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Advanced Planning and Scheduling (APS) system supported Sales and Operations Execution (S&OE) process

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ABSTRACT

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Sales and Operations Execution (S&OE) is a relatively new planning process that aims to balance the short-term demand and supply. The process has been developed and studied extensively by the IT service management company Gartner. S&OE process works as a tool to connect Sales and Operations Planning (S&OP) more tightly into the operational execution process. The S&OE process consists of multiple planning categories which are demand planning, inventory management, supply & replenishment planning, manufacturing planning and transportation planning. The case company is in a process of implementing a new Advanced Planning & Scheduling System (APS). APS system implementation means that the current planning environment needs to be analyzed and redesigned. In this thesis the aim is to design a S&OE process, that is supported by the APS system. Current process analysis concluded that there are challenges in differentiating between mid-term and short-term planning, and also connecting S&OP plans into the production plans. KPI review was also rather narrow. Process was formalized into 3 main steps: Disaggregation, evaluate opportunities and deviations, and define fulfillment. The process has a weekly and monthly cycles. The monthly cycle disaggregates plans imported from the APS system in the beginning of each month. The weekly cycle consists of demand and supply plan optimization, KPI analysis and S&OE meeting. Each meeting has an additional topic that varies every week. Demand and supply plan optimization is done by generating scenarios in the APS system and they are validated in the S&OE meeting. Additionally, KPI's are analyzed in this meeting and KPI's selected for the process are forecast consumption, backlog and schedule attainment.

TIIVISTELMÄ

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Avainsanat: S&OE, Sales & Operations Execution, APS, Advanced Planning & Scheduling, UPM Plywood, S&OP, Sales & Operations Planning

Sales and Operation Execution (S&OE) on melko uusi suunnittelun prosessi, joka tähtää tasapainottelemaan lyhyen aikavälin kysynnän ja tarjonnan muutoksia. Prosessia on kehittänyt ja tutkinut IT konsultointiin erikoistunut Gartner. S&OE prosessi toimii työkaluna, jonka avulla voidaan yhdistää Sales & Operations Planning (S&OP) paremmin operatiivisiin prosesseihin. S&OE prosessi sisältää useita suunnitteluosioita, joita ovat esimerkiksi kysynnän suunnittelu, varastosuunnittelu, tarjonnan ja hankinnan suunnittelu, tuotantosuunnittelu ja kuljetussuunnittelu. Case yritys on työn tekohetkellä implementoimassa uutta Advanced Planning & Scheduling (APS) järjestelmää. Järjestelmän implementoinnin takia yrityksen suunnitteluprosessit on analysoitava ja suunniteltava vastaamaan uutta järjestelmää. Tämän työn tarkoituksena on suunnitella S&OE prosessi, joka tukee uuden järjestelmän käyttöä. Nykytila-analyysissa havaittiin ongelmia esimerkiksi lyhyen ja keskipitkän suunnittelun erottelussa, sekä S&OP suunnitelmien yhdistämisessä tuotantosuunnitelmiin. Myös suorituskykymittareiden käyttäminen oli vähäistä. Prosessiin valittiin 4 vaihetta, jotka ovat dissagregointi, tilausten syöttö ja hyväksyntä, mahdollisuuksien arviointi ja toteutumisen määritteleminen. Prosessissa on kolme samanaikaista sykliä: viikko-, kuukausi- ja päiväsyklit. Kuukausisyklissä APS järjestelmästä tuodaan suunnitelmat ja disagregoidaan ne. Viikkosyklissä luodaan optimointiskenaarioita, joista yksi valitaan ja hyväksytään S&OE viikkokokouksessa. Jokaisessa kokouksessa käsitellään myös yksi ylimääräinen viikoittain vaihtuva aihe. Suorituskykymittarit analysoidaan myös kokouksessa ja mittareiksi valittiin ennustekulutus, tilauskannan riitto ja suunnitelman toteutettavuus. Viimeisenä päiväsykli koostui tilauslupausten muodostamisesta käyttäen APS järjestelmää hyväksi.

PREFACE

I would like to thank UPM Plywood for supporting me through my master's studies by providing interesting job opportunities and the topic for this thesis. The past years have been educational, and I feel that I wouldn't have achieved all of this without the support from the company. The given topic for this thesis was most certainly challenging due to the shortage of academic research regarding the topic, but I felt that this was crucial for the meaningfulness of this thesis.

I would also like to thank LUT University and the professors for providing challenging studies but also giving the flexibility to study and work simultaneously. Lastly, and most importantly, I'm thankful to all my friends and family who have supported me throughout all these years. They have made these years memorable.

In Lahti 24.10.2019

Lasse Paarma

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Abbreviations

APS	Advanced planning & scheduling system
ATP	Available to Promise
BPMN	Business Process Model and Notation
CTP	Capable to Promise
ERP	Enterprise Resource Planning
FSC	Forest Stewardship Council
IT	Information Technology
KPI	Key Performance Indicator
LNG	Liquefied Natural Gas
MES	Manufacturing Execution System
MPS	Master Production Schedule
MTO	Made to Order
MTS	Made to Stock
OTIF	On Time in Full
PEFC	Programme for the Endorsement of Forest Certification
RFP	Request for Proposal
S&OE	Sales and Operations Execution
S&OP	Sales and Operations Planning
SCM	Supply Chain Management
SKU	Stock Keeping Unit

1. INTRODUCTION

1.1. Background

Currently approximately only 30 percent of businesses can continuously tie operational plans into their operational execution. It has been one of the most difficult challenges within the Sales & Operations Planning (S&OP). Planning and operations models are often separate from each other, which causes a situation where plans and execution are done differently. This gap between planning and execution often leads to a passive planning exercise. (Toolsgroup 2016)

During the past years, companies have mainly invested on how to create plans, but not specifically on how to transfer them into an executable form. This is however, about to change with a new planning process called Sales and Operations Execution (S&OE). Connecting S&OP planning tightly into the S&OE helps closing this gap between planning and execution. The main difference between the S&OP and the S&OE is the planning horizon. Whereas S&OP focuses on creating plans for the next 3- to 24-month horizon, S&OE takes these plans to a 0- to 12-week horizon. (Elementum) Supply chain management software company Logility decribes S&OE as "S&OE deals in weekly time slots at the SKU level to track how demand and supply match the plan and then adjusts when differences arise between plan and actuals". S&OE works as a link between the daily operations execution and tactical S&OP planning. (Logility)

To support lower level planning, Advanced Planning and Scheduling Systems (APS) can be used for short-term planning activities, in a large-scale process production. (Mauerqauz J., 2016 p. 16) If the organization already uses a planning system, its capabilities for the S&OE process should be assessed. If the system doesn't meet the requirements, it can be either expanded with an extension or a new system can be implemented. (ChainAlytics) The implementation includes many different steps where one of them is to analyze the given supply chain, and redesign the long-, medium- and short-term planning levels to reach a "superior enterprise wide and supply chain wide planning". (Stadtler H. et al., 2015 p. 501)

The case company is currently implementing a new APS system and their S&OE process needs to be designed and the use-cases of APS system defined. The case company has

previously implemented a S&OP planning process for their tactical planning level, but now there is a need to connect these plans more tightly into the operational execution. Figure 1 illustrates the main focus area in this thesis.

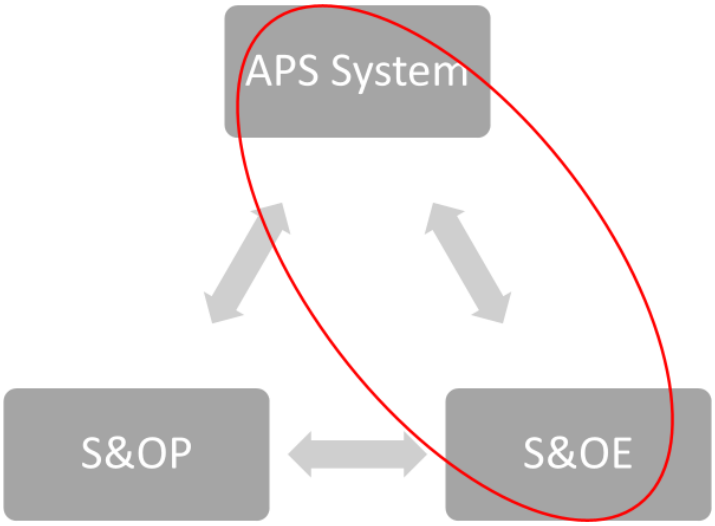

Figure 1. Thesis focus areas

1.2. Research scope

This master thesis focuses on implementing a Sales & Operations Execution (S&OE) process and defining how to use an Advanced Planning and Scheduling (APS) system to manage the S&OE process. The theoretical part focuses on defining the S&OE process and the APS systems, along with the connection between them. Also, the S&OP process is described in detail to understand the relation and input given to the S&OE process. The empirical part studies on how to utilize this theoretical knowledge in the case company and it answers the main research objectives. The first objective is to define a S&OE process for the case company. The aim is to create a formalized process that can be implemented seamlessly into the case company's current planning environment. The second objective is to find the ways to use an APS system so that it benefits the case company's S&OE process. To answer these research questions, there is a need to study what the S&OE process activities are, how to link APS systems into these process activities and what are the consequences of using APS systems for the S&OE process, see figure 2. Lastly, the consequences of each planning activity need to be discussed to better understand the benefits of implementing the

new planning process. This helps the case company to evaluate the need for implementing the proposed S&OE process.

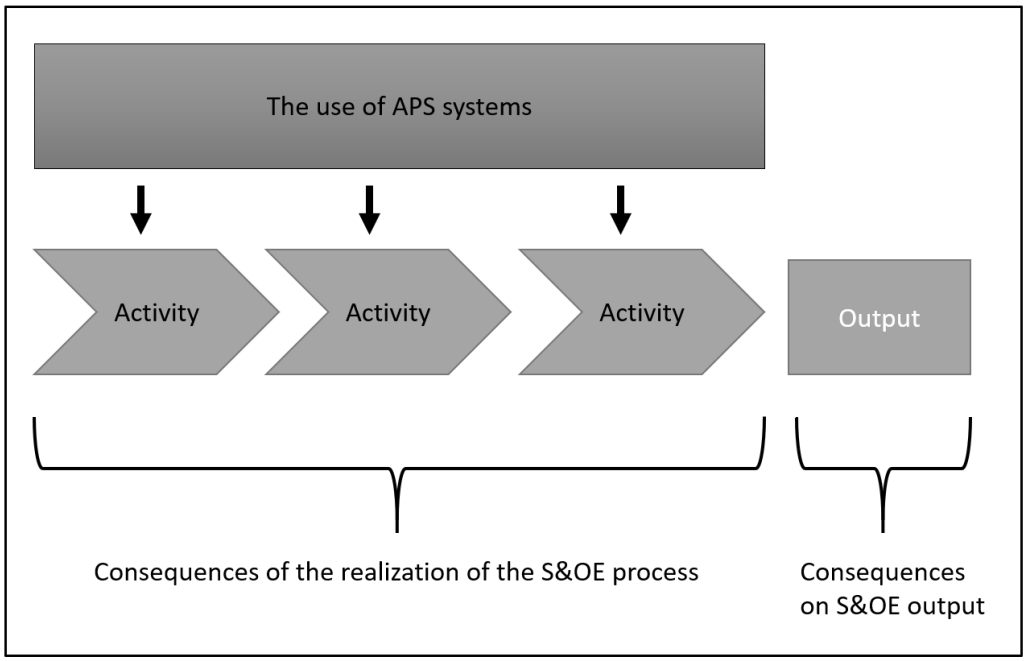

Figure 2. The consequences of using APS systems in S&OE process (Ivert L., 2012. p. 17 applied version)

1.3. Research process and methods

The research process started by collecting research material regarding Integrated Business Planning (IBP), Sales & Operations Planning, Sales & Operation Execution and Advanced Planning and Scheduling systems. All these research materials were reviewed, and the main theory was concluded by joining these research findings together. The research regarding the theory follows a qualitative study approach and the literature is supported with scientific articles and marketing material provided by most APS-system consulting and supplier companies.

The empirical part follows the first three steps of the general scientific research framework proposed by Van Aken, van der Bij and Berends (2012). The first three steps are common research steps for a thesis work, as they only focus on designing a new solution and leaves the implementation for the case company. The steps include problem definition, analysis and diagnosis and solution design. The problem definition phase includes defining the case company's need, and the topics that should be analyzed in the next step. The analysis and diagnosis phase focus on analyzing the company's current situation and finding the related

process problems. Lastly a solution design is conducted by using three inputs: problem related inputs, a model of the present business system and ideas for possible solutions. (Van Aken, et all. 2012 p. 87)

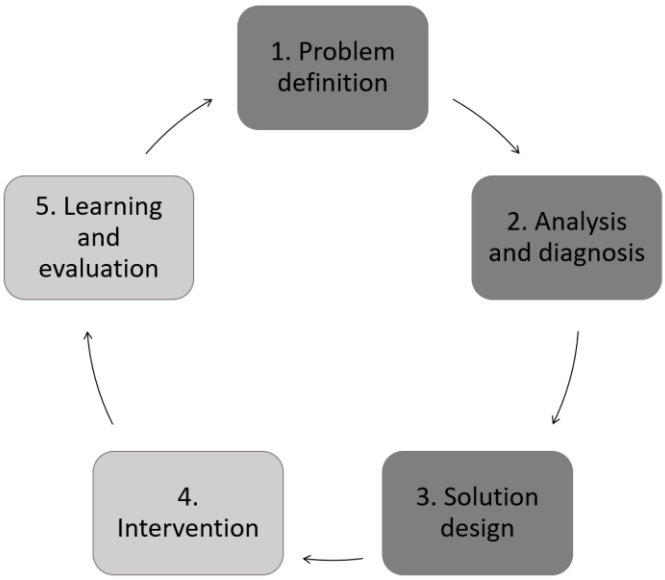

Figure 3. Problem solving cycle (van Aken, van der Bij & Berends, 2012)

Empirical data has been collected from the company's documentation and by unstructured interviews with the employees. Total of 6 employees were interviewed and these included supply chain managers and specialists, production planners and sales representatives. The research questions were answered lastly by defining the S&OE process and this was done by connecting the literature review to the empirical findings.

1.4. Limitations

Advanced Planning and Scheduling systems are only discussed from the S&OE process point of view and the actual plan creation and mathematics behind the systems are not in the scope of this study and they are only described briefly to understand the whole planning process. Also, all the APS modules are not described in detailed level since they are not relevant for the S&OE process.

Usually, APS systems combine several different systems together and work alongside with ERP and other planning systems. However, APS systems in this thesis are considered as a

one individual system, and the inputs and outputs are being discussed from the S&OE process point of view. S&OE process activities are often referred with various names as discussed in the background chapter, but for the simplicity of this thesis only the term “Sales & Operations Execution” or “S&OE” is used in the text, even if it was closely related to other similar terms. Other lower level planning activities that are not related to S&OE planning are excluded from the thesis.

Since the Sales & Operations Execution process is a completely new planning practice, many of the process steps and activities are often referred with multiple different names throughout the literature. These include short-term planning, MIX planning, weekly S&OP, weekly SCM workflow, demand control, quick response forecasting and sometimes it is included in the operational planning. Many of these terms however include or exclude some elements that aren’t or are supposed to be a part of the S&OE process. Thus, these planning elements are not covered in this thesis.

1.5. Structure

This thesis is divided into 4 main parts: introduction, literature review, empirical study and conclusions. The introduction part discusses the background for choosing the topic for the thesis and as well the research scope, process and methods.

The second chapter focuses on literature review and it is divided into three main topics: Integrated Business Planning (IBP), Sales & Operations Execution (S&OE) and Advanced Planning & Scheduling (APS) systems. Integrated Business Planning introduces the main planning levels to get a better understanding about planning hierarchies. Then, Sales and Operations Planning is briefly discussed to get an idea of the main outputs given to the Sales and Operations Execution process.

The third chapter focuses on the S&OE process. The main process steps are discribed in detail and the main framework for the process is presented. The fourth chapter focuses mainly on APS system functionality, benefits and how to use them in the Sales & Operations Execution process.

The fifth chapter introduces the case company and analyses the current planning environment. This chapter aims to find the current short-term planning related challenges, so that they can be addressed in the fifth chapter.

The sixth chapter concludes the thesis by creating a S&OE process for the case company and discussing how to use APS systems in the proposed process. Lastly, theory and empirical parts are concluded and summarized in the seventh chapter.

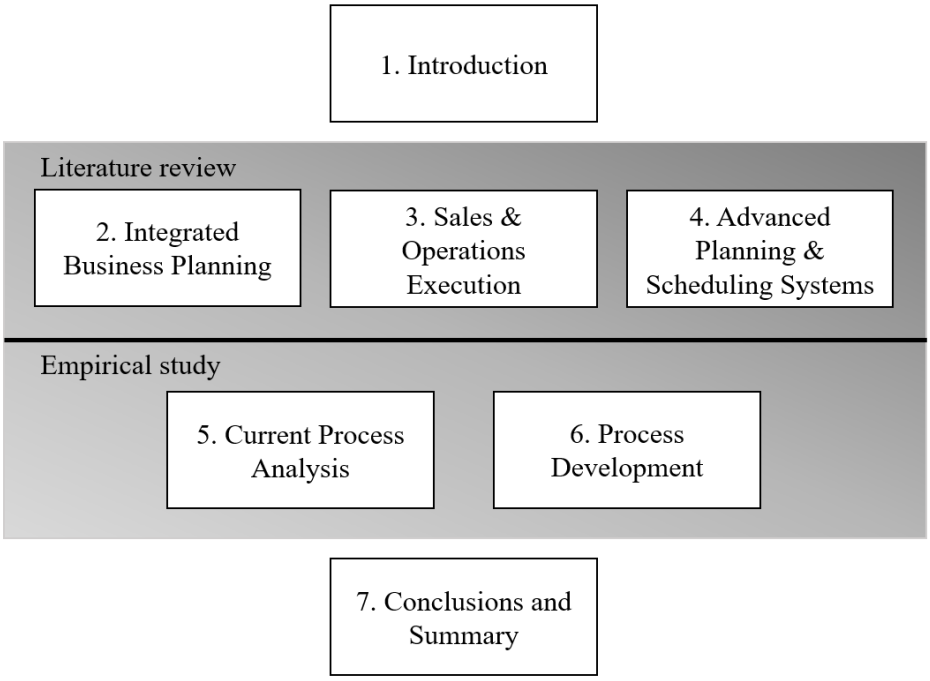

Figure 4. Structure of the thesis

1.6. Case Company

The case company for this thesis is a Finnish plywood producer UPM Plywood. It operates in a global market selling high quality plywood products for multiple industries including construction, vehicle flooring, LNG shipbuilding, parquet and other industrial manufacturing. The case company is currently implementing a new Advanced Planning and Scheduling (APS) system and there is a need to develop and analyze a planning process that suits the new planning system. This master thesis aims to analyze and redesign the short-term planning level by using a rather new planning point of view, the Sales & Operations Execution.

2. INTEGRATED BUSINESS PLANNING

Integrated Business Planning (IBP) is a planning process that integrates supply, demand and financial planning processes into a one common operating plan. This plan is utilized across a company's all functional areas. (Deloitte) Integrated business planning aims to increase company's revenue, forecast accuracy and schedule adherence. It also reduces inventory levels, improves logistics planning and has various financial benefits for the company. Benefits can be generated most efficiently when all the aspects of planning included in the IBP are being addressed. (Kepczynski et all., 2018 p. 9) This chapter focuses on explaining the connection between these planning levels. Also, the general tactical planning level is introduced and described in a detailed level using the Sales & Operations Planning process steps.

2.1. Planning Levels

Successful Integrated Business Planning transformation means integrating different planning types together. Planning processes usually happen over long-, mid- and short-term horizon. These are also referred as strategic, tactical and operational planning. Every planning level has a different focus and importance. (Kepczynski et al., 2018 p. 1-7)

Strategic plans are usually done for many years ahead and they are done in the most aggregated level. The typical granularity for these plans is brand, product line, business line and region level. Tactical plans have a shorter planning period, usually from few months to couple years. These plans have more detail than the strategic plans, but they are also updated more frequently. They are aggregated to product group, country, plant and SKU level. Lastly, there are operational plans and they have the shortest planning horizon of them all. These plans focus on the real-time business activities and they are often done for a maximum planning period of few months. Typically, they include SKU, plant, production line and detailed transportation planning. (Lapide, L. 2016 & Kepczynski et al, 2018)

Decision points are often decomposed into multiple decision levels. Each decision is assigned to specific level so that top level handles long-term decisions and the lowest level handles the short-term decisions. Long-term decisions have the greatest impact on competitiveness and profitability, and therefore they are the most important decisions. This hierarchy model allows plans to be aggregated and disaggregated, which means going up or

down in the hierarchy. (Stadtler H. et all., 2015 p. 24, 75) In many cases, companies struggle to define what is the amount of detail needed for each main planning level. Figure 5. illustrates the amount of detail needed for each planning level. In general, the operational planning should focus on a very short horizon and handle planning with high detail. Tactical planning should focus on mid- and long-term planning in a more aggregated level. Strategic planning should only focus on a highly aggregated and long-term level. Defining the right amount of detail for each planning level helps to connect these planning levels together. (Kepcynski R. et all p. 7)

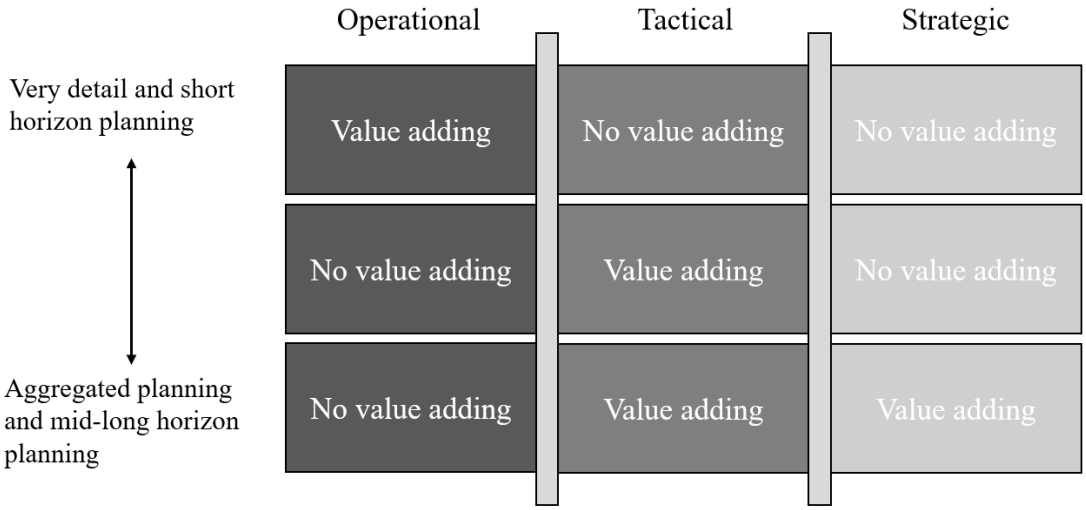

Figure 5. Planning detail for different planning levels (Kepcynski R. et all p. 7)

Wallace (2004) introduced the basic resource planning model in 2004 that included the S&OP process. In this resource model, S&OP plans are sent to the so-called MIX-planning process where the plans are disaggregated to individual product and customer order level. This planning process is similar to the Sales and Operations Execution process. Ultimately, plans were sent to the lowest level that includes entering orders, master scheduling, plants scheduling, purchasing etc. (Kepczynski R. et all. pp. 7 & Mendes P., 2018) Recently, Logility proposed a similar IBP hierarchy, where S&OP was complemented with the S&OE process and these plans are sent to the finite scheduling, order management, vehicle routing and other lower level planning activities. (Logility) Figure 6 illustrates an applied version of the basic resource planning model and the new IBP model. It is also visible that both demand and supply affect the S&OP, S&OE and ultimately operational execution.

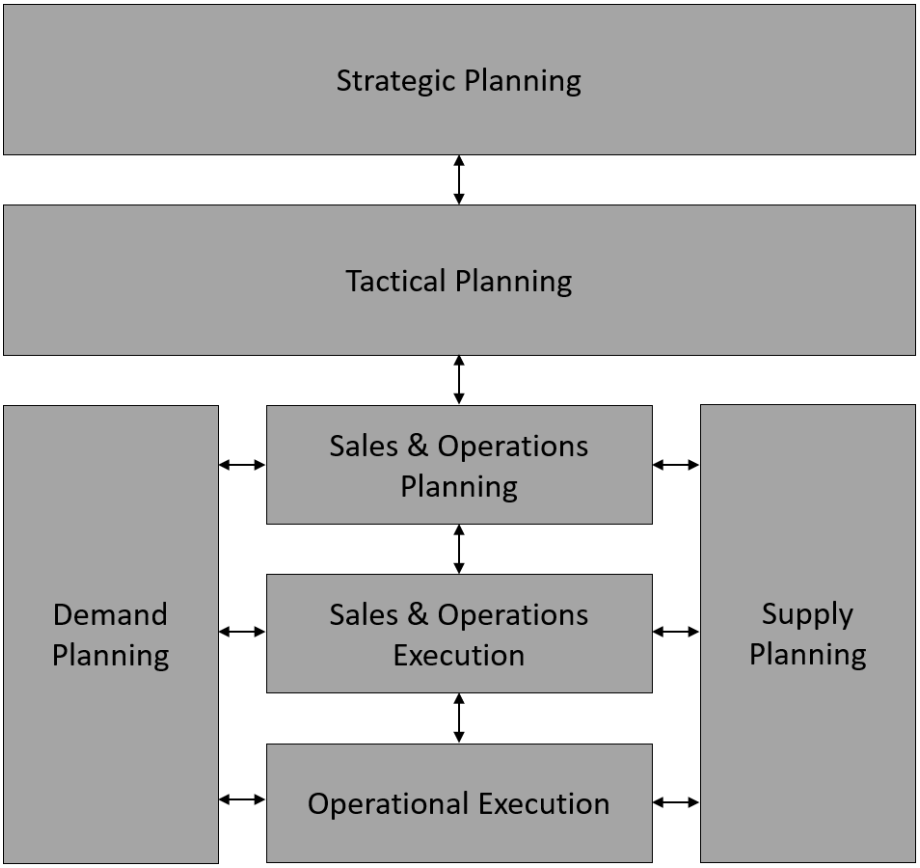

Figure 6. Applied resource planning model (Wallace 2004 & Logility)

Lower level planning practices are often introduced to the company after noticing that the S&OP process can't handle supply and demand imbalances in a product level. This is mainly because the S&OP only handles aggregated volumes, for example product families or product groups. Lower level operational planning aims more specifically to use available materials, machines, money and manpower as efficiently as possible. Data in this level has a high granularity and is handled on daily and weekly buckets. The process aims to steer the operational execution and align execution to tactical planning. (Kepczynski R. et al. p. 7)

In general, strategic, tactical and operational planning processes include the same dimensions as in the S&OP but importance and focus per each planning type is different. These process dimensions are product, demand, supply, reconciliation and S&OP. (Kepczynski R. et al. pp. 7 & Mendes P., 2018) Main planning tasks are divided to period disaggregation, product allocation, resource allocation and material reservation. This means that plan includes information about when, where, to whom and with what materials and resources the demand is fulfilled. (Vincent, W. & De Kok, T. 2018 p. 78)

2.2. Sales and Operations Planning

Sales & Operations Planning (S&OP) has its roots in the beginning of 1980's when businesses started to create production plans for medium to long-term periods. The process started to evolve in the 90's when companies realized the benefits of the process. Before the success of S&OP, business planning, production planning and sales planning were all executed separately. Because of this, all these functions were disconnected, and this led to situations where individual operations didn't understand the big picture of the ongoing business. Nowadays S&OP is seen as an integrated decision process that allows companies to monitor and update its strategies through the monthly operating plans. This forces individual operations to agree every month how the business will be conducted in the future. (Coldrick et al. 2003)

Mendes categorizes the S&OP planning into 5 different levels, where the lowest level doesn't include any formal S&OP process and the fifth level is an advanced S&OP process supported with IT systems. Maturity levels are presented in the appendix 2. Planning meetings are often in an important role when trying to achieve higher S&OP maturity levels. (Mendes, P. 2018 p. 125) In general, to achieve a successful S&OP process, company should implement routine S&OP meetings with structured agendas. Meetings should include employees from all the related functions, and all the participants should be empowered to make decisions. Process should be continuously measured and possibly supported with a supply-demand planning technology, for example Advanced Planning and Scheduling (APS) system. (Mendes, P. 2018 p. 57)

In general, S&OP process should be thought as a separate process from Sales and Operations Execution (S&OE) so that the process would not focus on near term (0-3 months) planning horizon. This means that S&OP meetings should not include discussion regarding operational issues and the S&OP plans should be sent to the S&OE process that handles the short-term planning issues. In other words, S&OP results should function as an input for the S&OE process. (Gartner, 2019)

S&OP process consists of 5 or 6 individual steps that are completed in a sequence during each planning round. In this thesis I will use the 6-step process, which is more commonly used practice among literature regarding S&OP processes. These 5 steps are: gathering data,

unconstrained statistical forecast, demand planning, S&OP analysis, pre-S&OP meeting and executive meeting. Tactical planning is usually solely based on the Sales and Operations Planning process.

Detailed S&OP process is described next to better understand the output given to the Sales & Operations Execution process. (Mendes, P. 2018 p. 56)

Step 1: Gathering Data

Data is gathered into the information system usually right after the end of the month. This includes updating the data files from the past month and creating sales analysis data, statistical forecast reports and other data to support the creation of unconstraint statistical forecast. This step happens mostly in the demand planning side.

Step 2: Unconstraint Statistical Forecast

Next step is to generate the unconstraint forecast. This is done by running a statistical forecast model that considers business units, geographic regions, SKU's, product families and future volumes. Forecasting techniques like regression or conjoint analysis are often used to create the forecast.

Step 3: Demand Planning

Demand planning is the most important step as it aligns the demand figures by using previously collected demand data. This step includes reviewing the previous data and analyzing it to generate demand figures for the next planning period. New product launches are also added to the aligned figures. Also, all the assumptions regarding to the forecast should be documented.

Step 4: S&OP Analysis

Supply analysis is performed for each functional area, including manufacturing, inventory, distribution, transportation and warehousing. Each functional area should provide their operational capacity so that the demand can be fulfilled. Also, company's financial results are estimated according to the forecast. S&OP analysis include graphical comparisons between required and available capacity for each functional area. Also, all the unsolved supply problems are documented and sent to the next step for managers to decide. S&OP

analysis may sometimes include a separate supply planning meeting to solve the amount of supply available for the planning period.

Step 5: Pre-S&OP meeting

In this step all the business areas make decisions together regarding the balancing of demand and supply. Different business areas present their findings and results. Balance between demand and supply is reached by creating alternative situations about different planning problems. Often all these problems cannot be solved, and some areas can't find agreement. Therefore, the meeting will also decide how to present these disagreements in the next executive meeting. Meeting usually includes managers from logistics, demand, customer service, supply planning, production, finance, sales and marketing. Lastly, the agenda for the Executive S&OP meeting is decided.

Step 6: Executive meeting

The last step of the monthly S&OP cycle is the executive meeting, where final decisions about the plans are being made. Either the pre-S&OP recommendation is accepted, or an alternative plan is being chosen. If authorizations are needed for executing these plans, they are done during this meeting. Financial figures of the plan are also compared to the main business plan. Meeting often includes CEO, director of marketing and employees from supply chain, sales, logistics, human resources and finance. Meeting notes, including the selected decisions and business plan modifications, are the outputs of this meeting.

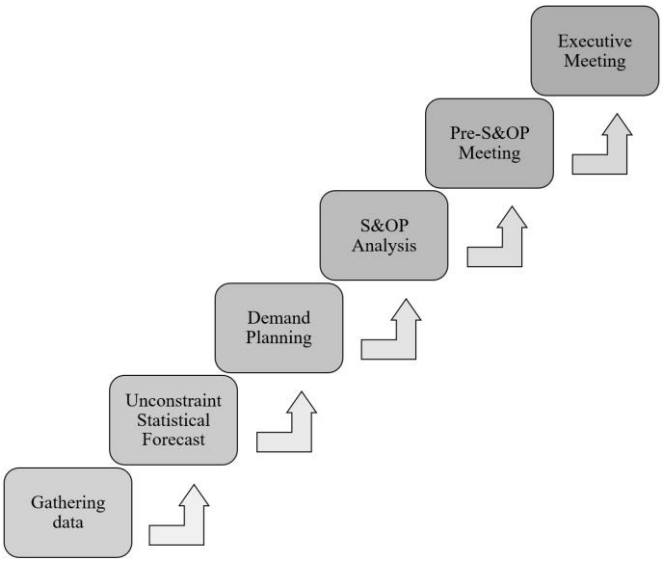

Figure 7. S&OP Process steps (Mendes, P. 2018 p. 56)

3. SALES & OPERATIONS EXECUTION

The Sales & Operations Execution process connects company's tactical and operational planning together and transforms the S&OP plans into less aggregated level. These plans have a more frequent time bucket and shorter planning horizon. The S&OE process reacts to deviations and manages the short-term demand volatility. Figure 8. illustrates how the S&OE is situated between the S&OP and Operational Execution. (de Carvalho A., 2018. p 93)

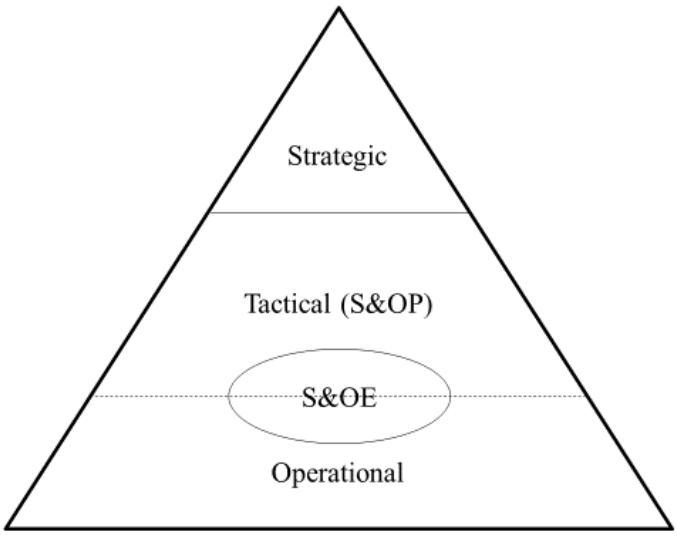

Figure 8. S&OE in the Anthony's triangle (de Carvalho A. 2018)

Sales and Operations Planning is often not directly connected to the daily execution and operations. In many cases, it is not even recommended for execution managers to attend the S&OP meetings since these meetings focus on the higher-level aggregated plans. However, it is highly important that these plans are communicated to the executional managers in detail, so that they can do their best to connect their actions into the S&OP plan. According to Gartner Vice President Marko Pukkila, many companies struggle to achieve benefits and value out of the S&OP because the process isn't strictly connected to the execution process. S&OP is designed to give managers an overview of the big-picture, but this doesn't usually benefit the lower level processes, including production and sales. (Cheng, R. 2019) To improve this situation, the S&OP process should be complemented with the Sales and Operations Execution process (S&OE), which helps to keep the S&OP process in a more aggregated level. (de Carvalho A., 2018. p 93)

Simply put, the S&OE process eliminates the disconnect between tactical S&OP and the actual operational execution of plans and it complements already existing processes and creates communication bridges between them. However, to implement the S&OE process into a company's current planning environment, some changes are often required. IT systems, meeting cadences, planning processes and data models need to be reviewed and analysed. (ChainAlytics, 2019)

As mentioned before, all planning levels share the same planning process dimensions as in the S&OP planning. However, the importance and focus differ per each planning type. Logility splits S&OE planning process types into five different sections; demand planning, inventory planning, supply and replenishment planning, manufacturing planning and transportation planning, see figure 9. (Logility) These key action items are tracked on a weekly basis so that visibility and accountability are being maintained. (Elementum/Cheng R., 2019) However, these short-term planning tasks may vary greatly depending on the industry and their supply chain models. (Stadtler H. et all., 2015, p. 101)

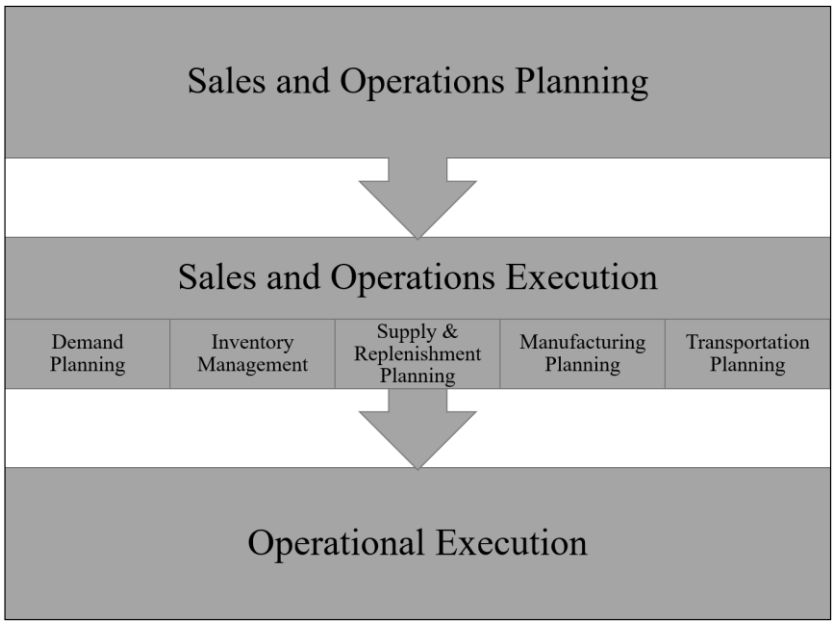

Figure 9. S&OE process activities (Logility)

Sales and operations execution process is in many companies included within the S&OP. This means that the S&OP process itself takes the planning into detailed level. Setting up

the S&OE process means that these activities should be taken out of the S&OP process and managed as a separate process. (Ostdick, N., 2017) Decision making is usually delegated to lower level management to make the higher-level planning less complex. The higher-level planning benefits from the easier execution of these plans made in the lower planning level. (Vincent, W. & De Kok, T. 2018)

Additionally, gathering feedback related to the plans is often seen more efficient on the lower levels and because of that, it is often easier to improve these plans in the future. (Vincent, W. & De Kok, T. 2018) Supply related feedback often includes unexpected incidents that have an affect on the current plan. These can be production shortfalls, inventory shortage, late shipments, late raw material supplies, late or incomplete customer deliveries, quality problems, excess inventory and other disruptive events. It is important to react to these incidents quickly with the S&OE team. (Elementum Webinar 2019)

3.1. Sales and Operations Execution Process

Carvalho (2018) defined the S&OE process in a cross-case analysis into 5 main process steps: disaggregate plans, generate and program orders, evaluate opportunities and deviations, define fulfillment and confirm orders. These steps are modelled into a PBMN model, see appendix 1. These process steps are now described in detail. See also table 2. for process inputs and outputs.

Disaggregate plans

Plan disaggregation process consists of importing S&OP plans, disaggregating them into SKU-level, validating and documenting disaggregated plans. Demand side managers need the plans in a country, product and account-level in able to execute sales and marketing processes. Execution side includes managers from the manufacturing, transportation, warehousing and inventory, and it is important for them to know detailed information about product-level detail ass well and additionally about specific warehouse-, plant- and ship-to location plans. Plans needs to be disaggregated into weekly level and in many cases, this is simply done by dividing the monthly demand forecasts by four. However, this hardly ever a good way, since it does not consider the higher-level plans and weekly fluctuation. (Lapide L., 2016).

Generate and program orders

Generating and programming orders consists creating the base MPS plan. When the S&OP results are published, the S&OE process uses them to create the MPS plan. S&OP demand forecasts are dealing with monthly level and therefore these can't be used as a raw input to the MPS. Consequently, MPS plan can be created only after the plan disaggregation is done. The idea of MPS planning is to show how the available production capacity can be utilized cost efficiently. It balances the cost of production capacity against the cost of seasonal inventory fluctuation costs. It considers demand fluctuations and therefore, the MPS plans need to be adjusted from time to time. MPS planning often deals in a product family level and does not consider single production processes. If material or products are being sent from one facility to another, the transportation costs should be considered as well. MPS plans also give an overview for the amount of personnel needed to execute these production plans. (Stadtler H. et all., 2015 p. 80)

Creating MPS plans may be a difficult task due to many complicated questions that should be considered. For example, choosing the right production resource when multiple resources are available or finding the best way to assign product quantities to minimize changeovers. In general, the number of resources, products and periods increase the complexity of MPS planning. (Stadtler H. et all., 2015 p. 81) MPS planning is often done by using spread sheets and simple calculations, which often doesn't represent the real-world scenarios that well. Advanced computer algorithms and optimization techniques are therefore often suggested for the MPS process. (Ivert L., 2012 p. 26)

Allocated customer orders and planned orders work as a frame for the transportation plan. Transportation planning may happen also in the procurement side, if transportation isn't handled by the supplier. Short-term transportation planning translates aggregated transportation plans into daily quantities for single products. Transportation capacities, customer orders and short-term forecasts are considered when creating transportation plans. (Stadtler H. et all., 2015 p. 81)

Order confirmation

Order confirmation step consists of fulfilling the demand and giving order promises. The most accurate demand information is available on the lowest demand planning level. This is

because many customer orders have been already received for the short planning period. The problems arise when matching these customer orders with the existing forecasts. (Stadtler H. et all., 2015 p. 91) Schedule adjustments happen frequently in many organizations and it is a daily task for most planners. This daily work is often referred in literature as short-term demand or sales planning. Demand fulfillment tracks on how well the actual customer demand is fulfilled. (Stadtler H. et all., 2015 p. 178-179, p. 100)

Order promising can be done using ATP (Available-To-Promise) functionality in an APS system, but traditionally order promises are done using supply lead-times and/or inventory levels, which often results in less feasible order promises. (Stadtler H. et all., 2015 p. 178-179, p. 100) Additionally, production metrics and data can be used to have an accurate picture of the current demand and production stages (An S&OE FAQ, Flexis, 2017).

Evaluate opportunities and deviations

Evaluating opportunities and deviations step consists of performing simulations that consider the short-term changes in operations. Short-term planning benefits of the more accurate information about the customer orders already in the system. This can be used in the demand planning process by using a forecast netting process. Weekly forecast netting supports supply and demand balancing decisions. It brings actual orders and forecasted demand together to reduce forecast inaccuracy. (Li S. & Ma L., 2010) Forecast netting is done to avoid forecast changes to those demands that are already in the system as actual customer orders. Netted demand plan is sent to the master planning process and the fulfilment plan is created using the netted forecast. (Stadtler H. et all., 2015 p. 91) Netting can be done as a weekly forecast netting process. (Ma, L. & Li, S. 2010.) Table 1 presents a simple netting example where netted forecast is created by subtracting order stock from the forecast on a weekly level. Other way to adjust forecasts is to use forecast reconciliation methods. Forecast reconciliation process aims to make forecasts coherent by considering for example forecast errors and other mathematical models. (Hyndman, et all., 2019)

Table 1. Forecast netting example

Planned week	1	2	3	4
Order stock	15 m^3	20 m^3	10 m^3	0 m^3
Forecast	50 m^3	50 m^3	70 m^3	40 m^3
Netted forecast	35 m^3	30 m^3	60 m^3	40 m^3
Total netted forecast	165 m^3			

Define fulfillment

Last S&OE process step is defining fulfillment. This step includes a S&OE meeting where all important decisions are made, and fulfillment is defined. (de Carvalho, Weekly meetings also support the short-term demand planning, especially in situations where demand fluctuates frequently. S&OE meetings should be held weekly or bi-weekly to analyze how effectively plans are being followed. Focus on these meetings should be in short-term demand and supply. (Gartner, 2019) It has been also suggested to change the topics in the S&OE meeting cycle, by focusing on different execution challenges each week. First week can focus on forecast consumption and the second week to the forecast updates, for example. (Elementum/Cheng R., 2019)

Flexis proposes S&OE meeting for the end of the week, so that there is an accurate view of the current week and so that changes can be still done for the upcoming week. (Flexis) As discussed in the previous chapter, to achieve a second level S&OP process maturity, this meeting should be set up to review actual performance against the operational plans. Meeting also aims to manage short term demand and supply volatility. (Mendes, P. 2018 p. 125)

Table 2. General S&OE process framework

Steps	Description	Process input	Process output
1. Disaggregate plans	S&OP plans are disaggregated by product and sales channel. Plans are analyzed, validated and documented.	Aggregated plans generated during the S&OP planning round	Disaggregated plans ready to be programmed into the system
2. Generate and program orders	Orders are generated and MPS plan is created.	Disaggregated plans are used as an input.	MPS plan and sales quotas
3. Confirm orders	Orders are entered into the system and prioritization rules checked. Possible alternatives are discussed, and changes being done. Lastly orders are confirmed.	MPS plan and sales quotas	Confirmed orders and data promises
4. Evaluate opportunities and deviations	Opportunities are being simulated and evaluated their impact. Best scenario is selected and either accepted or sent to the defilement step.	Orders that need reprogramming from the previous step are being evaluated.	Accepted orders are sent back to the order confirmation and the orders needing reprogramming are sent to the define fulfillment step.
5. Define fulfillment	Prepare and perform the S&OE meeting to evaluate opportunities, deviations, fulfillment definition and prioritization.	Decisions not accepted in the previous step will be brought to the define fulfillment.	Fulfilled orders are sent to the confirm orders step.

3.1.1. Process participants

S&OE process usually has 3 types of participants: S&OE leaders, S&OE analysts and coordinators/managers. Leaders role is to align plans and understand the consequences of trade-offs. Leader should be a neutral person who is not linked to specific organizational function but rather sees the company as a whole. They usually also participate in the S&OP process. S&OE analyst's task is to analyze KPI's, look for the fulfillment opportunities and follow deviations in both demand and supply side of the supply chain. The analyst must also understand what is best for the company and how to analyze and select the best planning scenarios. (Carvalho A., 2018. p. 61)

Coordinators and managers work together to integrate the S&OE plans into the actual execution. These participants may be from production, sales, logistics and S&OP organizations. (Carvalho A., 2018. p. 61) As the process runs mostly among the planning teams and operational managers, higher level management is only involved when issues of greater significance arise. (Chainalytics, 2019)

3.1.2. Process planning cycle and horizon

Planning cycle length is also important to determine how well the process reacts to short-term changes in the real world. For example, during the end of the planning cycle, data may already be obsolete due to data being too old. Planning cycle length should be determined according to the process aggregation level, planning effort and horizon. (Stadtler H. et all., 2015, p. 46) General planning cycle length for the S&OE process is one week and the planning horizon from 0- to 12-weeks. However, some planning elements repeat also in a daily or monthly basis. (de Carvalho A., 2018)

S&OE planning horizon should start where the S&OP horizon ends. The exact timing should be determined specifically for each business. Often in manufacturing, the end of the frozen production period is the start of the S&OE cycle. So-called S&OE calendar can be defined to ensure timely execution of different process tasks. Daily process steps are often event-based processes that are triggered after a specific event. Event-based processes often refer to such supply or demand deviations that cannot wait until the next weekly S&OE cycle. (Chain Analytics, 2019)

3.1.3. Process benefits

The benefits of implementing a successful S&OE process include better service level, integration between organizational areas, higher revenue, cost reduction, flexibility and lower inventory levels. (de Carvalho A., 2018. pp 93) Elementum research (Elementum webinar, 2019) concluded that 60 % of interviewed companies continuously achieved a lower service level than what they forecasted in the S&OP process. 73% of the companies reported that a 1 % service level improvement would lead to a 1-million-dollar yearly savings. 29 % of the companies valued a 1 % improvement to save over 50 million dollar a year. Only 25 % of the companies had a structured S&OE process in use.

3.1.4. Process deployment

S&OE process deployments consists of five general main steps that aim to implement full process into the company's planning environment. These steps are: assess current end-to-end planning, design fundamentals, design S&OE process, develop solution and deploy S&OE. See figure 10.

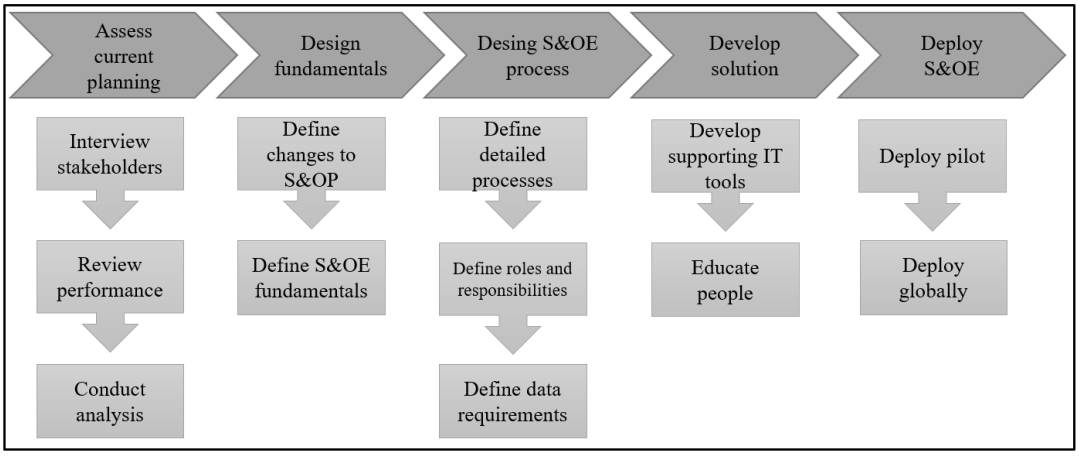

Figure 10. S&OE process deployment (Chainalytics, 2019)

Process deployment is started by interviewing different stakeholders and reviewing the current process performance. This information is conducted into an analysis that is used in the next deployment step. Next step includes defining the changes needed to be done in the S&OP process and defining the main fundamentals for the S&OE process. In case that the current S&OP process exists solely for the sake of creating tactical plans, there are often no

need for changes. However, this is rarely the case and the S&OP should be analysed to understand what elements should be excluded from the process.

The third step focuses on defining the detailed S&OE process and the roles and responsibilities for the process participants. Data requirements should be also defined since the data often works as an input or output for many S&OE process steps and related IT systems. Outputs include i.e. plans and decisions from the S&OE process. Fourth step is to develop supporting IT tools and educate people to use them and to understand the process. Lastly, process is piloted and deployed globally. (ChainAlytics, 2019)

3.2. Key Performance Indicators

KPI's suitable for the S&OE planning environment are usually associated with the order book and production balance, order fulfilment and service level. In the S&OE multi-case study, several fitting KPI's were found: forecast consumption, schedule attainment, OTIF (On Time in Full), backlog, change in sales order and adherence to the production, distribution and purchasing programs. (de Carvalho A., 2018. p. 100) See appendix 3 for KPI formulas. Many of these KPI's are related to the company's delivery performance. Delivery performance measures how quickly the customer demand is fulfilled. This mostly depends on the forecast accuracy and the ability for the supply chain to execute plans. Therefore, if the forecast is not representing the real future orders, it will affect master plans and eventually customer orders. Poor delivery performance will lead to a situation where customer orders are delivered late. (Stadtler H. et all., 2015 p. 180)

OTIF KPI reflects on how well the MPS plans reflect the reality and how efficient and accurate are the delivery and logistics. It consists of two parts: on time and in full. On-time can refer to production cycle, agreed response time or requested delivery time. (QPR) Order promise quality can be measured with on-time KPI. This KPI is highly influenced by the accuracy of MPS plans. Using ATP with an accurate MPS, order quoting can take on-time-delivery closer to 100 % accuracy. In this case, only supply deviations will be affecting the KPI value. (Stadtler H. et all., 2015 p. 178) Delivery in Full refers to the situation where customers receive the order with the same amount as in the order. (QPR)

Forecast consumption KPI assumes that the actual sales orders consume the forecasted values. This helps to separate available sales plan from the orders that are already in the system as customer orders. Consumption can be calculated for different periods and for specific customers. (Oracle)

Schedule attainment KPI follows how effectively a specific target level of production is attained during a specified time. The aim is to maximize attainment and follow the changes in production to find the root causes for changes in the KPI. (Cerasis & TaskManagementGuide) Schedule attainment is affected by supplier, internal and customer integration. Supplier integration helps to achieve a better availability of materials and components that are needed to produce the scheduled orders. Better coordination with suppliers helps receive materials on time and this can be done by sharing information about company's demand forecasts and production plans with the suppliers. Better internal integration helps transferring information between internal operations, especially regarding new product development and product quality improvement. Better internal integration can be achieved by adapting integrated software platforms, for example ERP systems. Lastly, customer integration can be improved by sharing inventory levels and other information with the customers. This leads to a better information accuracy regarding customer's needs. (Zhao L, et al. p. 120)

Backlog KPI simply follows the current order stock by calculating how much of the received orders are not produced yet. Backlog should be in balance, and too low or too high level should be avoided. (Bscdesigner.com & Stadtler H. et all., 2015 p. 85) Sales organization should always consider the current state of the backlog when promising delivery dates to customers. This is especially crucial in high demand situations, to achieve as accurate lead-time quotations as possible. Generally, in low margin businesses, achieving higher backlog information availability is beneficial, due to the high flow of customer orders. (Slotnick, S. & Sobel, M. 2004)

"Change in sales order" KPI follows the amount of changes done to the existing sales orders. High degree of changes requires higher degree of reactivity from the planning system. (Stadtler H. et all., 2015 p. 489)

Adherence to the plans KPI follows how effectively the plans have been followed. It can measure multiple different type of plans including production, distribution and purchasing. The way to measure adherence is to compare actuals with the plans, for example actual production to the production plans. (bizfluent & de Carvalho A., 2018)

4. ADVANCED PLANNING & SCHEDULING SYSTEMS

Advanced Planning and Scheduling (APS) system is defined by the Association of Operations Management (APICS 2010) as any computer program that performs simulations and optimization for capacity scheduling, sourcing, resource planning, forecasting and many other tasks by using mathematical algorithms and logic. These systems can be used for decision support and real-time planning/scheduling. APS systems can be integrated into company's enterprise resource planning (ERP) systems or work as standalone add-ons. This chapter focuses on describing the characteristics, functionality and benefits of APS systems. Also, the theoretical ways to use APS systems for the Sales and Operations Execution are being discussed.

4.1. System Characteristics

Advanced Planning and Scheduling systems are designed for the long-, medium- and short-term planning processes. (Mauergauz Y., 2016. p. 17) APS planning is based on large amounts of data, and it is highly important to have as accurate data as possible. This is highlighted especially in real-time and finite capacity planning situations. The aggregation level of the data also has an important role on determining how effectively and precisely plans can be done. Lower aggregated data results into more planning objects but can make plans more uncertain due to the complexity of the plans. Also, time bucket size will affect the amount of detail in the plans. Generally, APS systems are constructed out of multiple planning modules. It is important to have a strong coordination between the different modules and planning levels, to have consistent plans throughout the whole supply chain. (Jonsson P. & Linea K., 2007)

APS-systems are often structured to work alongside with ERP-, MES- and other IT-systems. APS-systems usually do not have detailed product, personnel and equipment data stored but instead it is loaded from the ERP-system into the APS. Often the results are sent back to the ERP-system for operational execution. (Mauerqauz J., 2016 p. 16) Therefore, APS systems don't substitute ERP systems, but instead complements them by taking over some of the planning tasks. ERP continues working as an execution and transaction system for the planned orders. APS systems also support better inter-organizational use, compared to ERP systems that are designed more for single firm use. (Stadtler H. et all., 2015, p. 13)

4.2. Functionality

APS functionality is divided into basic functionality, automation and optimization. Basic functionality consists of regular calculations like translating order volume into weight. Also, different planning action consequences can be calculated to support the decision making. Using the automation functionality, APS systems can perform a set of actions, for example using algorithms to create plans and schedules. Lastly the optimization functionality can find the most feasible plan out of all the generated plans and schedules. (Vincent, W. & De Kok, T. 2018)

APS systems can be tailor made systems where mathematical models are created to support customer's needs. They can also be complete commercial systems which often come with a complete mathematical model, and these can be fitted into the company's planning environment without drastic modifications. APS systems are suitable for planning environments where objectives are conflicting and where there are many capacity and material limitations. APS systems support proactive planning and they help planners finding optimal plans and schedules. They can generate integrated plans that result in optimized resource allocation of products, production volumes, transportation and inventories. (Ivert L., 2012 p.98)

One of the main functionalities is the possibility to create scenarios and evaluate them in the APS system. Scenario planning is usually suitable for demand and supply driven planning environments. Customers and suppliers can be integrated within the planning environment, but it is not always possible to receive customer and supplier data that is accurate enough. Scenario planning can be used to find bottlenecks within the production by adjusting different production attributes, e.g. availability, process times and capacities. Scenario planning works as a way to deal with uncertainty, due to the possibility to create several scenarios which reflect different types of future developments. (Ivert L., 2012 p.98, 32, 113)

When implementing an APS system, it is important to look at the trade-off between the plans complexity and generation speed. High complexity results in longer computing times, which may be harmful if plans are generated frequently. (Ivert L., 2012 p. 49) APS systems are usually based on a hierarchical decision-making model. Planning is therefore based in five elements: aggregation, decomposition and hierarchical structure, hierarchical coordination,

model building and model solving. This allows decomposing the planning problems into different planning levels. (Stadtler H. et all., 2015 p. 25)

Every system supplier offers a different variety of planning modules to be integrated into the APS system. These modules are named differently by each system supplier, but they are often similar to each other. Some examples of system modules offered by the suppliers include network optimizer, supply chain planner, supplier visibility and planning, distribution scheduling, transport scheduling, advanced planner and optimizer etc. They usually include what-if analysis and scenario planning features.

The general APS planning module matrix can be seen in the figure 11 and it is divided into the three main planning levels: long-term, mid-term and short-term. APS developers select some of these modules to the main APS system and some of them might be integrated into the ERP system. Different planning modules are divided to the four main operations: procurement, production, distribution and sales. All the planning modules are divided into these main operations depending on their main functionality. Long-term planning consists of strategic network planning and that is used by all the main operations. Mid-term planning uses two main modules: master planning (often referred as supply planning) and demand planning. Mid-term planning modules are used in the S&OP process to create monthly sales plans. (Mayergauz Y., 2016 p 214)

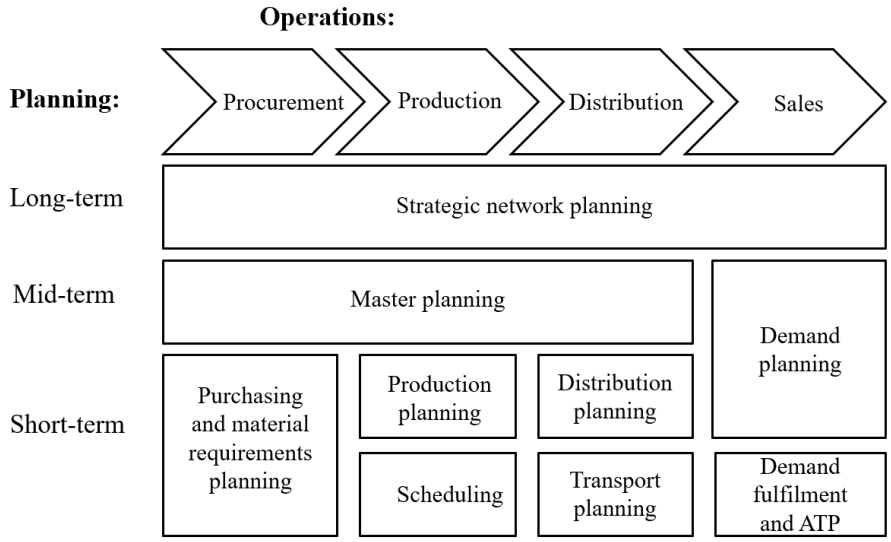

Figure 11. Planning module matrix for Supply Chain (Mayergauz Y., 2016 p. 2014)

Lastly, there are planning modules for short-term planning which include purchasing and material requirements, production planning, scheduling, distribution, transport planning, demand planning, demand fulfilment and ATP functionality. (Mayergauz Y., 2016 p. 214)

Available to promise

APS system can work as a tool to give information to the sales about whether an order can be delivered on time or not. This functionality is called Available to Promise (ATP). ATP's main target is to make more reliable and faster order promises and it is often seen as one of the most favourable features of APS systems. APS system-based ATP uses master production plans to create order promises. This means that order details are compared to the latest MPS plans and inventory quantities, and ATP determines the available lead times for the requested orders. Figure 12 demonstrates how ATP order quotes don't exceed the given MPS plan. ATP is often structured to different dimensions including product, region, market, sourcing type, supply location, time etc. Most important dimensions are however product, time and customer. ATP structure should be constructed to the same level of details as the master plans. (Stadtler H. et al., 2015 p. 179)

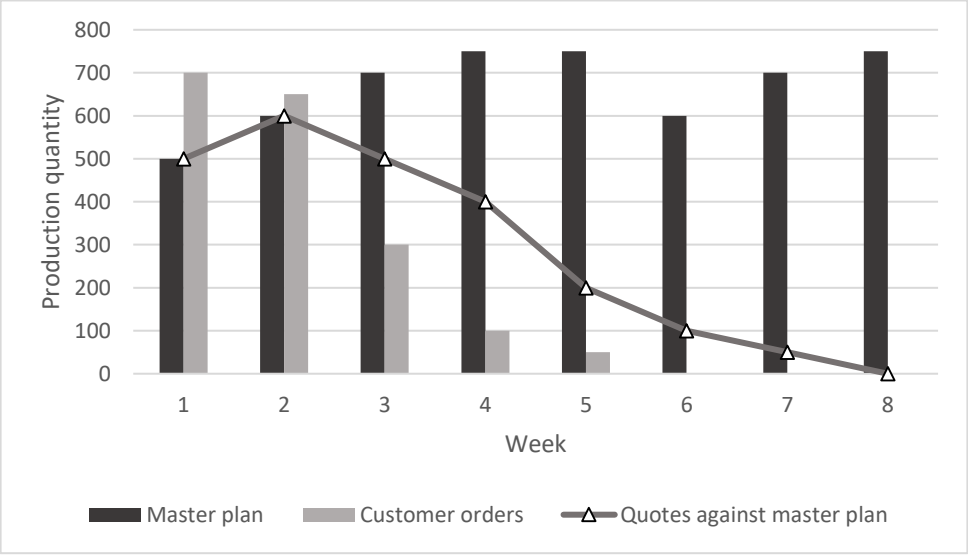

Figure 12. Quoting orders against master plan (Stadtler H. et al., 2015 p 179)

Usually ATP has allocation rules that make decisions on whether the additional demand can be accepted or not. These rules may include having so-called order classes, where the incoming orders are quoted to their own order classes first. If allocation isn't available, it can also be quoted against other order classes according to the business rules. Allocation to

order classes may increase profitability and revenue due to prioritization of higher margin products or customers. (Stadtler H. et all., 2015 p. 178-179, 186) There also exists so-called capable-to-promise (CTP) functionality which takes ATP order promising further by quoting orders to the actual production units and resource availability. Some systems may include constraints that are not production-related, but instead transportation-related, for example. (Gartner)

4.3. Benefits

In general APS systems have been identified to support short-term production scheduling, long-term production and distribution planning and master production scheduling. Using APS systems for these tasks can reduce overtime, inventory levels and planning time. Additionally, it can result into less emergency transport between distribution centres. APS systems also support demand fulfilment, procurement planning and forecast accuracy. (Ivert, L. 2012, p. 39) Benefits of using APS systems for the Sales and Operations Execution can be divided into qualitative and quantitative. Qualitative benefits can be difficult to measure as financial values, but they can still act as a major driver for APS system implementation. (Vincent, W. & De Kok, T. 2018)

One major benefit is responsiveness. This will affect the time spent for creating new plans or changing existing plans. APS systems can increase the availability of information by having the plans visible for all related personnel. This will reduce the amount of inquiries sent to the planning department regarding current plans, and therefore planning departments role as an information hub will be smaller. Naturally valuable time from unnecessary communication will be freed and transformed into the actual planning process. APS system can also increase communication and decision making by having the ability to simulate potential decisions. Better visualization of plans inside the APS will help planners to choose between different scenarios.

APS can help standardize the way of working. This means that planning department can align their practices and training new planning personnel will become easier. Standardization also makes the use of many spreadsheets obsolete, since all planners can work using the same planning system. (Vincent, W. & De Kok, T. 2018)

In many companies lower planning decisions are delegated to different planning levels due to the high complexity of the higher-level planning. APS can be used to centralize some planning decisions, for example by combining material assignment and detailed scheduling together. Higher planning levels also benefit when an APS system is also implemented for the lower planning levels. However, this can also lead to a situation where the people in the lower planning levels feel that the decision making has been taken away from them. They might have different objectives and ideas about the lower-level plans and how they should be conducted. This may lead to a poor adherence to plan, where lower level plans are not followed precisely. In this case even if optimal plan is achieved, it won't benefit company's overall operations. Centralized planning may also cause infeasible plans, where the plans can't be physically executed. Often this is due to an incorrect modelling of the APS system. (Vincent, W. & De Kok, T. 2018)

Lastly, APS based plans can be created by using so-called event-driven planning method. Event-driven planning aims to create new plans after important events occur, instead of planning between regular intervals. This works well for lower level planning, like S&OE, that deals with high demand fluctuation, major order book changes, machinery breakdowns etc. (Stadtler H. et all., 2015 p. 74)

4.4. Key Performance Indicators

For the company to be able to deal with both short- and long-term planning issues using the APS, there should be a set of KPI's (Key Measurement Indicators) defined. These KPI's should be reviewed in every decision point and planning meeting. The KPI's should be decided so that they can be performed with the APS system by using the data that is previously imported to the APS system. After these KPI's are defined and in use, they should be discussed periodically with the people who are involved to the KPI's. For example, the people who are responsible for confirming orders should be discussing about the KPI's related to how well orders are confirmed against the given due dates. When creating automated planning and scheduling systems, there should be clear potential economic value that can be visible through the KPI measurements. These KPI's should be affected when creating plans. Also, it is suggested to create a business case that shows the actual KPI improvement. (Vincent, W. & De Kok, T. 2018, p. 133) Figure 13 illustrates the 3 steps of re-defining KPI's after an APS system implementation.

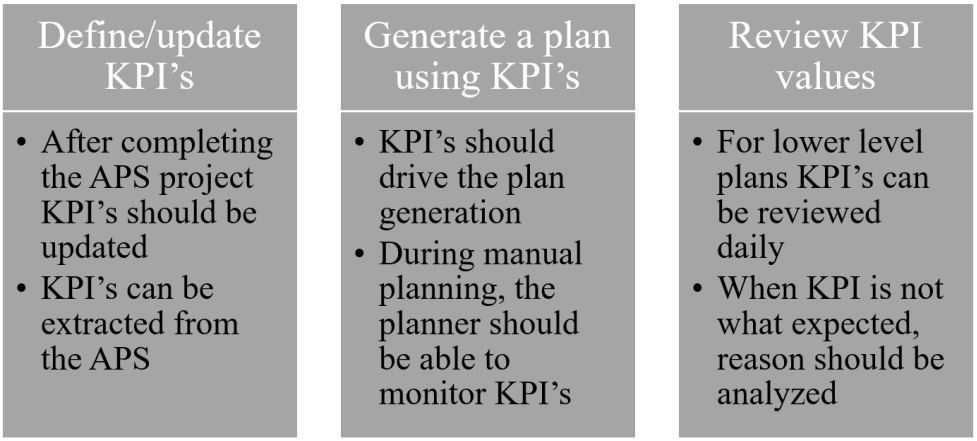

Figure 13. Key Performance Indicators with an APS system (Vincent, W. & De Kok, T. 2018 p. 182)

4.5. Use in Sales and Operations Execution

The S&OE process implementation opens new requirements for the company's IT tools. APS systems that are designed for the Sales & Operations Planning usually fit the need for the Sales & Operations Execution as well. Currently used systems may already be single data model systems and include functionality to integrate S&OP and S&OE planning together. Additionally, companies with an existing system can try to expand its use to the S&OE through a software extension that supports the S&OE process. (ChainAlytics, 2019)

To integrate S&OE planning into the higher-level S&OP planning, the same data model should be used for both planning levels. However, plans should be done on a higher level of detail to create accurate weekly plans. (Adexa) After implementing an APS system, all the planning levels should be analyzed. This includes analyzing the lower planning level, or in this case the Sales & Operations Execution. (Stadtler H. et all., 2015 p. 501).

The reasons for using APS systems for the S&OE planning include higher responsiveness, visualization of plans, better plan follow-up, automatic planning and scheduling, and more accurate demand fulfillment. As mentioned before, APS system can increase the responsiveness of the supply chain and it is especially crucial for the S&OE process, since the process itself is created to respond better to the short-term demand and supply fluctuation. (Ostdick, N., 2017) Companies that use real-time information to handle their S&OE process can add value to their traditional S&OP workflow and reduce its volatility. Real-time information also helps handling the daily operational tasks, like rerouting transport plans or optimizing freight usage. (Brian Hoey, Flexis, 2018)

Visualization of plans for the S&OE process is highly important since plans can be changed rapidly without having an immense amount of work to demonstrate how the change would affect the big picture. (Vincent, W. & De Kok, T. 2018) The S&OE is often followed by using Excel spreadsheets but in advanced supply chains an APS system can be used as a S&OE cockpit. (de Carvalho A., 2018. pp 91) Director of operations at Levi Strauss & Co. explained that they had implemented a common dashboard, that included all the S&OE related reports and KPI's. (Cheng R., 2019)

To follow the plans efficiently, S&OE process should basically have a reporting tool that tracks forecast consumption and raises red flags in situations where forecast has been exceeded. Forecast error reports are often reviewed too infrequently, which means that it is impossible to tell what the reason was for forecast overconsumption. With an efficient reporting tool, i.e. APS system, S&OE process can track the changes and learn about the market and customers. (Elementum/Cheng R., 2019)

As discussed before, the S&OE process includes elements from the MPS process. Often, MPS process can involve representatives from different business functions, but it can also be run as an automated calculation process within the APS system by one person. MPS process needs to be more dynamic due to the shorter planning horizon and it often involves more cancellations and rescheduling than the S&OP process. Part of the MPS process is to give information to the sales function about available capacity and delivery times. This can be done with the APS system by using the available/capable-to-promise functionality. (Ivert, L. 2012, pp. 36) This way there is no need for order promising using supply lead-times and inventory levels, and order promising becomes more accurate. (Stadtler H. et all., 2015 p. 178-179, p. 100)

Vehicle routing and scheduling however can be done with transportation planning modules. They support transportation scenario planning and offer cost structure calculations. Route- or distance-based calculations can be used depending on the operation location. However, in many cases there are no standard structured APS modules for transportation planning in the APS. In that case these tasks are done by using multi-functional modules within the APS. (Stadtler H. et all., 2015 p. 238)

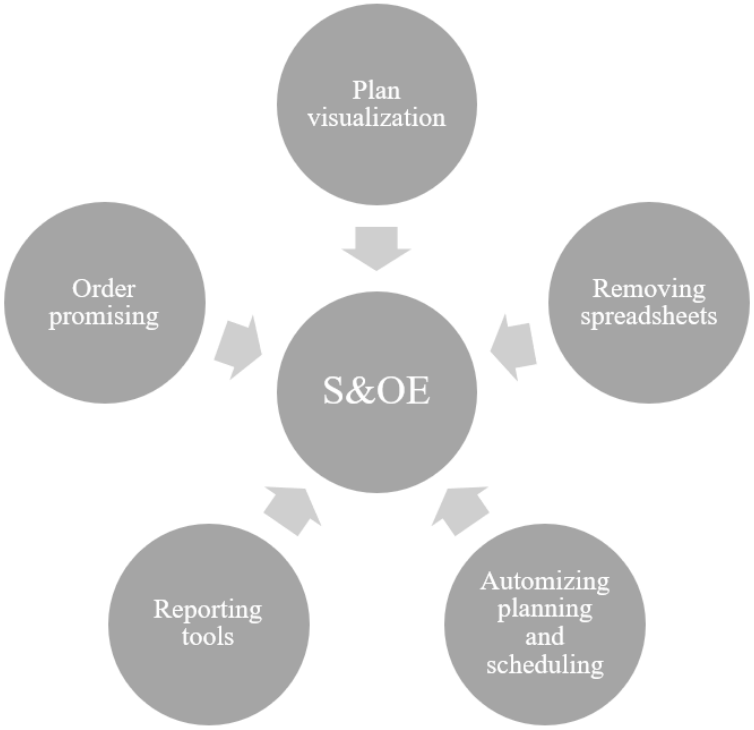

Figure 14. Realization of APS in the S&OE

5. CURRENT PROCESS ANALYSIS

This chapter introduces the case company and studies the current planning environment. It concludes the first part of the S&OE process deployment, which includes stakeholder interviews, performance review and conducting an analysis. First the tactical planning, including the S&OP process, is explained and how it affects short-term planning. Then different short-term planning processes are described in outline and the current problems are identified and analysed. The current tactical planning process (S&OP) has been already developed during the past years and now the company is trying to develop the lower level planning processes.

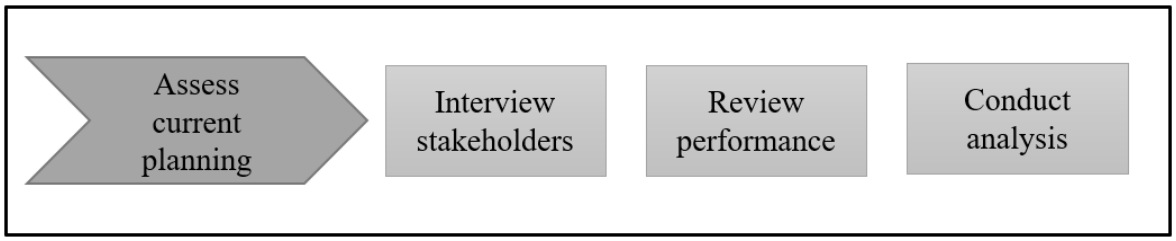

Figure 15. Current planning assessment

5.1. Intro of UPM Plywood

UPM Plywood produces plywood and veneer products for construction, vehicle flooring, LNG shipbuilding, parquet and other industrial manufacturing. UPM Plywood employs over 2500 people within development, manufacturing, delivering and sales. Production only consists of birch and spruce products, and each mill is mainly specialized for producing exclusively either one, with few exceptions. Manufacturing is located within Europe in 3 countries: Finland, Estonia and Russia. The main product is called “WISA Plywood” and it is produced in various shapes and sizes, depending on the end-use. All of the WISA Plywood products are either PEFC (Programme for the Endorsement of Forest Certification) or FSC (Forest Stewardship Council) certified, which are certificates for sustainable and eco-friendly forest products. The production is highly labour- and capital-intensive. (UPM.com)

UPM tactical and operational planning environment consists of 3 business functions; sales, supply chain and production. These functions communicate together to create plans and eventually execute them. However, the supply chain function is ultimately in charge of organizing and confirming the supply and demand plans, while sales and production give

input for the process. Communication between these organizations happen mostly via email, meetings and skype. Case company follows a basic integrated planning process, introduced on chapter 2, but the operational planning process has been based mostly on ad-hoc rules and exception management.

The case company often deals with high demand situations and all demand cannot be always fulfilled. This means that a constrained demand plan needs to be created each month, which is done by using the S&OP process. Therefore, the S&OP process is vital for the company to plan mid-term demand fulfilment. High demand however, also causes short-term demand fluctuation and the company cannot react to these fluctuations effectively by using the S&OP process due to the long planning cycle. S&OP plans are created in a monthly cycle and the S&OE process will aim to follow and modify these plans in a weekly level.

UPM Plywood chose to implement a commercial solution, due to the high cost and complexity of a tailor-made mathematical system. The new system is configured to support both S&OP and the designed S&OE processes. Supplier selection process was executed between 2017-2018 and included several RFP (Request for Proposal) rounds to find a consensus between the project budget and desired system requirements. The main selection criteria included integrated planning platform for demand, supply and inventory management, cloud integration possibility, advanced optimizing and scenario analysis tools and other contract related criteria. Gartner Magic Quadrant research methodology was used during the selection process and several suppliers were evaluated. Gartner Magic Quadrant for S&OP systems of differentiation aims to analyse the market by defining 5 maturity stages for the system suppliers. Total of 13 key capabilities are used to determine the maturity of the systems. (Gartner)

Gartner Magic Quadrant for S&OP systems of differentiation key capabilities:

1. *Support for multienterprise environment*
2. *Ability to manage hierarchy within the system*
3. *Process management*
4. *Integration to supply chain planning system of records*
5. *Integration to other systems of differentiation*
6. *Supply chain modelling that supports scenario planning*

7. *Scenario planning and management*
8. *Solution configurability*
9. *Support for global deployment/use*
10. *Financial planning and impact analysis*
11. *Performance management and analytics*
12. *Simple user experience*
13. *Project planning*

One of the main reasons for implementing the APS system was that the current planning systems didn't support business decision evaluation tools. The systems also did not consider production efficiency, and inventory management was done with manual tools, i.e. using Excel. S&OP and S&OE planning included a lot of manual work in the sales, production and supply chain organizations. Also, the current planning system support was ending. Main goal of the APS implementation is to make these processes more efficient and increase the Gartner MQ maturity from level 2-3 to 3-4.

5.2. Tactical planning process

The tactical demand and supply planning process is run in a monthly Sales & Operations Planning process. The overall process generally follows the theoretical S&OP process steps introduced in the chapter 2.2. with some exceptions. The process is already supported by the previously implemented APS system but will be replaced with the new system soon. The process starts by collecting data from the sales organization regarding the future sales. Sales organization enters demand figures on a product and customer level. Statistical forecast is created for the items that the sales organization have not forecasted manually. Statistical forecast is created with the help of a supply chain analyst team.

Capacity planning is the third step and it includes a meeting where the mill managers and the supply chain organization creates an aggregated plan on how much capacity each mill has for the planning period. These capacities are disaggregated to daily level. After the sales and the capacity planning are done, supply chain planners create a scenario proposal and this scenario is reviewed in the fifth step along with the sales management. Sales management gives recommendations for possible changes and supply chain planners make possible changes before the last step. In the last step, executive S&OP meeting is held where all the

different business functions present their current state status. Supply planners present their scenario and the plan is confirmed during the meeting.

During the demand planning process a consensus demand forecast is created from 3 to 6 months ahead. For example, the plans for April to August are created in January. The supply planning process is done after the demand plan is created and the aim is to optimize the production to fulfil customers' needs as effectively as possible. Sales plans are disaggregated to SKU-level, but they are only handled in a monthly time-bucket. These plans are loaded into the reporting system with the current order stock. Therefore, it is used by all the related business functions to track forecast consumption in different aggregation levels.

Product hierarchy

Product hierarchy in UPM Plywood consists of 4 levels: main product group, detailed product group, main product and planning item. The main product group consists Birch, Spruce and Veneer. These are further divided into detailed product groups to help separating planning from different types of products. For example, one group can be all the regular sized birch products produced in Finland and Estonia. Main product level includes the main product attribute which is often separated by the type of Plywood being produced. This group includes for example Wisa Trans products that are sold to the vehicle flooring industries. Lastly all these main products are divided into planning items where the plywood sheet size is the main attribute. Each planning item has an attribute type which determines whether the item is an MTS or MTO product. S&OP plans are currently taken into the planning item level.

5.3. Operational planning process

The operational planning process is currently mostly an unstructured process where certain repeated tasks are being executed each month. These tasks include disaggregating MTS-plans to weekly/daily level and generating the orders. Also, daily adjustments to sales plans are done to allocate orders to production mills that are missing sales plan. However, this is done without any help of planning systems. MTS-orders are usually created each month for the next 1-2-month planning period depending on the current situation.

After the release of S&OP plans, MTS-plans are disaggregated to weekly level by supply chain specialists that communicate with sales organization and production planners to find a consensus on how to place the orders. Often this means that the monthly plans are divided by 4, using spreadsheets, and then possibly agreeing them once with the sales. Small changes may be done to the plans on a planning item level. After this, the plans are sent to the production mills where specific ex-mill dates are given by production planners. An ex-mill date is a date when the shipment should be ready to leave the production facility. Most of the deviation concerning plans happens on the demand side. The supply side of the operations is mainly constant, except for maintenance breaks and mill holidays. Occasional breakdowns happen in the production, that cannot be planned beforehand, and they are handled case-by-case without structured processes.

Operational planning is handled with two individual meetings. First one involving production and supply chain members and the second one including sales and supply chain members. Supply Chain weekly meeting with the production planners is held weekly where the capacity utilization is reviewed, and other ad hoc topics are discussed. Capacity is reviewed by analyzing order stock, capacity reservations, free capacity and production capacity in weekly level for the next 3 months. During the supply chain weekly meeting, production planners inform delivery times by product and 12-week orderbook length in days. Ad hoc topics often include possible production issues, maintenance breaks, etc. The planning meeting is held every Tuesday and the attendees includes supply chain managers and specialists and production planners from each mill. Usually a representative from the wood procurement is also present during the meeting to discuss about the raw material availability. This meeting does not include representatives from the sales organization. Also, the only official KPI reviewed in this meeting is the current backlog as a 12-week order book.

Sales management meeting is held biweekly where a variety of operational topics are discussed together with sales and supply chain organizations. In turn, the sales management meeting doesn’t include representatives from the production, which means that the operational issues are always handled through the supply chain organization. Sales orders are generally entered for the following month onwards and all the sales orders need to be

entered into the system by 21st of the ongoing month. After this, they will be accepted only in a case of additional sales plan available.

Currently the only operational KPI used is backlog which is reviewed every week with the production planners. The KPI tracks the 12-week order book in days and compares it to the backlog history. Backlogs are presented by each mill during the weekly meeting, and after the meeting they are processed into a yearly chart that includes values from the past five years. This information is shared among the top management, mill managers, sales management and other various people within the organization by email. However, sales organization is not taken into the meetings where the backlog is reviewed. Forecast consumption is used as a tool for sales to see how much plans are left for customers for the planning period. These charts aren't reviewed during the current operational meeting, as they are made after each meeting and share via email.

5.4. Identified challenges

To create a new Sales and Operation Execution process, all the current process challenges need to be defined. Some challenges were found during the interviews from all the business functions. These challenges included lack of performance follow-up, non-standardized disaggregation process, disconnect between sales and production plans, and inability to perform plan optimizations in a weekly basis.

Commitment

The Sales & Operations Planning suffers from different levels of commitment from the sales organization. Statistical forecast is used in these situations and it might differ from the real-life future demand. This means that the plans imported to the S&OE process are not as accurate for each item and customer combination, and it often causes disconnection between plans and reality.

Demand planning

High demand situations often cause demand fluctuation and changes needs to be done in short notice. Currently these changes cannot be evaluated in any type of metrics or scenarios. For this reason, most short-term demand plan change decisions are done solely by relying on the expertise of the sales and supply chain specialists.

Disaggregation

The MTS-plan disaggregation process is not standardized and differs vastly between products, stocks and customers. This leads to an inefficient plan disaggregation process. This may cause unnecessary communication and sometimes even same work being done twice by two different people. For example, MTS-plans are already disaggregated to SKU-level during the S&OP optimization cycle, but some items are re-disaggregated after the release of S&OP plans. It is often also uncertain whether the supply chain specialist has an autonomy to confirm the plans without sales organization input. Sometimes disaggregation is done by the sales organization and sometimes it is done by the supply chain organization.

The S&OP plans are also already taken to SKU-level and as discussed before, S&OP process should only handle aggregated volumes. Because of this, the monthly plans are too detailed, and a lot of changes are needed during the S&OP's 3-month frozen planning period.

Master planning

The Master Production Scheduling (MPS) isn't connected to the S&OP plans in the current planning environment. Most of the MPS plans are created by sending the existing order book from the ERP system to the MPS. Therefore, the MPS-plans mostly consist of sales and purchase orders that are already entered to the system by the sales and supply chain organizations. Only exception are the LNG-orders, which are entered to the MPS as reservations according to the ongoing S&OP plans. These plans are communicated via supply chain specialists to each production mill, to ensure that there is production capacity reserve left for each LNG-order. This doesn't apply to regular sales and refill orders which may cause problems with executing the S&OP plans.

KPI's

The operational KPI follow up is rather narrow and not reviewed frequently among the operational business functions. The only KPI included in the weekly meeting is the backlog. The sales organization is not present in this meeting, therefore backlog information is only shared via email. The KPI follow-up should be redesigned for the S&OE process and potentially supported by the APS system.

6. PROCESS DEVELOPMENT

This chapter formalizes the solution design and discusses how to use the currently implemented APS system to benefit the S&OE process. This chapter works as second and third S&OE process implementation steps, which are; design fundamentals and design S&OE process. First, the S&OE fundamentals and S&OP process changes are defined by applying the S&OE framework introduced in the theory to the case company's operational planning process.

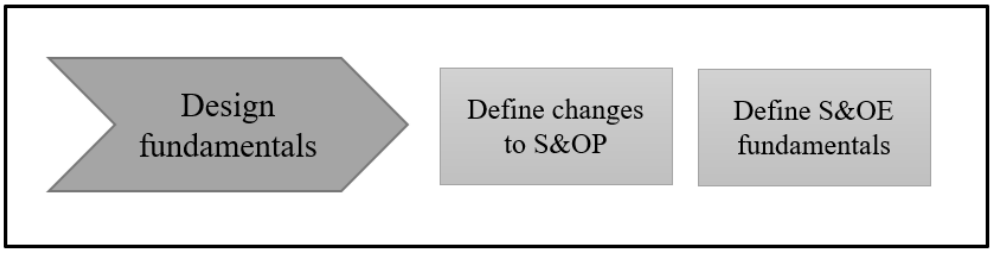

Figure 16. Design fundamentals

After that, the planning processes and cycle are defined in detail and the processes are portrayed graphically with BPMN (business process model and notation) models. Possible data requirements are discussed as well. Lastly, the S&OE meeting and KPI follow up are defined and the meeting participants and their responsibilities are being discussed.

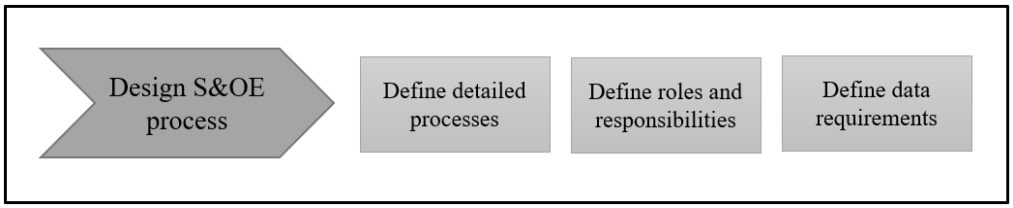

Figure 17. S&OE process design

6.1. PROPOSED FRAMEWORK

The conceptual framework for the S&OE process in this thesis is an altered version of a multi-case study of the Sales and Operation Execution process that was completed in 2018 in the University of São Paulo. The study compared the S&OE processes in 5 different industries and formalized the process into detailed process models. The study concluded the process into five individual steps, and these S&OE steps were also presented in the literature

review. However, only three steps are selected to the case company's S&OE process and the process steps included are: disaggregate plans, evaluate opportunities and define fulfillment. In this proposal, it is assumed that all the key capabilities of the APS system are in use, as described in the Gartner Magic Quadrant.

The order generation and confirmation process steps are not included in the proposed S&OE process, since they are already handled as a separate daily operational execution by the company's business operators. The different planning tasks on each level are presented in the figure 18 and it represents how the planning detail varies between different planning levels. S&OP handles plans in monthly time-buckets and the S&OE in weekly time-buckets. Operational Execution turns these plans into daily buckets when the orders are generated and confirmed.

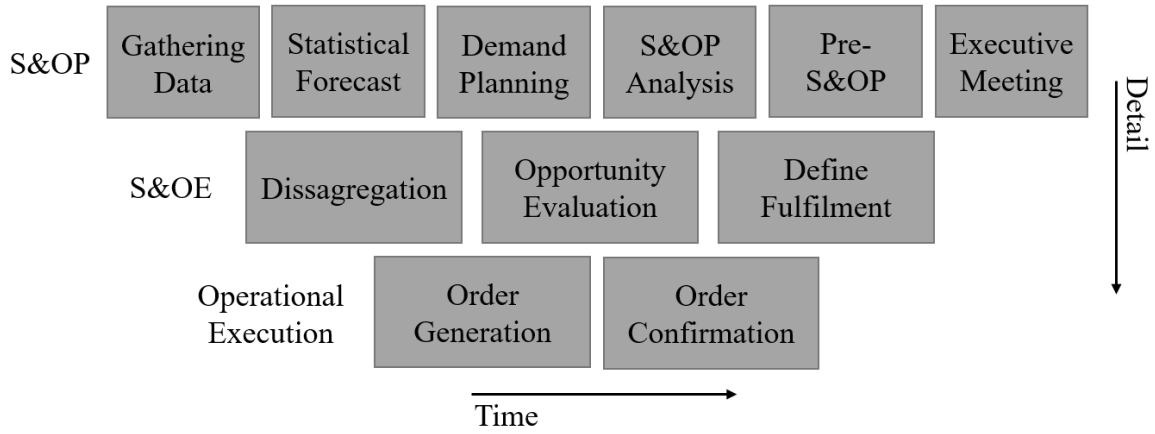

Figure 18. Case company integrated planning levels

Plan disaggregation is done periodically for the sales plans in the beginning of each month. The S&OP sales plans are used as the baseline for the plan disaggregation and they are exported from the APS system in the end of each S&OP cycle. After that, the disaggregation is done by the supply chain specialists. When disaggregation is done, sales organization reviews these plans and request for alterations. Then these plans are validated in the S&OE meeting together with the production planners. Therefore, plan disaggregation is one of the S&OE meeting topics during the first week of the S&OE cycle. Opportunities are evaluated in a weekly level by running the optimizer, after the production data from the previous week

has been imported. This means that forecast is netted and reconciliated, and then plan is optimized.

The orders that are missing sales plan are being evaluated by the supply chain organization. They can give order promises by using the ATP functionality by simulating the scenarios of additional demand. The S&OE analyst will also analyze the current performance and prepare a presentation for the S&OE meeting. In the last phase, the S&OE meeting is performed where all the decisions are reviewed. Some decisions may have to be evaluated one more time together with the sales and production attendees. Also, all the necessary S&OE KPI's are reviewed in this meeting.

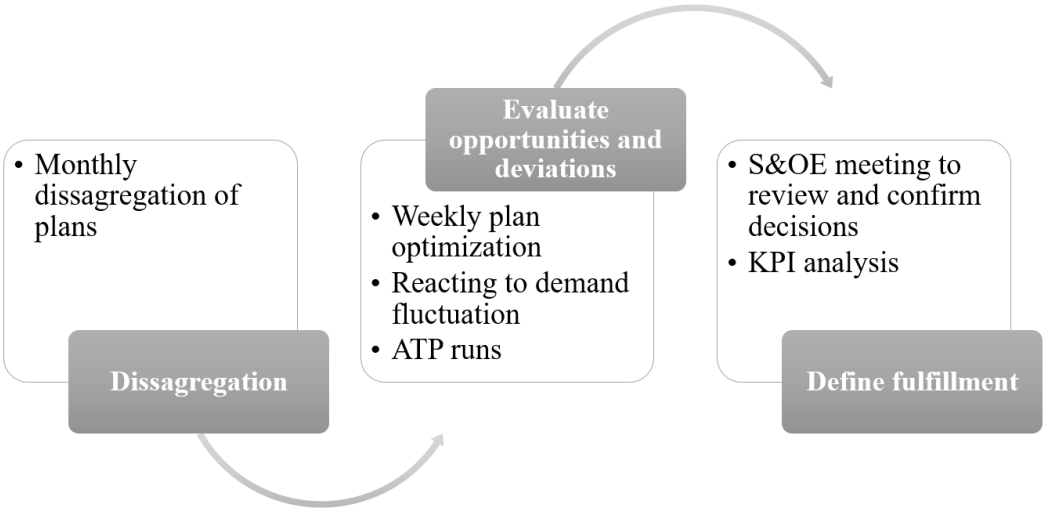

Figure 19. The S&OE process

The Advanced Planning and Scheduling system planning modules/functionalities chosen to support the S&OE process include available-to-promise, short-term demand planning, production planning and transport planning. Demand, production and transport planning modules work together to optimize plans in a weekly level.

6.2. Process Cycle

The S&OE process cycle consists of monthly and weekly tasks. Figure 20 illustrates the monthly S&OE calendar that includes tasks on a weekly and monthly level. The process runs smoothly alongside the S&OP process and starts immediately after the aggregated plans from the S&OP process have been validated and released. Weekly tasks include demand and

supply plan optimization, KPI analysis, S&OE meeting and ATP runs. Each week starts by running demand and planning optimizations after the last weeks actuals have been imported to the system. The ATP runs are also done alongside the optimization. Each week concludes into the KPI analysis which is presented in the S&OE meeting. During the S&OE meeting, possible new short-term demand and supply plan scenarios are discussed and ultimately validated. Plan disaggregation is a monthly occurring task and it happens during the first week of each S&OE cycle.

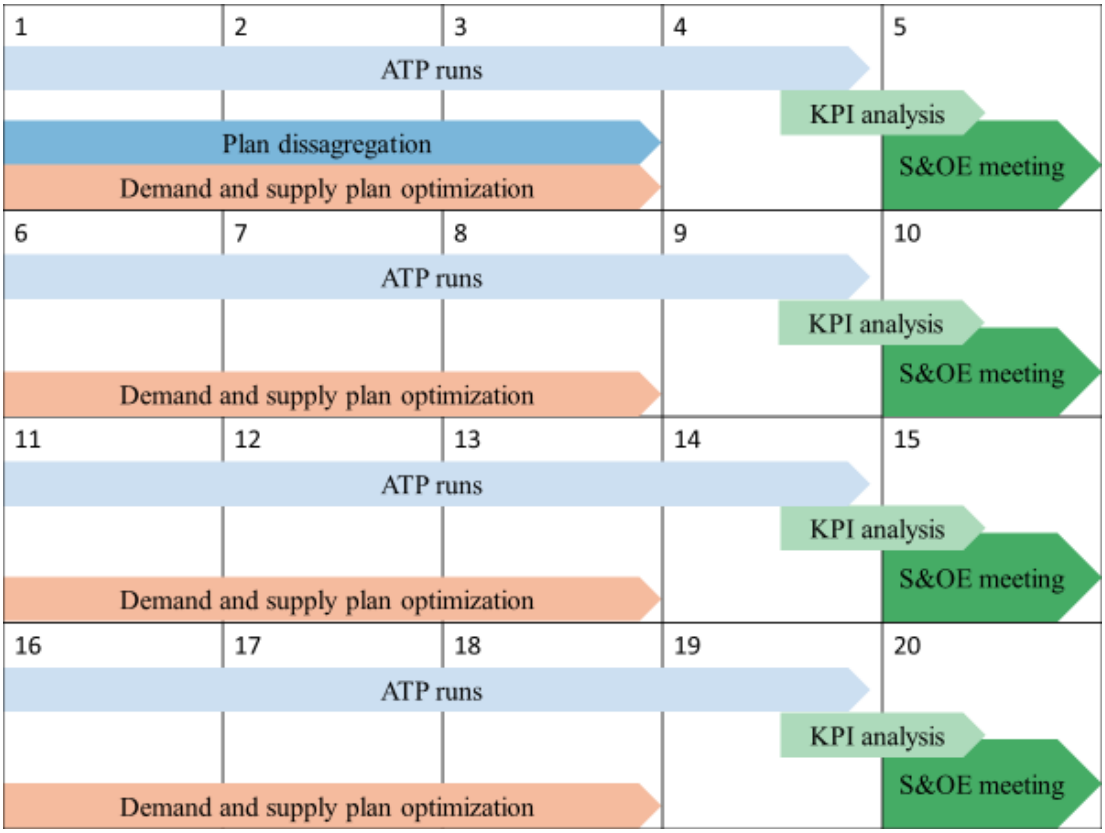

Figure 20. Monthly S&OE process cycle

6.3. Detailed Process

In this chapter, the S&OE tasks are described in detail and presented with BPMN process models. Also, the relationship with the APS system is being discussed and presented in the process models. The main process model is presented in the figure 21, which shows that the first week of the cycle starts with the disaggregation step. Weekly process includes evaluating opportunities and deviations and finally defining fulfilment.

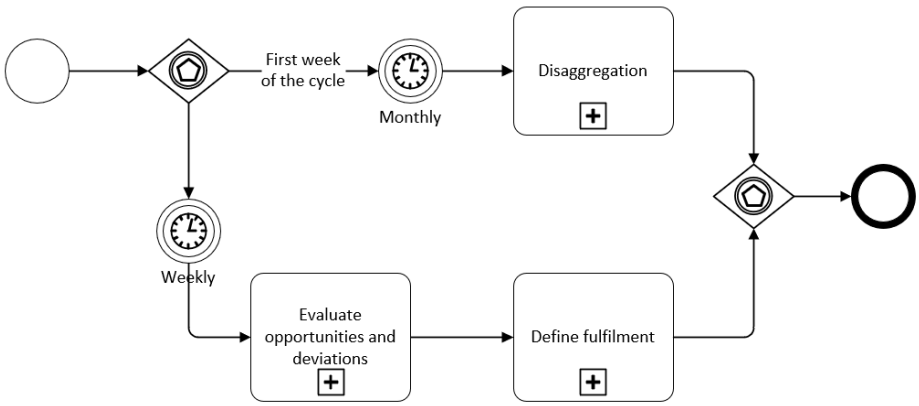

Figure 21. S&OE process model

6.3.1. Disaggregation

The MTS-plan disaggregation consists of supply chain, sales and production organizations. Supply chain organization oversees plan disaggregation and communicates together with the sales and production organizations to receive input regarding the short-term demand and supply fluctuation. Process starts by importing the monthly MTS-plans from the S&OP cycle. These plans are disaggregated according to their product group A or B. Sales organization will review group B plans and request for possible alterations needed and supply chain organization reviews these requests and either accepts or declines them.

Next, all the plans are sent to the corresponding production mills and ex-mill dates are generated by the production planners and sent back to the supply chain organization. Plans are validated and confirmed. If plans cannot be accepted, they are sent back to disaggregation phase and they are being discussed with the sales and then re-sent to the production until they are confirmed. Process output is a file that consists of all disaggregated MTS plans for the planned month. APS system should be used to disaggregate plans, which helps to get rid of unnecessary use of spreadsheets.

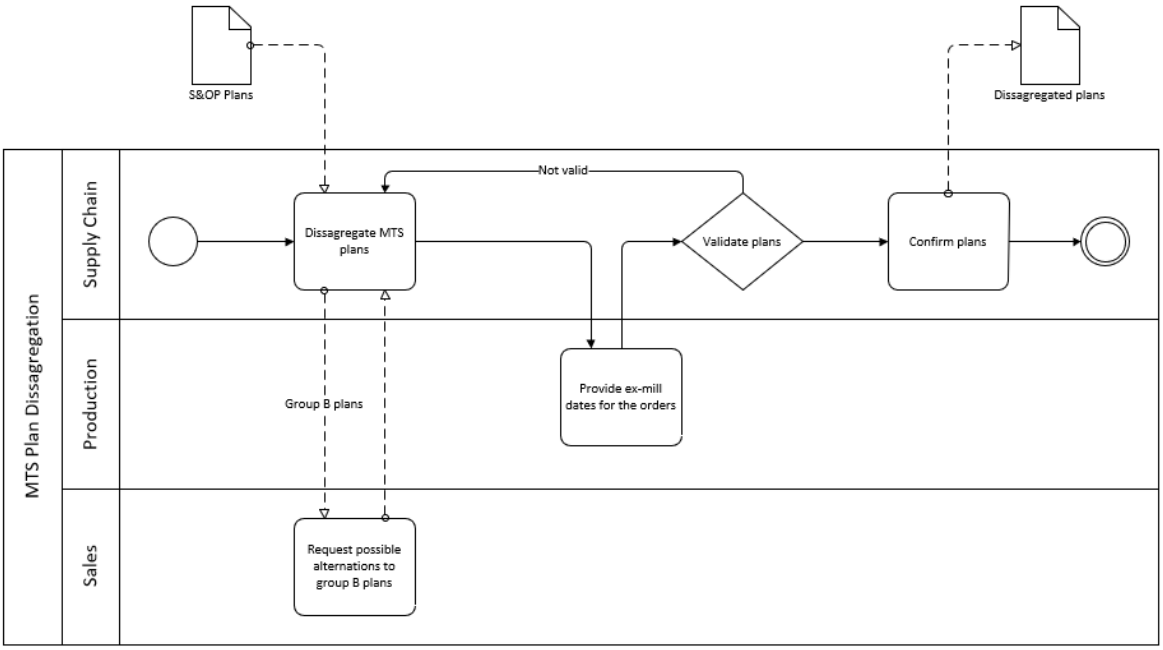

Figure 22. MTS-plan disaggregation

The sales plan, that was created in the S&OP planning cycle, is already disaggregated to product level. So, the S&OE process only consists of time-bucket disaggregation from monthly to weekly level. However, the S&OE process has the autonomy to make changes to the product level plans, but they need to be reviewed and confirmed by the supply chain organization. MTS-plans are disaggregated to weekly level by the supply chain specialist responsible for the MTS-planning. This is done each month after the release S&OP sales plans.

Disaggregated MTS plans are done differently depending on the product and stock. Some MTS products have a steady demand and some products have a high demand fluctuation. Most orders are disaggregated to weekly level by simply dividing monthly sales plan by 4. The rest of the orders are communicated with the sales to balance short-term demand fluctuation. To separate these planning practices from each other, they are divided into 2 planning groups: A and B, see Table 3.

Table 3. AB-analysis for MTS items

Group	Group A	Group B
Demand type	Low demand fluctuation	High demand fluctuation
Autonomy level	Autonomy to confirm plans without sales organization input.	Plans needs to be communicated to sales organization and alterations done accordingly, if possible.
Disaggregation type	Monthly plans are divided by 4 to achieve weekly MTS plans. In case of demand changes, sales organization is responsible for informing and requesting changes to the plans.	Weekly plans are being proposed by the supply chain organization and confirmed by the sales. In case of short-term demand changes, sales will make corrections to the plans which are then confirmed by the supply chain organization. Lastly production planners will confirm these plans and/or request changes to them. They will also provide the corresponding production ex-mill dates.

The MTO-order time-bucket disaggregation is done by the sales organization according to the customer demand. Sales organization receives orders from the customers and sends them to the ERP system accordingly. Sales representatives need to follow the given monthly sales plans and the product lead-time reports, that follow the available capacity for each product group. If capacity and sales plan are available, orders are set to the requested customer due date. In case that sales plan is missing, orders are sent to the "Evaluate opportunities" step, where additional demand is tested by using the APS systems ATP-functionality.

6.3.2. Evaluate opportunities and deviations

The evaluation of opportunities and deviations includes the short-term demand, supply and transportation planning processes. Process step is divided into weekly optimization and ATP runs. They consider the short-term demand fluctuations, by taking into account the current order stock and by having the ability to test additional demand with the ATP functionality. This process step is based on event-driven planning and may change depending on the short-term demand and supply availability.

The weekly optimization run starts by importing S&OP plans as a baseline and the production actuals, including inventory levels and current order stock. Current forecast is netted by using the order stock figures, and after that the forecast is also reconciliated.

Forecast netting is part of the process where forecast quantities and order stock are separated. This is done because the confirmed orders are always handled as a priority, and therefore changes into the confirmed sales orders are not wanted during the optimization. Changes to the forecast are therefore done only into the demands that are not yet confirmed as actual sales orders.

Forecast reconciliation in this case is a process where the order stock is used to estimate whether the demand forecast will be reached or not. Reconciliation is done for each demand item and the forecast is then evaluated and validated. Supply chain planners can either choose to use the netted or the reconciled forecast depending on the current demand situation. If order accumulation can be predicted for a certain item, the forecast accuracy can be increased using the reconciled forecast for the given sales plan. Reconciled forecast is calculated in a main product and customer level and disaggregated to planning item level. Reconciliation is done separately for MTS and MTO items.

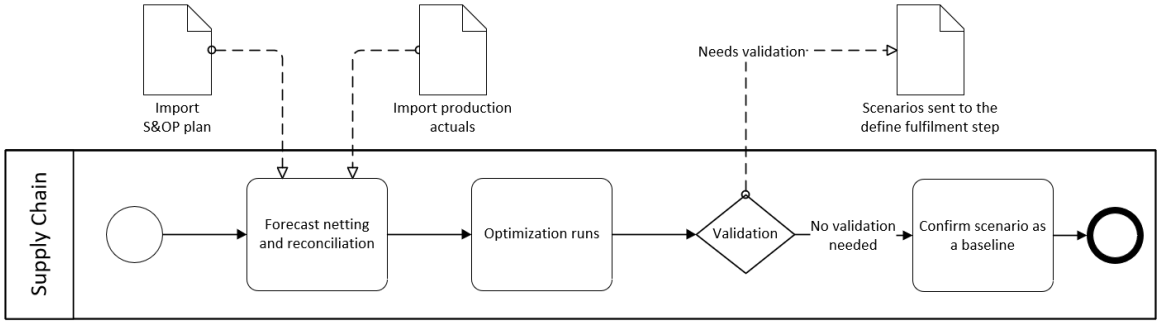

Figure 23. Weekly optimization runs

The ATP functionality is used to test whether the orders without sales plan can be accepted as an additional demand or not. The ATP implementation allows the S&OE process to generate order promises for customers by quoting orders against the weekly updated inventories and supply plans. Using the ATP, it is possible to give order promises that are faster and more reliable, since they are reflecting the actual planned production. Latest supply plan is utilized when doing ATP runs.

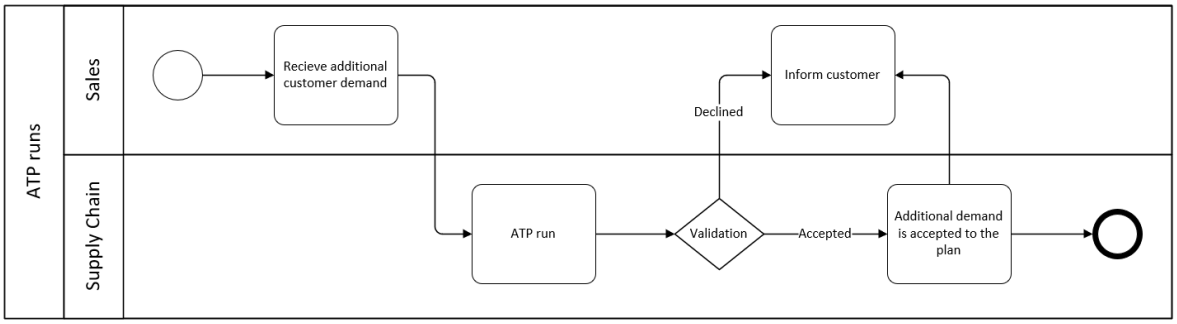

Figure 24. ATP runs

Due to deviations in demand, there might be an additional demand available and this can be tested with the ATP by creating a new scenario that includes the additional demand. The ATP process is used in cases where additional sales orders are needed to be accepted in a short notice. Supply chain specialists and managers can use this functionality to test scenarios where additional sales demands are added to customers. These decisions and their consequences are reviewed in the weekly S&OE meeting, if needed.

S&OE supply planning process is run in a weekly cycle. The supply plan uses monthly S&OP plan by taking the previously planned scenario as a baseline for the weekly S&OE plan. Data needed for the short-term supply planning process is imported to the APS system daily, except the netted and reconciliated forecast is imported weekly. Daily data includes updated order stock, inventory levels and produced quantities. The supply plan is run in the optimizer and updated supply plan is send to the ERP and MPS systems each week. Therefore, this weekly plan works as a baseline for the master plan. Supply plan also creates a baseline for a transportation plan since transportation capacity in most cases isn't limited. Is there is limitations needed, constraints are added to the supply plan. Due to MTS-orders being generated once a month, there is no reason to optimize inventories each week. Optimization therefore consists of demand and supply plan balancing.

6.3.3. Define fulfilment

The define fulfilment phase consists of the S&OE meeting where all the previously analyzed opportunities are defined and the weekly plan is confirmed. The S&OE meeting is set up where opportunities, deviations, fulfilment definitions and prioritization are discussed and evaluated. This meeting discusses the short-term demand and supply topics that cannot be

handled by the supply chain team alone. The meeting is part of the define fulfilment phase, which is the last step of the S&OE process. The main goal of each meeting is to analyse how effectively plans are being followed.

Each week during the monthly cycle, a new separate topic is also analysed. Topics are introduced later in this chapter. Weekly meeting is the last part of the weekly S&OE process, where many weekly process details are being reviewed and analysed. Weekly meeting is held in the end of the week so that the optimization runs and the KPI analysis have been already done. This way the meeting participants also can get the best view of the current week and changes can be done for the following week.

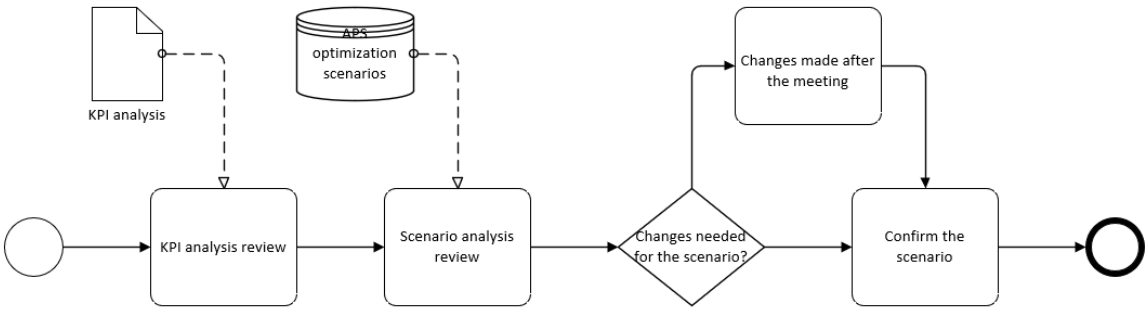

Figure 25. Define fulfilment process

S&OE meeting

S&OE planning team is a cross-functional team that consists of participants from various business functions. Participants include S&OE leader, analyst and few coordinators from different business functions. The leader oversees the short-term plan alignment and is part of the supply chain organization. The leader is also making the final decisions and allocates all the open tasks to the participants. Analyst prepares and presents the KPI analysis for the participants.

The coordinators include participants from sales, supply chain and production. The participants from sales give information about short-term demand changes. This includes possible new demands, order cancellations and other discussions with the customers. The participants from the production give information about possible delays or other supply

issues that may cause poor adherence to the plan. Sales area leaders can participate the meeting by themselves or assign a other participant from the sales area.

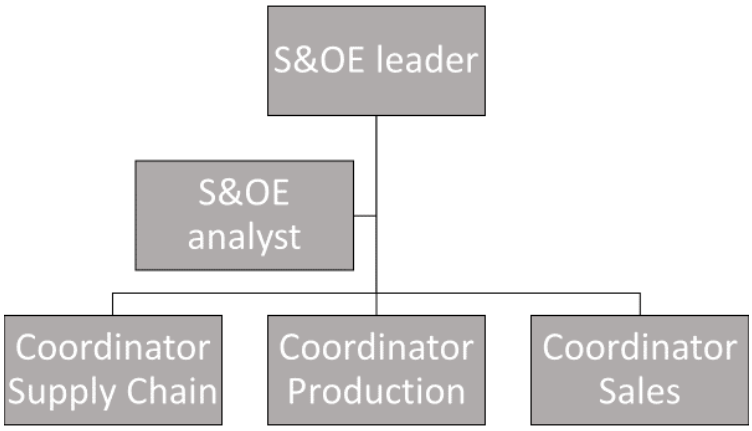

Figure 26. S&OE meeting participants

The S&OE meeting preparations include sending meeting invitations to each participant and this is organized by the S&OE leader. The S&OE leader also prepares the topics that needs to be discussed in the meeting. The analyst will import the data needed for the KPI's, calculate and analyse them. The analysis will be presented in the meeting for the participants and shared to the relevant sales, production and supply chain personnel after the meeting by email.

The KPI's selected for the S&OE analysis include: forecast consumption, backlog, schedule attainment and adherence to sales plan. Each meeting includes a weekly optimization review and validation. Additionally, as proposed by many companies that implemented S&OE processes, there are separate meeting topics for each week. Meeting topics are chosen depending on the current situation in the monthly cycle.

1. Meeting:

Weekly topic for the first meeting is the plan disaggregation. After plans have been disaggregated and set to the given production weeks, they will be presented for each production planner and the sales organization. Production planners and sales representatives

can request for changes or accept the given proposal. After the meeting, changes will be done, and the refill plan confirmed. Meeting is structured by handling each stock at a time. Coordinators from sales include one or more people who are responsible for handling the given stock. Sales representatives inform about the short-term demand fluctuations and production planners inform about how the capacity should be utilized in each mill.

2. Meeting:

Weekly topic for the second meeting is the capacity follow up. The MTS-orders are already entered to the system for the following month, and the remaining capacity is left for the MTO-orders to fill up the order stock. This is valuable information for all participants to know how much sales plan is left for the customers and how much capacity is available for these sales plans. Adherence to sales plan is measured in this meeting and possible actions are discussed in case of supply or demand shortage. In case that there is less MTS-orders entered into the system than planned, sales plan can be released for any possible additional customer orders. Demand shortages can be simulated with the APS using forecast reconciliation. In case of demand and supply changes, new values are entered to the APS system and optimization is being done.

3. Meeting:

The forecast consumption is the third meeting topic as all the sales orders for the next month are entered by 21st of the ongoing month. Therefore, all the plan that was not used previously can be released for additional sales orders. In an optimal situation, all the sales plan should be used by this time for the following month, but as it is likely to have short-term demand fluctuation, this leftover capacity should be aligned with the additional demand. It is important to communicate these figures for sales to receive orders as soon as possible before next month's production starts.

4. Meeting:

By this time, all the available sales plan should be allocated to customers for the following month. The last weekly meeting focuses on overseeing all the metrics of the currently ending month and analysing how well plans were executed. This is the best moment for learning about the changes in operations and preparing for the following month.

6.4. KPI analysis

Key Performance Indicators are defined for the S&OE process to deal with the short-term planning issues. KPI's are being reviewed and presented by the S&OE analyst during the end of each week in the S&OE meeting. This allows the managers to still make decisions for the following week. The meeting works as a platform for discussing these operational KPI's and how to improve the operational performance. KPI's also drive the weekly short-term supply and demand plan generation.

Only three KPI's are selected for the weekly follow-up to keep the focus in the relevant short-term planning issues. KPI's selected for the S&OE process are: backlog, forecast consumption and schedule attainment. All these are also presented visually, so that the S&OE meeting benefits from a better visualization of these KPI's. If possible, S&OE KPI analysis should be implemented into the APS system to have a common dashboard that updates metrics automatically every week. This way there is no need to manually calculate KPI values and use spreadsheets for the KPI reports. Also, all the reports would be always available for the S&OE process participants in the system.

Figure 27. Common S&OE dashboard in the APS

Forecast consumption:

The forecast consumption is the first KPI included in the weekly S&OE meeting and it is calculated for each mill separately. Since sales organization cannot send orders to the ongoing monthly period, the forecast consumption only considers the next month. Consumption is presented as a value and percentage. They give information to the mills about the orders yet to be received for the given planning period. Forecast consumption value is the amount of sales forecast left for the given production mill. Forecast consumption percentage is the forecast consumption as a ratio of the current order stock and forecast on a weekly level. Additionally, the aggregated total forecast consumption can be reviewed in the meeting. Forecast consumption comparison is illustrated in the figure 28. This helps managers to allocate resources more evenly to different production plants and realizing the current state of received sales orders. If distribution is uneven, actions should be considered to even the order stocks between production plants.

$$\frac{Weekly\ order\ stock\ m^3}{Weekly\ forecast\ m^3} * 100\ \% = Monthly\ forecast\ consumption\ \%$$

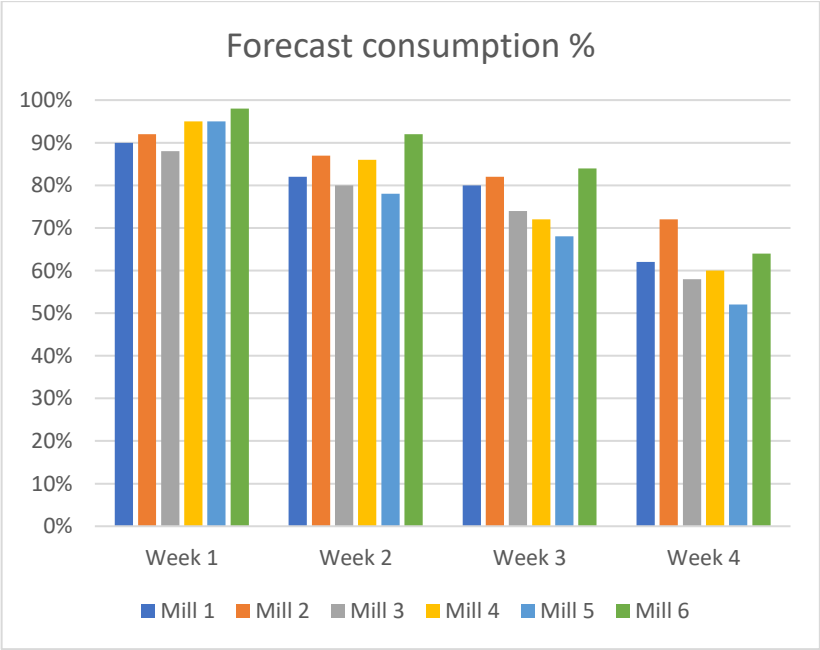

Figure 28. Forecast consumption % for 6 production mills

Backlog:

Backlog KPI had been already implemented previously but some changes are needed to make follow up more efficient. The backlog follows how much of the received orders are yet to be completed. The backlog is provided by the production planners for each mill as a 12-week orderbook in days. The S&OE analyst will gather this information into a chart that represents the orderbook development during the past year. This chart is presented during the S&OE meeting individually for each production mill. In case of high imbalance between different production mill backlogs, order allocation changes should be considered.

Backlog is calculated as the ratio between 12-week order stock and supply plan multiplied by 84, which is the amount of days in 12 weeks. Figure 29 illustrates the backlog development for one production mill during last 12 weeks. Comparisons in this case are done periodically for the past 3 years. Similar figure should be presented as a comparison between production mills.

$$\frac{12\ week\ order\ stock\ m^3}{12\ week\ supply\ plan\ m^3} * 84\ days = 12\ week\ orderbook\ in\ days\ (backlog)$$

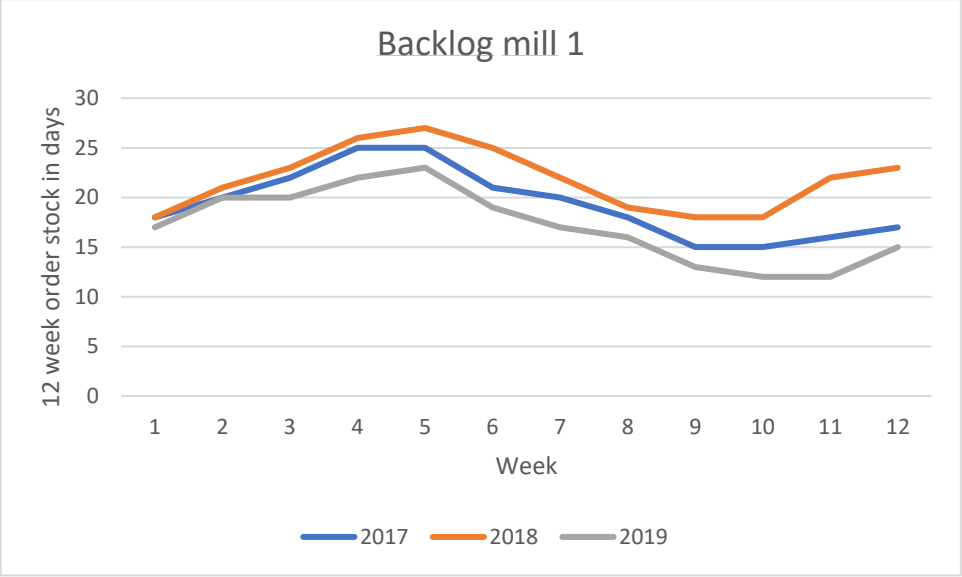

Figure 29. Backlog visualization example

Schedule attainment:

The current case company's planning process doesn't include official schedule attainment follow up, but it is often presented by the production planners verbally. Schedule attainment follows how well the production is currently being able to follow the production plans. In this proposed solution, schedule attainment is actively followed as a value and percentage metrics. Value represents the amount of produced cubic meters that were left out from the production target. For example, if the production during past 7 days was 800 m3 and the target is set to 1000m3, the KPI value is 200 m3. Schedule attainment ratio is calculated dividing the actual production with the target production. If schedule attainment decreases remarkably, the S&OE team should focus on finding the reasons for the misalignment, which are often related to changes in production. Figure 30 represents the schedule attainment percentages between 6 production mills.

$$\frac{Actual\ production\ in\ m3}{Target\ Production\ in\ m3} * 100 \equiv Schedule\ Attainment\ \%$$

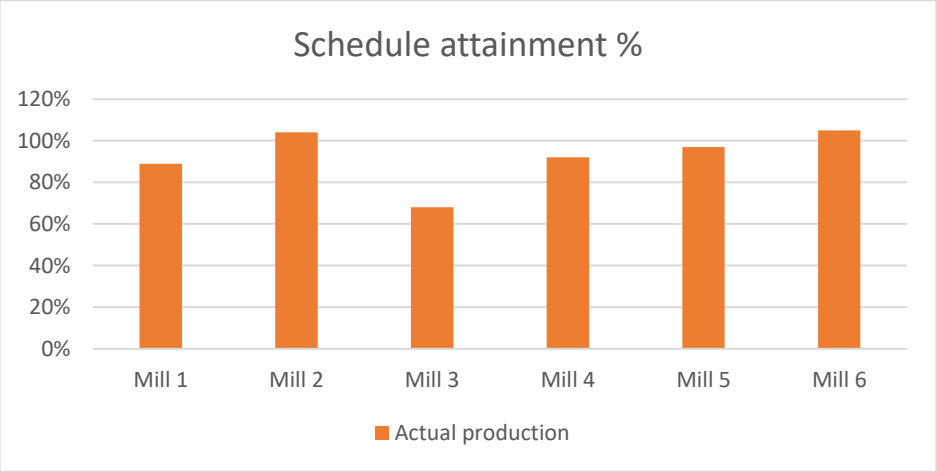

Figure 30. Schedule attainment %

7. CONCLUSIONS & SUMMARY

Objectives of the thesis

The main objectives for this thesis were to design a Sales & Operations Execution process for the case company and find ways to use an Advanced Planning System to benefit the designed process. The theoretical part focused on defining the S&OE process and the characteristics of an APS system. Also, the connection between these two were discussed. This was done by researching written material regarding APS systems, and both S&OP and S&OE processes. Empirical research process was conducted by using the general scientific research framework introduced by Van Ake, van der Bij and Berends. The process steps included defining the problem, analysing and diagnosing the case company and creating a solution design. The empirical study was conducted by using the case company's available material regarding planning processes and with unstructured employee interviews.

Theoretical findings

Sales & Operations Execution is a process that aims to connect Sales & Operations Planning into the operational execution of these plans. It reacts to deviations of both demand and supply in a disaggregated level and aims to benefit the company's service level, plan integration, revenue, flexibility, inventory levels and cost reduction. The S&OE process consists of the same dimensions as S&OP process, including demand planning, inventory management, supply planning, manufacturing planning and transportation planning. However, they are managed with more detail and the focus is on a 0-12-week horizon. The general S&OE process framework divides the process into 5 steps: disaggregate plans, generate and program orders, confirm orders and evaluate opportunities and deviations and lastly define fulfilment. The process includes participants from production, sales and supply chain. The S&OE meeting is generally held weekly or biweekly and the participants include S&OE leader, analyst and coordinators from all business functions. The S&OE process generally runs in a weekly cycle alongside with the S&OP process.

The APS system can be used by planners as a communication tool to simulate potential decisions. This can make decision making easier in planning meetings, because plans can be visualized for other attendees. For example, planners can simulate a situation where additional order is placed into the production and how it affects all the previously planned orders. APS systems can be used in the S&OE process and benefit the process. APS system

can help visualizing the short-term plans and, thus making it easier to communicate plans throughout the supply chain. The system also helps getting rid of commonly used spreadsheets, as the planning and reporting can be transferred into the system. Order promising steps includes the ATP functionality that helps the company to achieve faster and more reliable order promises. Automatized planning and scheduling can help planners adjust the plans in a short notice, and therefore react better to short-term demand fluctuation. Lastly, APS system works as a common reporting tool and this way all the process participants can have the same S&OE related KPI's, plans and reports visible.

Current process analysis

Current process analysis concluded the main activities for tactical and operational planning levels. The case company is using the Sales and Operations Planning process to generate tactical plans. S&OP plans are already disaggregated to SKU-level in the S&OP process and these are executed in the operational level. The S&OP process itself includes various lower level planning tasks and the S&OP meetings often includes discussion about short-term planning issues. Plans are sent to the informal operational planning process where the focus centralizes mainly on finding ways to allocate additional demand to the production plants. Case company is currently implementing a new APS system to improve their ability to create mid- and short-term plans. Case company selected a commercial software solution due to a high cost and complexity of implementing a tailor-made system.

Operational planning process consists of using S&OP plans to generate and confirm customer and stock refill orders. Plans are disaggregated to daily buckets by sales and supply chain organizations after the release of S&OP plans. Identified challenges included the disconnect between S&OP plans and production plans. KPI review is rather narrow for operational planning process and the indicators are not reviewed together with the sales organisation weekly. Disaggregation is done differently depending on the related customers and inventories, and sometimes disaggregation to SKU-level is done twice. This causes additional workload for the supply chain planners.

Proposed solution

The case company was currently implementing a new Advanced Planning and Scheduling system solution and it was necessary to analyse the current planning processes and redesign the processes to fit the new planning system. Proposed solution included defining the S&OE process activities and the use cases of APS systems in the defined S&OE process. To highlight the benefits of using APS in the S&OE process, also the consequences were discussed.

S&OE process activities

The proposed solution answers both research objectives. The S&OE process runs in a monthly cycle and includes process steps that occur in both weekly and monthly basis. Three steps were selected to the case company's S&OE process and the process steps are: disaggregate plans, evaluate opportunities and define fulfilment.

The Disaggregation step includes importing the sales plan from the S&OP process and disaggregating these plans to the weekly level. Disaggregation steps occurs during the first week of the monthly cycle and includes participant from supply chain, sales and production. The opportunity and deviation evaluation occur each week during the S&OE process cycle. It includes optimizing the supply, demand and transportation plans using the APS system. Lastly, fulfilment is defined by confirming the selected optimization scenario during the weekly S&OE meeting.

The weekly meeting occurs each Friday and includes attendees from sales, production and supply chain. Topics vary depending on the week but basic KPI analysis and optimization review is executed each week. Topics include order disaggregation, capacity follow-up, and forecast consumption review. The KPI analysis is executed by the S&OE analyst and reviewed together with all the meeting attendees. Attendees include personnel from sales, production and supply chain. Sales give input regarding short-term demand fluctuation. Production aims to inform about possible changes in the production, including maintenance breaks and machinery breakdowns. Supply chain attendees include a leader, an analyst and other coordinators. They together with sales and production aim to define fulfilment for the weekly optimization.

Use of APS in the S&OE process

Multiple different end-uses were found for the APS system in the case company's S&OE process. These include supply, demand and transportation optimization, ATP-functionality and KPI follow-up. Benefits include better order promising, ability to visualize and atomize the plan creation, and a common reporting tool that removes the use of spreadsheets. APS systems role in the S&OE process is especially vital in the weekly process steps. Optimization runs can be done using the APS systems scenario planning tools and this way the S&OE process can better adjust the short-term demand and supply deviations in to the actual plans. These plans can be used as a base for the Master Production Plans, and this helps reducing the disconnect between the S&OP and the Operational Execution.

Future recommendations

As discussed in the chapter 3.1.1, S&OE process development consists of assessing the current planning environment, designing fundamentals, designing the process, developing solutions and deploying the S&OE process. As this master thesis has focused on the first three steps, the case company should focus on the last two. These steps include developing the IT tools to support the designed process. As this is currently being done during the APS system implementation, there is no need to focus on designing the tools but rather find the best ways to use them. Also, education of employees is an important step during the solution development. See figure 32 for the following implementation steps.

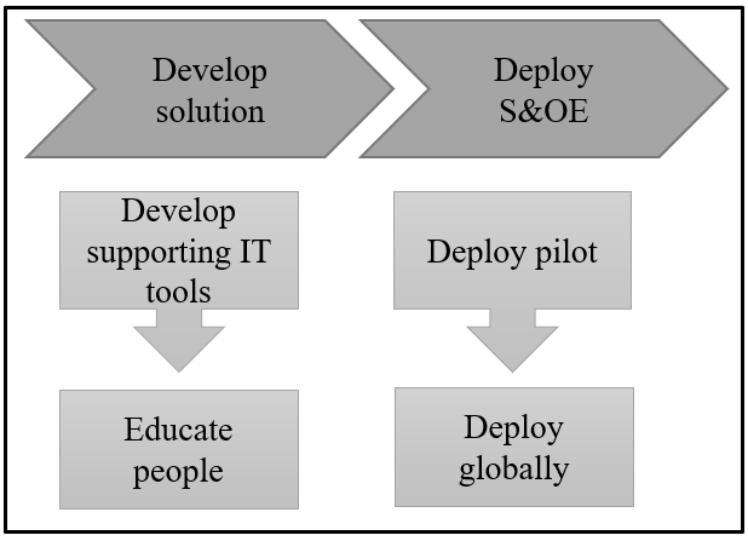

Figure 31. Future development steps

The process deployment phase should include deploying a pilot process to test if there are changes needed to the systems, processes, roles, data requirements etc. After piloting the solution, it can be deployed globally for all business units and operations.
The case company should look into creating a customized S&OE dashboard that includes all the given S&OE related KPI's and plans. This helps keeping the focus on important things and centralizes the information to avoid people viewing different versions of the S&OE related KPI's, plans and reports. It should be also discussed, whether disaggregation to planning item level is necessary in the S&OP process, and should it be moved into the S&OE process.

As discussed in the theory, a KPI implementation based on an APS system consists of defining KPI's, generating a plan using KPI's and reviewing KPI values. The first step is already covered in this thesis, and the case company should proceed to the last two steps. A plan should be created using these KPI's and the values should be reviewed in a weekly, or even daily basis. If the KPI results are not expected, actions should be considered.

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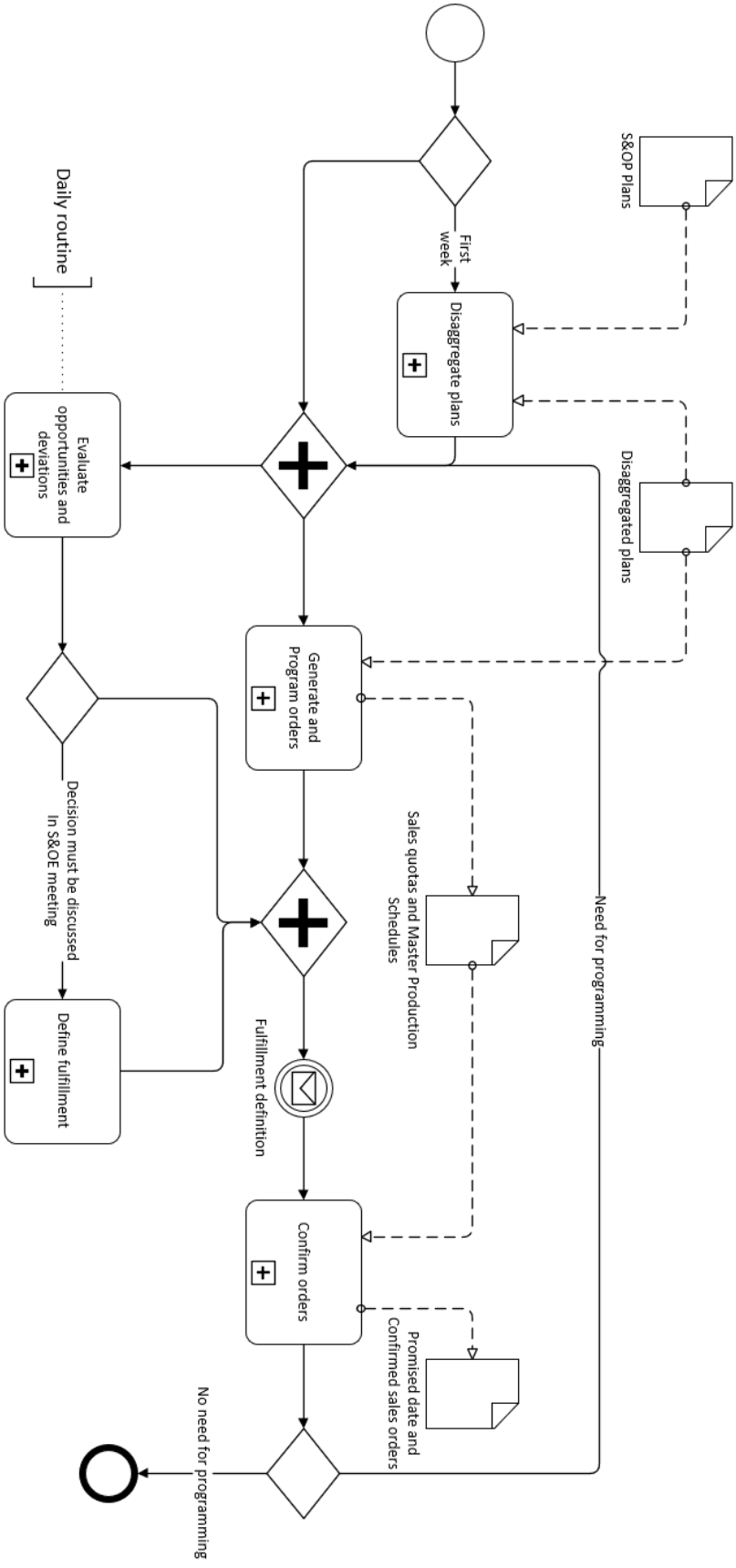
Heikki Kujala. Manager, Supply Chain, UPM Plywood. Interviews during summer 2019.

Appendix 1. BPMN model of S&OE process (de Carvalho, A. 2018)



Appendix 2. S&OP Maturity (Mendes, P. 2018 p. 125)

Level 1	- No formal S&OP process - Meetings formal agenda and participants - No tool to support S&OP - S&OP results not clear - No support from the senior management - Standard metrics are not discussed
Level 2	- Formal process in use - Weekly S&OE meeting - All functional areas participate in the meetings - Plans are reconciled to generate operational plan - Senior managements support - S&OP tools in use - Standard metrics reviewed
Level 3	- Additionally, separate plans for push and pull volumes discussed - Demand signals shared for all functional areas - Standard metrics discussed, including forecast accuracy, working capital, demand error, total supply chain costs
Level 4	- S&OP is part of the organizational culture - Ad-hoc meetings for demand changes that require attention - S&OP process has effect on inventory reduction, profitability and customer service - Meeting ownership is shared for all functional areas - Collaboration with customers and suppliers to get extra information - "What if" demand shaping capability that evaluates revenue, profitability, customer service and working capital
Level 5	- Supply plan aligned with key suppliers and demand plan aligned with customers - Advanced S&OP tool integrated with suppliers and customers IT systems - Opportunities are evaluated with event driven meetings - Senior management uses S&OP as a main tool to align supply chain with suppliers and customers

Appendix 3. S&OE KPI's

Key Performance Indicator	Use in S&OE	Formula
Forecast consumption	Core KPI for most planning systems. Calculates how much of the forecast is consumed by actual planned orders. (Suryadevara S., 2018)	Forecast consumption % = (Total actual demand) – (Forecasted demand) * 100 %
Schedule attainment	Ability to execute the production according to the plans. Approved production schedule should be implemented. Changes in production should be always monitored to find the root cause in case of poor schedule attainment. (TaskManagementGuide)	(Actual production output in units / Target production output in units) * 100
On Time in Full	On time KPI reflects on how well the MPS plans reflect the reality and how efficient and accurate are the delivery and logistics. It consists of two parts: on time and in full. On time can refer to production cycle, agreed response time or requested delivery time. Delivery in Full refers to the situation where customers receive the order with the same amount as in the order. (QPR)	On Time in Full = (Cases matching the criteria)/(Total number of cases) On Time = (Delivery time) – (Confirmed delivery time) In Full = (Delivery amount) – (Confirmed amount)
Backlog	Sales backlog calculates how much sales orders have been received but not yet completed. High backlog often means a high customer demand and financial stability in the future. There has been a research that states that a healthy backlog	Backlog = Total open orders as of measurement day / Orders closed per day

	ranges between 1 day to 2 weeks. However, this varies highly depending on the business. Lower backlog may be a sign of decreasing demand or increasing performance (Bscdesigner.com). High backlog may reduce customer's trust in the company. (Stadtler H. et all., 2015 p. 85)	
Change in sales order	If there is a high degree of change in sales, planning system reactivity should be high enough. If not, it may result in lost sales and excessive finished goods inventories. (Stadtler H. et all., 2015 p. 489)	Order changes = (Number of order changes)/(Total number of orders)
Adherence to production plan	Adherence to production follows how effectively production plans are followed. Adherence to plan can be also measured with multiple different variables. These include production, distribution and purchasing plans. (de Carvalho A.)	Adherence to plan = (Scheduled Production – Actual Production)/Scheduled Production