a time. The mapping starts from the end-product and traces the process upstream. Value stream maps typically include in-depth process details, such as cycle times, setups times, machinery up-times, batch sizes, all product variations, amounts of needed workers, working times, scrap rates, and so on. Bottlenecks and constraints can also be identified in the value stream map. The information is mapped using standardized, simple icons, example is shown in figure 5. In addition to the current state value stream map, a future state map of a more optimized process may also be designed, and an implementation plan may be developed, detailing the benefits of the improved process, such as reduced lead times, improved production flow or reduced waste, and the steps for how the current state system will be transformed in accordance with the future state plan. An example VSM map is presented in Figure 6.

Mapping is helpful for visualizing the entire value stream and understanding the current state of a process and as a diagnostic tool to identify inefficiencies, bottlenecks and other causes of delays, the eight types of waste in the process, or as a method for designing future processes (Bicheno & Holweg, 2016). Value stream maps can help bring clarity and understanding of the process for both workers and management, enabling continuous improvement and process development. Thus, value stream mapping can be a good starting point for companies who wish to implement lean practices.

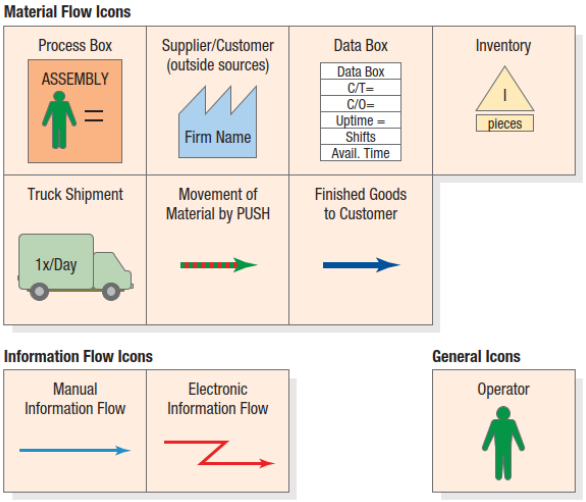

Figure 5. VSM Material Flow Icons (Krajewski et al., 2012, p. 307).

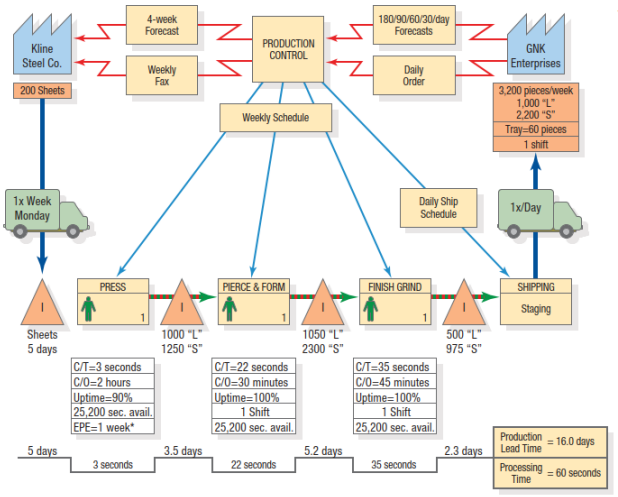

Figure 6. Example VSM map (Krajewski et al., 2012, p. 309).

2.1.5 Kanban System

Kanban, according to Kanban University (n.d.), is a workflow management methodology that uses cards to visualize how workflows are progressing. The kanban system has its roots in lean manufacturing, and was first developed by Toyota, according to Hopp & Spearman (2011). Kanban has multiple different areas of application: outside of lean manufacturing, kanban is heavily used in managing knowledge work, such as in software development or project management.

In Lean Manufacturing, Krajewski et al. (2012) describes the kanban production system as a pull-system based manufacturing system, where cards are used for controlling the flow of production in a factory. In a Kanban system, cards are placed on empty containers, signaling that the item on the cards needs to be produced, in a quantity predetermined on the card. The items are then produced, and the full containers of items move forward to be used further in the production process. When the worker has used the entire container, the card is removed and placed into a receiving post, and the empty container is moved to storage. The card is used to signal the need to produce a new container of the items as replacement, and the cycle begins again. Figure 7 shows an example of single card Kanban system. In addition to the single card system where the same card is used for starting and ending the production cycle, a two-card system may be used, where there are separate cards, a withdrawal card and a production order card, for more precise control of inventory quantities. In the two-card system, the production order card is used to start production of a container, which is moved to storage for the following department. A withdrawal card is used by the following department to withdraw the container from storage. The benefit of a Kanban system is that it facilitates just-in-time production of goods and helps reduce excessive inventory of goods.

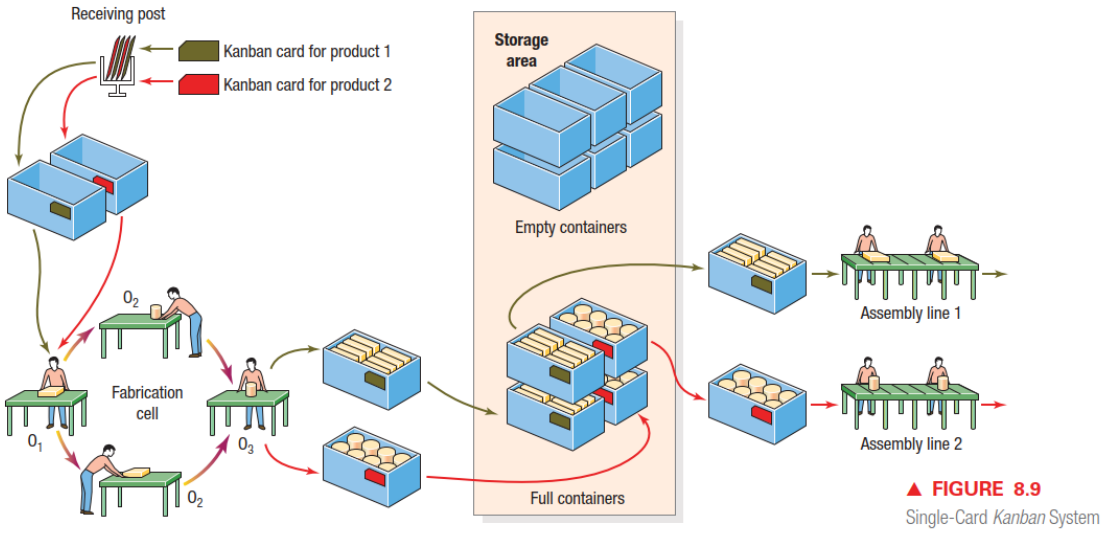

Figure 7. Single card Kanban system (Krajewski et al., 2012, p. 311).

2.1.6 Benefits of LM

Overall, the implementation of lean manufacturing principles brings many benefits. Melton (2005) for example summarized that successful implementation of lean practices can result in improved processes with less defects, less rework and less waste, decreased inventories and lead times, and in improved knowledge management practices in the organization. Similarly, Bhamu & Sangwan (2014) states that companies can achieve increased competitive advantages by reducing production costs, and by improving productivity and production quality driven by lean philosophy. Operational performance can enhance due to reduced lead times, cycle times, setup times and processing times, and costs related to inventories may be reduced as inventory levels are reduced due to enhanced inventory management and just-in-time manufacturing. Job satisfaction and operational performance among the workers can also see improvements due to more efficient communication, decision making, standardized housekeeping and other practices related to LM.

2.2 Theory of Constraints

The Theory of Constraints (TOC) is a systems management theory developed by Dr. Goldratt, aiming to identify the single most limiting factor, i.e. the constraint, in a system. A system can be thought of as a chain of actions, and every system has a constraint, the weakest link in the chain. A constraint is any variable that acts as the chokepoint or a bottleneck in the system, for example a production process, limiting the performance of the entire chain, causing for example idle times in other links on the chain, thus preventing the system from reaching its maximum output (Goldratt & Cox, 2022).

TOC argues that any improvement efforts on the system, directed somewhere other than the constraint is a waste, because the constraint dictates the maximum throughput of the entire system. As an example, optimizing production output in a system where sales orders are the constraint, will only result in either idle-time or overproduction, which will result in excessive inventory levels and increased costs related to holding that inventory (Theory of Constraints Institute, n.d.). The core idea of TOC is to first identify and locate the constraint, and then to improve the utilization of the constraint, thus increasing the overall throughput of the system.

According to the Theory of Constraints Institute (n.d.), constraints can be located in a few different areas, namely the market, the demand, capacity, the supplier, the supply, or cash:

- **A market constraint** is a situation where a company has captured most of the market they operate in, thus the company is constrained of further growth opportunities in the market.
- **A demand constraint** is when demand for the product is lower than the capacity to produce, while **a capacity constraint** is when demand exceeds the capacity to produce.
- **A supplier constraint** is caused by supply chain shortages, constraining the company from servicing all the demand it receives due to supplier shortages, while **a**

supply constraint is a broader global supply chain shortage, where the shortage is not tied to a single supplier, but the overall limited supply for the materials, for example certain rare earth elements.

- **A cash constraint** is a situation where a company doesn't have enough liquid cash or is otherwise unable to pay suppliers to purchase inputs, to serve customer demand.

Dr. Goldratt (Theory of Constraints Institute, n.d.) defined five steps that he called 'The Five Focusing Steps' that can be followed when managing constraints, as illustrated in figure 8:

- Step one is to identify the constraint, i.e. the weakest link in the process, that limits the output of the process or the system.
- Step two is to exploit the constraint as much as possible, maximizing the constraint equipment's utilization rate and productivity.
- The third step is to subordinate everything else in the production system to the constraint, because non-constraints have more capacity to produce than the constraint itself. Therefore, by subordinating everything else to the constraint and supporting the performance of the constraint, work-in-process inventories and lead time issues can be mitigated.
- The fourth step is to elevate the constraint, meaning increasing the capacity of the constraint by, for example purchasing new production equipment to increase the capacity.
- The final step is to prevent inertia from becoming the constraint. That is to say, to re-examine the system to identify whether the constraint of the system has shifted elsewhere, after the improvement efforts of steps 1-4 have been implemented, as the improved constraint may no longer be the weakest link in the production process.

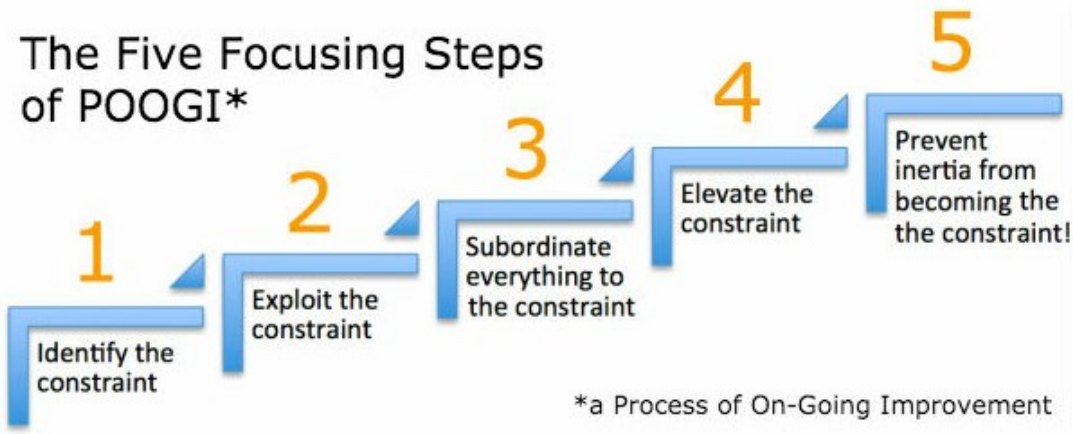

Figure 8. Goldratt's Five Focusing Steps (Theory of Constraints Institute, n.d.).

According to Watson et al. (2006), the Theory of Constraints started out as a production scheduling program but has since evolved into a full-scale operations management philosophy with various practices and principles. According to the authors, TOC techniques have been implemented in many Fortune 500 companies, such as 3M, Amazon, Ford and Boeing, to name a few, who have publicly disclosed significant improvements achieved by implementing TOC solutions. Production systems that implement TOC reduce manufacturing lead times, inventory levels, and standard deviation of cycle times, while producing more output.

Gupta and Boyd (2008) argue that the Theory of Constraints view many concepts common to traditional operations management from a unified perspective. Thus, the theory is not only concerned with operations management or manufacturing efficiency, but the overall achievement of the company's goals, and as such does not only cover the manufacturing operations of the company but requires one to view the entire operations of the company, to identify constraints and to improve the operational efficiency. The authors point out however, that the theory of TOC needs more empirical testing by researchers, and its implications across other business functions, outside of operations, need to be studied and developed, in order for the theory to take a unifying role in the field of OM.

As such, although TOC has its roots in manufacturing operations, it has evolved into a framework that is applicable across business functions, from manufacturing operations, to sales, supply chain management and optimization, and project management (Critical Chain Method) to name a few. In essence, TOC is a mindset: Find the constraint in the system or the network, improve the constraint, thus the flow and performance of the entire system is improved.

2.3 Business Process Management

Business Process Management (BPM) is a management discipline focusing on defining, engineering and controlling business processes and dedicating the organization to continuous improvement, as a means to build internal capability and to achieve organizational goals, according to the Association of Business Process Management Professionals (2013). Managing business processes efficiently requires cooperation from the entire organization to ensure that BPM practices become integrated into the company culture, to build capability for efficient business process management. This includes all functions and roles, operational staff, management and executive management.

According to the Association of Business Process Management Professionals (2013), an organization's business processes should be arranged such that they support the management of the business processes. Thus, business processes should be definable and designable, buildable and deployable, they should enable the monitoring and control of process execution, and they should also enable continuous improvement of the processes over time. In addition, there should be clearly defined roles and responsibilities among the people involved in managing the business processes. These can include (but are not limited to) process architects, which are responsible for defining and designing the processes, process analysts, which are responsible for building, deploying, monitoring and optimizing the processes, and process owners, who are responsible for the execution of the processes against performance targets to deliver value in the form of products or services to the end-customer.

Business Process Management is typically introduced to smaller companies when they desire to improve a specific business process, while larger companies typically already have some type of corporate business process architecture, as well as a business process management group dedicated to overseeing and managing business processes and change initiatives (Harmon, 2014).

2.3.1 Business Process Modeling

In order to build effective capability for business process management, processes need to be modeled. Modeling is an activity aiming to visualize existing or proposed future processes, useful for organizing, analyzing, explaining or controlling business processes. Modeling business processes enables companies and their employees to understand and more effectively communicate about the issues and challenges related to the processes and helps management by ensuring that the business processes are monitorable, controllable and manageable. Process modeling is thus a foundational activity for managing the company and its operations, according to Association of Business Process Management Professionals (2013).

A process model can be expressed in a simplified or a detailed level, and consists of icons as elements, representing activities, sequences or workflow, events or gateways, dataflow and decisions, among others. Figure 9 shows an example of the basic process model elements, according to Business Process Modeling & Notation (BPMN) method. A process model utilizes standardized elements and icons (called notations) and are typically highly precise and detailed. A process diagram or a process map, by comparison, is typically less detailed, and may use un-standardized icons for describing the process (Association of Business Process Management Professionals, 2013).

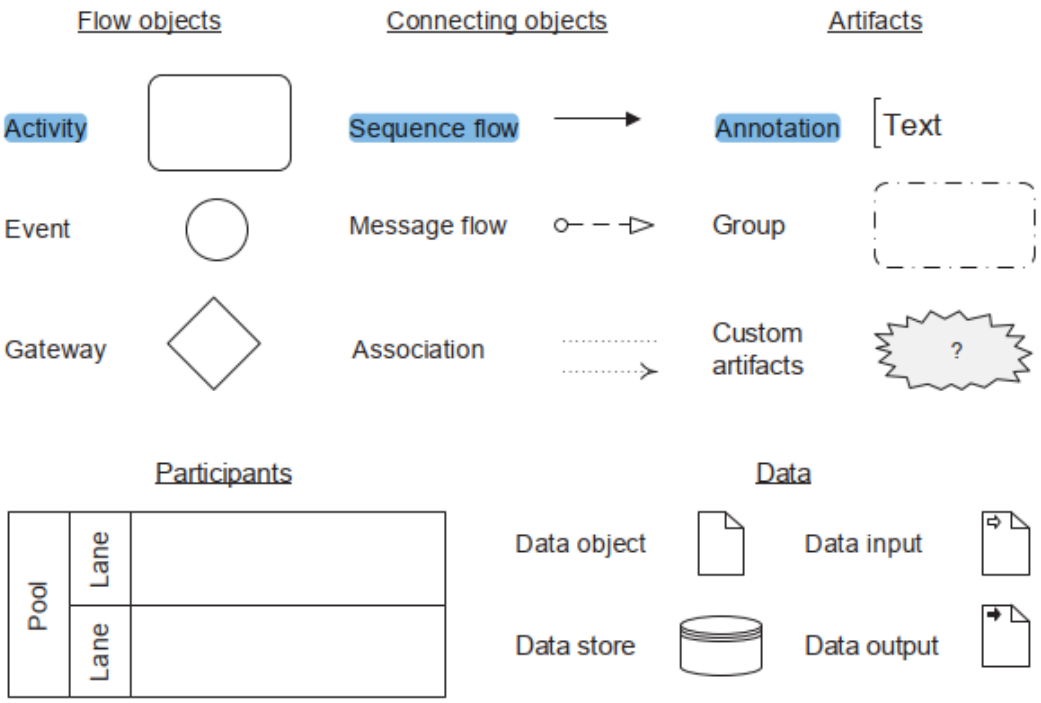

Figure 9. Basic elements of BPMN (Freund & Rücker, 2019, p. 24).

There are many alternative approaches to modeling or mapping production processes, according to the Association of Business Process Management Professionals (2013):

Business Process Modeling and Notation (BPMN) 2.0 is a standardized approach that is widely included with different modeling tools, offering a large set of standardized symbols for modeling business processes and their various aspects. BPMN 2.0 is best used when modeling a process for a wide audience of different stakeholders, or when simulating a business process digitally. Figure 10 illustrates an example of BPMN 2.0 styled process model.

Flow charts are a widely used method to visualize the process steps, machines, flow of materials, and roles into sequential steps. Flow charts include a simple symbol set for actions, decisions and other elements of the process. Flow charts are best used to quickly visualize process flows where in-depth process modeling is not required or feasible.

Swim Lanes are an extension of other modeling approaches such as BPMN or flow charting, where horizontal or vertical lanes are included to signify the performer who is responsible for performing the mapped activity. The process flow, tasks and activities are mapped into the lanes, to easily identify the change in responsibility of performance in the process. The advantage of swim lane diagrams is that they are good for training purposes and facilitate collaboration, as it is much easier to distinguish the roles of the performers in relation to others and the limits of their responsibilities, from the swim lane diagram.

Other notable process modeling methods include Event Process Chains (EPC), Unified Modeling Language (UML), Integrated Definition Language (IDEF), and Value Stream Mapping (VSM).

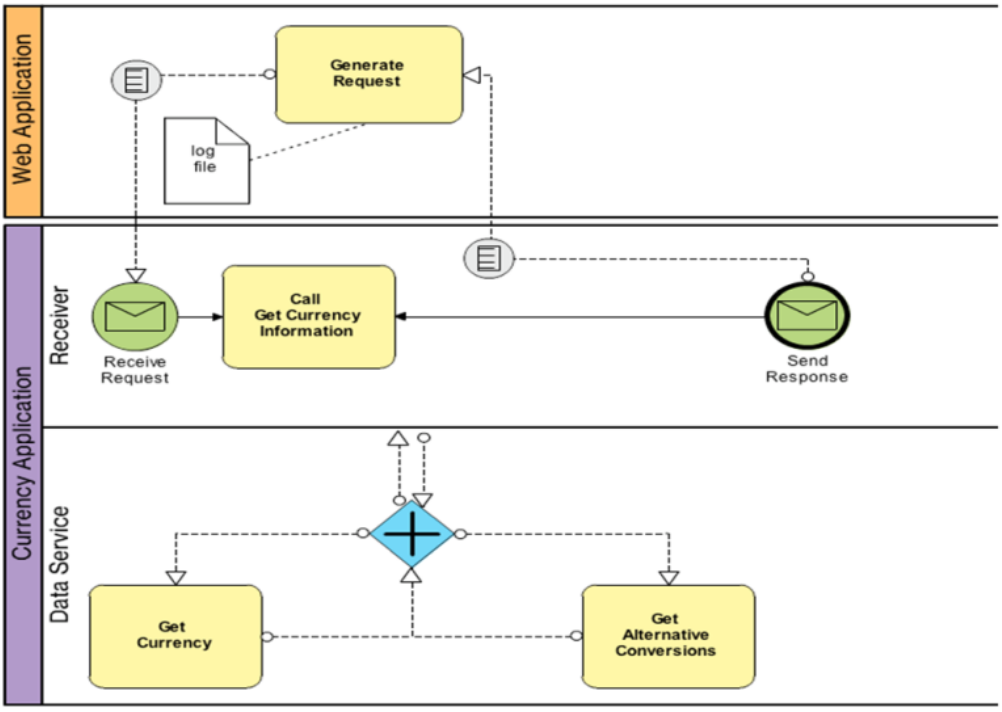

Figure 10. Example of a BPMN 2.0 based process map (Association of Business Process Management Professionals, 2013, p. 96).

Another good framework for approaching business process modeling is the five levels of process mapping, as described by SowFlow (2024, October 15), offering a structured method to identify and manage processes. In SowFlow's model, the first Level is called the 'category', showing the big picture of the business and its processes, categorizing the organization into functions, each with their own underlying business processes. Level 2 is called the 'process group', which categorizes the various business processes under each level 1 function into key process groups. Level 2 brings more structure to the process mapping, helping to prioritize how or where resources are allocated. Level 3 is called the 'process'. This level identifies individual processes belonging into the level 2 process group. Level 4, called 'activity', identifies activities belonging into each level 3 process. Finally, level 5, the 'task' level, details each task that is required to complete the activity identified in level 4. Figure 11 summarizes these five process levels.

Level	Level name	Mapping technique	What to map
1	Category	Create a breakdown into related groups	Overview of major functions
2	Process group	Create a breakdown into related groups	Breakdown into related groups
3	Process	Flowcharts & Process maps	Specific events and steps during execution
4	Activity	Activity Diagrams, Standard operating Procedure Documents, Job Aids & Checklists.	Detailed actions within a process, including specific events and steps during execution
5	Task	Standard operating Procedure Documents, Work instructions, Job Aids & Checklists.	Breakdown into specific step-by-step instructions

Figure 11. SowFlow's 5 process levels (SowFlow, 2024, October 15).

Overall, business process modeling is an effective method for documenting, analyzing and improving business processes, by representing the processes visually by interconnected tasks, process phases and work- or information flows. Modeling business processes is beneficial because modeled and clearly defined business processes help formalize existing processes, facilitate mutual understanding of complex business operations between managers and workers, and provide clarity for roles and responsibilities

among workers. Havey (2005) states that the motivations and benefits behind decisions to implement business process modeling in organizations include the formalization of existing processes, identifying areas for process improvement, facilitation of efficient process flows, the increase of productivity and decrease of head count enabled by process improvement that is achievable with BPM, and simplifying regulations and compliance issues by creating business processes that are easier to manage and audit for compliance with various regulatory requirements.

Additionally, process maps are useful in process development for identifying inefficiencies, constraints and bottlenecks in the processes. Thus, process modeling is often a prerequisite for any serious efforts for process development and improvement, productivity enhancement and lean practices such as waste reduction, or for the implementation of the Theory of Constraints. Business Process modeling can also help align manufacturing operations with various systems such as Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES) and Warehouse Management Systems (WMS), and can provide clarity inside an organization for managers, engineers, workers and other employees, helping to facilitate cooperation and mutual understanding between them, and helps managers identify, assess and optimize resource allocations. Overall, BPM is a useful tool to visualize complex business operations to enable strategic planning and continuous development inside manufacturing organizations.

2.3.2 Process Descriptions

A process description is a document that details process steps in sequence into a clear workflow. According to Operations1 (n.d.) and ProcessNavigation (2025, April 12), a process description is a document that describes a process and its details, such as inputs and outputs, workflow and process steps, the purpose of the process and its benefits, in order to create clarity and transparency so employees and other stakeholders can more easily understand processes, especially when processes are complex. Process

descriptions are often based on process analysis, such as mapping and modeling work, or expert insight.

An effective process description, according to ProcessNavigation, should provide clarity and be written clearly in plain language, avoiding complex jargon, should be structured into a sequential workflow, and should be specific and consistent in using the same terminology and tone and offering sufficient detail to understand the process in depth. Visual aids such as diagrams or process maps and models are useful to complement the process description. According to Operations1, process descriptions can consist of five aspects: control, organizational, information, monitoring, and the safety aspect (explain aspects). The control aspect helps employees identify the actions that are taken in the process, and the reasons behind them. The organizational aspect defines roles by assigning tasks and activities to employees or departments. The information aspect details what information is needed for the process, while the monitoring aspect defines goals for the process, such as process times or costs. The safety aspect accounts for guidelines, legal requirements, and approval and decision-making processes.

One very practical reason why companies may need process descriptions is that some standards, such as the ISO-9001 standard for Quality Management Systems (QMS), require companies to identify and define their processes that are needed for the QMS (International Organization for Standardization, 2015). This can create a need for companies to create process maps and descriptions, in order to receive certifications for the standard. ProcessNavigation and Operations1 both highlight that process descriptions can also provide process transparency, especially for complex processes, can help in knowledge transfer, training and onboarding of new employees, and preserve knowledge within the company, helping to mitigate, for example, knowledge loss due to employee turnover, and the transparency the process descriptions provide can also increase employee satisfaction and retention, and promote efficiency.

Process descriptions are distinct from work instructions in the sense that while work instructions provide very specific and detailed step-by-step instructions for employees, process descriptions are more general in scope, and can detail larger, more complex processes where multiple departments may be involved in the process, not just individual employees, according to operations1.

ProcessNavigation also highlights the importance of maintaining the process description, to ensure the accuracy and usefulness of the descriptions. Regular reviews and revision control are recommended to keep the descriptions up to date, the documentation should be made easily accessible so workers can find them, and continuous improvement should be encouraged, for example by creating feedback loops to enable the 'end-users' (workers) to provide feedback and recommend improvements for the process descriptions to ensure the documents remain up to date and as detailed and useful as possible.

2.3.3 Modern Process Modeling Methods

In addition to traditional process mapping and modeling methods, modern industry 4.0 technologies offer new and emerging digital techniques for production process modeling.

Digital dashboards for example, i.e. displays showing crucial information, offer an easy way to visualize important real-time information to facilitate agile manufacturing. Takala et al. (2016) noted that the use of dashboards would likely increase, driven by digitalization of production control methodologies. The authors surveyed Finnish manufacturing companies to determine the KPI's the companies were most interested in, and recommended the creation of individual dashboards for all three hierarchy levels in manufacturing companies: an operational dashboard for the workers, a tactical dashboard for managers and analysts, and a strategy dashboard for the executive level.

Digital Twin (DT) platforms, such as those offered by Zuant3D (n.d.) or Process Genius (n.d.), enable the creation of a virtual 3D models of a factory, enabling simulation, analysis and visualization of production processes in real time. These Digital Twin platforms can offer database integration with ERP, MES and other systems and can connect to IoT (Internet of Things) devices such as sensors, enable the creation of customizable digital dashboards for tracking Key Performance Indicators to monitor production and to generate reports, tools for quality control, and production simulations can help identify bottlenecks and areas of improvement. 3D-modeling offers virtual touring through production facilities for better contextual understanding and offer alternatives to combine models with AR and VR technologies. Zuant3D for example offers solutions to create digital scans of manufacturing facilities, using 360-cameras, while Process Genius offers a SaaS (Software as a Service) solution, based on 2D or 3D CAD and STEP models.

DT technologies will likely see growth in the future, but the technology is still in its infancy, and bring many common challenges related to emerging industry 4.0 technologies, such as lack of standards and regulations, challenges related to finding engineers and technicians with ready-made DT competencies, lack software support, and data security challenges (Singh et al., 2021).

Overall, these modern methods help support the goals of BPM theory to create process models, increase process management competencies and process transparency, and to drive continuous development in manufacturing operations.

2.3.4 BPM and Change Resistance

For companies to remain competitive, companies need to be flexible and must have the ability to grow, evolve, adapt and change in response to changing markets and emerging trends, to meet customer needs. BPM practices are essential for any small and medium-sized enterprises (SME's) with complex processes that wish to improve, develop and

scale their operations further. But one of the key barriers preventing successful BPM implementation is change resistance within the organizations.

Fernandes dos Santos & Aires (2023) point out that change resistance is usually linked to workers opposing change due to not understanding why the change is needed. Prosci (n.d.) supports that claim, describing that resistance is natural response to perceived threats, uncertainty or fear of the unknown, and has many different root causes and ways the resistance shows up in the workplace. Possible root causes include workers being excluded from decision making and left uninformed about the justifications why a change is required, fears about reduced job security and job loss, poor role modeling and reception of mixed messages from leaders or managers due to negative or disengaged leadership attitudes, and anxiety caused by uncertainty or unclear expectations and loss of familiar routines during or after the change. Change resistance may show up as increased negative emotions and attitudes among the workers, complaints, reduced morale, disengagement and loss of energy among the workers, reduced productivity, increased errors and need for rework, avoidance of responsibilities, and more (Prosci, n.d.).

The implementation of BPM, process mapping or re-engineering of business processes can stir many different fears among workers, leading to increased change resistance. For example, the fear of losing familiar routines could be a big reason for change resistance in many SME's still operating with informalized processes. As such, mitigating change resistance is paramount for successfully implementing BPM practices. To decrease change resistance, Santos & Aires (2023) suggests communicating the benefits of BPM implementation, and why the changes are needed, more clearly to the 'end-users' (the workers affected by the change). The authors also recommend management to take into account the end-users' thoughts, feelings and actions during the change process, emphasizing the positive aspects the change will bring. Pereira et al. (2019) emphasize that in order to be successful, BPM implementers need competencies related to specifying goals, communicating and influencing, negotiating, and team building, to build trust and to mitigate change resistance among employees. Similarly, Prosci (n.d.) recommends

planning for resistance prevention, raising awareness about why change is required, offering training and support to ensure people can adapt to the change, and to emphasize leaders' roles in inspiring workers and to support in change management by reinforcing the message of why the change is needed.

2.4 Summary

The theories covered in this chapter: Lean Manufacturing, Business Process Management, and Theory of Constraints, are distinct but closely related approaches for managing processes and improving performance of manufacturing operations. Lean Manufacturing is an approach to maximize customer value by minimizing waste in the process, by utilizing multiple different tools, approaches and methodologies that are included in the lean framework. Business Process Management offers a framework for modeling, visualizing, analyzing and managing business processes for better understanding and for enabling process improvement. Theory of Constraints argues that improvement efforts in the process are vain, unless the improvement effort addresses the single most limiting constraint in the process. Thus, TOC focuses on identifying this single most limiting factor, the constraint, in the process, and to improve the process throughput by improving that identified constraint.

Underlying each of these theoretical frameworks is the foundational, prerequisite need to map or model the production and business processes, in order to then enable operational improvement efforts by identification of constraints, areas of improvement, waste reduction or other means. Together, these frameworks complement each other as means of improving production operations and enabling and driving a culture of continuous improvement in manufacturing companies.

The Business Process Management framework in particular offers a robust basis for the process mapping work using swim-lane diagramming methodology that is done for the case company, and for preparing the general descriptions to supplement the swim-lane

process maps. The swim-lane diagrams can be used by the case company as a practical tool to apply BPM, LM or TOC principles for analyzing their manufacturing processes. The theories will also help facilitate the data collection process, ensuring that crucial information is captured, in order to produce good quality process maps that are accurate and useful for the case company.

3 Methodology

This chapter describes the methodology used for collecting and analyzing the data used in the study. As the objective of the study was to explore the current state of the manufacturing process, a qualitative research approach, an approach focusing on addressing 'who, what, how, when or why' type of questions and best used for exploring phenomena with little prior research according to Denzin & Lincoln (2000), was selected. As the research focuses on a single company and aims to map and describe existing but unmapped production processes, it can be characterized as an exploratory and descriptive case study, as defined by Schell (1992). Multiple sources of data were used for mapping the manufacturing processes: primary data was collected using semi-structured interviews, supplemented by observations made during multiple factory tours through the production departments, and pre-existing documentation provided by the case company was also used.

Five different manufacturing departments, and their team leaders were interviewed in person at the case company. The interviewed departments included punching department, pressing & press braking department, ladder department, and powder painting department. In addition, the chief of production planning from the production planning department, and chief of production were also interviewed.

The interviews were designed as semi-structured interviews. The questionnaires were designed according to Bhandari's (2023, June 22) insights into questionnaire design. The Semi-structured interview method was chosen, due to the additional flexibility it offered to explore emerging topics during the interviews, in addition to the pre-defined, open-ended questions that were prepared in advance for the interviews. The interview questions were grouped thematically into five categories: workflow and work phases, process inputs and outputs, information flow, inefficiencies, and general questions (appendix 1).

The interviews were recorded, and the recordings were reviewed. Based on the recordings, the interviews were transcribed into text format and analyzed thematically.

Patterns, themes and key items were then identified from the transcribed data. Thematic data analysis process, as illustrated in figure 12, starts by reading the transcripts multiple times, getting familiar with the data. Next, important keywords or sentences are highlighted (coded), and related codes are then grouped into themes. Themes are then reviewed, and concepts are developed based on the themes (Naeem et al., 2023; Ahmed et al., 2025). This aligns well with Creswell's (2009) views on qualitative data analysis, describing it as an ongoing process of making sense of the data, building deeper understanding, akin to peeling back layers on an onion, and making interpretations based on it. To build deeper understanding, the interview transcripts and thematically grouped interview questions were helpful in facilitating the thematic analysis process, making it easier to identify themes such as key process steps, equipment and tools being used, the material flows (process inputs and outputs) and critical information flows related to the manufacturing processes. The "general" and "inefficiencies" category questions helped to identify key challenges and other relevant information and also allowed to explore emerging topics during the interviews, helpful in building deeper understanding of the overall manufacturing processes in each production department.

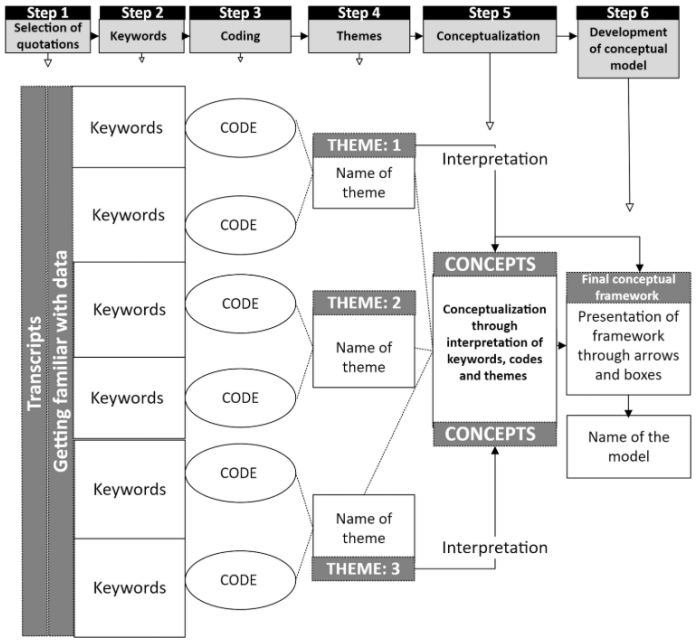

Figure 12. Thematic Data Analysis Process (Naeem et al., 2023).

From the data, the key process steps, raw material and information inputs, process and information outputs were first identified, and recorded as elements into a diagram. Next, the interrelations between each element in the diagram were recorded, based on the transcribed interview data. Next, the produced process maps with steps and interconnections were arranged into lanes according to the collected data, with each lane representing responsibilities of workers and departments, thus producing swim-lane diagrams for the production processes. Following this, descriptions were written for the manufacturing departments, including descriptions for the main streams of material flows through the different departments, starting from raw materials to finished end-products, the tasks of the individual departments, the tasks of the department team leaders, the department's operators, the key inputs and outputs from the departments, and the key tools and equipment (both software and hardware) used during the manufacturing processes, to supplement the swim-lane process maps.

Good quality qualitative research, according to Golafshani (2003) consists of three parts: validity, reliability and triangulation. Reliability, as described by the author, stems from the consistency of the research findings and the replicability of the study findings, using similar methodologies. Validity, on the other hand, is a measure of how accurate the research results are. Triangulation is a strategy for testing and increasing the validity and reliability of the research results, by using multiple methodologies or data sources to support the study findings.

Triangulation, as defined by authors such as Golafshani (2003) and Denzin & Lincoln (2000) was used in the study. By using multiple data sources, the validity and reliability of the results for the process mapping work was increased. In addition to the semi-structured interviews for primary data collection (which itself used multiple people as data sources, i.e. team leaders of departments, chief of production, and chief of production planning), several factory tours were arranged through the manufacturing departments to make observations and to gain better understanding of the manufacturing departments and their workflows in their real-life context. In addition, pre-existing

documentation provided by the case company was used to complement the interview data and the observations and to align the process mapping work with previously made process maps, such as sales-order processes.

After the interviews and the preparation of the initial process maps, they were sent to the production department team leaders for commenting to reduce researcher bias and to increase the validity of the process maps. After accounting for comments from department team leaders, a final meeting was arranged to review the process maps together with the plant manager, the chief of production, and employees from each production department and the production planning department, to ensure the results are consistent, valid and to make any final adjustments to finalize the process mapping work.

Thus, all three aspects of quality research, i.e. validity, reliability and triangulation, were included in the research, to increase the overall research quality and to reduce the risk of researcher bias and errors.

4 Results

This chapter will present the results from the interviews and the process mapping work. Process maps were prepared for the five production departments, as well as a process map portraying a general overview of the production control philosophy, managed by the production planning department. The process maps were based on swim-lane diagramming method, where tasks and their interconnections are mapped into lanes, which identify who is responsible for said tasks. Section 4.1 describes the production planning and control process, while section 4.2 describes the general overview of the production department's operations. Appendix 2 includes the prepared process maps.

4.1 Production planning and control

Figure 13 presents an overview of the production control philosophy, as managed by the production planning department. The process starts with the customer who places a request for quotation (RFQ). Sales department responds to the RFQ with an offer, based on the product category being requested by the customer. There are three categories of products, detailed in subchapters 1-3: inventory-driven products, order-driven products, and tailored products. Each product category has a different control philosophy of how they flow through the inventory and production processes.

In order to manage production, production planning department collects various sorts of data from the production departments, to manage and control production. This data can include capacity and equipment utilization rates, inventory balance recordings from production departments and production phases, among others.

4.1.1 Order-driven products

Order-driven products are products which aren't feasible to produce readily into inventory. These can include low-demand products, produced start to finish from raw materials to finished products, or high-demand products with specialized, rarely requested paint-colors, that can be processed or finalized from semi-finished products in the inventory.

For order-driven products, a pull-system is used. The production planning department supports the sales process by evaluating the delivery capability. This check assesses the current inventory levels and the current production capacity utilization rate to determine the lead time that can be promised for the customer. Based on the check, an offer can be made to the customer.

After the customer places the order, the order is booked into the order backlog, and the production work is scheduled into the production queue, via Advanced Planning and Scheduling (APS) software. The production departments then produce the product based on the production queue of the APS software. After the order flows through the production departments, the finished product is then packed and dispatched to deliver to the end customer.

4.1.2 Inventory-driven products

Inventory-driven products are high-volume, high-demand products that can be produced ready-made into the inventory, based on demand forecasts. These products can be unpainted, or painted with standard, high demand colors. These products typically have standardized lead times, due to readily maintained inventory levels.

A push-system is used for these types of products. Similar to order-driven products, the production planning department supports the sales process by evaluating the delivery

capability for the inventory-driven products, checking whether the product can be delivered in accordance with the standard lead times promised to customers. This check assesses the current inventory levels and the current production capacity utilization rate to determine whether the product can be delivered in time for the customer. Based on the check, an offer can be made to the customer, adjusted with a realistic lead time in case standard lead times aren't feasible at that moment.

After the customer places the order, and the order is booked into the order backlog, the order is forwarded to the warehousing department for order picking, and then to dispatching for arranging the final delivery to the customer. Here, inventory levels play a crucial role. Inventory levels are recorded and managed by an Enterprise Resource Planning (ERP) system. The ERP system has an alarm threshold (a reorder point) for minimum inventory level to be maintained, based on demand forecasts. As such, accurate demand forecasting is one of the most critical challenges to manage the production capacity as efficiently as possible. When the inventory levels drop below the reorder point, new products are planned into the production queue to refill the inventory above the threshold level. While the order-driven products have priority in the production queue, the refill orders for the inventory-driven products are added into the production queue, into suitable slots to balance the production schedule, minimizing downtime and maximizing the capacity utilization rate, without compromising the lead times for order-driven products.

4.1.3 Tailored products

Tailored products are customized products that are designed according to customer needs by product planning department. Product planning department communicates with the team leaders of the production departments, to verify the manufacturability of the designed products.

A pull system is used for these products, similar to order-driven products. After manufacturability has been verified, the production planning department performs a check of delivery capability for the product, in the same way as with order-driven products. Based on this, a lead time and an offer can be given to the customer. Based on customer order, an order confirmation is sent, but prior to this, acceptance of the product design must be received. After the order confirmation, the order is scheduled into the production queue and flows through the production departments to dispatching and final delivery, similar to order-driven products.

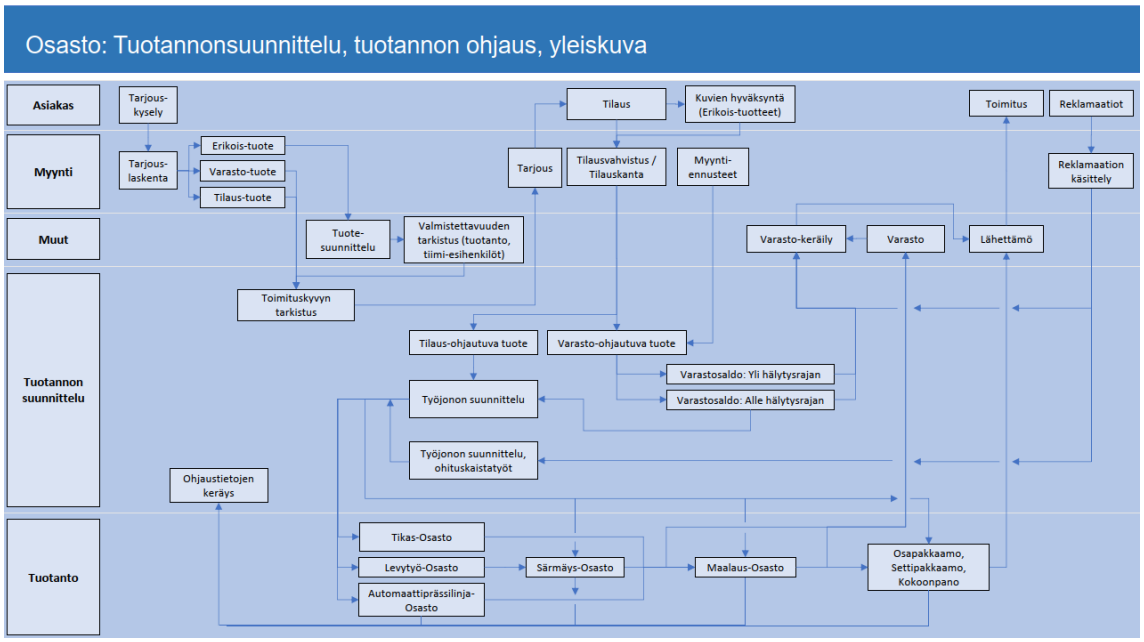

Figure 13. Overview, Production planning & control principles.

4.2 Production Departments

The actual production operations start with the production planning department, which designs the rough production queue into the ERP software based on the order backlog and demand forecasts. The rough production queue plan determines the manufacturing deadlines for the products to be produced, and the rough production queue is optimized

further in the APS software, which records the fine-tuned production plan back into the ERP.

The manufacturing department's team leaders plan a detailed production queue in the APS based on the rough production queue prepared by the production planning department, accounting for department specific factors, such as staffing, equipment setup times and so on. The detailed production queue is planned to bulk similar products together into the queue in order to minimize setup times, such as tool changes needed for production equipment when changing between different product types, while also ensuring that the manufacturing deadlines, determined by production planning department, are being met. The goal is to ensure that the production flow is as smooth and efficient as possible, maximizing capacity utilization and minimizing idle time. The production department operators then execute the detailed production queue.

In each production department, although the production equipment and products differ, each department's operators follow the production queue from the APS software, making work log entries to open production batches, and close the log entries when the batch is completed. The work log entries shape the inventory balance data in the ERP, which is a crucial input for the production planning department. The production planning department also collects other information, such as production times spent on work phases, equipment utilization information from the production machines software, among others, to help prepare production plans, to evaluate the delivery capability and so on. The operators also perform quality checks and prepare quality reports, makes CE- & P- markings for the products and print pallet labels for the completed production batches, which are crucial information input for following production departments. The department's operators are also responsible for daily maintenance and smaller maintenance jobs for the production equipment in each department.

The department team leaders also communicate with the procurement department or the previous production department in case of material shortages, and with product

design department to ensure manufacturability, and to support with product designs, prototyping and pilot production runs.

In addition, team leaders partake in daily manufacturing meetings with the chief of production planning, chief of production and the plant manager, among others, where for example production challenges, equipment malfunctions, capacity and staffing challenges can be discussed and solutions, such as decisions on overtime work, can be discussed.

4.2.1 Punching department

The punching department is a raw material processing department, equipped with two fully automated punching machines or cells, and an automated sheet metal storage unit. The process map for the punching department is presented in figure 14.

The department operators receive and shelve raw materials (sheet metal) and ensure the automated sheet metal storage unit is stocked with raw material. The operators execute the detailed production plan according to the APS software, starting by making work log entries into the software to start a production batch. The operators retrieve the correct product designs and work instructions, perform the required tool changes for the punching machines, select the correct programs for products to be manufactured with the punching machines, and are responsible for overseeing the punching machines operation. The automated sheet metal storage unit feeds raw material to the punching machines automatically during production runs. The department produces semi-finished parts, called blanks, that are further processed in other departments into finished goods.

After the production runs, the operators perform quality checks and prepares quality reports for the production runs, prints pallet labels, and makes the work log entries into the APS to mark the batch complete, reporting the quantities produced, defects and so

on. The operators then deliver the pallets of blanks to the next production department, which is the pressing & press braking department.

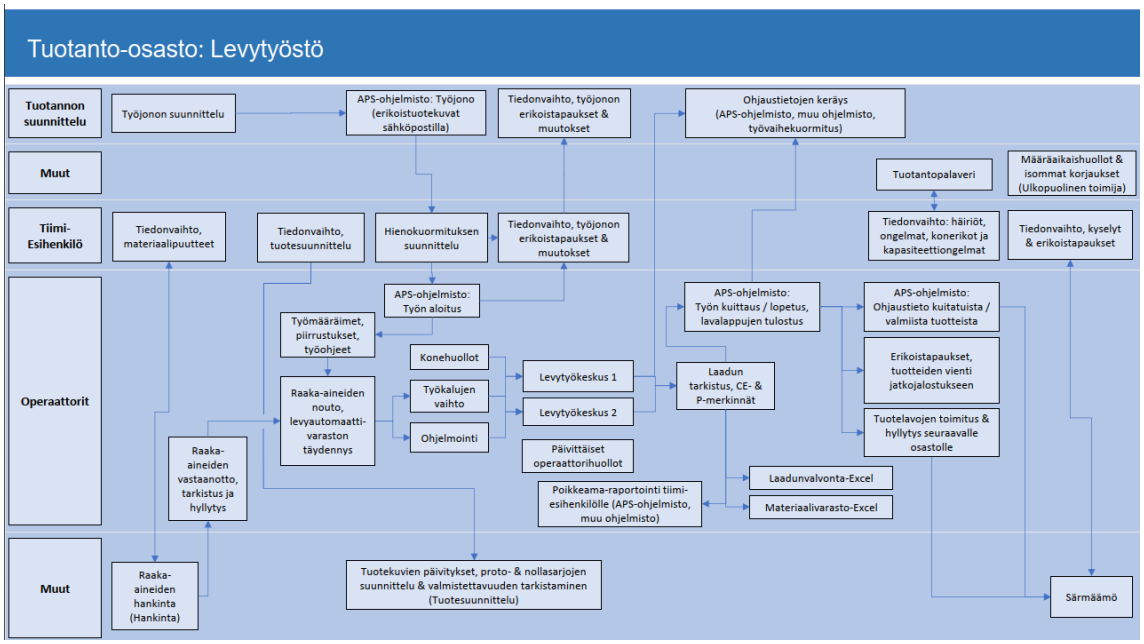

Figure 14. Process map, punching department.

4.2.2 Pressing and press braking department

The pressing and press braking department receive the pallets of sheet metal blanks from the punching department for further processing. Additionally, some raw materials are procured externally. In this department, bending equipment is used to process the sheet metal blanks, for example into brackets, spacer plates and end plates for snow retention systems, which hold the snow guard tubes in place in roof installations.

The department is equipped with manual press brakes, eccentric presses, and robotic bending cells for sheet metal processing. Additionally, the department has an automated robotic press line, called RWS-line (Robotic Work Station line).

The department's operators follow the production queue from the APS system, make the work log entries to open production batches, retrieve the designs, work instructions and sheet metal blanks, change the tools for the bending equipment or select the correct programs for the automated robotic cells, and operate the manual bending equipment.

After completing the production batches, the operators perform quality checks and prepare quality reports, make the work log entries to complete the production batches, print pallet labels and moves the pallets of products into designated collection points. Internal logistics then retrieves the products from the collection points, transporting them to the painting department. The process map for the pressing and press braking department is presented in figure 15.

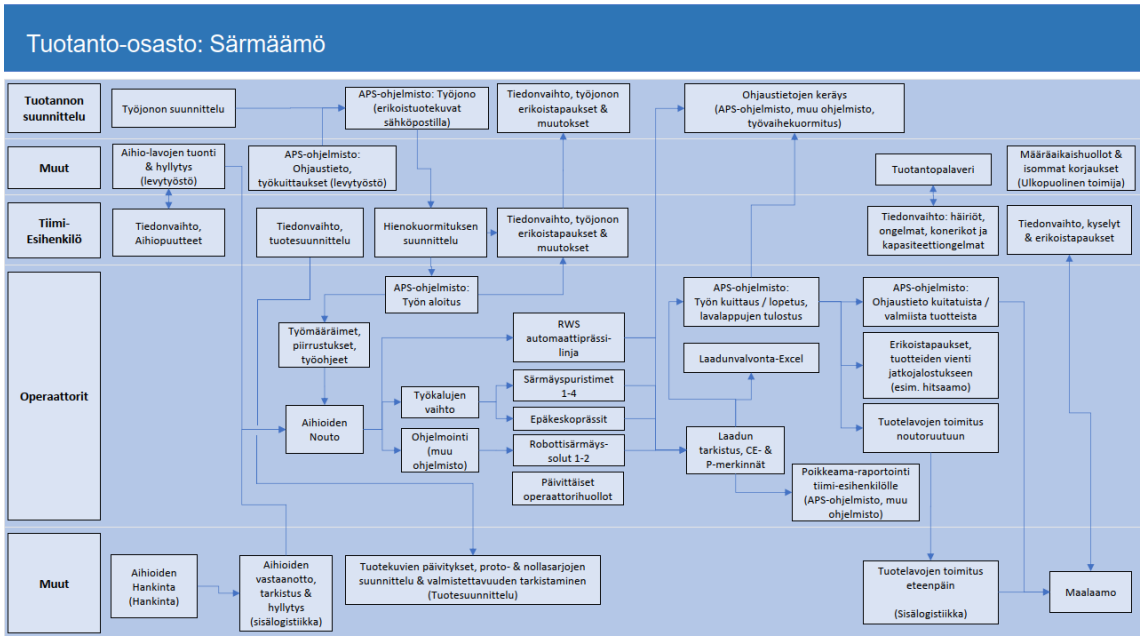

Figure 15. Process map, pressing and press braking department.

4.2.3 Ladder department

The ladder department is the second raw material processing department, producing ladders from raw materials such as pipes. Additionally, the department produces snow guard tubes for snow guard systems.

The department has a leg-forming machine cell for producing the legs or wall brackets for the ladders, a top arch-machine cell for producing the top arches for the ladders, a snow guard machine to produce snow guard tubes, and a rung forming machine cell to produce rungs, i.e. the steps of the ladder. Lastly, the department has an automated ladder machine, which combines side rails and rungs to produce ladders. All machines, except the ladder machine, use various kinds of pipes as raw materials.

The next process step after the production machines is quality check, where operators check the production quality, make the quality reports, make CE- & P- markings for the production batches, make work log entries into the APS software to mark production batches as complete, marks the production pallets with pallet labels and delivers the pallets into designated collection points, where internal logistics will retrieve and deliver to the next departments, or warehousing. Figure 16 presents the process map for the ladder department.

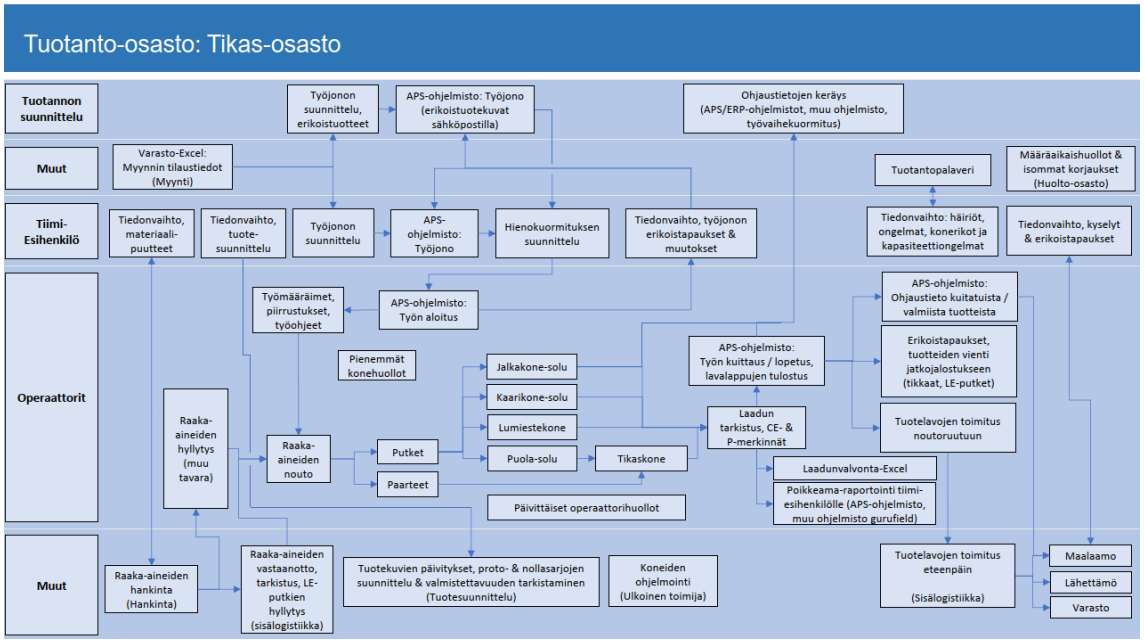

Figure 16. Process map, ladder department.

4.2.4 Mechanical press lines department

The mechanical press lines department is the third raw material processing department, producing products from sheet metal coils using pressing equipment. The department is equipped with three automated press lines producing various ladder components such as for example clamps and brackets, base plates for the ladder feet, mounting hooks, and more. Additionally, the department has an automated “cassette” line, producing roof access walkways and snow fences.

As with the other departments, the operators retrieve the raw material, i.e. the sheet metal coils, install the sheet metal coils into the press lines, installs the correct pressing tools to the press lines, select the correct programs according to the product designs and work instructions, and supervise the equipment during the production runs. After the completion of the production batches, the operators perform quality checks, prepare quality reports, marks the products with CE- & P- markings, make the work log entries, prints pallet labels and delivers the pallets into a collection point, where internal logistics

will pick and deliver the pallets forward to the painting department, warehousing or the dispatching department. Figure 17 presents the process map for the mechanical press lines department.

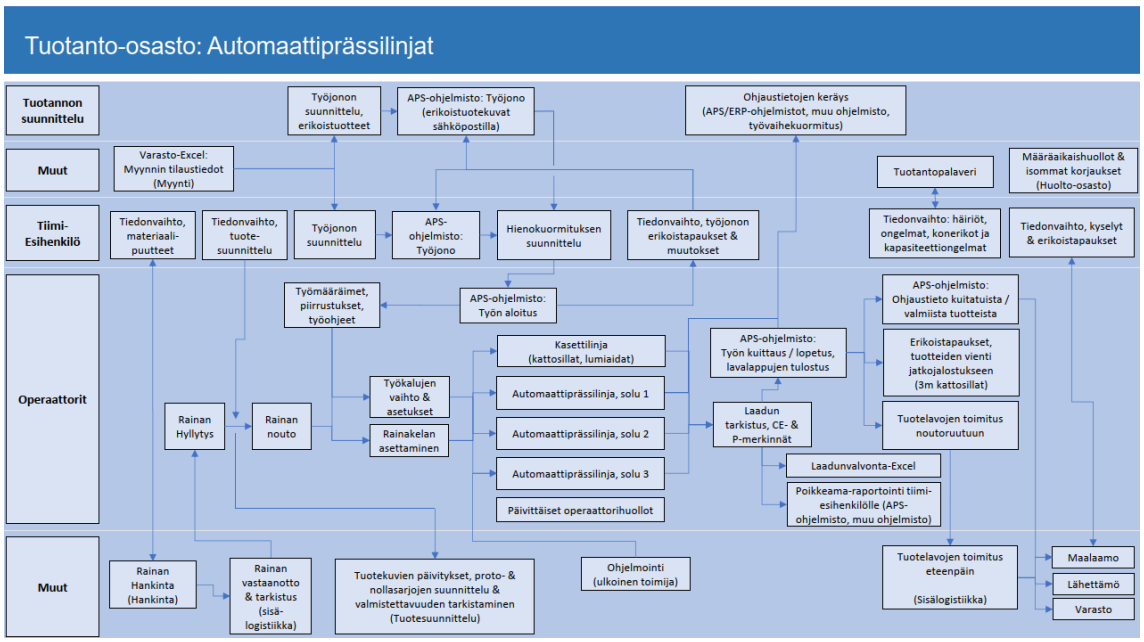

Figure 17. Process map, mechanical press lines department.

4.2.5 Powder painting department

The powder painting department is the final main production department, receiving the raw material flows either directly from the previous production departments, or retrieved from storage. As such, it can become the main constraint in the overall production process. The department is equipped with several sizes of hanging racks, the actual painting line, and the disassembly point.

The operators hang or mount the products into the hanging racks, and the products are then painted according to order with the desired color. After painting, the products are disassembled from the racks, the paint coat is inspected, quality reports are prepared and the products are packed into pallets, marked with pallet labels, and delivered to the

collection point. Internal logistics then transport the finished products forward, either directly to storage, or to smaller finishing departments, where the product parts are assembled and packed into partial or set packages. The packed items are then dispatched to the end customer. Figure 18 presents the process map for the powder painting department.

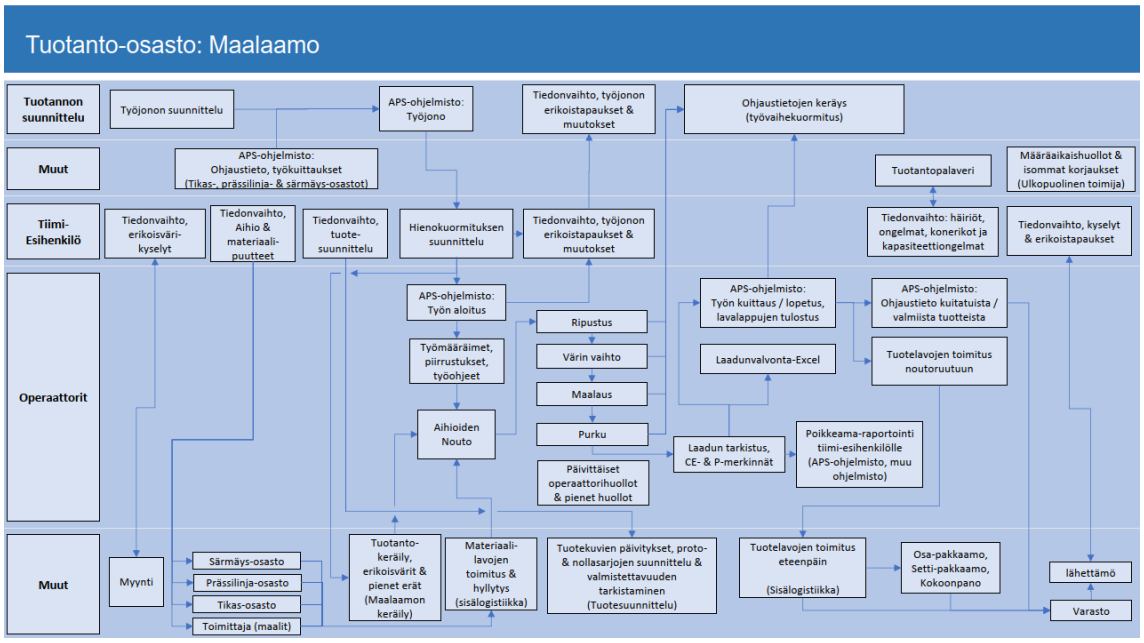

Figure 18. Process map, powder painting department.

5 Discussion

As detailed in chapter 4, the production processes related to the production of the case company's roof safety product group were mapped using simple swim lane diagramming methodology.

The prepared swim-lane process maps can serve as a basis for the case company for more extensive and detailed process modeling work in the future. The prepared simple swim-lane diagrams could be used as a basis for developing a more in-depth process models according to for example Business Process Modeling and Notation methodology, or Value Stream Mapping, incorporating deeper level of details into the process maps, such as decision points, setup times, cycle times, machinery up times, working times, and activities, events and gateways, and incorporating standardized symbol sets into the process models, as outlined by Krajewski et al. (2012) and the Association of Business Process Management Professionals (2013). The process maps can also serve as basis for the case company, to map the case company's other product groups, outside of the roof security product family, which was mapped in this study. The prepared process maps can also be used as a basis to identify areas for improvement, to develop similar process maps for possible future processes detailing the proposed improvements, and enables the company to more effectively pursue or implement further Lean Manufacturing practices, the Theory of Constraints, or Business Process Management principles, as these theoretical frameworks often relies on mapping the production processes as a prerequisite step.

Process mapping will also help the case company in formalizing their processes, and to improve process transparency. The process maps are helpful in training workers. Particularly the swim-lane diagramming style will help workers more easily identify their areas of responsibility, and where their responsibilities transfer over to others, while also introducing them to process-based thinking, and building understanding for how their role impacts and relates to the bigger picture, i.e. the individual department, the other production departments, and the overall production plant. This increased process

understanding can help reduce unwanted suboptimization within individual departments that can cause unnecessary delays, idle-time and unnecessary time spent on problem solving in other departments, reducing the overall efficiency of the factory.

Better process understanding can also help facilitate more effective teamworking, communication and collaboration between management and workers, and can clarify roles, responsibilities and expectations, increase employee satisfaction and morale, and can help reduce change resistance related to process improvement efforts, which may often stem from fear of the unknown and the lack of understanding behind the motivations for why the proposed changes are needed, as explained by authors, such as Fernandes dos Santos & Aires (2023), Prosci (n.d.), and Pereira et al. (2019).

6 Conclusions

The goal of this thesis was to analyze and map the current state of the production processes at the case company. The research questions and objectives guiding the thesis work were as follows:

Research questions:

1. What are the key steps, inputs and outputs in the Case Company's production processes for their roof safety products?
2. What are the key information flows between production process phases in the Case Company's production processes for their roof safety products?

Research objectives:

1. To document the production process of the Case Company's roof safety products, using swim-lane diagramming methodology.
2. To create descriptions detailing the main steps, inputs, outputs and key information flows between the different stages of the production process.

The research questions were formulated into comprehensive interview question lists (appendix 1) to collect data from the production departments and the production planning department at the case company. With the interviews, key process steps, raw material inputs and departmental outputs were identified, and mapped using swim lane methodology. Key information flows were identified and included in the prepared swim lane diagrams, with the most important being the APS-work log entries, guiding the inventory control process, and enabling the start of work orders according to the production plans for the subsequent departments.

The case company's roof safety production processes were successfully mapped using swim-lane diagramming methodology (see appendix 2 for process maps), and descriptions for the production departments were written to supplement the process maps, detailing the responsibilities of team leaders and operators as defined in the swim lane

diagrams, as well as describing the process steps on a general level. The process descriptions were excluded from the appendixes of this report. Thus, research questions were answered, and the research objectives were achieved.

The process mapping work closely followed the principles outlined in the BPM theory. While the work for the case company focused on simplified mapping of processes, avoiding in-depth process details, the produced maps can serve as basis for the case company for more extensive process modeling in the future. This would help the company align its practices even more closely with the BPM theory, further expanding the case company's process management capabilities. In conclusion, the literature clearly demonstrates the potential of process mapping work for enabling operational improvement efforts, confirming the importance of the work for the case company.

As a case study, the results of this thesis are limited and applicable only to the case company, and thus the results cannot be generalized to other manufacturing companies in the metal industry. Nevertheless, the process mapping methodology is replicable in other companies as well, and it is highly recommended for companies with unmapped processes to pursue business process mapping and modeling efforts to further improve their operational performance.

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Appendices

Appendix 1. Interview Questions for Production Departments (Finnish)

Työvirta ja työvaiheet:

Kysymys:
Voitko kuvata osastosi tuotantoprosessiin liittyvät valmistusvaiheet/työvaiheet, järjestyksessä?
Minkälaisia koneita osastosi työvaiheisiin liittyy?
Minkälaisia työkaluja, järjestelmiä tai ohjelmistoja osastosi työvaiheisiin liittyy?
Mikä käynnistää työn (käsky tai järjestelmä), ja milloin katsot työn olevan valmis?
Onko osastosi valmistusprosessin eri vaiheiden aikana yhteydessä muihin osastoihin? Missä vaiheissa ja millä tavoin?
Onko tuotantoprosessissa mielestäsi epävirallisia tai ei-dokumentoituja vaiheita?
Onko osastolla mielestäsi turhia tai ylimääräisiä työvaiheita tai koneita?
Minkälainen on osastosi tiimirakenne? Kuvaile rooleja, ja rooliin liittyviä vastuita.

Prosessisyötteet ja tuotokset:

Kysymys:
Minkälaisia syötteitä (raaka-aineet ja materiaalit, informaatio, ohjeet jne.) osasto tarvitsee edeltäviltä osastoilta, ja kuinka niitä käytetään?
Minkälaisia raaka-aineita, materiaaleja, ohjeita tai hyväksyntäprosesseja vaaditaan, ennen kuin työ voidaan aloittaa?
Minkälaisia tuotoksia (tuotteet, puolivalmisteet, dokumentaatio, informaatio jne.) osastosi valmistaa, ja minne ne menevät seuraavaksi?

Minkälaiset virheet, haasteet tai puuttuvat syötteet vaikuttavat työn edistymiseen tai estävät työn edistymisen?
Onko osastosi valmistusprosessiin liittyen tyypillisiä virheitä tai väärinkäsityksiä, jotka aiheuttavat samanlaisia ongelmia säännöllisesti?

Informaatiovirta:

Kysymys:
Mitä informaatiota täytyy siirtyä osastollesi muilta osastoilta, jotta osaston työ voi edetä tehokkaasti?
Kuinka informaatio siirretään osastollesi (dokumenttien avulla, ohjelmistoilla, suullisesti, jne.)?
Onko osastosi kohdannut viivästyksiä tai muuta sekaannusta puuttuvan tai puutteellisen informaation tai ohjeistuksen takia?
Jos voisit parantaa kommunikaatiota osastojen välillä, mitä muuttaisit?

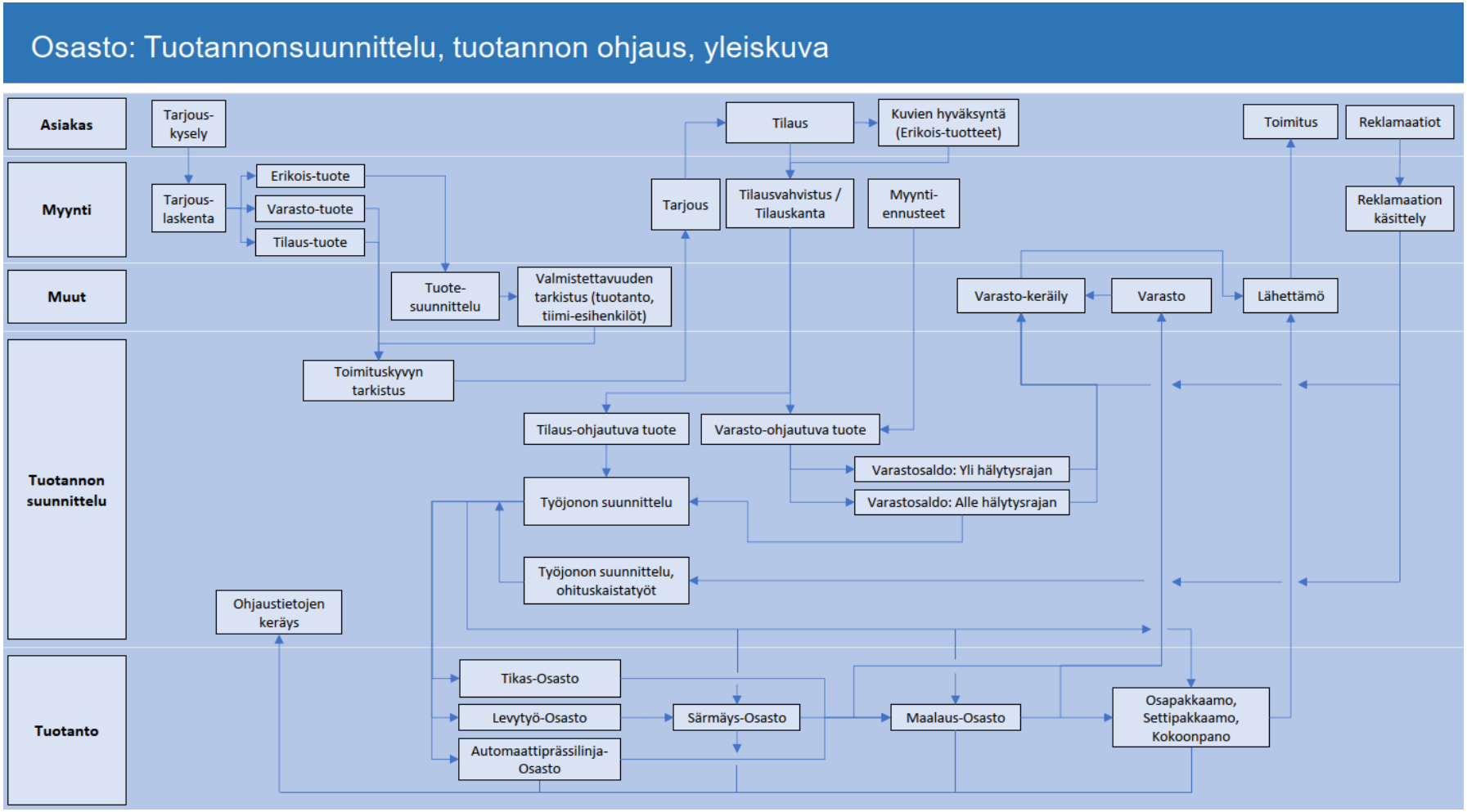
Epätehokkuudet:

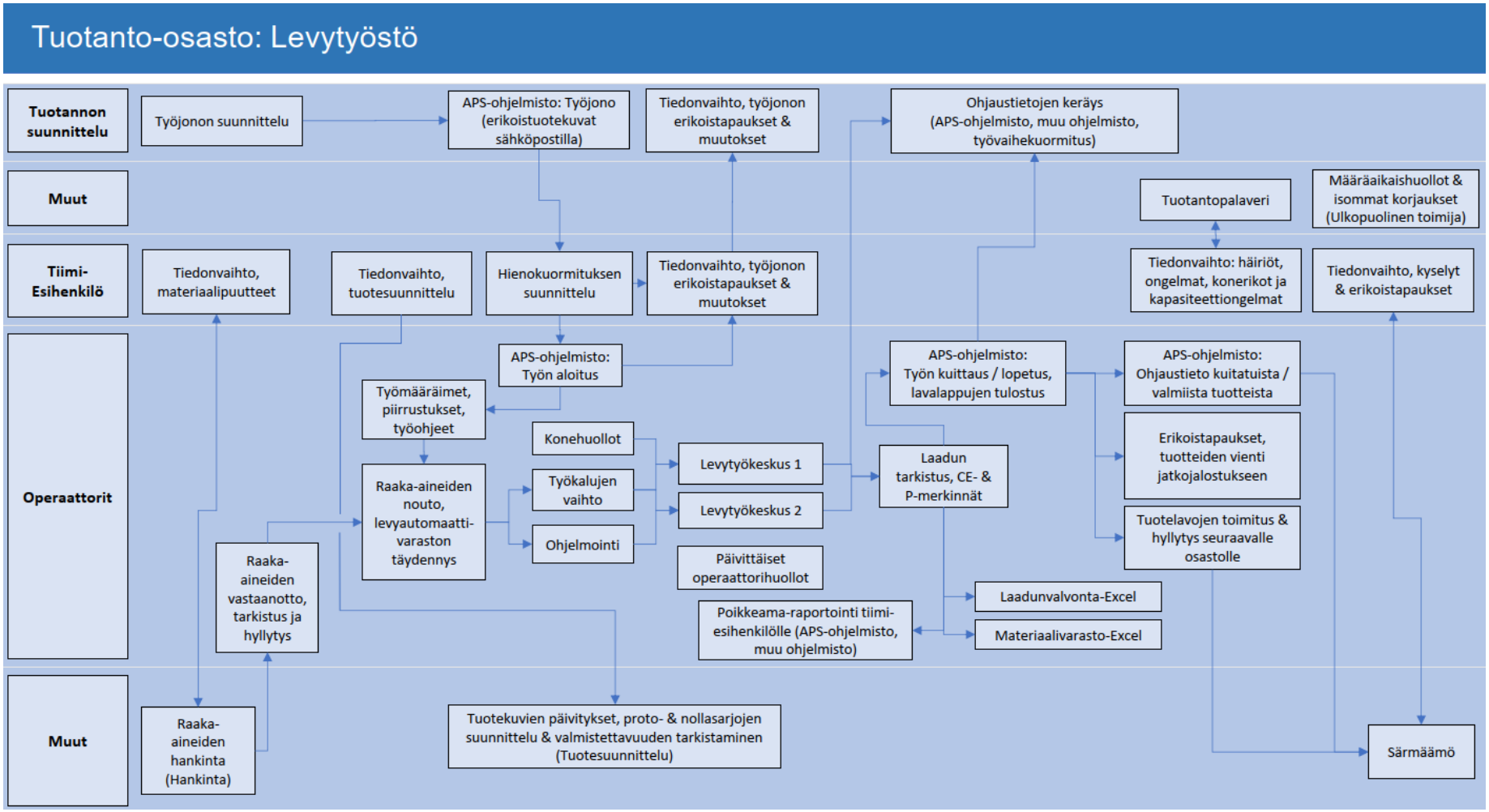
Kysymys:
Mitkä asiat estävät osastosi työn onnistumisen? Mitkä ovat suurimmat kipukohdat?
Mistä esteet tai kipukohdat mielestäsi johtuvat tai mihin ne liittyvät (informaatio, työkalut, koneet, järjestelmät, ym.)?
Minkälaisia haasteita tai epätehokkuuksia kohtaat säännöllisesti osastosi/prosessin päivittäisessä toiminnassa?
Onko osastosi tuotantoprosessissa jokin tietty vaihe, joka hidastaa tuotantoa, toimii pullonkaulana, tai joka vaatii ylimääräistä työtä?
Jos voisit tehostaa yhtä osastosi tuotantoprosessin vaihetta, niin mikä se olisi?

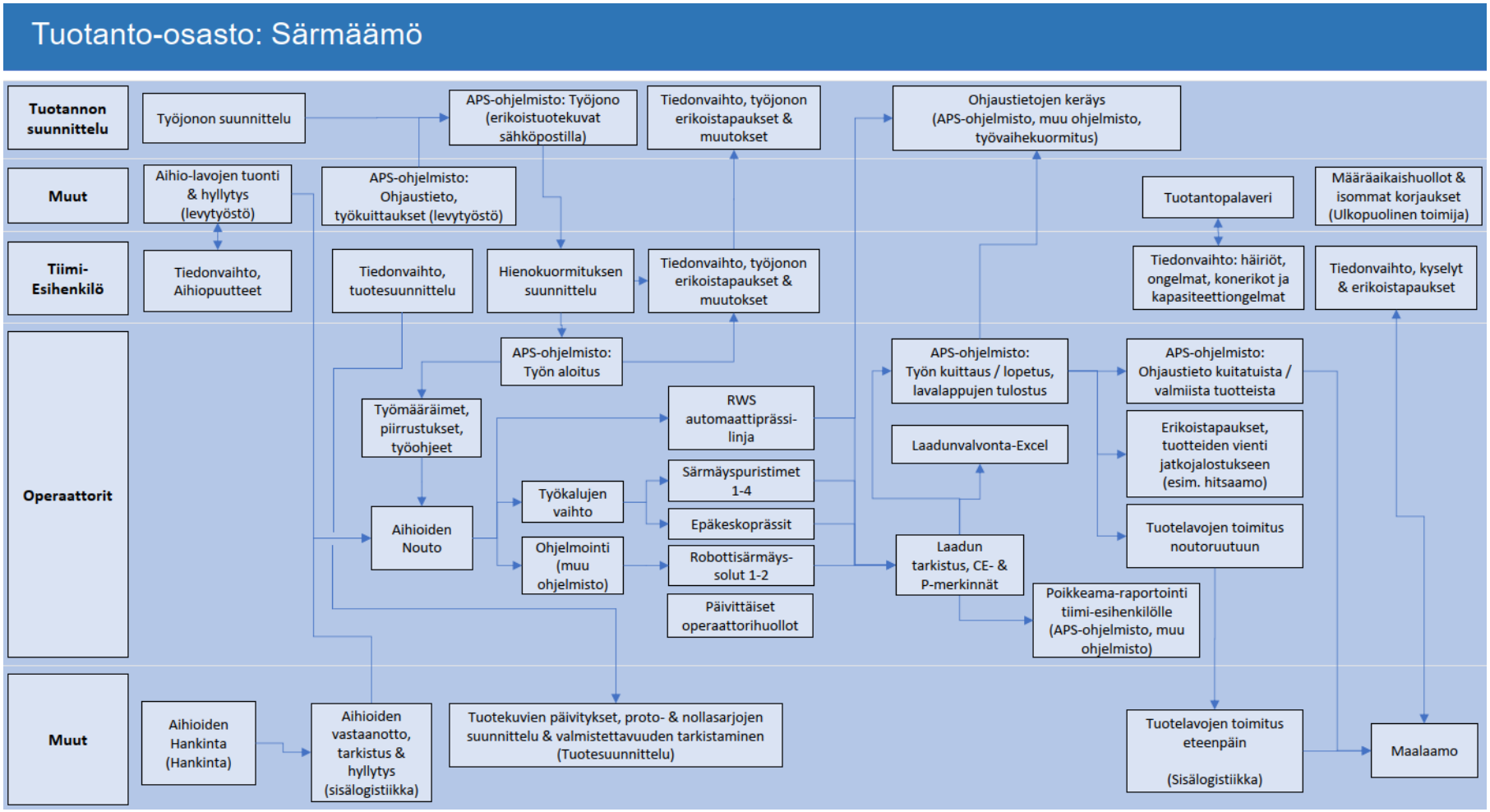
Yleiset:

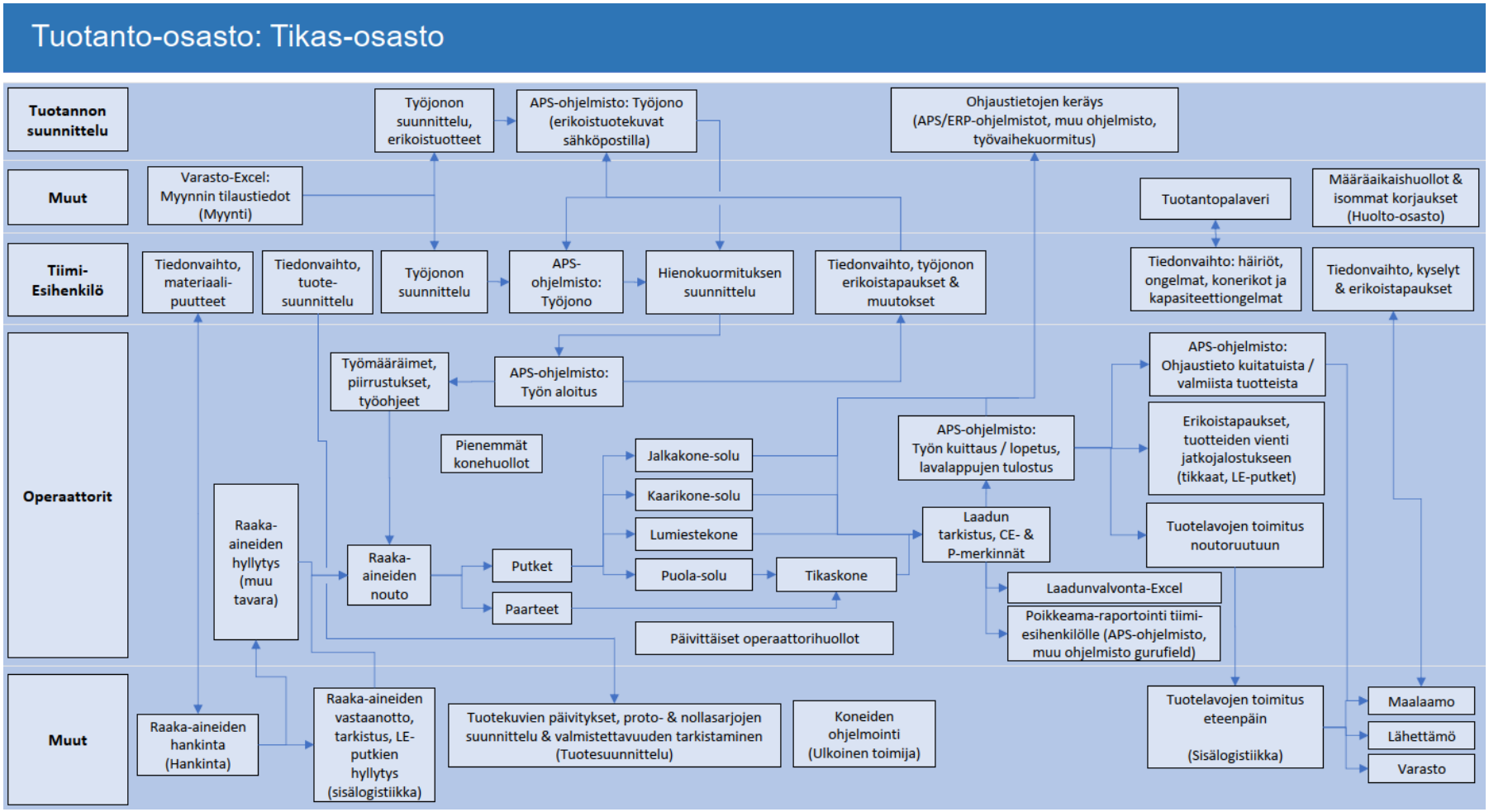
Kysymys:
Minkälaisilla suorituskykymittareilla (KPI) osaston toimintaa mitataan?
Onko osastolla mielestäsi riittävät resurssit ja tarvittava informaatio, jotta osasto voisi toimia mahdollisimman tehokkaasti?
Miten osastolla voidaan varmistaa, että tuotantosuunnitelma toteutuu ja että valmistumispäivämäärissä pysytään?
Mitkä on suurimmat tuotantosuunnitelman toteuttamiseen liittyvät haasteet?
Mitkä on suurimmat kriittisten päivämäärien (valmistuspäivämäärien) täyttämiseen liittyvät haasteet?
Mitkä on suurimmat osaston hienokuormitukseen liittyvät haasteet?
Mitä seuraava osasto tarvitsee tältä osastolta, onnistuakseen heidän työssään?
Millä tavoin osasto voi varmistaa tai tukea työn onnistumista seuraavalla osastolla?
Mitkä ovat yleisimmät haasteet, jotka ovat voineet hankaloittaa työtä tai aiheuttaa viiveitä seuraavalla osastolla, ja millä tavoin niitä voidaan ratkaista tai minimoida?

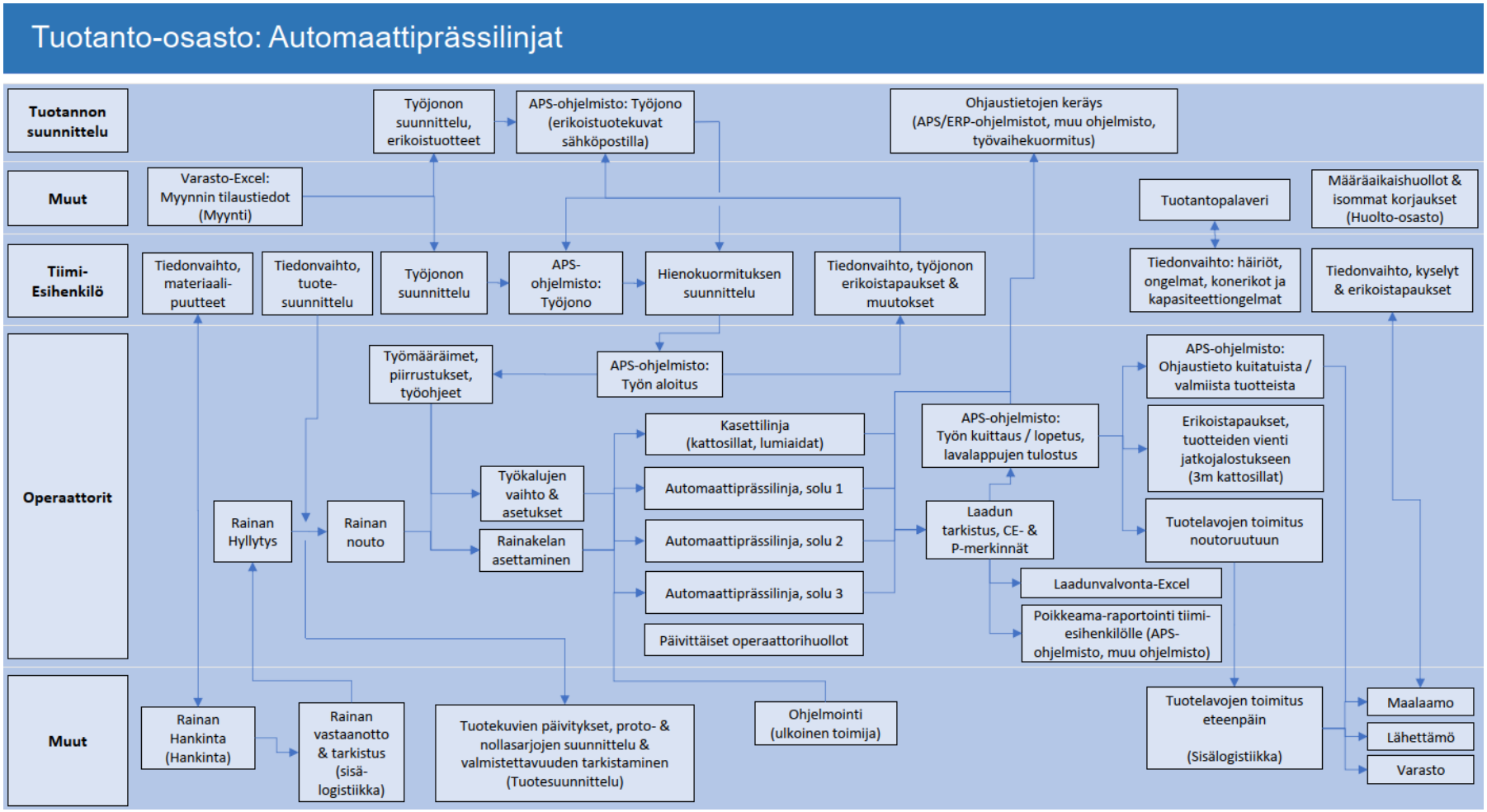
Appendix 2. Process Maps (Finnish)

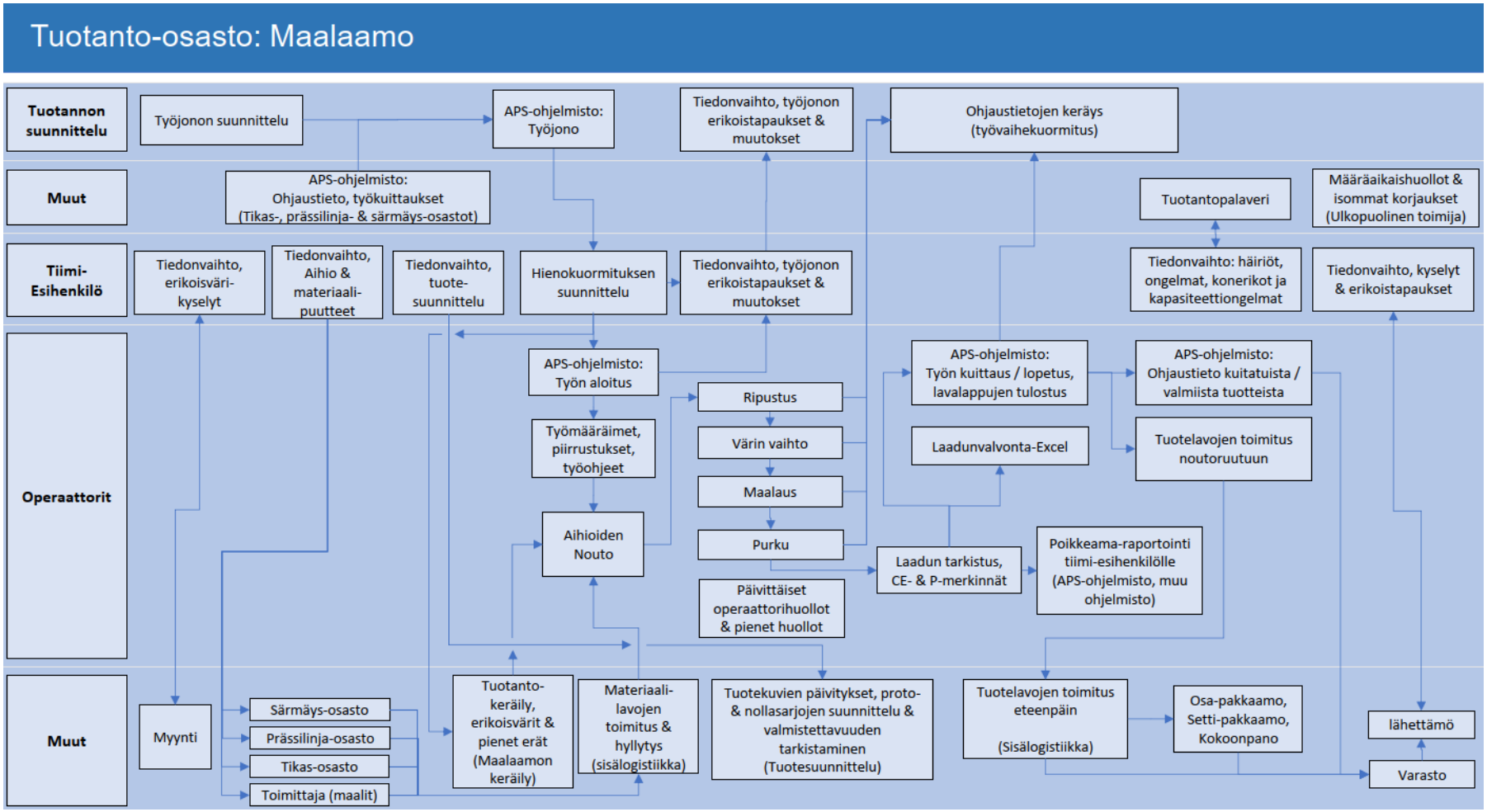



Tuotanto-osasto: Levytyöstö
Tuotannon suunnittelu
Muut
Tiimi-Esihenkilö
Operaattorit
Muut
Työjonon suunnittelu
APS-ohjelmisto: Työjono (erikoistuotekuvat sähköpostilla)
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Ohjaustietojen keräys (APS-ohjelmisto, muu ohjelmisto, työvaihekuormitus)
Tuotantopalaveri
Määräaikaishuollot & isommat korjaukset (Ulkopuolinen toimija)
Tiedonvaihto, materiaalipuutteet
Tiedonvaihto, tuotesuunnittelu
Hienokuormituksen suunnittelu
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Tiedonvaihto: häiriöt, ongelmat, konerikot ja kapasiteettiongelmat
Tiedonvaihto, kyselyt & erikoistapaukset
APS-ohjelmisto: Työn aloitus
APS-ohjelmisto: Työn kuittaus / lopetus, lavalappujen tulostus
APS-ohjelmisto: Ohjaustieto kuitatuista / valmiista tuotteista
Työmääräimet, piirrustukset, työohjeet
Konehuollot
Levytyökeskus 1
Laadun tarkistus, CE- & P-merkinnät
Erikoistapaukset, tuotteiden vienti jatkojalostukseen
Raaka-aineiden nouto, levyautomaatti-varaston täydennys
Työkalujen vaihto
Levytyökeskus 2
Ohjelmointi
Tuotelavojen toimitus & hyllytys seuraavalle osastolle
Päivittäiset operaattorihuollot
Raaka-aineiden vastaanotto, tarkistus ja hyllytys
Laadunvalvonta-Excel
Poikkeama-raportointi tiimi-esihenkilölle (APS-ohjelmisto, muu ohjelmisto)
Materiaalivarasto-Excel
Raaka-aineiden hankinta (Hankinta)
Tuotekuvien päivitykset, proto- & nollasarjojen suunnittelu & valmistettavuuden tarkistaminen (Tuotesuunnittelu)
Särmäämö


Tuotanto-osasto: Särmäämö
Tuotannon suunnittelu
Muut
Tiimi-Esihenkilö
Operaattorit
Muut
Työjonon suunnittelu
APS-ohjelmisto: Työjono (erikoistuotekuvat sähköpostilla)
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Ohjaustietojen keräys (APS-ohjelmisto, muu ohjelmisto, työvaihekuormitus)
Aihio-lavojen tuonti & hyllytys (levytyöstö)
APS-ohjelmisto: Ohjaustieto, työkuittaukset (levytyöstö)
Tuotantopalaveri
Määräaikaishuollot & isommat korjaukset (Ulkopuolinen toimija)
Tiedonvaihto, Aihiopuutteet
Tiedonvaihto, tuotesuunnittelu
Hienokuormituksen suunnittelu
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Tiedonvaihto: häiriöt, ongelmat, konerikot ja kapasiteettiongelmat
Tiedonvaihto, kyselyt & erikoistapaukset
APS-ohjelmisto: Työn aloitus
APS-ohjelmisto: Työn kuittaus / lopetus, lavalappujen tulostus
APS-ohjelmisto: Ohjaustieto kuitatuista / valmiista tuotteista
Työmääräimet, piirrustukset, työohjeet
RWS automaattiprässi-linja
Laadunvalvonta-Excel
Erikoistapaukset, tuotteiden vienti jatkojalostukseen (esim. hitsaamo)
Työkalujen vaihto
Särmäyspuristimet 1-4
Aihioiden Nouto
Epäkeskoprässit
Tuotelavojen toimitus noutoruutuun
Ohjelmointi (muu ohjelmisto)
Robottisärmäys-solut 1-2
Laadun tarkistus, CE- & P-merkinnät
Päivittäiset operaattorihuollot
Poikkeama-raportointi tiimi-esihenkilölle (APS-ohjelmisto, muu ohjelmisto)
Aihioiden Hankinta (Hankinta)
Aihioiden vastaanotto, tarkistus & hyllytys (sisälogistiikka)
Tuotekuvien päivitykset, proto- & nollasarjojen suunnittelu & valmistettavuuden tarkistaminen (Tuotesuunnittelu)
Tuotelavojen toimitus eteenpäin (Sisälogistiikka)
Maalaamo


Tuotanto-osasto: Tikas-osasto
Tuotannon suunnittelu
Muut
Tiimi-Esihenkilö
Operaattorit
Muut
Työjonon suunnittelu, erikoistuotteet
APS-ohjelmisto: Työjono (erikoistuotekuvat sähköpostilla)
Ohjaustietojen keräys (APS/ERP-ohjelmistot, muu ohjelmisto, työvaihekuormitus)
Varasto-Excel: Myynnin tilaustiedot (Myynti)
Tuotantopalaveri
Määräaikaishuollot & isommat korjaukset (Huolto-osasto)
Tiedonvaihto, materiaali-puutteet
Tiedonvaihto, tuote-suunnittelu
Työjonon suunnittelu
APS-ohjelmisto: Työjono
Hienokuormituksen suunnittelu
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Tiedonvaihto: häiriöt, ongelmat, konerikot ja kapasiteettiongelmat
Tiedonvaihto, kyselyt & erikoistapaukset
Työmääräimet, piirrustukset, työohjeet
APS-ohjelmisto: Työn aloitus
APS-ohjelmisto: Ohjaustieto kuitatuista / valmiista tuotteista
Pienemmät konehuollot
Jalkakone-solu
Kaarikone-solu
Lumiestekone
Puola-solu
Tikaskone
APS-ohjelmisto: Työn kuittaus / lopetus, lavalappujen tulostus
Erikoistapaukset, tuotteiden vienti jatkojalostukseen (tikkaat, LE-putket)
Raaka-aineiden hyllytys (muu tavara)
Raaka-aineiden nouto
Putket
Paarteet
Laadun tarkistus, CE- & P-merkinnät
Tuotelavojen toimitus noutoruutuun
Laadunvalvonta-Excel
Poikkeama-raportointi tiimi-esihenkilölle (APS-ohjelmisto, muu ohjelmisto gurufield)
Päivittäiset operaattorihuollot
Raaka-aineiden hankinta (Hankinta)
Raaka-aineiden vastaanotto, tarkistus, LE-putkien hyllytys (sisälogistiikka)
Tuotekuvien päivitykset, proto- & nollasarjojen suunnittelu & valmistettavuuden tarkistaminen (Tuotesuunnittelu)
Koneiden ohjelmointi (Ulkoinen toimija)
Tuotelavojen toimitus eteenpäin (Sisälogistiikka)
Maalaamo
Lähettämö
Varasto


Tuotanto-osasto: Automaattiprässilinjat
Tuotannon suunnittelu
Muut
Tiimi-Esihenkilö
Operaattorit
Muut
Työjonon suunnittelu, erikoistuotteet
APS-ohjelmisto: Työjono (erikoistuotekuvat sähköpostilla)
Ohjaustietojen keräys (APS/ERP-ohjelmistot, muu ohjelmisto, työvaihekuormitus)
Varasto-Excel: Myynnin tilaustiedot (Myynti)
Tuotantopalaveri
Määräaikaishuollot & isommat korjaukset (Huolto-osasto)
Tiedonvaihto, materiaali-puutteet
Tiedonvaihto, tuote-suunnittelu
Työjonon suunnittelu
APS-ohjelmisto: Työjono
Hienokuormituksen suunnittelu
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Tiedonvaihto: häiriöt, ongelmat, konerikot ja kapasiteettiongelmat
Tiedonvaihto, kyselyt & erikoistapaukset
Työmääräimet, piirrustukset, työohjeet
APS-ohjelmisto: Työn aloitus
APS-ohjelmisto: Ohjaustieto kuitatuista / valmiista tuotteista
Kasettilinja (kattosillat, lumiaidat)
APS-ohjelmisto: Työn kuittaus / lopetus, lavalappujen tulostus
Erikoistapaukset, tuotteiden vienti jatkojalostukseen (3m kattosillat)
Työkalujen vaihto & asetukset
Automaattiprässilinja, solu 1
Rainan Hyllytys
Rainan nouto
Rainakelan asettaminen
Automaattiprässilinja, solu 2
Laadun tarkistus, CE- & P-merkinnät
Tuotelavojen toimitus noutoruutuun
Automaattiprässilinja, solu 3
Laadunvalvonta-Excel
Päivittäiset operaattorihuollot
Poikkeama-raportointi tiimi-esihenkilölle (APS-ohjelmisto, muu ohjelmisto)
Rainan Hankinta (Hankinta)
Rainan vastaanotto & tarkistus (sisä-logistiikka)
Tuotekuvien päivitykset, proto- & nollasarjojen suunnittelu & valmistettavuuden tarkistaminen (Tuotesuunnittelu)
Ohjelmointi (ulkoinen toimija)
Tuotelavojen toimitus eteenpäin (Sisälogistiikka)
Maalaamo
Lähettämö
Varasto


Tuotanto-osasto: Maalaamo
Tuotannon suunnittelu
Muut
Tiimi-Esihenkilö
Operaattorit
Muut
Työjonon suunnittelu
APS-ohjelmisto: Työjono
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Ohjaustietojen keräys (työvaihekuormitus)
APS-ohjelmisto: Ohjaustieto, työkuittaukset (Tikas-, prässilinja- & särmäys-osastot)
Tuotantopalaveri
Määräaikaishuollot & isommat korjaukset (Ulkopuolinen toimija)
Tiedonvaihto, erikoisväri-kyselyt
Tiedonvaihto, Aihio & materiaali-puutteet
Tiedonvaihto, tuote-suunnittelu
Hienokuormituksen suunnittelu
Tiedonvaihto, työjonon erikoistapaukset & muutokset
Tiedonvaihto: häiriöt, ongelmat, konerikot ja kapasiteettiongelmat
Tiedonvaihto, kyselyt & erikoistapaukset
APS-ohjelmisto: Työn aloitus
APS-ohjelmisto: Työn kuittaus / lopetus, lavalappujen tulostus
APS-ohjelmisto: Ohjaustieto kuitatuista / valmiista tuotteista
Ripustus
Työmääräimet, piirrustukset, työohjeet
Värin vaihto
Laadunvalvonta-Excel
Tuotelavojen toimitus noutoruutuun
Maalaus
Aihioiden Nouto
Purku
Laadun tarkistus, CE- & P-merkinnät
Poikkeama-raportointi tiimi-esihenkilölle (APS-ohjelmisto, muu ohjelmisto)
Päivittäiset operaattorihuollot & pienet huollot
Myynti
Särmäys-osasto
Prässilinja-osasto
Tikas-osasto
Toimittaja (maalit)
Tuotanto-keräily, erikoisvärit & pienet erät (Maalaamon keräily)
Materiaali-lavojen toimitus & hyllytys (sisälogistiikka)
Tuotekuvien päivitykset, proto- & nollasarjojen suunnittelu & valmistettavuuden tarkistaminen (Tuotesuunnittelu)
Tuotelavojen toimitus eteenpäin (Sisälogistiikka)
Osa-pakkaamo, Setti-pakkaamo, Kokoonpano
lähettämö
Varasto