OULUN AMMATTIKORKEAKOULU

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Improvement of Enclosure Supply Chain

Telecommunications

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Esimerkkiyrityksessä tuotteen valmistukseen liittyvää toimitusketjua ja niihin liittyviä prosesseja hallitaan maailmanlaajuisesti. Alihankintatehtaat ja materiaalien valmistajat sijaitsevat globaalisti eri maissa. Toimitusketjun hallintaan liittyvät prosessit ja käytännöt eroavat jonkin verran toisistaan, riippuen esimerkkiyhtiön tuotteesta ja niiden monimutkaisuudesta. Tietyn kategorian osalta toimitusketjun hallintaprosessi ei ole ollut täysin toimiva ja sen eri osa-alueita on jouduttu aika-ajoin selventämään. Prosessien ja käytäntöjen selkiyttämistä kaivattiin, jotta olisi helpompi ja nopeampi toimia sekä saada tukea oikeilta organisaatioilta ja vastuuhenkilöiltä silloin, kun toimitusketjun hallinnassa on tarpeita. Käytäntöjä olisi jatkossakin helpompi vakiinnuttaa selkeällä prosessikuvauksella, toimintamallilla ja vastuumatriisilla.

Tämä opinnäytetyö hahmottaa toimintamallin ja toimitusketjun haasteet tukiasemakabinettien valmistuksen osalta. Tässä opinnäytetyössä tarkastellaan sisäisten prosessien ja toimitusketjun suunnittelun eroja valmistuksen alihankinnan ja sisäisten sidosryhmien yhteistyön kautta. Työssä keskitytään kehitysalueisiin, joihin voidaan vaikuttaa analysoitujen tietojen perusteella. Tuloksena on selkeytetty prosessi ja toimintamalli, joka auttaa toimitusketjun tehokkaammassa suunnittelussa ja hallinnassa myös tulevaisuudessa.

Tämän tutkimuksen tiedot kerättiin eri lähteistä kyselylomakkeilla ja useiden haastatteluiden kautta, jotka kerättiin eri alihankkijoilta ja esimerkkiyrityksen sisäisiltä sidosryhmiltä. Opinnäytetyö tehtiin laadullisena tutkimuksena. Teoreettisessa kehyksessä analysoitiin toimitusketjun suunnittelua, päätöksentekoa, riskienhallintaa ja ennusteiden suunnittelua.

Toimitusketjun hallinnan kehittämisessä täytyy analysoida kaikkia osatekijöitä, jotta kokonaisuuteen voidaan vaikuttaa. Myös riskit, niiden proaktiivinen analysointi ja siten ennaltaehkäisy on erittäin tärkeää, jotta toimitusketjun luotettavuuteen saadaan vakautta.

Asiasanat: Supply Chain, Material Planning, Forecasting

ABSTRACT

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In the case company, the supply chain and the processes are managed globally. The subcontractors and material manufacturers located globally in a different country. The process and practicalities related to supply chain management differ from each, depending on the product and those complexity. For a certain category, the supply chain management process has not work fluently and its various aspects have had to be clarified from time to time. Clarification of processes and practicalities was needed to make it easier and faster to get information from accountable organizations and individual contributors when there is a need for supply chain management. It would be easier to establish practices with a clear process description, operating model and responsibility matrix for the future needs.

This thesis outlines the challenges of the operating model and supply chain for base station cabinets manufacturing. This thesis examines the internal process and differences in the supply chain planning through manufacturing subcontracting and collaboration with internal stakeholders. The work focuses on areas of development that can obtain data from the impact analysed data. The result is a clarified process and operating model that will help in more efficient supply chain planning and management also in the future.

Data for this study were collected from various sources through questionnaires and through several collected interviews from various subcontractors and internal stakeholders of the case company. The thesis was done as a qualitative research. The theoretical framework analysed supply chain planning, decision making, risk management and forecasting.

In a development of supply chain management, it is necessary to analyse all the influencing factors, that the wholeness can be improved. By proactive analysing it is possible to mitigate risks and ensure the supply chain reliability.

Keywords: Supply Chain, Material Planning, Forecasting

CONTENTS

ACRONYMS

CM	Category Management
CPFR	Collaborative Planning, Forecasting and Replenishment
CT	Customer Team
DDMRP	Demand Driven Material Requirements Planning
MRP	Material Requirements Planning
OTDr	On Time Delivery Rate
SCM	Supplier Collaboration Management
S&OP	Sales and Operations Planning
SPI	Supplier Performance Index
VAT	Value Added Tax
VMI	Vendor Managed Inventory

1 INTRODUCTION

In the telecommunication industry sector, where the case company have their main business, manufacturing of products, and supply chains are globally located. The products' complexity and equipment level vary, but the rising trend is that the products may contain several integrated elements or equipment. This kind of products can create challenges in a manufacturing and supply chain if planning and processes are not fully optimized.

Lead times for different equipment and component can be very long, whereas manufacturing subcontractors plan their volume production and materials according their end customer forecast. In the other hand, when engineering teams develop new products into the market, the production ramp up and materials availability must be secured. Forecast may change occasionally and cause availability risks in a long lead time materials and components. When changes happen, in some cases it will complicate materials supply chain management, lead to shortages, adding more cost and impacting to delivery accuracy to the final customer. Usually in such case materials do not have a proper process for the risk mitigation plan, alternative material or manufacturing sources and a buffering plan available. The timely communication and information sharing between customer, manufacturing and supply chain must be seamless in order to support smooth and cost-effective manufacturing.

1.1 Objective and purpose of thesis

The purpose of this study is to find development ideas that can improve the planning of subcontractors manufacturing as a part of the supply chain process. To react into development needs, this study and methods were designed. Supply chain is an extensive entity hence this study reviews these aspects of the supply chain management: demand planning, forecasting, and purchasing. These areas are strongly interlinked to each other and therefore are needed to evaluate together for the manufacturing planning improvement.

This thesis aims to respond to the research questions:

1. *What are the challenges in the manufacturing planning from a Subcontractor's perspective?*
2. *What kind of development areas we can recognize in the case company's internal functions related to a Subcontractors manufacturing planning?*

Through practise and daily business relationship we basically are knowledgeable of these challenges but have not evaluated from the various manufacturing subcontractor's perspective. By analyzing this more in details, we get knowledge also about the possible differences between each manufacturing subcontractors and better understanding what is causing those differences. Additionally, the case company process description has been scattered and responsibilities not summarized according functions.

To identify development ideas through the real case it requires deeper analyses from a subcontractors and the case company's internal functions which currently support those three focus areas. Analyzing development ideas through different perspectives, helps to outline the overall picture and to formulate the final outcome proposal. This development method can be utilized as a continuous improvement plan in a global supply chain and in a changing environment.

1.2 Research method

When the topic of the thesis was discussed, it was clear at the outset that the study could draw on previous experience, conduct extensive surveys and interviews with the manufacturing subcontractors and internal stakeholders, related to the case company supply chain management. By having benchmarking interview with different supply chain category in the case company, it was possible to observe new insights. Yin (2011) describes the qualitative research strives to collect, integrate, and present data from a variety of sources of evidence as part of any given study. Data collection was fluent via surveys and interviews. Yin (2011) defines potential data collection activities are interviewing, observing, collecting, and examining and feeling. The research scope was limited to the specific product category and the supply chain, enabling extensive and global subcontractors network involvement, as a case study. Yin (2011) Case study studies a phenomenon (the "case") in its real-world context.

1.3 Research design

Yin (2011) describes, the research designs are logical blueprints. The designs serve as "logical" plans, not the "logistics" plans often referenced by others. The logic involves the links among the research questions, the data to be collected, and the strategies for analysing data so that study's findings will address the intended the research questions.

This research consists of five elements. The first element is the purpose, which formulates the need for the research. The second element is the current state, analysed by surveys and interviews. The third element is the benchmarking comparison process to identify differences in the case company internal function. The fourth element is the evaluation of improvements and process definition, reflecting the research findings and starting point. The fifth element is the validation and implementation of the new process, and the conclusions of the results.

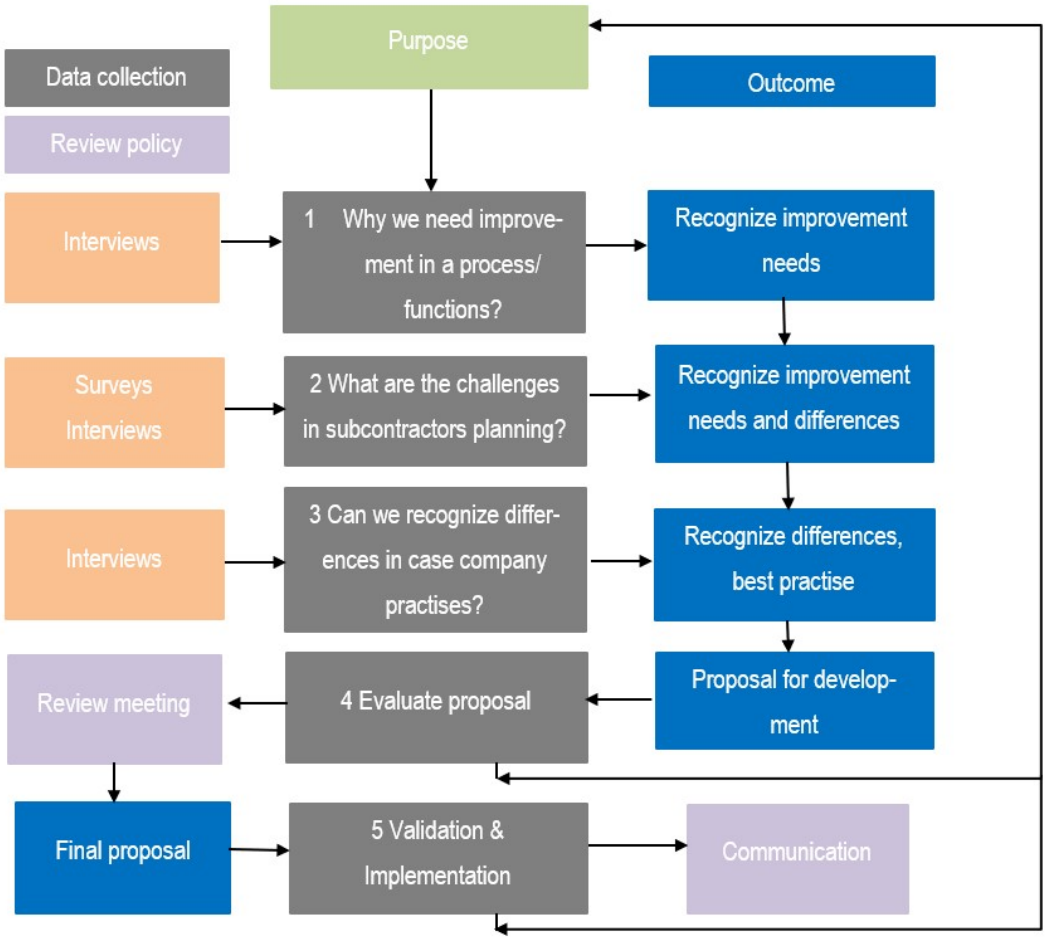

FIGURE 1. Research design

2 SUPPLY CHAIN

Shapiro (2007, 5) defines fundamentals of the supply chain. The company's supply chain contains geographically dispersed factories where the raw materials, intermediate products, or finished products are acquired, transformed, stored, or sold. Transportation links connects factories, along which products flow. The company's goal is to add value to its products as they pass through its supply chain and transport them to geographically dispersed markets in the correct quantities, time, and competitive cost.

Supply chain network does not generally operate at a steady state. It will face continuous challenges. Usually, product demands vary with time as a result of fluctuations in consumption patterns and product life cycles. For this reason, companies are forced to predict demand variation and to be prepared to face possible increases or decreases (Georgiadisa, Tsiakis, Pantelis & Sofioglou, 2011). Companies and countries struggle to cope with the pandemic (Covid-19), as well as other supply chain disruptions such as Brexit and the grounding of the Ever Given in the Suez Canal, reminding also of the constant challenges to our supply chains (Breen, Hannibal, 2021).

Agility of the supply chain is critical because in a most industries, both demand and supply fluctuate more rapidly and widely than they used to. Most of the supply chains cope by playing speed against costs, but agile ones respond both quickly and cost-efficiently. Agility has become more critical in the past few years because sudden changes to the supply chains have become more frequent (Lee H. 2004).

Lee (2004) has six main points, how agility can be built into supply chains:

- provide information on changes in a supply and demand,
- develop collaborative relationships with the suppliers,
- design products with the harmonized materials and key processes,
- keep buffers of key / bottleneck components,
- build a dependable logistics system, and
- keep a team who can manage risk and mitigate those.

In the telecommunications industry, product manufacturing and supply chains are global and located in different countries. Materials and components are purchased from the various suppliers worldwide. Lead times for different type of materials and components can be very long, depending on different reasons. Long lead time items may create challenges in a manufacturing subcontractor planning if the supply chain management and planning is not done carefully. Fluctuations in a forecast and demand planning will complicate materials supply chain management and delivery accuracy to the final customer. If all parties in a material chain cannot respond synchronized and agile to the changing situation, it may lead to material shortages, increased delivery costs and other problems. Supply chains are constantly subject to unpredictable events that can adversely influence its ability to achieve performance objectives (Datta & Martin, 2010).

Rushton, Croucher & Baker (2017, 140) have listed key elements involved in the supply chain:

- sourcing
- manufacturing
- distribution network (number, location, and role of warehouses)
- transport modes (road, rail, sea, or air freight)

The implementation of the supply chain requires decision on all these elements. For example, an agile supply chain may require the local manufacturing supplier that can react quickly, a network of local warehouse to hold small buffer stocks to service the immediate needs of the customers and use of road freight, which tends to be relatively fast and flexible. The design of the supply chain requires involvement of various organizations across a company e.g., manufacturing, sourcing, and logistics.

In the other hand products ramp up and ramp down phases shall be planned properly. In the old products, which are in the end of life cycle the supply chain management is essential to manage systematically to avoid excess materials cost. In a new product ramp up demand can fluctuate very suddenly to the high manufacturing quantity's and therefore the supply chain planning, quick reaction, and close follow up is very important. With a growing demand for make-to-order (customized) products, supply can be achieved by agility, with a quick response and economically to such changes in a product demand. (Shapiro 2007, 325)

Jacobs & Chase (2017, 6-7) defines each of the supply chain elements key roles in a complete process. It is important to understand, how many different roles and responsibilities involves typically into the supply chain.

Planning consist of different processes which are needed to an existing supply chain strategically. Major aspect is to define metrics to monitor the supply chain efficiency and quality of delivery and value to customers. Sourcing makes decision of the supplier's selection that will deliver the goods and services. Sourcing organization also agree prices, delivery, and payment terms which are needed for measuring and monitoring of the suppliers as well for possible improvement of the suppliers' performance. Manufacturing requires scheduling different processes, materials co-ordination, insurance of needed equipment's availability. Metrics that measure speed, quality and productivity are used to monitor those processes. Delivery is a logistics process, where carriers deliver products to warehouses and to the customers, co-ordinate and schedule the goods delivery and information through the supply network. The longer the supply chains are, and the more organizations they involve, it will be more difficult coordinate them (Syntetos, Babai, Boylan, Stephan & Konstantinos, 2016, 4).

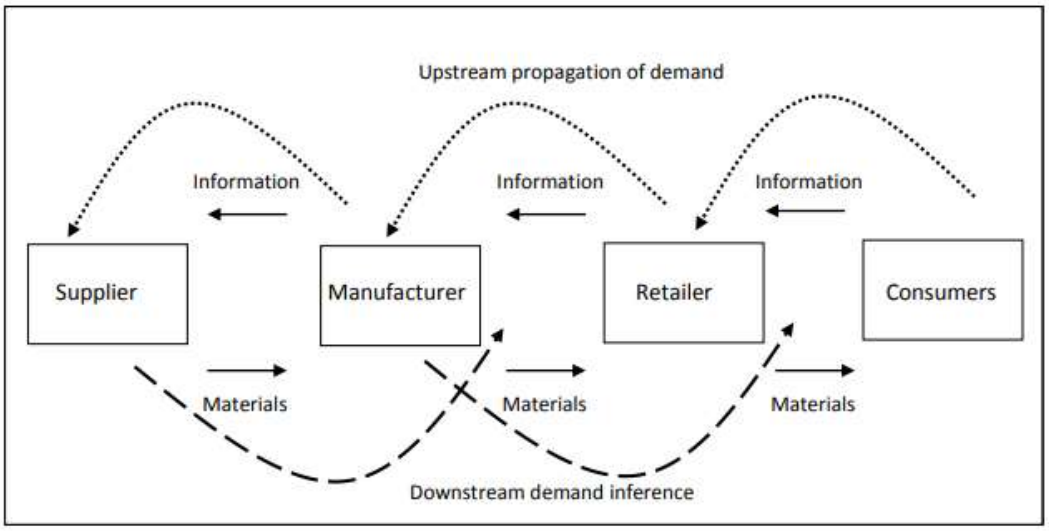

FIGURE 2. Supply chain structure, length. (Syntetos, Babai, Boylan, Stephan & Konstantinos, 2016, 4)

Drake M. (2012, 59-60) defines how the supply management relationships improve further whole supply chain. Supplier development programs implementation helps the suppliers to improve their operations and performance, measurement of the supplier's overall performance in a supply chain can be monitored more detailed. Collaborating with the suppliers and customers brings benefits.

Some of these benefits are reduced inventory and transaction cost, improved forecasting and planning, and higher levels of customer service.

2.1 Demand planning

Christopher (2011, 89-90) Defines that demand planning is the translation of our understanding of what the real requirement of the market is, i.e. to make sure that products can be made available at the right times and place. Many companies today have put in place a formalized approach to demand management and planning that is often referred to as sales and operations planning (S&OP). S&OP ensures that the organization is able to anticipate the real requirement on the market and to react cost-effective way. The aim is to ensure the highest level of customer satisfaction through on-time, in-full deliveries with minimum inventory. The sales and marketing team reviews the latest data, discuss other possible known intelligence, and determines the product forecast into the future (Kerber & Dreckshage 2011, 27).

Products lifecycles creates also challenges in a planning. For example, Christopher (2011, 122) describes that the time to develop new products and to launch those is significantly shorter, nowadays products must be available much faster in a market. Hence, the ability to 'fast track' the product development, manufacturing and logistics becomes a key element of competitive strategy. When product is on the market, the ability to respond quickly to demand is equally important. The lead time to market determines the organization's ability to exploit demand during the life cycle.

When designing a planning system, it is important to agree key principles. What to plan and when, which items to use, what type of forecasting technique to use, how planning process is designed and what tools are needed to use. Different time horizons would also require different level of details for the planning e.g. short-, mid- and long-term planning. Appropriate planning should be based on understanding the market demand pattern and customer needs in general (Collin & Lorenzin, 2004).

Sople V. (2012) have defined three planning cycles as follow:

- Long-term planning decisions have long-term effect and involve investment decisions. Including facility locations and system implementations planning which effects are noticeable over the several years.
- Mid-term planning is done in a scope of the strategic decisions. Determines an outline of regular operations in terms of quantities and time frame. Planning horizon from 6-24 months.
- Short-term planning is for activities at the operation level and focus on the short time planning horizon (a few days to 3 months). It is lowest planning level and requires high level details and accuracy in data and information. Might be limited by the decisions from mid-term planning.

Feigin (2011) has a clear perspective, what the company should produce or procure. Requires taking into a consideration issues about demand uncertainty, supply constraints, production capacity, product profitability, and market share objectives. This decision is the outcome of the consensus- based S&OP process, a process that logically follows the initial demand planning process (Feigin G., 2011, 18).

2.2 Forecasting

Christopher (2011, 124) presents that no matter how sophisticated the forecasting techniques are employed, the volatility of the markets ensures that the forecast will be wrong. Forecast error increases as the lead time increases. The conventional response to such a problem has been to increase the safety stock to provide protection against such forecast errors. For long-term planning, we need a forecast with the correct level of detail to support the executive S&OP process. Detailed forecasts may be fine for short-term horizons, but forecasts are typically very inaccurate in long-term horizons. (Kerber & Dreckshage 2011, 31-32)

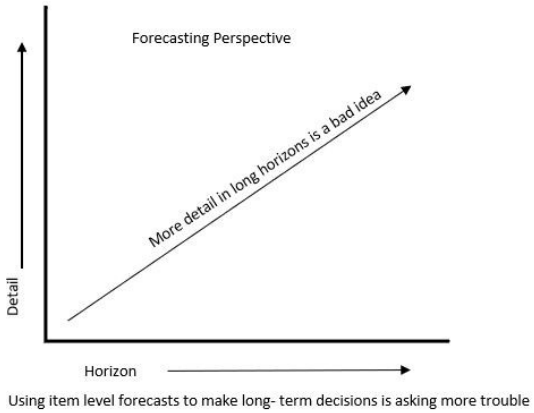

FIGURE 3. Forecast uncertainty (Kerber & Dreckshage 2011, 32)

It is maybe simple to think about the forecast as number of specific customer demand within specific timeframe. However, as (Kerber & Dreckshage 2011, 36) have illustrated in figure 5, forecasting involves much more than simply data and conclusions to future projections. New products forecasting can be more challenging. It may require more background analysis about the product markets, new customers, or existing customers interest whereas existing, stabile product has customer base and more predictable forecasting trend. In the other hand competition in a market e.g. certain material categories may be a global challenge, where multiple customers are seeking same type of material in a same competitive market situation. Competitive situation in a growing market leads to longer lead times and forecasting accuracy is more challenging to adjust.

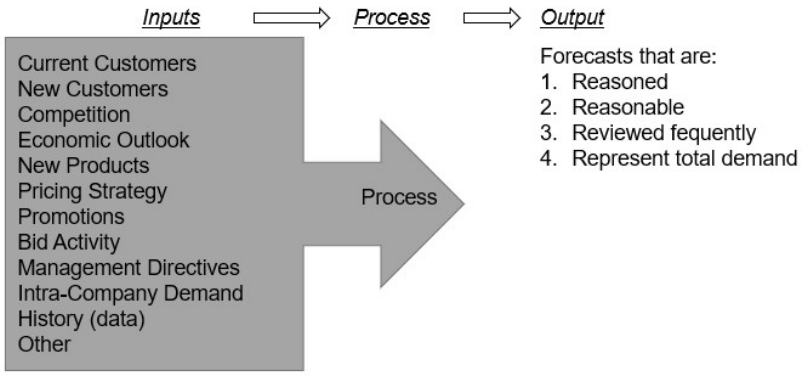

FIGURE 4. Various inputs from different sources influencing forecasting. (Kerber & Dreckshage 2011, 36)

Syntetos, Babai, Boylan, Stephan & Konstantinos (2016, 3) have listed three key features that have implications for the supply chain forecasting.

- The variance of demand is amplified in a beginning of the supply chain
- the impact of cooperation on the accuracy of forecasts, for example, the sharing of demand data between different levels of supply and
- the practice of collaboration which has resulted in some major initiatives like Collaborative Planning, Forecasting and Replenishment (CPFR) and Vendor Managed Inventory (VMI) systems that have had important implications for the practice of the supply chain forecasting.

The importance of the forecasts is not limited to manufacturing planning, but also influences a different decision making and controlling. Decision making may concern the investments budgeting to support additional capacity of increased forecast and demand, e.g., new machines, factory building, employees, and other required expenses. Budgeting requires annual demand forecasts, inventory control requires a lead time demand forecasts, contract arrangements and price negotiations based on the annual forecasts, and distribution management and scheduling require weekly or monthly demand forecasts. (Syntetos, Babai, Boylan, Stephan & Konstantinos, 2016, 13).

TABLE 1. Forecasting needs of different functions (Moon M., 2018, 72).

	Marketing	**Sales**	**Finance**	**Sourcing**	**Logistics**	**Operations**
Needs	Marketing needs a forecast of expected demand so it can effectively analyze promotional programs, new product introductions, and other demand-generation activities.	Sales needs a forecast of expected demand to be able to derive reasonable sales quotas, and to effectively allocate sales resources to those territories and customers where they can be best utilized.	Finance needs a forecast to be able to plan for working capital requirements and to be able to create financial projections for both financial markets and for government reporting.	Strategic: long-term contracts with suppliers of needed raw materials, components, or capital equipment providers. Tactical: manage short-term raw material and component part deliveries and inventories.	Strategic: long-term contracts with transportation providers and warehousing assets. Tactical: manage short-term transportation needs and day-to-day distribution center management	Operations needs a forecast to be able to schedule manufacturing runs in the most efficient manner possible, and to plan for expanded (or contracted) capacity to stay in line with market demand.

In a many occasions forecasting has been divided to demand forecasting and sales forecasting. Sales forecast focus is more on a question, how many units will be sold in a future. It does not take account e.g., manufacturing capacity constraints and it does not support strategic business planning. In a demand forecasting, focus is on questions “how many can we make?” or “how many would customers buy from us if the product or service were available to them?”. When the purpose of the demand forecast is supply chain planning, the forecasting horizon should be no shorter than the production lead time and at least as long as it takes to create new capacity (Moon M., 2018, 68-69).

2.3 Critical elements in supply chain of materials

Christopher (2011) has multidimensional view to define criticality in a supply network.

> Supply networks are in effect of complex web of interconnected nodes and links. Nodes represent the entities or facilities such as suppliers, distributors, factories, and warehouses. The links and the means by which the nodes are connected (i.e. information flows, financial flows, physical flows). The vulnerability of a supply network is determined by the risk of failure of nodes and links. Company need to identify the critical paths that must be managed and monitored to ensure continuity. Critical paths have number of characteristics such as long lead time, a single source of supply with no short-term alternative, dependence on transport modes, high degree of concentration amongst the suppliers and customers, bottlenecks through which material or product must flow, high levels of other identifiable risks i.e. supply, demand, process, control, environmental risk. Once the critical nodes and links have been identified by risk analysis, question is how to mitigate risks or remove risk. The size of the supplier base can add to supply chain complexity by increasing the number of relationships that must be managed as well as increasing total transaction costs. The effect of a smaller number of suppliers can be risk in a supply chain. Too high level of dependence on just a few critical suppliers can be dangerous. With the smaller supplier base, a company can more proactively manage supplier relationships through the supplier development program Christopher (2011, 164-201).

Rushton, Croucher & Baker (2017, 135) defines, where lead times are short, quick response and continuous replenishment policies can be adopted in unpredictable demand changes to supply just-in-time, keeping inventory and waste in a minimum. While in long lead times, unpredictable demand may lead to oversupply of goods or material shortages and loss of sales. Buffering is one of the most commonly used strategy to mitigate unpredictable demand changes. It helps to protect supply

chain from any kind of disruptions or risk by keeping sufficient inventory (Mishra, Sharma, Kumar & Dubey, 2015).

> Maintaining a buffer inventory is often desirable, providing a means of overcoming unforeseen production disturbances or unexpected product demands. In general, the higher the level of inventory, the better the customer service, with fewer stock outs. On the other hand, excess inventory causes higher operating costs. Consequently, safety stock is usually only as much as is necessary to keep the network functioning for a short period of time in case of disruption at one or more of its nodes. (Georgiadisa, Tsiakis, Pantelis & Sofioglou, 2011). In a business where products are made ahead of firm customer orders (build-to-forecast), there is a need to hold buffer inventory. This buffer inventory is required to fulfil higher-than-expected demand as well as a cushion against delayed arrival of raw materials (Ganesan R., 2015).

Oliveira & Gimeno (2014) describes that safety stocks may lead to the uncertainty costs. Buffers of inventory are created at the interfaces between supply chain entities. Safety stocks are necessary because of the forecast uncertainty and/or lack of confidence, on the one hand and the supplier's ability to supply on the other. As a result of this uncertainty, it is quite common to encounter a high degree of duplication of the inventory. In other words, the supplier is holding inventory because they are not sure when the customer's order is coming or the size of that order. At the same time, the customer is holding inventory of exactly the same material/product because they know from past experience that they cannot always rely on the supplier to deliver what they want, when they want it. True cost of inventory might be different than expected. The key to reducing these unnecessary buffers of inventory is clearly improved supplier/customer communication. Also, proper agreements reduce uncertainty, and those agreements and buffer stock levels needs to be reviewed regular basis.

Miclo, Lauras, Fontanili & Lamothe J. (2019) presents in table 1 basic logic for selecting or making decision of buffered and non-buffered items. Importance of the strategic parts, volume, and lead time influences to the category decision. Especially when circumstances change e.g. customer demand (forecast) dynamic buffers can also react to those changes.

TABLE 2. Unique features of DDMRP (Miclo, Lauras, Fontanili & Lamothe J., 2019).

Trait	Explanation	Key decisions/implications
Different categories of parts	This is not ABC analysis. Rather, it is a recognition that parts fall into one of two categories: buffered and non-buffered Buffered parts are strategic parts; parts are strategic for one or more of the following reasons: customer tolerance time, market potential lead time, external variability, inventory leverage, resource protection Non-buffered parts are not strategic parts: e.g. Not sufficient volume, DLT really short (category C in general in a Pareto analysis)	• Which parts are strategic (and why)? • Only buffered items have planned inventory.
Different categories of lead times	Two categories of lead times are introduced. For non-buffered parts, classical production lead times are used (as per traditional MRP logic) Buffered parts have a new lead time – Decoupling Lead Time (DLT) – also known as the Actively-Synchronised Lead time (ASRLT) DLT – defined as the longest, unprotected (unbuffered) lead-time in the BOM	• Non-buffered lead-times – static • Buffered-times – dynamic
Different planning approach	MRP plans by dependence through the BOM. DDMRP daily plans at the positions of independence (buffers) using the net flow equation (on hand + on order – qualified demand) Between the buffers, planning is dependent as in MRP	• Forward order release utilising actual demand and full lead time • Buffers stop system nervousness • Net Flow Equation protects buffer integrity
Dynamic Buffers	The stock buffers associated with strategic parts are allowed to fluctuate to reflect the impact of factors, such as seasonality, volatility of customer demands, load balancing and production ramp-up/ramp-down	• Which buffers are to be allowed to fluctuate? • Why? • What adjustments to make?

3 METHODS TO IDENTIFY IMPROVEMENT NEEDS IN A SUBCONTRACTOR MANUFACTURING PLANNING

Changes in a manufacturing planning, such as the forecast / demand fluctuations (positive or negative), lead time changes in a component or raw material may require close follow up with a specific manufacturer to supply needed products according the required lead time. Changes which are not planned and comes suddenly due the different reasons are the most critical cases. Urgent change might cause additional cost in a final product delivery, used components or raw materials cost and eventually in a final product cost. To prevent better the actual cause of the problem, related functions to the subcontractors manufacturing planning was required to understand and analyze, what are the improvement areas to have possible influence.

3.1 Data collection

The research started by planning, which subcontractors and the internal functions be useful to select in the research scope. By selecting 4 different manufacturing subcontractors, delivering similar products from a different geographical location was the best option to get information widely and to compare what kind of similarities or differences we can recognize in their manufacturing planning.

Subcontractor W, manufacturing location in Asia
Subcontractor X, manufacturing location in North America
Subcontractor Y, manufacturing location in Asia
Subcontractor Z, manufacturing location in Asia

The case company's internal functions were selected based on those key processes, related to the subcontractors manufacturing planning. The research continued according data collection plan, involving right people, and focusing to the needed outcome.

TABLE 3. Data collection plan

Research key elements	Method	Members	Outcome
How the case company see improvement needs?	1. Team discussion	Enclosure Category Manager, researcher	Define internal functions and contact persons to involve into key processes
	2. Interview	Delivery Capability Managers, Enclosure Category Manager, researcher	Understand product phase in/out process Product lifecycle management influence on materials planning
	3. Interview	HUB planners, Enclosure Category Manager, researcher	Demand planning / S&OP Forecast communication
What are the challenges in subcontractors planning?	4. Define right questions	Enclosure Category Manager, researcher	To get information specifically to focused areas
	5. Send questionnaire to subcontractors (W, X, Y and Z)	Researcher	Recognize subcontractor's view of the current planning process and what are their proposals/views for the further development
	6. Review questionnaire responses (W, X, Y and Z)	Enclosure Category Manager, researcher	To understand in first point, what are the possible challenges in manufacturing planning.
	7. Interview subcontractors (W, X, Y and Z)	Enclosure Category Manager, researcher	Discuss all points and understand further subcontractors' comments in questionnaires. Collect possible updates, concerning subcontractors' responses.
	8. Create response summary	Enclosure Category Manager, researcher	To collect data for the further analysis, comparison, and improvement areas.
Can we recognize differfences in the case company practices?	9. Team discussion	Enclosure Category Manager, researcher	Select different material category from internal functions for the benchmarking.
	10. Interview	Category Manager from another category area	Understand how the key processes in a different category area are managed. Recognize differences in processes.

3.2 Key topics of subcontractor's survey and interviews

Questionnaires to the four subcontractors contained same questions and format. Questions were selected based on the practical experience and based on the pre discussions within team. In those surveys team aim was to concentrate on the key topics and to have a development idea from the subcontractor's perspective. Key areas in a questionnaire were:

- Demand planning (S&OP)
- Forecast accuracy and communication
- Critical components or materials planning

The received questionnaires were reviewed with the case company's team and pre-analysed before the interview sessions. Interview's purpose was to have an open discussion about the responses, more detailed explanations for the short responses and define more possible development ideas. By interviewing the subcontractors, more fluent interaction was possible to have.

4 ANALYSIS OF SUBCONTRACTORS RESPONSES

This chapter 4 aim is to respond into the research question 1: ***"What are the challenges in the manufacturing planning from the Subcontractor's perspective?"***

For the further development in the case company processes it was important to know what the responses from the manufacturing subcontractors are, and which topics are the most relevant to improve in a future. The project team evaluated differences in the responses for the same questions or topics to understand better what the root causes for those differences might be.

4.1 Evaluation of demand planning

Questionnaires were defined to get an overview, how the demand planning meetings are organized, what is the frequency of the meetings, how the demand is communicated and if the demand fluctuations happen, what are the methods to control those changes.

Half of the manufacturing subcontractors in the research scope had demand planning meeting practise, meetings were hold monthly or weekly basis. Based on the responses and discussions practise is not consistent with all of the subcontractors.

Due the fluctuating demand, risk with a materials shortages or the other delivery problems is also higher. Risk is also high in the global pandemic situation (Covid-19) limiting availability of the production or materials, for example due to the reduced capacity (different countries government regulations e.g., lock downs), changes in a transport arrangements due restriction on airfreight or other possible limitations. A lot of uncertainty, especially in a changing pandemic situation.

According to the responses all the subcontractors propose to build buffer stocks in a case demand will suddenly increase. Especially in a critical material, with a long lead time or due the other limitations the buffer stock planning would help to mitigate a risk level lower. In the other hand, in the case of decreasing demand, more flexibility is needed to adjust materials and components shipping plan and to have a fast communication between the case company, the subcontractors, and the materials/component suppliers to ensures fast reaction and later to avoid unnecessary excess

stocks. In a practise it is important to have a good planning in place and to study closely market demand trends (e.g., a metal raw materials price increases, global demand in a different material/component categories).

4.2 Forecast accuracy and communication

The questionnaires focused into the forecast communication, what are the possible challenges to plan raw materials and components according to given forecast, how the manufacturing subcontractors communicate forecast to their material and the component suppliers in a planning phase.

All four manufacturing subcontractors receive the forecast information, however there is some differences concerning a short- and a long-term forecast information communication. The long-term forecast visibility was same for all four subcontractors, which they can load through the case company's specific system (System X). The short-term forecast communication practices were different, either through the email communication or through the specific planning/collaboration meetings.

Forecast communication from the subcontractors to their own material and the component suppliers varies. The long-term forecast can be either six months or twelve months, depending on the subcontractor. The short-term forecast from two to three months, which also depends on the subcontractor. In some of the cases, info will be not shared without a separate request from the material and the component suppliers. Frequency in a forecast communication can be weekly or monthly basis.

Based on the responses and discussions the forecast communication practise is not consistent in the subcontractor's side, also the case company forecast communication might have differences in the short-term communication plan.

4.3 Critical components or materials planning

The questions related to the critical components and the material planning focused to understand better, what are the reasons for the possible material shortages, how the purchase orders are

placed to the suppliers, does the subcontractors prepare buffer stocks of their own, what could be the risk mitigation plan to avoid further material and component shortages.

All of the four subcontractors responded similarly concerning the importance of the buffer stock planning. Especially for the long lead time components, delivery times can be even much longer in a case that materials are needed to order from Asia to North America, compared to case when the material and a subcontractor are both located a same country or region. More careful planning is needed because of the long-distance deliveries, for example the purchase orders needed to place much earlier. In this case also quick changes in a demand may bring additional costs due the delivery model changes for example from the sea freight to the air freight.

To mitigate the long lead time and long-distance deliveries the subcontractor have proposed to evaluate possibility to build materials localization or to have an alternative sources and components, to purchase from the nearest sources, instead of using the overseas deliveries.

5 RESULTS AND CONCLUSIONS

This chapter 5 aim is to respond into the research questions 1 and 2.

The research question 1. ***"What are the challenges in the manufacturing planning from the Subcontractor's perspective?"***

The results and conclusions to answer the research question 1 are discussed in chapter 4, which are summarized according to the received data from the manufacturing subcontractors' questionnaires and interviews.

The research question 2. ***"What kind of the development areas we can recognize in the case company's internal functions related to the Subcontractors manufacturing planning? "***

Interviews and a data collection were planned based on the detailed plan, presented on table 3. This plan helped to identify, what are the key process steps, internal stakeholder's responsibility areas, ownership and understanding, to capture required output deliverables. A data collection process (method 9 and 10) was used for the internal processes and practices benchmarking, to recognize what are the differences between different type of the category areas in a global supply chain.

In the beginning of the process definition, it was necessary to identify the right internal functions and the organizations which are involved in the case company's supply chain management process. The demand planning team, the sourcing team including category management (CM), the buyer teams, the customer teams (CT), the logistics center planners (HUB planners) and the supplier collaboration management (SCM). Reviewing the other teams in a different supplier category, their processes and responsibilities was more streamlined and clearer, hence it was very useful to have benchmarking of different teams and their practicalities. In a benchmarking evaluation, we also had possibility to interview different teams individually and to outline their roles, how they support other categories and later on their role was easier to define into the enclosure supply chain process. When the process and responsibilities were clarified, it was easy to make alignment what are the necessary inputs for enclosure manufacturers, to support better their manufacturing planning.

Figure 5 illustrates all internal functions related to the process in the case company. In the research study only part of the functions will be taken into more close review, those are the materials buffering and the forecasting. These two areas of development needs are discussed more in a detail in the following paragraphs.

It is difficult to evaluate immediately how the new defined process performance or efficiency work in the normal daily business. But when the roles and needed inputs are clarified, it is easier to look closer to those functions later on if there is still a gap in a daily operation. The process can be adjusted later on, or it can be reviewed systematically within the specific timelines together with the enclosure manufacturing partners once the outlines have been created.

Part of the process is the SPI (Supplier Performance Index). This evaluation has been part of the procurement quality measures for a very long time. However, the performance of the supply chain process is not directly measured with the SPI index, but it is good indicator to see where the possible challenges are at supplier's end. The SPI includes for example the OTD (On Time Delivery) measures. In a case of systematic problem in a delivery delays with some of the products, the root cause can be started to evaluate and trace if that is related to the supply chain process and mitigation actions can be started if needed.

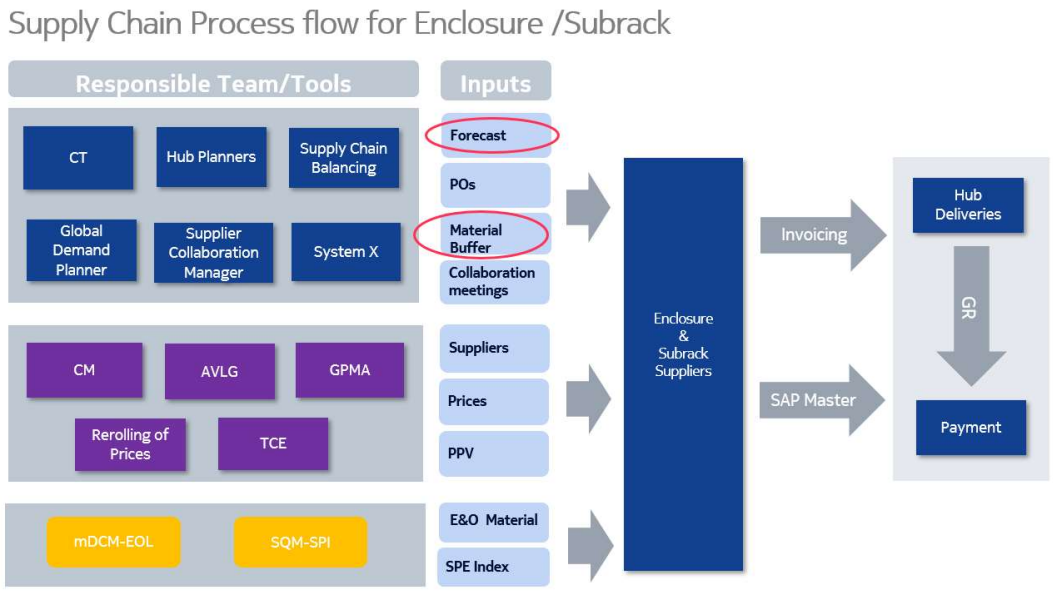

FIGURE 5. Enclosure supply chain process. (Supply Chain Process for Enclosures/Subrack 2021.)

5.1 Improvement of forecasting and communication

In a manufacturing subcontractors questionnaire response, differences in the case company's practices and accountabilities were noticed. An interview with the company's internal stakeholders revealed that the process and responsibilities need a clarification. Focus was to look into details what are the accountabilities, communication, and process in place.

Figure 6 illustrates the different organizations, the accountable teams which are involved to the forecast communication and planning. The manufacturing subcontractors themself can directly view the forecast data from System X, but the accurate forecast data requires always separate communication, in a case of the possible fluctuations in the short- or long-term forecast. The forecast fluctuations and timely reaction of those changes are very important, especially on the critical materials which have a longer lead time.

For the communication and the collaboration, the responsible teams are now defined. Effective and timely communication beside the direct data from System X will be managed by the planner teams. 6 months' and 13 months' forecast is required for the planning of the production, the materials procurement and the buffering. The manufacturing subcontractors communicate the forecast further into their own suppliers and subcontractors, to help the planning of the raw materials and resources in the long supply chain network.

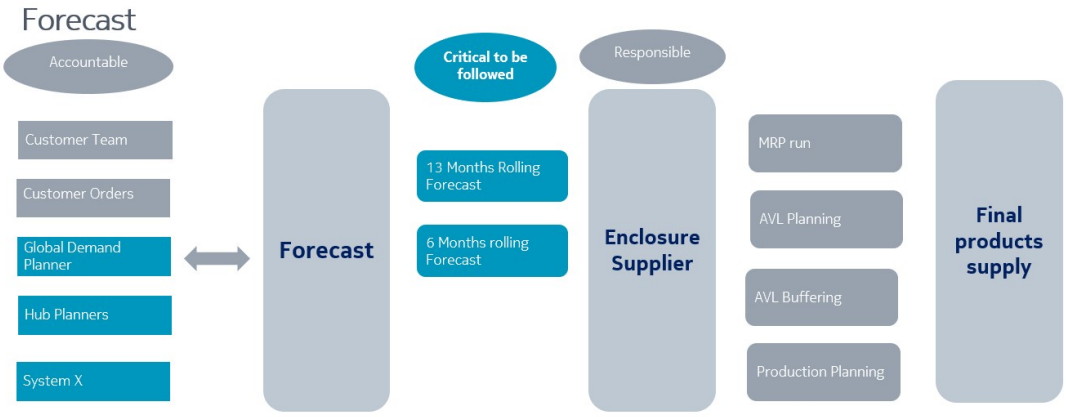

FIGURE 6. Enclosure supply chain forecast communication, process, and responsibilities. (Supply Chain Process for Enclosures/Subrack 2021.)

5.2 Risk mitigation in critical component or materials

The importance of the material buffering came up in a questionnaire response of the manufacturing subcontractors. A certain critical material and the components have a long lead time in addition to the long transportation time. This have been extremely complex for the manufacturing planning and the risks in manufacturing are therefore higher. The risk could eventually have an impact on the final product and the delivery time of the enclosures for the customer. For the risk mitigation a new developed process for the buffering defines the main process steps: assessment, planning (including min and max level), value analysis and the agreements. The case company's internal functions will evaluate the need of the material criticality, the buffering and make a final decision in a co-operation with the manufacturing subcontractors.

At the operational level, material buffering requires periodic management, e.g., the reassessment of the buffer levels if the demand changes or the product life cycle changes (ramp down) or the buffer is relocated to the other geographic location.

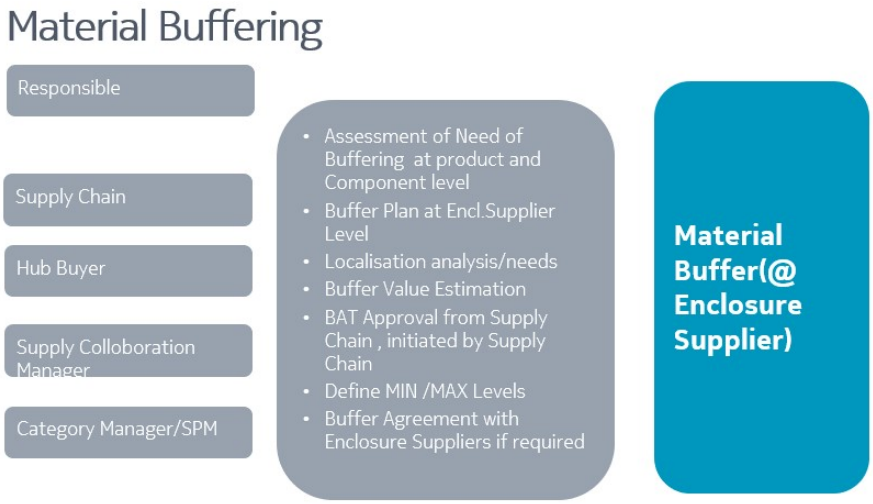

FIGURE 7. Material buffering process and responsibilities. (Supply Chain Process for Enclosures/Subrack 2021.)

Buffering may not be the only solution for the critical items supply chain and planning risk mitigation. The manufacturing or the subassemblies / materials localization can be possible action for the risk mitigation, which is good to evaluate and analyze in a whole process as early as possible. Especially the product's heavy weight or the transportation costs of physically big items transportation

cost can be very high and the time for the transportation can be long (e.g. sea freight). Tariff costs (materials, products or components duty costs, VAT) can also influence the overall supply chain cost, which is good to understand and evaluate the influence from the total cost's point of view. Raw materials or components duty cost can be percentually high. If there is a potential subcontracting partner or the material/component manufacturer and they have possibility to support locally, that could even lower the total cost of product. The localization decision in general would require a business case analysis (possible investment needs for tools, manufacturing equipment, critical processes), for the decision making and it is usually a longer process. Localization may require the building of manufacturing capabilities from the very beginning, and it can also require more close collaboration with engineering, quality, and sourcing specialist teams.

5.3 Conclusions

When the internal functions and responsibilities are known but not outlined into the process and responsibility matrix it is easy to face challenges in a daily business. The manufacturing partners can face slowness and confusion because of the different practises in a company interface.

The thesis process gave the author a very good understanding of the current supply chain management practise and the communication challenges by interviewing the manufacturing subcontractors and the case company internal functions. It was very useful to benchmark other subcontracting category in the case company's supply chain organization, to get visibility what are their processes and responsibilities and to reflect how those practises could be utilized in a supply chain of the enclosure category.

What kind of development areas we can recognize in the case company's internal functions related to the Subcontractors manufacturing planning?

The importance of the collaboration between the suppliers and the subcontractors in all levels of the supply chain is essential. The information flow from the manufacturing partners to the material or component suppliers must be seamless and systematic as the supply chain of the enclosure category is very long and complex. Especially in a such product where many of the subassembly

levels are integrated into the final product. The most significant information from the case company's side to the manufacturing partners is the forecast communication. Possible changes and the communication frequency must be kept tightly in a co-operation scope. The change impacts (higher demand or the lower demand or the product phase out / ramp up decisions) have to be evaluated if there is a requirement for the critical materials buffering planning or the other risk mitigation actions e.g., using of multiple suppliers, ensuring sufficient capacity and processes, a proper quality control or to reduce risk of the excess stock.

By defining a process, a critical data, and the overall responsibility matrix, it provides a good tool for the future cases to manage the supply chain process more smoothly and with the consistent practices. It is also possible to adapt the process and responsibilities later on as they are strengthened and refined. Practices and improvements should be re-evaluated with the manufacturing subcontractor, e.g., in collaborative meetings or in a company evaluation where they can provide open feedback.

What are the challenges in the manufacturing planning from the Subcontractor's perspective?

Based on the findings, challenges in a manufacturing planning can be improved by having a systematic forecast communication, it creates confidence in a whole supply chain planning. Systematic planning may eventually reduce a total cost (e.g., additional expedite costs, transportation costs due urgent deliveries, excess stock cost). Secondly, on the critical materials, which are limiting the production and the delivery schedules of the final product, the material buffering process is required. A clearly defined material buffering process includes a checkpoint list for the different actions; however, it is important to evaluate in the early phase the need for the buffering together with the manufacturing subcontractors, but also to maintain the buffering plans according to the possible changes. The third point was the localization of the materials or the critical parts, which can also give a benefit in reductions of the delivery time and transportation costs. The evaluation of the localization and the localization planning together with the manufacturing subcontractor would also help further on their manufacturing planning.

6 DISCUSSION

The topic of the thesis Improvement of Enclosure Supply Chain came from the need to find out how the planning of the global subcontracting chains can be improved. From time to time, challenges were identified in the subcontracting chain in the form of the material shipment risks, extended delivery times or just on the basic communication. On the other hand, the required formula for the continued collaboration in the enclosure supply chain was to be taken to a new level and to manage risks better. In the case company a separate project was started for the Enclosures Supply Chain Improvement. This project included the several different areas but only three are in a focus of this thesis, which are the demand planning, forecasting and the critical materials planning.

It is easy to recognize improvement needs in a daily operation, but by having a more systematic approach to analyse more deeply what kind of challenges are, which functions we need to improve, do we have the right organizations in a responsibility role available to support the process and to see also in a larger view, what kind of improvement ideas and overall process can be proposed.

When the surveys were conducted, it was noticeable that the change in the subcontracting manufacturers had been desired in the past and they wanted to cooperate and give their views openly on what are the improvements they would think that could work. It was great to have four subcontractors in the surveys and interviews, who really were interested to change and to influence.

On the basis of the improvement results it cannot be evaluated immediately how the new process and clarified responsibilities really work. Later, in supplier performance reviews, for example OTD-rate might be improved as a result of the new process, a more flexible buffering practises can be used in the planning of critical materials, and the communication in a supplier collaboration will be clearer and more focused.

In the thesis we were able to outline a new process and to clarify responsibilities, which will support generally in supply chain operation and help the manufacturing subcontractors to improve their supply chain and to mitigate risks.

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APPENDIX

INTERVIEW QUESTIONS ATTACHMENT 1

Meeting practice's

1 Do you have a Sales and Operations Planning (S&OP) meeting with company X specific to the products you are supplying? Specific to enclosures business.
2 What is the frequency of these meetings?
3 Do those meetings help in planning?

Forecast communication

4 What are the periods of long-term and short-term forecast from company X?
5 Is the current forecast info adequate?
6 Is the frequency for forecast info update in a satisfied level?
7 Are You communicating the company X forecast to Your approved vendor list (AVL) ssupplier's?
8 What is the long and short term forecast Your company is communicating with AVL suppliers?

Demand planning

9 How is the demand communicated from company X to Your company?
10 What are the ways to control the fluctuating demand?
11 How the planning is done at Your supplier end once the demand is communicated from company X?
12 Is company X releasing the purchase orders according to the lead time? If yes, why there are shortages? If no, why not asking company X to release PO?
13 Are You releasing the POs to AVL suppliers as per the lead time?
14 Are You releasing the POs to AVL suppliers based on the company X purchase orders, (not only on the lead time)?
15 What is the issue in planning the RM today based on the company X forecasts or purchase orders?
16 You are working with other telecom customers or other big customers in other industry sector, how the planning cycle is done?
17 Is company X planning better or other customer planning better? If yes, Why? And If No, why?

Critical elements in a supply chain of materials

18 Due to Fluctuating demand, there are always challenges of shortage and excess materials. How do we avoid this?
19 What is the reason for shortages?
20 Based on the historical sales and on the forecast, are you planning enough raw materials and are you keeping buffers for the critical long lead time parts?
21 Any suggestion to improve the lead time from AVL suppliers?
22 Any suggestion to improve the excess and shortages?

Supply chain process, general

23 Any other point You want to highlight on improving the supply chain process?
24 Any other point You want to highlight on the shortening of lead time for our products?
25 Any other suggestions?