University of Twente

Master Thesis Assignment

Assessing Uncertainty and Risk in 12-Month Tactical Planning for a Company Experiencing Hypergrowth

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Management Summary

During this research we developed a framework to assess risk and uncertainty for the tactical planning process for 12 months with NX Filtration. This company produces different types of membrane solutions for filtering, focusing on Direct Nano Filtration Membranes, which is a breakthrough technology. As a result of this technological breakthrough, the company has grown rapidly over the past couple of years and is currently experiencing hypergrowth, expecting an exponential growth of production to facilitate the hypergrowth. The company has created a strategic plan to position itself for this hypergrowth. A tactical planning process, to determine the right tactical actions to realise this strategy is lacking at the moment. The goal of our research is to provide a structure for the company to improve its tactical planning process. This is done by researching three main pillars: A rolling forecast of the cash flows, innovation, and performance measurement. A literature study is performed to design our framework, followed by a thorough analysis of relevant company processes. Based on literature and findings, we propose a structure to manage the S&OP cycle. The structure aims to present a manageable and structured cycle, involving all relevant inputs to create the right tactical planning within the strategic direction of the company, creating a comprehensive approach with hypergrowth.

Our research starts with an analysis of the current situation of the company. The main mode of tactical planning is the S&OP process, which was recently introduced in the company and therefore still immature. To achieve a higher level of maturity for this process we investigated three pillars. Starting with the construction of a rolling forecast, this forecast incorporates all cash flows related to the company's S&OP process, adding analyses of the production process resulting in improved recommended safety stocks and a recommendation regarding customer order decoupling point.

The next step is a decision framework regarding product and process innovation. The goal of this framework is to align the current mode of innovation management with the S&OP process, incorporating innovation in the tactical planning. The third step is a performance measurement and evaluation framework, making the S&OP process circular and easier to manage throughout the organisation.

Finally, with the insights and outputs generated, we designed a framework, using Enterprise Architecture Management. This starts with a framework analysing the current situation of the company. The model presents four layers: The overall process, the responsible person/department, the business processes, and the application layer. We developed a new structure based on the findings, the current situation, and the literature. The main process is based on five steps: Data gathering, demand planning, capacity planning, pre-S&OP meeting, and a final executive S&OP meeting. In the pre-S&OP meeting, multiple scenarios are evaluated, incorporating the currently excluded departments: finance and R&D. Our framework is made cyclical via performance measurement and evaluation. The cycle should be repeated on a monthly basis, with an underlying weekly rhythm. This results in a closed-loop process that repeats itself on a monthly basis. To make the cycle operational, weekly performance meetings should be held to align tactical and operational planning.

Key conclusion of this investigation is that in a situation of hypergrowth, our proposed framework can be used to assess the risk and uncertainty of the company and manage the future growth. For our research key elements of this framework are: working with a rolling forecast, a multidisciplinary approach, assessing multiple scenarios, and a closed-loop performance system.

Key Words

Tactical planning, S&OP, SIOP, Cash flows, Inventory Management, Customer Order Decoupling Point, Working Capital, Innovation, new product introduction, new production process introduction, Decision tree, Performance Measurement, Cycle, Framework.

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In front of you lies my thesis: Assessing risk and uncertainty in a 12 month tactical plan for a company experiencing hypergrowth. With the completion of this thesis, my time at the University of Twente has come to an end. Over the last two years, I have had the pleasure to fulfil my master program in Industrial Engineering and Management specialising in Financial Engineering and Managment, after a Bachelor's program in Industrial Engineering at Eindhoven Unversity of Technology.

I got the opportunity to write this thesis in a very rare environment, which NX Filtration has as they are currently experiencing hypergrowth. NX Filtration originated in 2016, with the groundbreaking Direct Nanofiltration (dNF), which has been growing rapidly over the past couple of years. With its strong ESG profile and groundbreaking technology, NX Filtration provided a very special and interesting environment for my master's thesis. I would like to express my gratitude towards all involved NX Filtration Employees, for providing data, having meetings and providing a supportive environment during my project. I especially would like to thank my supervisor, Marc Luttikhuis for providing this assignment and guiding me through the project.

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1 Company

1.1 Company Description

NX Filtration produces different types of membrane solutions for filtering. The goal of the company is to give a solution to provide clean and affordable water for all. Currently, NX Filtration sells 8 types of different filtering membranes, focusing on Direct Nanofiltration Membranes (dNF). In this type of water filtration is based on a unique, nano-based technology, with very specific advantages. The company wants to provide a solution for clean water, for both drinking and other purposes. Shortages in water are a worldwide challenge, and the need for water is a worldwide problem. NX Filtration offers membrane solutions that filter water, capable of selectively removing organics from polluted water, including micropollutants, color, antibiotics, PFAS, bacteria, and viruses. This filtration system is a module consisting of multiple bundles consisting of membranes, resulting in a solution that treats wastewater for reuse. This groundbreaking solution offers the world a different option for reusing polluted water, a green solution as it can be re-used completely and has to possibility to be connected to current existing installations easily. This fully fits the company strategy, which is to provide environmentally friendly solutions for providing clean water to the world. Due to the high potential of the solutions the company offers and the expected exponential demand for water filtering solutions, the company has the potential for hypergrowth.

NX Filtration is still a fairly new company that originated in 2016. Over the past years, the company has already shown serious growth, resulting in more than 8 million annual sales in 2022, targeting 18-22 million sales in 2023. To enable this growth, timely investments are necessary. To fund necessary investments NX Filtration became a stock-listed company in 2021. This listing resulted in funding of 150 million in capital for investments in the company's future growth. The goal of growth for the company is assessed by the commission of new global water markets and a further rollout of full-scale projects. One of the first tangible and visible investments is the new factory in Hengelo, for which construction has started. Planning is to commission the new factory from 2024 on. Besides that the company rents a location that will be used as a distribution centre, to hold fast-moving stock items. Currently, these logistical tasks are outsourced. Alongside the exponential growth, the company is increasing its global presence and is growing internationally. This growth and internationalisation of the company require fast changes and further professionalisation of the organisation and processes. The main company goal is to provide a solution to offer clean and affordable water for all with the use of the dNF solutions. Currently, the company is not making any profit as the company is still sub-scale and needs to invest in further growth. As the organisation is growing and professionalising, the company is aiming at making a profit in the mid-term future, and for the long term, the company foresees a further increase in value creation, based on exponential growth.

The company was originally organised into four departments: Sales, Technology, Operations, and G&A (general and administrative). In 2023 another department has been added: the supply chain department. This department has the responsibility to control the end-to-end value chain and reports to the director of operations.

The company has made a strategic plan for the coming 5 years, expecting hypergrowth. On a tactical level, the company needs more insight into risks, uncertainties, and financial resources, to make sure the hypergrowth can be managed properly. This is the background of this thesis. Our research focuses on the entire value chain of the company and is given by the board of the company. The focus of the research is to create insight and improvement on a tactical level, with an assessment of risks and uncertainties, from a financial point of view. To create these insights, the inputs and outputs are used by the entire organisation.

1.2 Current Situation

In this section, we describe the current situation and directly involved departments regarding the planning process. This gives insight into the current methods used, and the problem context of the company. The goal of the project is the development of a tool making the tactical planning decisions visible in the planning process of the company, by assessing risks and uncertainties. All described aspects are in the scope of this research, and directly affected by the research.

1.2.1 Demand Forecast

The company divides its demand forecasts into two different types. The sales budget, on which the long-term planning is based, this long-term planning is the main source for the monthly S&OP supported by the second type the Hotlist and sales funnel. The demand forecasts within the Hotlist and sales funnel are reviewed weekly.

The demand forecast is the first input for the S&OP. The forecast is based on two components; the backlog orders and a forecast for the sales. To define a proper forecast the outstanding sales should be translated into a demand forecast, which is used as an input to determine the number of products that need to be produced. Sales of the company are registered in Salesforce. This is a customer requirements tool in which, the progress of an opportunity is processed. At the start of the year a budget for sales is defined, this budget shows how many products the company should sell over the upcoming year, based on the already known sales opportunities complemented with an indication of what sales opportunities are expected and the capabilities of production. Sales are divided into multiple departments each corresponding to a region, whereas each region has a responsible director. To make a proper forecast of the sales for the upcoming year, a sales budget for 2023 has been made by the company. In this sales budget, the expected sales are a cumulation, based on estimations of each sales department, relying on opportunities of sales and backlog. These inputs are used for the long-term planning process of the company.

In Salesforce, the progress of the sales is processed, into multiple steps, to which a percentage is connected. This percentage is presented as the progress percentage. A second percentage is given per sale, these percentages are based on the number of boxes that need to be checked. Based on the number of boxes checked the system derives a second estimation of the progress. The percentages of the progress and the checked boxes should be approximately the same, to make an as accurate as possible prediction of the possibility that the opportunity ends in a sale. However, due to the hypergrowth, the expected amount of sales is hard to predict and percentages proved to be incorrect in the past. This is the reason that the company introduced the Hotlist, as mentioned above. This Hotlist is a list of opportunities, that is checked, by only a limited amount of people, to enhance the authenticity of the opportunities on the list. To make sure all Hot opportunities make the Hotlist, orders that have high percentages are checked more frequently and when they have a high progress percentage but are not checked as Hot, an explanation should be made why this is the case. The company is working on improving the precision of these percentages, making it possible to track progress and interpret demand based on those, making the Hotlist unnecessary. Historically, the manually constructed Hotlist has been a better indicator for the demand forecast. However, the practical implication of the Hotlist is currently lacking due to the limited number of people being allowed to check the Hotlist. Due to the limited number of authorised people, when some have other duties and no time to monitor the hotlisting of items, the hotlisting of items is lagging, which has negative results for the planning and forecasting, as the Hotlist and backlog items are used to align the short term production capacities with demand.

To improve insights into forecasts of the opportunities and customer fulfilment, the company introduced bi-weekly meetings. These meetings are hosted with all sales directors, focusing on the dynamics between backlog, sales funnel and Hotlist. The goal of this meeting is to achieve better insights into the visibility of the progression.

1.2.2 Order Entry

As stated above, the progress of the sales is tracked in Salesforce, which is discussed later on in this chapter. The concept of the company is that when a request for an order is made with a new customer this all goes via the original equipment manufacturer (OEM). The company does normally not have direct contact with the customer. The OEM runs a pilot phase with the new customer. This pilot consists of a smaller concept of the demanded filtering system, to test whether the product fulfils requirements. After successful completion of the pilot phase, the full order is produced. This process has a relatively long time span, meaning that potential orders are already known by the system long in advance. However, as the company is maturing and potential customers become familiar with the products of the company, direct orders of full-scale projects, also known as repeat projects are received by the OEM. These orders are not always known long in advance. The final and third type of order that is currently coming in, are replacement orders. These orders are predictable as module replacements are necessary each couple of years, between 3 and 5 years depending on the project. This means that the company has three different types of orders, with all very different levels of predictability. Figure 1 derived from the 2022 annual report, gives insight into the current situation regarding the pilots, which continues into demos or full-scale projects and the replacement orders. Showing the number of projects for each category, the goal for 2023 is the establishment of more full-scale projects, also replacement projects are occurring more regularly.

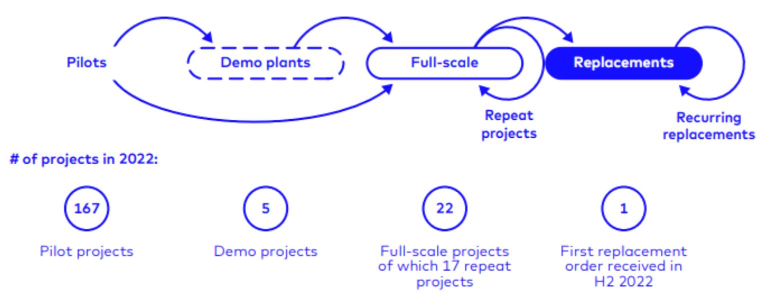

Figure 1: Roll out commercialisation type of orders [40].

1.2.3 Production Process

As the company is growing rapidly, the production processes are also ramping up. Even during the relatively short period of this project a lot of changes are planned in the production process. The situation described is based on the situation at the starting point, the beginning of January 2023. The company has currently two production locations. In the first production location, membranes are produced. These membranes are shipped to the second location, at which the membranes are assembled into the modules. This means that the first location is a supplier of the second location and this location depends on the products produced at the other location. The membranes are also the main intermediate (semi-finished) products, of which the company holds inventory.

One module uses numerous membranes, which resulted in a necessity for a faster production of the membranes than modules. The membrane production is a continuous process, organised into five shifts, producing seven days a week. Each step is done continuously, except for the final step, the testing of the products. At the moment this is done five days a week. The module production process just changed from one to two shifts producing five days a week, 16 hours a day. At the start of this change, this led to faster module production compared to membrane production. Currently, alignment between departments is improving and membrane stocks are stabilised.

The membrane production is in the current situation operating with two, so-called spin lines. These spin lines are essential in the production of the product. However, there are three different types of membranes produced by the company which can be divided into three categories:

- Microfiltration membranes (MF).
- Ultrafiltration membranes (UF).
- Nanofiltration membranes (dNF).

Changing the spin line from one to another category, results in loss of production, due to changeover time and restart of the production. At the moment changing is necessary as two spin lines are available for three categories of products. One spin line is solely used for dNF production, while the other one changes between MF and UF. The expected growth of customer demand resulted in a lack of capacity in the current factory in the near future. Therefore as indicated above the company is building an entire new factory in Hengelo. In this new factory, more spin lines will be available, resulting in the disappearance of the changes between categories on the spin lines, and thus a more effective production process.

At the moment raw material stocks are held at numerous locations. As of February 2023, the company operates a new warehouse. In this warehouse, all stocks of raw materials will be held. In the new warehouse, also a new warehouse management system (WMS) is introduced making it possible to track stocks digitally and create insights into the progress of products within the company.

The WMS is an important step forward, operations management experiences that, the company currently has insufficient insights into the progress of the current operating processes. Performance indicators are lacking in the process. Especially insights into root causes for disruptions or quality problems are unavailable.

1.2.4 Procurement

As stated above, the current enterprise resource planning (ERP) system of the company is not able to derive the entire bill of materials (BOM) as the program only calculates the demand for the first level in the BOM. The first level means the first set of intermediate products necessary to produce the finished goods. This means that the ERP system sets the demand for semi-finished products, derived from sale schedules and not for raw materials. The demand for underlying materials is calculated with Excel. This Excel sheet is also used as the representation of the procurement in the current S&OP.

In this Excel sheet the number of materials that will be delivered, the number of materials that are in stock, and the number of materials that are necessary for production are calculated and displayed. This all adds up to a number of materials, which shows in red when it is negative, meaning that the company will have problems if new materials do not arrive within this week. The calculations are based on the production plan of the monthly S&OP. Plans are made for orders of products when necessary, relying on deals with the suppliers, concerning minimum order quantities, prices, and lead times. Currently, the number of units available for stocks, and the price of holding stock are not computed. However, since February 2023, the new warehouse is in operation, for this warehouse estimations are made concerning the number of needed stocks, based on the stock held per production order in the past. In the recent past the number of necessary stocks was added to the material resource planning (MRP) file, making sure orders are released when an item goes below the threshold stock, this recommended stock could also be interpreted as the reorder level.

In the procurement process, the problems are presented and solutions are found. A production plan looking forward 12 months is derived regarding the necessary materials to deliver on time and when delivery of new products is necessary, taking stock levels into account. This planning is not confirmed entirely as new orders keep coming in and updates or changes are possible. However, these numbers are shared with the suppliers and an estimation is made in agreement with the suppliers around their estimated delivery schedule and possibilities. When a supplier is not able to deliver on requested dates or has shown to not meet the required delivery date the cause of this problem is analysed and it is determined whether these alternatives are available or other options should be considered. Currently, only one problem concerns the limitation of the production capacity at the supplier. In case of a supplier not being able to produce or deliver the required amounts, the buyer has multiple options, depending on the type of product. The first option is discussing the possibilities of growth with the supplier, whether they can deliver more in the future and what time will it take them to expand their production. The second option is searching for other suppliers of the products, who are able to deliver the demanded quantities. For commonly used items, switching suppliers is quite easy as multiple suppliers are able to produce and deliver. However, for the more specialised products switching becomes harder. For this reason, the company is targeting a multi-sourcing strategy, making it possible to switch suppliers easily.

On top of that, the company has contracts with suppliers for a longer time period and the number of materials needed based on the planning is scheduled for a period of time, meaning that switching suppliers is only possible when the fault is on the side of the supplier and not at the company. The framework agreements with the customer are over a period of 5 years, and agreements on the number of products are planned for a period of one year, with for some products the possibility of changes.

1.2.5 Planning

In the current situation, the company has two different types of mechanisms to align the sales, which sets the demand for the production process. This is done in a weekly evaluation, called the Sales Inventory and Operations (SIOP) meeting, and a monthly evaluation called the Sales and Operations (S&OP) meeting. Both these methods are explained in this section. The goal of the S&OP is to look 12 months forward, while the SIOP focuses on short-term disruptions and weekly production progress.

The planning is based on the earlier mentioned split in modules and membranes, the membranes are combined into bundles. Some bundles can be used in multiple types of membranes. With the number of forecasted modules, the number of bundles needed is calculated. The long-term S&OP planning is based on these calculations. This planning process is shortly described in the diagram in Figure 2. The diagram shows that the sales budget for the upcoming year is translated into an MRP for modules, which is translated into an MRP for bundles, which results in a detailed S&OP. The MRP for modules and bundles is constructed in the so-called 'S&OP Master file', which is an Excel file running scenarios from the sales budget on the production capacity. With this the preparations for the S&OP are done, which results in the detailed S&OP planning. To develop a consistent and precise plan the data is updated monthly. In the S&OP planning safety stocks for both bundles and membranes are included. However, no exact calculations regarding those are made, which means that currently, no insights are available into safety stocks and related risks and uncertainties.

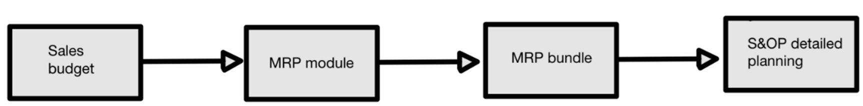

Figure 2: Plan process S&OP.

1.2.6 S&OP

In 2022 the S&OP process was introduced at NX Filtration. Its goal is the alignment of sales and production. In other words, this model is the link between the sales and the operational planning process; a seamless connection between the two and the ability of operations to fulfil the demand arising from sales. A monthly S&OP meeting is held to evaluate the performance of past months, backlog, and necessities and adjustments for the upcoming months.

The S&OP meetings are the main process the company is using, as the mode of integrative business planning. In Figure 3 a representation is made of all functions involved in the S&OP process.

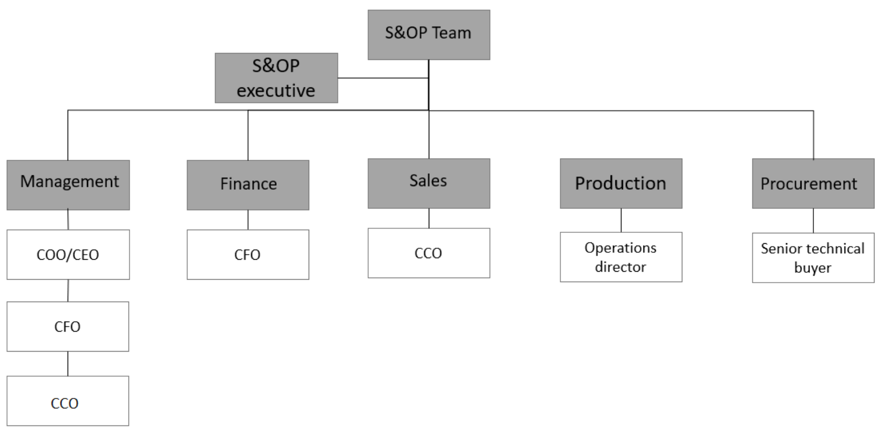

Figure 3: Organogram S&OP team.

To construct the S&OP, data are gathered from all departments, as presented in Figure 3 Sales are responsible for the demand forecast, production for production capacity, and procurement for supply capacity. Management of the company is present in the meetings to evaluate, integrate and synchronise all data and processes. Finance is present in the meeting to determine the impact on the control of the company and cash flows related to the process. The S&OP executive combines all information and is responsible for hosting the meetings. In the current situation R&D, which is an important department within the company, is not presented in the S&OP. Momentarily a vacancy is open for the function of supply chain manager. The goal is to achieve that the supply chain manager can hold responsibility for the S&Op process, becoming the S&OP executive for the company.

1.2.7 SIOP

In the SIOP of the company, an alignment is made between the latest order entry, backlog, the inventories, and the production of the company for the short term. In this SIOP first, a total overview of the number of products produced and sold is made, for a period of 6 months. During the year 2022, the company produced between 4000 and 5000 products. The next step is a representation of the new orders won by the company, presented in both quantity and price. The next step is the representation of the current backlog and Hotlist items of the company. The backlog items are already confirmed orders that are not delivered yet and the Hotlist items are sales in progress, with a high probability of winning. The number, which is used as demand input consists of the backlog and the Hotlist items. The number of orders is aligned with inventory resulting in the number of products that need to be produced. During the SIOP, the short-term planning is determined, focusing on the hotlist and backlog items, making sure the planning is aligned with this.

The main difference between the SIOP and the S&OP is that the S&OP focuses on the mid-term processes, and derives a planning for the mid-term. In the case of NX Filtration, mid-term is defined as a time span of 12 months. While the SIOP has a time span of 1 to 6 weeks. Looking at what happened in the past weeks and aligning, the planned processes, with the actual sales and sales that are added to the Hotlist.

1.2.8 ERP System

The main ERP system of the company is Exact Online, in this system, the planning of inventory and necessary products are tracked. However, due to the growth of the organisation and the ramp-up, the system does not fulfil all desired functions. Therefore, recently the earlier mentioned, CRM package Salesforce was introduced, to track the progress of the sales. On top of that, the company uses multiple Excel sheets to cover the functions Exact Online does not offer. The main issue is that Exact Online only gives the possibility to plan one product-level resulting in; incomplete, BOM structures, as the products in the company, have product structures with at least three levels. These Excel sheets make the alignment between different departments harder to establish. The best solution for this would be to invest in a more robust ERP solution, which covers multi-level BOM structures. On top of that Exact Online does not offer the possibility to track changes in the system, which means that it is not known whether the data is the original input or if it was changed. However, implementation of a new ERP system is considered time-consuming, and not coherent with the current situation of growth and establishment of the new factory.

1.2.9 Product and Process Innovation

Currently, product and process innovations are not integrated into the S&OP of the company. Innovations are known within the company, and discussed in monthly S&OP meetings, however not integrated into the long-term planning. This results in the company currently using a meeting every two weeks to align innovations with the correct procurement. In these meetings the possibilities of the supply of needed materials are assessed. This is done early on in the innovation process to make sure the correct materials are available. In the direct planning process, only products that are at the end of the innovation life cycle are considered that are already being sold and marketed.

To assess the progress of product innovation, the company uses a Stage-Gate model, which was introduced recently. Innovations go through six different stages:

1. Business case.
2. Concept.
3. Design free and manufacturability.
4. Validation.
5. Implementation.
6. Feedback.

Every stage has very specific deliverables. When all deliverables of a stage are met, a stage gate review meeting is organised where the deliverables of the finished stage are evaluated, followed by the key milestones and timeline for the next stage. The meeting is authorised by the stage gate review committee, which is currently represented by the board. For each different stage, definitions are made regarding the requirements a product should have to finalise the stage, this is done for both new product introductions (NPI) as well as new production process introductions (NPPI).

On top of the introduction of new products and processes, the company is constantly working on the optimisation of existing processes. Maximising the production capacities and the yield percentages of the production processes.

Monitoring cash flows, regarding the NPIs and the necessarily related investments should be presented as a deliverable of the Stage-Gate process in the future. However, except for the budget calculations, and costs target in the first stage of the process, no evaluation regarding the costs and possibilities for additional profits are part of the review cycle in the Stage-Gate. The company is currently working on integrating this into the model, however, for current innovations, this is lacking and barely incorporated. The company introduced return on investment (ROI), as a measurement for the cash flows of innovations, however, this is only in the early stages of development, and no real ROI evaluations are done yet.

1.2.10 Investments

As mentioned earlier the listing of the company resulted in significant funding for future growth. This funding allowed the company the opportunity to do major investments enabling and supporting the company's growth plan. The most tangible investment is the construction of a new factory, which is currently being built in Hengelo. Openings of the new factory will release significant additional capacity for further growth and will therefore also result in a lot of changes within the company. New resources will be needed, both in materials and in new employees to make sure there will be no delays when the factory is ready to operate. In the past, the company highly invested in pilot systems and the development and optimisation of the products. Currently, the company is focusing on stabilising the production and workforce to enable and support the company's growth. Other investments, beyond the funding related, should be funded their by own generated cash flows.

1.2.11 Performance

In the current monthly S&OP meetings, no performance measurements are included or evaluated. The only measure, which is presented during the meetings, is the number of sales won, representing the number of new sales that were won and entered the process. The ERP system, Exact Online, currently does not offer data to derive important performance measures for the company. The main pillars at which the company does evaluate their performance currently are sales, operations, and finance. Power BI dashboards are used to present performance and weekly or monthly reporting is done on these aspects. In the results, the performance measurement of the company is discussed in more depth.

1.3 Strategic Business Goals of the Company

In this section, we shortly discuss the strategic business goals of the company. As the unique position of the company is based on filtering water sustainably, the company strongly focuses on the environmental, social, and governance (ESG) profile and impact. The vision of NX Filtration is to be a leading company regarding ESG performance. This is in line with the establishment of the ESG committee within the company, adopted to set forth the duties, responsibilities, and degree of authority of the ESG performance.

The company is growing rapidly, aiming at high growth in revenue each year. This ambition is driven by the strong market position that NX Filtration all ready has, based on the technology, and is aiming to expand. This is mainly focusing on the breakthrough dNF products in which the company is worldwide, the only one providing this product. In the past year, the company focused on pilot projects and demo plants, to introduce its products to the world. In the longer term, the company wants to focus on converting these pilot projects into full-scale projects and larger projects all over the world, eventually resulting in OEMs, buying projects repeatedly.

The building of the new factory allows the company to assess larger and more projects, giving them more flexibility in supplying new customers. The new factory also improves the effectiveness of the company, allowing for profitable growth.

From a financial point of view, the company is mainly focusing on the following pillars:

- A 10% market share in the growing sweet water market, which is a market growing from 5-6 billion euros currently to 15 billion.
- Resulting in a revenue of 1.5 billion euros for the company, comprehensive with the hypergrowth.
- Earnings Before Interest, Tax, Depreciation and Amortisation (EBITDA), targeting similar numbers to peers in the industry.

These goals are focusing on the long-term, resulting in the company being one of the market leaders in the water filtration market.

This research focuses on a tactical time span, therefor a demarcation is derived of the long-term strategic business goals into their 12-month prospects. This is based on road maps the company constructed for the upcoming year. Due to confidentiality, some exact terms are missing and some goals have to be presented in general terms. The tactical business goals presented, focus on sales and operations.

Regarding sales, the following goals were set by the company:

- Structure the planning of pilot projects.
- Support team locally; to ensure smooth product introduction world-wide.
- Align and make decisions regarding the introduction of new products and processes.
- Focus on applications with high commercial success.
- Develop the total solution; offering customers also the complementary goods.

- Expand the team globally.

Regarding operations, the road map demarcates in the following goals:

- Stabilise output of production processes.
- Measure and present performance.
- Scale-up of production.
- Facilitate R&D in the development and implementation of products.
- Improve production processes.

2 Research Problem

2.1 Problem description

As stated above, NX Filtration has a unique technology, enabling expected hypergrowth for the coming years. To realise this growth, the strategic plan for the coming 5 years needs to be translated into tactical plans, which make clear what decision needs to be taken at what moments and what the risks and uncertainties are. In the past due to the small operations, a proper tactical planning method was not necessary, however, due to the growth integration is necessary to manage growth and its corresponding factors. At the moment, this tactical planning process is lagging in the company, resulting in sub-optimal decisions regarding capacities, investments and design of the supply chain and mainly not being prepared for the expected growth. In 2022 a S&OP planning for the company was developed, which gives insight into the forecasts related to the sales and operations. However, the current S&OP process is time-consuming, not scalable and does not focus on optimisation of the process. The process lacks overall integration in the company and alignment of departments. To professionalise further and be comprehensive with the growth, the S&OP process needs to be improved.

The current S&OP process does not have financial goals incorporated, such as cash flows, investments, and contingencies, enabling the establishment of possibilities to create transparency towards customers and suppliers, but also for the company itself, to take correct decisions at the right time. This has to start with integrating the correct interpretation of expected sales, correct safety stocks and buffers, to be prepared for uncertainties, from suppliers, production, or changing markets. Another related challenge is the planning of investments; proper planning and business cases are missing, as a result of the lacking tactical plans. This results in machines standing idle or machines being installed too late, as a result of investments done without proper checks and knowledge of necessities. Another missing link is the integration of innovation in the planning cycle of the company, new product introductions, process innovations, and product innovations are currently done without a proper assessment of impact from both a financial as supply chain point of view. Resulting in incorrect capacities for supply and production and unnecessary development of stock for finished goods.

A 12-month rolling forecast with a proper insight into the financial parameters is missing, a forecast helps in being better prepared for unforeseen circumstances in for example supply, investments and organisation. The following problem is the missing integration of innovation, as the company is experiencing hypergrowth, innovation is still an ongoing process. However, planning decisions are not integrated currently. Finally, an integration of a proper performance evaluation cycle is missing, to assess the performance according to the planned processes of the company, key performance measures should be developed integrated, and evaluated.

2.2 Research Question

This problem description and demarcation of the project can be summarised in the following research question:

How can the tactical planning process of a company be improved, evaluated and integrated, giving insights in the uncertainties and risks for an organisation experiencing hypergrowth?

This main research question is divided up into multiple sub-research questions:

1. How can a 12-month rolling forecast for the company be constructed?
   (a) What is the volatility of the sales funnel and how is this forecasted and evaluated?
   (b) What is the time required to complete the tasks in the production process, and what is the critical path?
   (c) What safety stocks are necessary?
   (d) Are the suppliers able to cope with the company's growth?
   (e) What is the impact of investments?
   (f) What is the impact on working capital?
2. How can product and process innovations be incorporated in a planning with tactical time span?

(a) What is the impact of product innovation?

(b) What is the impact of process innovation?

3. How could the company improve their current performance measurement in the current tactical planning cycle?

We start with a demarcation of the theoretical framework. With the help of presenting important parameters and input for the research. This is followed by four chapters answering each sub-research question. For each research question first, the derived method and model are presented followed by the corresponding outputs and applications. These outputs are all combined into a final framework. This final framework is an extension and adaption of the presented current state framework, presenting adaptions and proposing a new structure for the process.

3 Theoretical Framework

In our research, we focus on the tactical planning processes within an environment of hypergrowth. A theoretical framework is provided, giving insights into the involved components of the project. Hypergrowth is defined as a phase of expansion, where companies experience a compound annual growth rate (CAGR) of 40 % or higher. Most hypergrowth companies are new companies, driven by high market demands. One important strategy supporting hypergrowth is the inventiveness of the product, only an innovative product can create this increase in demand [51]. High amounts of growth lead to uncertainties within planning processes. Multiple components within tactical planning are prone to uncertainties due to a situation of hypergrowth.

3.1 Planning

Planning normally exists on three horizons; strategic (3-5 years), tactical (12-24 months), and operational (0-13 weeks). This research focuses on the tactical component of the planning process. To make a clear description of the scope of the research and the tactical planning a short review is given on the three types of planning and the aim of tactical planning, based on definitions by Wilson [55].

The strategic plan gives a high-level overview of the entire business, the vision objectives, and value-creation. This is the foundation for the company and the basis on which it operates. A strategic plan is usually constructed over a long-term horizon, approximately 5 years.

The second planning horizon is tactical planning, the tactical plan describes the organisational plan to achieve the goals defined in the strategic plan. The tactical plan breaks down the strategic goals into achievable chunks and actions that could be taken and what short-term goals the company should be striving towards on a 12 to 24-month time span.

The third and final horizon is operational planning, this describes the day-to-day running of the company and describes the actions that the company should take on a short-term level to realise the required demand. This gives the focus on a short-term horizon, which in most companies typically lies within 0-13 weeks.

The goal of incorporating a tactical planning process is the alignment of strategic business goals coming from comprehensive integration, both horizontal and vertical [53]. The source of planning currently used as a tactical mean is a Sales & Operations planning (S&OP).

3.2 Sales and operations planning

S&OP (Sales and Operations Planning) is a planning process that aligns all planning processes within an organisation, an S&OP can be defined as a cross-functional long-term planning process that links different business processes into one integrated plan with as purpose of a balance between supply and demand. A S&OP is a cross-functional business process, which reconciles the different supply- and demand-related plans and connects them with the strategic business plan [51].

To derive a S&OP process five pillars should be constructed and integrated into a company [2]:

1. Create an unconstrained demand forecast.
2. Create an initial supply plan.
3. Develop a final consensus operating plan.
4. Communicate and implement the plan.
5. Measure the process performance.

The inputs for S&OP planning involve demand forecasts, information on customers, suppliers, resources, capacities, inventory and, S&OP goals [51]. This is translated into a five-step model which is displayed in Figure 4.

The model describes the concept of the S&OP process, which serves as a reference in multiple organisations [31]. Step 1, data gathering occurs at the start of each month. Gathered data include; production, supply, sales, inventory, new products, costs, and prices. Step 2 is demand planning, in which sales reviews historical data, including the introduction of new products and other market initiatives, resulting in demand forecasts. Step 3 is the planning of capacity

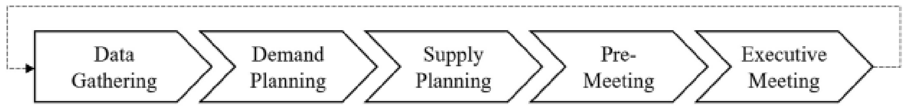

Figure 4: Five-Step S&OP process concept [54].

regarding supply and production. In this step, the unconstrained demand plan together with capacity data is used to identify possible constraints. In Step 4 representatives from different functional areas discuss gaps between demand and capacities, deriving a plan. This plan with some unresolved issues needing senior management is taken to the final meeting in Step 5: the executive meeting, in this step the company's highest level management team, takes part to approve the S&OP plan and takes all relevant actions regarding the realisation of this plan [47]. All these steps combined are seen as the entire S&OP process.

Grimson and Pyke [20] describe a framework describing five stages in which a company can stand regarding the maturity of their S&OP model, these stages are presented in Table 1.

	Stage 1: no S&OP process	Stage 2: reactive	Stage 3: standard	Stage 4: advanced	Stage 5: proactive
Meetings and Collaboration	None	High level	Executive S&OP meetings	Supplier/ customer participation	Event driven
Organization	None	No formal S&OP teams	No dedicated S&OP roles	Formal S&OP teams	Company-wide S&OP
Measurements	None	How well operations meet sales plan	Stage 2 plus forecast accuracy or lead time	Stage 2 plus new product introduction	Stage 4 plus profitability
Information technology	Spreadsheets, no consolidation	Spreadsheets, some consolidation	Centralized information with ERP	Standalone S&OP and ERP systems	Integrated S&OP with ERP
S&OP Plan integration	No formal plan	Sales driven	Some integration, uni-directional constraints	Highly integrated, bi-directional constraints	Seamless plans

Table 1: S&OP Maturity Framework [20].

In this table, a clear distinction is made between the different maturity stages. The current maturity stage of the company revolves between Stage 2 and Stage 3, in this research we focus on further development of the maturity of the planning process.

To set up a clear S&OP process, the team and departments involved should be cross-functional to assure all inputs for all functions are taken into account. Representatives should be involved, from sales and marketing to establishing demand management and forecasting and an operational team for inventory, supply chain, and production scheduling [21]. The success is also highly dependent on the S&OP champion ideally, senior executives, joining in meetings where the planning is reviewed and approved and final authority is granted to implement decisions [49].

Implementation of the S&OP process finds its difficulties in the fact that corporations need to change and integrate multiple business processes, and not solely one single business process. This often requires fundamental changes supported by incentive schemes, a task that requires major change management efforts [49].

Incorporating finance in the S&OP process is desirable in organisations giving clear gains for the entire S&OP process. Looking at the earlier described steps finance should have an important role in each step. The main benefits of incorporating finance are the assessment of different scenarios outcomes around risk and pending issues, measuring the impact of certain decisions, and evaluating the return on investment and impact cash flows. Shortly, finance can improve decision-making and support the measurement of progress, resulting in a higher level of holistic understanding [47]. Regardless of the level of maturity at which a company is operating regarding their S&OP process, financial parameters can help in the assessment and evaluation of assets, investments, revenues, costs, and profits [39].

3.3 Program Evaluation and Review Technique

The method of program evaluation and review technique is better known as the abbreviation PERT. PERT is a method that is used to assess and project uncertainties within the time-span of a project. The purpose of PERT is to give insight into the different tasks of a project and their duration. PERT gives three different time-spans of the tasks within a project, expected time, optimistic time, and pessimistic time. PERT determines the expected project duration of the critical path activities, the variance of the activities on the critical path is computed by the sum of the variances of the activities on the critical path [5].

When a PERT diagram is constructed it is possible and most often useful to derive the critical path; this is the sequence of steps within a project that define the minimal time-span of the project. In the critical path, the latest start, latest finish, earliest start, and earliest finish times are derived. With these times the float of each activity can be determined.

3.4 Demand forecast

Uncertainties in organisations related to hypergrowth lead to uncertainties in making the demand forecast. Different possible numerical methods are available to make demand forecasting possible, deriving a budget for the upcoming plan cycle and deriving inputs for the S&OP.

Demand volatility is a challenging risk to the supply chain, and threatens all facets of the entire supply chain, resulting in extra costs for stock-outs, inventory levels, and sub-optimal capacity utilisation. Volatility in demand is insurmountable in numerous organisations and markets, however making volatility predictable results in the possibility of incorporating correct measures in the supply chain reducing costs [11]. This is why setting the demand in the S&OP process is crucial for the successful execution of the tactical planning.

Nahmias and Olsen [37] describe two different methods for demand forecasting which are described shortly.

Moving average is a simple method for determining the forecast based on previous data, making it possible to update on a chosen time frame. Due to the desire for an forecast updating monthly the moving average method could be a useful method, in updating monthly based on the most recent data. The moving average method determines the forecast, based on the average of the most recent data set this average literally 'moves' with the new data. This results in the following formula:

$$F_t = (\frac{1}{N}) \sum_{i=t-N}^{t-1} D_i \tag{1}$$

In which F is the forecasted amount, D_i, the demand in past period i, and N the number of periods over which the average is taken.

However, in situations of rapid growth, recent data are more representative for the determination of the forecast than earlier data. Therefore the weighted moving average method could be used. As the company is growing rapidly the exponentially weighted moving average could be a fitting alternative for calculating the forecast. This is also known as exponentially smoothing Nahmias and Olsen [37] and Holt [24] describe the exponentially weighted average method with the following formula:

$$F_t = \alpha * D_{t-1} + (1 - \alpha) * F_{t-1} \tag{2}$$

When substituting F_{t-1}, with the formula including D_{t-2}, and repeating this, this leads to an exponential decline in the assignment of weights. The value of α can be determined by finding the minimal value for the mean squared error, this calculation is relatively easy on small data sets, applying the formula to already existing demands.

3.5 Inventory management

Inventory management is the management and organisation of supply via cycles of ordering, holding stock, selling, and reordering. This research focuses on inventory management, starting with the holding costs, which is an important determinant of the amounts of stock. The knowledge of holding costs is necessary as this is widely used in inventory management models.[3]. According to Schonberger and Knod [45] the cost structure is divided into three categories, evident costs, semi-evident costs, and hidden costs. Evident costs consist mainly of the overall costs of the plant, insurance, labour, and maintenance. Semi-evident costs are costs related to the risk of holding inventory. Examples of semi-evident costs are obsolescence, product damages, and product depreciation. The third pillar are the hidden cots, which are represented by inspection, re-manufacturing and lost sales, these are all costs that blend in with other costs and are hard to estimate. This results in the following common assumption: semi-evident costs and hidden costs are considered linear to the capital invested. The estimation of evident costs is relatively easy as this number should be available in administration, and easily assignable to the costs of inventory. However, in a situation of growth past data cannot always be seen as representative. As stated, the estimation of semi-evident costs and hidden costs is harder as they are more difficult to quantify, and more importantly it is difficult to assign which part of the costs are the holding of inventory. Computing the semi-evident costs is difficult and doing it precisely is most often not done. However, semi-evident costs can be estimated by looking at the historical data of cost and computing the percentage of the total value of products in stock. Due to growth, this data could be imprecise as circumstances rapidly change. Generally, a percentage of approximately 20 % of the total value of products could be seen as a plausible percentage for the semi-evident cost[23].

Maintaining and administrating correct inventories, is very important in any organisation, as having too much inventory leads to high holding costs, and insufficient safety stocks lead to unsatisfied customers and dis-balanced production flows[8]. However, as stated hypergrowth leads to uncertainties in demand, which causes challenges in production planning and control [48]. When assessing uncertainties safety stocks are most often the most realistic solution, to cover possible stock-outs and fulfil customer demand at all times.

The customer order decoupling point (CODP) is the point in the point in the supply chain at which the product is connected to a specific customer order. The placement of the CODP distinguishes three different types of strategies to connect sales with production; make-to-order, engineer-to-order and assemble-to-order. Within the process, before the CODP the production process is make-to-stock, based on demand forecasts. The supply chain after the CODP is controlled through make-to-order. The CODP is an important stock point in the value chain, which should be considered within a tactical planning process. At the CODP tactical inventories are held, downstream of the CODP no or only limited inventories are held, as each order is specifically produced based on a customer demand, which normally can be delivered almost immediately after finalisation of production [41].

3.6 Rolling Forecast

A rolling forecast is a method of budgeting giving insights into the results and cash flows of the company. A rolling forecast is set on a chosen time span, for example, a period of 12-months, and is updated every chosen time period. It gives an insight into the profit and the cash flow gains of the company for the upcoming year. In a rolling forecast, each month the actuals of that month are added with the known results, making the forecast more reliable and usable over a longer time period. A rolling forecast gives insight into the working capital for a certain time-span, giving the entire company more insights and combining the expenses and gains of different departments giving every department an insight into the progression of the company [34].

A rolling forecast focuses on a tactical planning horizon constructed for a 12- or 18-month time span. However, as the rolling forecast updates monthly or quarterly each new time period an extra period is added resulting in the length of the forecast being stable. The goal of the rolling forecast is to establish dynamic and proactive decision-making [23].

3.7 Working capital

In a mature S&OP process finance should be incorporated as stated above. This elevates the S&OP beyond a simple material-based supply and demand principle and is focused on the competing forces of revenue attainment, cost minimisation, and working capital efficiency[6]. Working capital emerges as the major mid to short-term value driver in the supply chain. Net working capital is defined as the difference between current assets and short-term debts [43].

3.8 Product and Process Innovation

A well-known element of the S&OP is the introduction of new products (NPI) into the supply chain, focusing on the fulfilment, integration, and management of the NPI, rather than the entire development cycle. S&OP can be helpful in the faster integration of the NPI within the planning process enabling easier plan cycles and involvement of correct supply and customer fulfilment [14].

According to Bagni et al. [4] six conceptual factors that impact the introduction of new products and production processes within the S&OP cycle are defined:

- The level of product innovativeness, impacts the predictability of demand for the new product. Predicting demand for completely new products is harder, therefor when introducing new products more frequent alignments should be performed than when a current product is innovated [27].

- The level of collaboration with suppliers, to which level can information be shared with the supplier. This is dependent on the level of secrecy that should be held with the supplier.

- The replenishment frequency, how fast is the company able to react to new sales or supply information.

- The lead time replenishment cycle, items with long lead times need less frequent forecast updates [31].

- The production restrictions that can be influenced negatively when introducing new products [33].

- The power of the company to influence demand. When focusing on these factors and the company's ability to influence them, implementation of the NPI into the S&OP process becomes more smoothly and supports the success of new products and processes.

Previous case studies have shown that organisational engagement and frequent updates on sales and supply chain information lead to the reduction of costs in the product introduction cycle. Frequent information updates regarding these topics lead to increased communication effectiveness and reinforce the alignment of members involved [52]. Looking at the innovativeness of a product, the higher the level of innovativeness, the higher the benefits of integration are, as products or processes that are more similar have demand that is easier to predict [39]. Next, looking at the relationship of the company with its suppliers, the better the relationship the higher the benefits of an established S&OP are. An integrated process combined with excellent relationships with suppliers may lead to lowering safety stocks, and better capacity definition of raw materials along the supply chain [35]. Wide engagement involving the suppliers leads to a better alignment of processes and following the common purpose [36]. As mentioned above short and frequently updated replenishment cycles could lead to increased efficiency of the NPI integration. However, when the product has high lead times, shortening these cycles has limited impact, which could result in a low impact of the generated S&OP [4].

Innovation leads to the continuously renewing of products and processes. The timing of these new product and process introductions should also be planned and should be integrated into the S&OP cycle of a company. Both for when the sales should start, but more importantly timing when the production should be started and what should be planned accordingly for example by looking at the supply of materials. Multiple studies have emphasised the importance of aligning the planning process with the introduction of new products [51]. Also, new products are important in sales, market fulfilment is a critical factor to gain market share and loyalty of customers [18]. Bagni et al. [4] Identified three key aspects, which a company needs to change to reduce additional costs of new product market fulfilment during pilot projects:

- The supply should be evaluated making sure it fulfils the demand and the other way around, this could be established with for example negotiation.
- To react to changes in demand quickly, there should be more updates regarding demand than the current monthly S&OP cycle.
- The alignment of functional areas. All departments should know the capabilities of other departments and should operate accordingly. The main decision variables in production introductions are timing decisions and alignment decisions, giving extra constraints regarding the work environment and capacities of the company a model can be constructed, computing the optimal moment and quantities of the new product introduction [9].

The planning of new products logically improves the results of products [27]. Looking at the S&OP cycle an extra cycle is recommended, introducing a specific forum with weekly meetings evaluating KPIs and specific questions, which are triggering certain actions. The KPIs should be focused on the functional plan of the NPI or NPPI and its performance [4]. Finally, the goal of the implementation of NPI in the S&OP cycle is the reduction of costs.

When deciding on the introduction of innovation within an organisation, the expected current value (ECV) can be considered. This gives the value of a project or option in the present, adjusted by the risk [46]. ECV is most often combined with a decision tree analysis, which is explained in the following alinea. The first important determinant for computing the ECV is the net present value of the product. The net present value has a couple of principles, making it an appropriate measure for the determination of the present value of successful innovation in the future [56]. The first principle is that a Euro today is less valuable than the same Euro tomorrow, which is reflected in the discount rate. The discount rate reflects the opportunity costs of the capital mobilised; the discount rate is determined by looking at the real costs of the capital, for small projects the cost of capital is usually assumed to be the same as the costs of capital of the whole company, known as the weighted average costs of capital (WACC). Secondly, the NPV takes into account all future cash flows linked to the innovation. Simply summarised: the NPV considers all future cash flows linked to innovation and discounts those to find the current value.

To determine the ECV the probabilities of success of an innovation are necessary. Hauschildt et al. [22], define three different types: Technical, economical also known as commercial success, and others. The focus is on technical and commercial success, as denominational factors of the eventual success of an innovation, both for product and process innovation. The determination of these probabilities is based on the determinants of technological and commercial success. To determine technological success, most often a project is divided into multiple stages of which each could be successful. To determine the success, success should be defined. Bizan [10] defines technical success as follows: an R&D project is technically successful if the firm achieved the goals set at the beginning of the project. Commercially successful is defined as; when a project generates sales and is conducting positive profits [10].

3.9 Decision tree analysis

Decision tree analysis is a tool that can be used for decision-making, modelling risk options responses, and optimising the selection and mitigation of risk [13]. Decision tree analysis is seen as a management risk review technique. In this risk analysis two components are important; the risk probability and the risk consequence. The risk probability indicates the chance of a risk happening, while the consequence gives the outcome of the risk event [1]. This is followed by the way of gathering risk information, which data is available and usable and whether is there a need for quantitative or qualitative measures. Rostami [44] defines two types of decision trees, a fault tree and an event tree. Fault trees structure cause-and-effect relationships of failure, while event trees give potential consequences.

3.10 Performance Measurement

In a tactical planning process, the final step described is the measurement of the performance of the company's key processes. Measurement of performance is essential both for implementation of processes as well as continuous improvement. Tuomikangas and Kaipia [52] define three types of performance; financial performance, operational performance, and process performance. Financial performance includes production and logistics costs, optimisation of profits, revenue costs, and the creation of economic value. Examples of operational performance measurements are order fill rate, delivery speed, delivery time, quality measures, product mix flexibility measures, forecast accuracy, inventory and delivery capability. Process performance measures can be found in decision support, planning efficiency, and learning effects. Examples of process metrics are Plan adherence, lead time span, temperature, and pressure.

3.11 Enterprise Architecture Management

In our research, a framework is developed deriving a future state for the company's planning process. This is done with the use of Enterprise Architecture Management (EAM) method. EAM is a method of representing organisational design and its guidance through evolution. In this construction, a differentiation is made between the user application, the business process and the responsible employee or department. On the top, the total S&OP process is present[30].

Enterprise Architect management has emerged as a discipline to describe a holistic view of an enterprise and to design and implement the desired future state [32]. According to Lapalme et al. [32] the method has been successful in a range of contexts, supporting the development of contextualised organisation structures. Research by Kreuter et al. [30] proposes EAM as a manner of presenting and implementing a new S&OP framework.

4 Analysis of Key Processes

In the first 3 chapters of this thesis, we described the context of the investigation, formulated our problem statement, and conducted a literature study, to create the theoretical framework for this thesis. In this chapter, all key problem areas and processes are analysed, using existing data and models. Per process, conclusions are withdrawn. All key conclusions by process are integrated in an overall S&OP framework in Chapter 5, to create an effective control framework for the company to execute tactical planning and address the key issues described in the problem statement.

4.1 Rolling Forecast

In this section, we answer the first research question. In the rolling forecast, a representation is made of all cash flows related to the computed components of the tactical planning process also incorporating some forecast accuracy measures. Considered cash flows solely focused on components, related to the calculated or analysed within the presented sub-questions. The generated inputs are complemented with data involved in the integrated planning process.

The following inputs are considered in the forecast:

Type	**Derived from**
Sales	Sales budget.
Inventory management	optimal safety stock calculations, MRP Excel.
Impact on working capital	Calculations and annual report.
Forecast accuracy	Calculations.
Stock accuracy	Calculations.

Table 2: Input rolling forecast.

In the rolling forecast, all values are translated into cash flows, this is done using price values from the company's price list. Forecast accuracy is based on the formulas presented in the following section, and stock accuracy is based on the actual stock compared to the calculated recommended stock level. The rolling forecast is constructed in such a manner that the possibility is enabled to update forecasts to actuals after the month has passed.

4.1.1 Sales

We developed a model giving insight into the sales funnel of the company, the accuracy of the forecasted amounts, and the methods of forecasting.

To derive the volatility of sales, we use the following formula [42], using the forecasted sales per week as input:

$$\sigma_s = \sqrt{\frac{\sum_{t=1}^{n}(D_t - \overline{D})^2}{n-1}} \tag{3}$$

σ_s :	total standard deviation of the sales.	€
D_t :	Forecasted demand in period t.	€
$\overline{D}$:	Average of (forecasted) demand from 01/2023 - 12/2023.	€
n :	Number of periods.	

The data we use for this analysis are derived from the sales budget developed by the company for 2023. This data set represents the upcoming expected sales, anticipated on actual orders and expected demand. These data contain all sales expected for 2023, with expected delivery dates. As these data are confidential we only present deviations in percentages and figures.

4.1.2 Sales Forecast Performance

The evaluation of customer demand fulfilment, is an important measure, representative for the delivery reliability of a company. The on-time in full (OTIF) score is an important measure to evaluate the delivery reliability of the company towards the customer. This formula computes the number of orders that were delivered on-time, complete and without any defects. This formula starts with the derivation of on-time in-full delivery of orders. On-time in-full is defined, as the company delivering the complete order on or before the requested delivery date by the customer.

on-time delivery:

$$OTS_i = T_{d,i} - T_{r,i} \tag{4}$$

OTS_i :	On-time delivery score of order i.
$T_{d,i}$:	Delivery date of order i.
$T_{r,i}$:	Requested delivery date of order i.

If the score of OTS is greater or equal to 0 a product is considered to be delivered on-time. The number of items delivered on-time (OT) is the number of deliveries with an OTS, which is negative or equal to 0. With these data, according to Bašić and Skender [7] the OTIF is modelled in the following manner:

$$OTIF = (\frac{OT}{S_t}) * (\frac{S_{t,f}}{S_t}) * 100 \tag{5}$$

$OTIF$:	on-time in-full delivery.	%
OT :	Number of orders delivered on-time.	€
S_t:	Total number of sales at time t.	€
$S_{t,f}$:	Total number of sales delivered in full at time t.	€

Data for deriving the OTIF, is currently not reliable. As the ERP system allows for changes, which are not tracked resulting in incorrect requested delivery dates in the system. On top of that for the future past data are not representative due to the hypergrowth. Therefore the OTIF score cannot be incorporated yet. In section 4.3, the importance of OTIF and how to integrate it in the future is discussed. Our goal is to derive and integrate this performance measure for the current planning cycle of the company. Integrating this is of high importance as an evaluation measure into the cash flow forecasts, data derivation should be possible from the ERP system and forecasts from the sales budget.

For each period the forecast accuracy is derived separately, this is summoned and divided by the total number of periods to derive the average forecast accuracy.

$$FA = (\frac{1}{n})\sum_{t=1}^{n}(\frac{D_t}{F_t} * 100) \tag{6}$$

FA :	Forecast accuracy.	%
F_i :	Forecast in period t.	€
D_i :	Actual demand in period t.	€
n :	Number of periods.	

4.1.3 Future Sales Prediction

In the time span of our research, the company derived a sales budget for 2023. As described earlier, the company has been aiming at opening this factory in 2024, starting operations in the first quarter of 2024. This results in a huge increase in capacity, and opportunities for the company. However, no exact forecasting is derived yet. However, estimations are made based on the strategic goals of the company. As the company has only existed since 2016, the availability of data is very limited. However, our goal is to assess the tactical planning of the company 12 months forward, and a prediction for sales in the first months of 2024 is derived. This is done solely based on data from 2023, incorporating the situation of hypergrowth. This prediction is made using the exponential smoothing method.

4.1.4 Production Processes

We start with an analysis of the main value-adding activities of the company. This focuses on the production process, showing all the different steps and their corresponding times.

This is started with a PERT analysis of the production process, the PERT diagram will help define the different steps in the production process and the length of those. To create these diagrams the following steps are necessary:

1. Define project events and milestones.
2. Define tasks to go from event to event.
3. Define tasks, which are dependent on each other.
4. Establish a timeline and needed time for all tasks.

These inputs are constructed into a diagram representing all activities incorporated in the production process. The presented time in the diagrams are the most likely times of activity, as actual lead times of products are not measured within the company currently. In the diagrams dots are used for milestones and time per task is presented in the arrows. The data for the diagram are derived from company production step plans and observations in the factory.

Next, the placement of inventory within the supply chain is analysed. Looking at the current situation of stock points, and comparing this with the outcome of the PERT diagrams. However, in the current situation of growth, the company does not have the possibility to change stock points at the moment. Therefore the focus is on analysing the current stock points and improving their inventory management.

Preceding the derivation of the diagrams, the utilisation rate, of the production processes is determined. This is done to get some insights of the practical performance of both production process steps. To achieve this the actual output is compared with the planned output. The output are plotted into a graph, in most situations, such a graph presents an S-curve. The graph shows, which output and failure of products, coming from the process is expected, taking into consideration both product and process failure. When the graph shows an S-curve pattern it can be assumed that the output relies around a certain percentage. When the graph does not show an S-curve pattern it can be assumed that the process is unpredictable. The following formula is used to determine the percentages. Planned and actual output are derived from the used planning tool of the company, this data is derived from April 2021 to March 2023.

$$\frac{Output\ on\ day\ x}{Planned\ number\ on\ day\ x} * 100 \tag{7}$$

The following step is the derivation of the possible placement of a customer order decoupling point. This is determined by comparing the time between the order entry date, also known as the order cycle time, and the order delivery date with the lead time of the process steps. A decoupling point is possible when the lead time between two process steps is higher than the time between order entry and requested delivery date, as coupling the order to the customer at that point will not lead to a too-late delivery. The order entry and requested delivery date are retrieved from the company's ERP system.

This analysis is done on the data of all orders currently in the Salesforce system, representing all upcoming orders, expected orders, and delivered orders for the year 2023. This gives a good representation of the time between the order being first known by the company and the time an order is expected to be delivered.

4.1.5 Inventory Management

We follow the answering of our first research question with a model for the management of inventory, within the S&OP process. This focuses on finished goods, intermediate products, and raw materials and is followed by an analysis of the impact of safety stocks on the balance sheet.

4.1.6 Costs

The holding costs are modelled to get an insight into the total costs of holding inventory. Holding costs are computed per item. There are three locations all with different rental costs, and therefore different costs per square meter. As the total number of locations is three, therefore a distinction will be made between the costs of Locations 1, 2, and 3. Next per product the depreciation costs, insurance costs, and obsolete risk are determined. As no past details and data are available, these costs are based on insights from Henttu-Aho [23], and are assumed to be 20 % of the product price, which are added on the holding costs.

Some assumptions are made due to necessary simplifications and processes within the company:

- Costs are calculated per month.
- Semi-evident holding costs are considered linear to the product price.
- Transportation costs are not considered as transportation is done by external companies and costs are often for the customer.

To derive holding costs we constructed the following formula:

$$Ch_i = \frac{R_i}{n_{a,i}} + \frac{Wc * n_e}{n_{a,i}} + 0,20 * p_p \tag{8}$$

$Ch_{p,i}$:	Holding costs of product put at location j.	€
R_i :	Costs location i.	€
$n_{a,i}$:	Number of product places.	
W_c :	Cost of logistics employees.	€
n_e :	Number of employees.	
p_p :	Price of product p.	€

The data for computing the holding costs are derived, using the area plans of all locations, financial inputs regarding prices of products, rental agreements, and wages of internal logistics employees.

In the current situation, as described, the company has to change production processes on different types of membranes on the spin lines, as multiple types of membranes need to be produced and only 2 spin lines are available. This results in changeover costs, which should be considered in computing the intermediate stocks. The changeover costs are assumed to be the lost products and are computed as follows:

$$Co = n_d * n_{p,o} * p_p \tag{9}$$

Co:	Change over costs, switching from one product to the other.	€
n_d :	Number of days without production output.	
$n_{p,o}$:	Number of products output per day.	
p_p :	Price of product p.	€

The data inputs of these calculations are derived from the company's planning data for the spin lines, giving planned and actual output, and giving insight into how many days it takes for the system to start stable production again after the changeover.

4.1.7 Model Safety Stock for Intermediate and Finished Goods

As described above, the market forecast is not always 100 % accurate and fully in balance with production capacity. Therefore, safety stocks are considered on a finished goods level.

The model starts with the calculations of safety stocks for finished goods, the following assumptions need to be made:

- Demand and lead time are independent.
- Demand is distributed according to a normal distribution.

- The lead time is not prone to variation and is a fixed number for every product.
- At t=0 the measure initial inventory is used, which is a fixed number.
- The semi-evident holding costs are not considered in the optimisation model, as they are linear to the number of products in stock, when the total products in stock are minimised this amount should also be minimised.
- All inventories are considered per product, intermediate products, and finished goods.
- Holding costs are considered per product.
- Production is operating at maximum capacity.

To calculate an improved inventory level we constructed a simple linear programming tool is constructed using the solver function in Excel. Our model is based on a model by Janssens and Ramaekers [26] combined with a formula by King [28]. The goal of our model is to decrease the costs of inventory while considering a certain coverage level of deviations, preventing stock-outs.

$$\min \quad \sum_{i=1}^{3} \sum_{t=1}^{n} Ch_i * inv_{it} \tag{10}$$

$$\text{s.t.} \quad inv_{it} = inv_{it-1} + \sum_{t=1}^{n}(x_t) - \sum_{t=1}^{n}(d_t) \quad \forall i, t \tag{11}$$

$$inv_{it} \geq Z * \sigma_d * \sqrt{LT} \quad \forall t \tag{12}$$

$$inv_{i0} = initinv_i \quad \forall i \tag{13}$$

$$inv_{it}, inv_{i0} \leq maxinv_i, x_t, d_t \geq 0 \tag{14}$$

Looking at our model and corresponding formula, the inventory equals the sum of the inventory at $t-1$, and the number of products produced during period t, subtracting the demand during period t. However, to make sure the inventories are prepared for deviations in demand, an extra constraint is included, considering σ_d (standard deviation of demand) and the lead time. The formula is derived from King [28] and helps to build a buffer against the high deviations in the forecasted demand. The next step is to consider inventory management for intermediate products. The intermediate product mix is less diversified than the final product. However, for the intermediate product, the earlier described membrane production process, cannot produce all products at the same time. This means that the production process is prone to changeover costs and stocks should be higher to compensate for longer lead times and uncertainties. There are 6 different types of intermediate products, influenced by the changeover on the spin lines. Due to the volume growth, the number of spin lines is prone to a lot of changes. Therefore the spin lines are modelled as a variable number. Due to necessary simplifications, the model relies on the following assumptions:

- 6 different types of intermediate products.
- Changeover costs are set, calculated by the average produced per day and the average days of production lost.
- Machinery is operating at maximum capacity.
- For the dNF products, the changeover costs are 0, as switching does not lead to losses.
- Resulting in only 4 out of 6 product types being prone to change over costs.

With these assumptions, we derived the following model:

$$\min \quad \sum_{i=1}^{3} \sum_{t=1}^{n} Ch_i * inv_{it} + \sum_{t=1}^{n} Co_t * y_t \tag{15}$$

$$\text{s.t.} \quad inv_{it} = inv_{it-1} + \sum_{t=1}^{n}(x_t) - \sum_{t=1}^{n}(d_t) \quad \forall i, t \tag{16}$$

$$d_t = Z * \sigma_d * \sqrt{LT} \quad \forall t \tag{17}$$

$$inv_{i0} = initinv_i \quad \forall i \tag{18}$$

$$y_t \in (0, 1) \quad \forall t \tag{19}$$

$$inv_{it}, inv_{i0} \leq maxinv_i, x_t, d_t \geq 0 \tag{20}$$

Definition of variables for both formulas:

Ch_i	Cost of holding at location i	€
inv_{it} :	Inventory at location i at time t.	
y_t :	Binary value.	
x_t :	Number of products produced at time t.	
d_t :	Average demand of products.	
Z :	Z-score for corresponding probability.	
σ_d :	Standard deviation of demand.	
LT :	Lead time.	
$initinv_i$:	Initial inventory at location. i	
$maxinv_i$:	maximum inventory capacity of location. i	

Data for the calculation of safety stocks are derived using company-defined inventory maximums, and current measured inventory levels, which are measured and presented in the current S&OP cycle of the company. The demand is based on the sales budget derived for 2023. Historical data are not used as, due to the hypergrowth, these data are not presentable for the future. Product lead time is derived from the PERT diagrams and outputs of the sales analyses are used for the determination of sales volatility. Altman score will be based on the company's desired coverage percentage.

4.1.8 Safety Stocks for Raw Materials

For the raw materials, the company already has defined the safety stocks, meaning that for the tactical span of this research, no new stock levels are calculated. However, the cash flows and the impact of the stock holdings on working capital and financial forecasts are in the scope of this research and therefore incorporated. Therefore raw materials are analysed. However, computing all cash flows and impact on the S&OP process is currently inconvenient due to the fact that data gathering is time-consuming.

4.1.9 Investments

As described in section 1.2, the company has recently done a very big investment. This results in the limited availability of cash flows for new investments. Investing is an ongoing process as the company is experiencing hypergrowth. Examples of this are the hiring of new employees and machinery for the new factory. However, no big investments influencing the S&OP directly are planned for the up-coming 12-months. Therefore investments are not included in our research.

4.1.10 Working Capital

The following step in the derivation of the rolling forecast process is the determination of the impact on working capital. In this research working capital is defined as the difference between current assets and current liabilities. The impact on working capital is analysed as part of the S&OP process. For this research, this includes sales, inventory, work in progress and investments. This is done as all those components have a impact on the availability of liquidity and working capital.

To calculate this the data is necessary from the previous steps, followed by data of the cash flows, assets and liabilities starting at 31 December of 2022. This can be derived from the company's annual report.

In literature working capital is defined as follows [32]:

$$working\ capital = current\ assets - current\ liabilities \tag{21}$$

$$= Accounts\ receivable + Inventory\ - Accounts\ payable \tag{22}$$

As we only integrate the impact of the S&OP process and corresponding cash flows on the working capital. In our research, the following cash flows are taken into account in determining the impact on working capital:

- Current assets: WIP and Stock assets.
- Current liabilities: Holding costs

All cash flows are considered for finished goods, intermediate products, and raw materials.

The working capital forecast process is finalised with a recommendation regarding the incorporation of the working capital in the S&OP process.

4.1.11 Sales Analyses

The sales budget is analysed deriving average weekly sales, and standard deviation for a time-span of 12 months. However, as stated earlier data is confidential, therefore these numbers are translated into percentages. These percentages are plotted in the graph in Figure 5.

The graph shows high deviations in demand per week, from 100 % less output than average to 300 % of the average output. This means that the demand is highly volatile and differs significantly over the weeks. This makes it hard to properly predict incoming orders. According to the expected sales budget, the sales are expected to equal approximately 18-22 million for 2023. Looking at the revenue for 2022, which equaled approximately 8 million. Using an exponential smoothing principle, derived from literature for calculating the forecasts for 2024. This led to a total number of sales of almost 63 million. Deriving the OTIF is not possible currently, due to missing data on expected delivery dates, in the system, the company could be helped by integrating these measures in the process. Data are available for 2022, however imprecise and because of the high growth and changes within the company irrelevant. This is further explained in section 4.3.

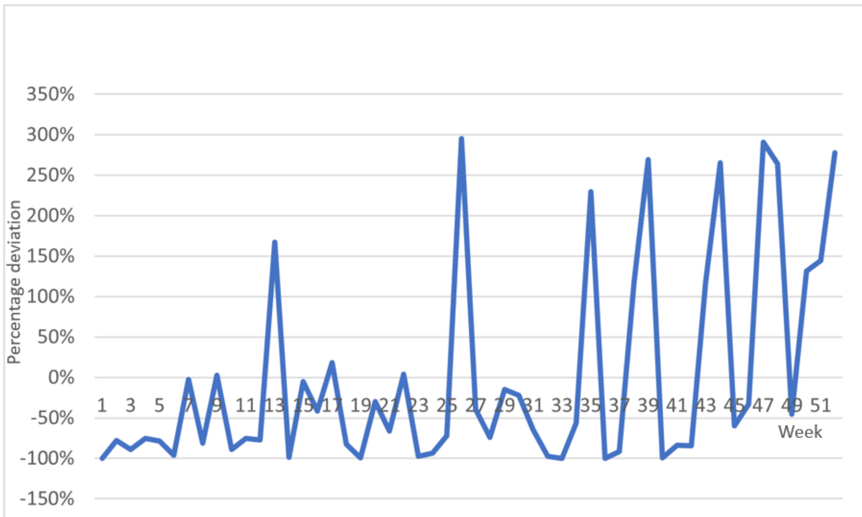

Figure 5: Deviation of weekly sales in percentages.

For 2023, a sales budget is derived on which the forecasts are based, which be presented due to the confidentiality of the data. However, during our research no forecasts were derived for 2024. With the exponential smoothing method in Excel based on past data, a sales forecast is made for 2024. Exact formulas and calculations cannot be presented due to confidentiality of the input data. These forecasted values are included to establish the 12 month time span in the forecasts presenting the tactical planning. Resulting in the following numbers for the first six months of 2024:

Month 2024	**Forecast sales**
January	€-
February	€-
March	€-
April	€-
May	€-
June	€-

Table 3: Forecast Sales 2024.

Due to confidentiality numbers of these forecasts are not shown in this version of the report. This forecast is purely focused on demand inputs and growth expectations in revenue. Not incorporating the extra capacities of the factory.

Therefore, numbers are probably differentiating a lot for 2024.

Next, our rolling forecast derives the forecast accuracy per month. The accuracy is calculated when the actuals of a month are available. As our research started in January, months are incorporated since January 2023. Averaging forecast accuracies of the past couple of months leads to a relatively low forecast accuracy it clearly shows that in the first couple of months of 2023, deviations of sales from forecast were quite high. This is even more underlined, by the derivation of the mean absolute percentage error, which is as high as 364 %. The high deviations in sales and forecasts were expected due to the growth and current size of the company. However, the company could use inputs of forecast accuracy measures to make demand more predictable and prepare for deviations in the future. The high deviations are noted by the company and in a new budget file, this file has the set up of 4-8, meaning it holds 4 months of actuals and new forecasts for the next 8 months of 2024.

4.1.12 Process Analysis

Our analysis of the production processes starts with the construction of PERT diagrams. As earlier described the production process consists of two main pillars; membrane and module production. As the membrane production is a supplier for module production and module production is not able to start without available membranes a distinction, between the two processes is made in the derivation of the diagrams. This is also supported by the fact that the production processes take place at two different locations. On top of that separate diagrams are constructed for the dNF production and MF/UF production within membrane production. The production of the different types of membranes can take place parallel, as they take place on separate machines and have no dependencies. For module production, production tasks are similar for each type of product. Due to confidentiality, we present all times of tasks in the percentage of the total lead time. As some tasks take place sequentially the total of all percentages is more than 100 %. Total time can be found by taking the longest activity of two sequential tasks.

This results in the following PERT diagrams for membrane production, presented in Figures 6 and 7:

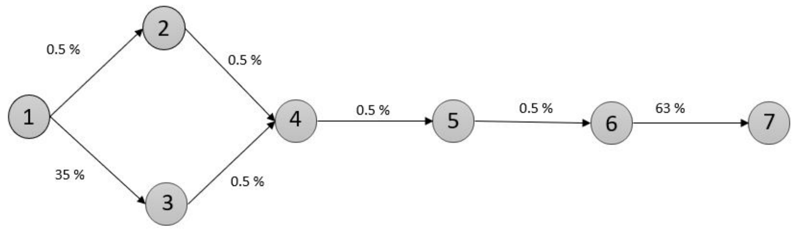

Figure 6: Membrane production dNF.

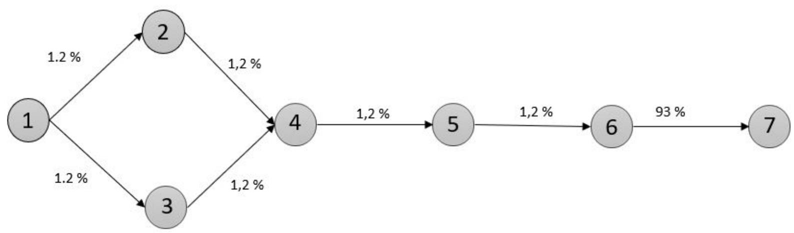

Figure 7: Membrane production UF/MF.

As shown for all types of membrane production the tasks and milestones are the same only the duration differs:

1. MRP membrane planning.
2. Recipe.
3. Materials.
4. Membrane straw.
5. Bundle.
6. Finished good.
7. Approved/disapproved good.

The diagram describes the process of the MRP membrane planning, from which a recipe and a list of materials are derived. With these materials, the spinning of the membrane straw is done resulting in numerous membranes. These membranes are bundled and presented as finished goods, followed by a test resulting in a disapproved or approval of the product. The approved products continue their flow to the second process, module production.

The duration between each milestone is given on the arrows in percentages of the total time. Looking at the entire process flow, the most time-consuming task is testing, which takes place between Milestone 6 and Milestone 7. For dNF also the development of materials takes a long period of time, taking place between Milestones 1 and 2, this results in slack for activity from Milestone 1 to 3, which is supplying the correct raw materials. The main difference between the dNF and MF/UF production is the activity from Milestone 1 to 3.

Next a diagram for module production is presented, in Figure 8:

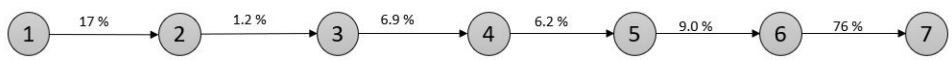

Figure 8: Module production.

Which consists of the following Milestones:

1. MRP module planning.
2. Stored membranes and other materials.
3. Kitted.
4. Coated.
5. Poured.
6. After-treatment.
7. Approved/disapproved.

This process describes the input of the MRP module planning, giving the number of needed membranes and other materials. After that the products are combined and kitted, followed by a coating, pouring after treatment, and finalised with a test resulting in approved or disapproved products. Also, in this process, the most time-consuming step is the testing phase.

The overall process and cohesion between the two separate processes is presented in Figure 9.

Figure 9: stock points

The figure describes the value network of the company, with the two processes as main value-adding activities. At the moment the company holds stocks at three locations, raw materials, intermediate products and finished goods. To determine possible placement of the CODP within the value chain of the company's production process, the three points presented as orange rectangles were considered. The lead times are derived, resulting in a maximal lead time of approximately 12 days for membrane (dNF), 6 days membrane (UF/MF) production, and 12 days for module production.

Next, a graph, comparing actual outputs with the planned output in percentages is derived for the membrane production this is shown in Figure 10. In this graph, the planning of the membrane production is analysed. This is done over a relatively long period of time starting from April 2021 till February 2023. The graph shows the deviation in production comparing actual with planned on the horizontal axis and the percentage of orders on the vertical axis. In the near past, the focus was on realising less disapproved products within the process. It can be noted that the graph does not show an S-Curve pattern, which could be expected in the situation of a controlled process. The variety and the pattern in the graph clearly indicate that the membrane process at NX Filtration is not controlled completely in terms of predicted output. The process is unpredictable regarding the number of products in output. This process is part of the action membrane which is presented in Figure 9.

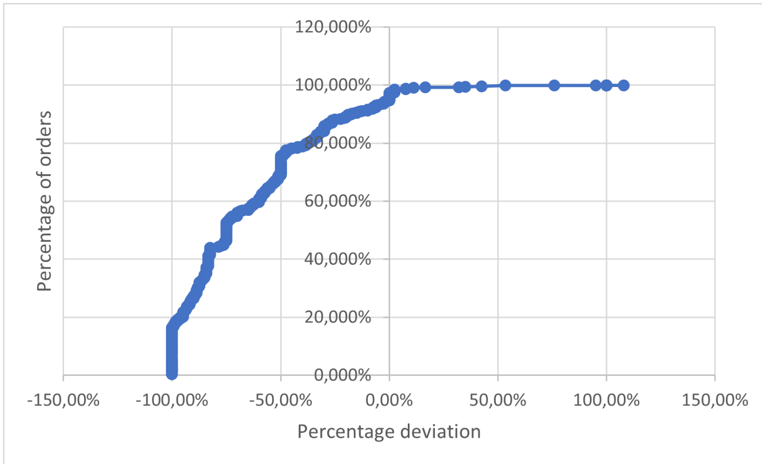

Figure 10: S-Curve membrane production.

Considering the weekly production reports the company presents, in which the performance of the module department is evaluated. The report shows the number of modules realised compared to the number of modules planned per week. Due to confidentiality, we cannot present this graph in the report. Interpreting these reports, it can be concluded that in 2023 only minor deviations seen. Comparing these deviations with the deviations at membrane production, deviations are way smaller. Since 2023, the company managed to stabilise this process, making outputs way more predictable. This is also the expected trend for the upcoming period, as the company is striving for higher stability in its processes. Based on this knowledge we assume a stable enough production pattern, producing outputs as expected.

The next step is the analysis of the time between order intake and expected delivery date and the time between the first contact moment and potential order introduced within the system and the delivery date. Calculations result in an average of 45 days and 382 days respectively. Hereafter the percentages of on-time delivery were calculated if a decoupling point was placed at the intermediate product stock point. Resulting in a percentage of 99,9 % in case the date that an order was introduced into the system was used, and 97,1 % if the order intake date was taken into account. Placement of a decoupling point at the intermediate products, a very high percentage of products will still be delivered on-time. However, to make this is achieved it is assumed that the company can produce every type of module at every moment in time. Currently, this is hard to achieve, due to limited capacities. However, with the hyper growth and building of the new factory, the company enables new capabilities and capacities in the near future. As earlier described and shown in Figure 9, the process becomes unpredictable going further upstream and therefore placing a CODP further upstream, becomes much more risky. On top of that, the process of spinning and bundling within the membrane process results in bulk production making a CODP inconvenient.

Looking at the best placement of safety stock points, these are the raw materials (RM), approved membrane bundles (IP), and approved modules (FG). This is in line with what the company is doing currently. In Figure 9, a diagram is presented, showing these stock points.

4.1.13 Holding costs

For this thesis, we calculated the holding costs to give an insight in the costs of holding one product. To simplify calculations the costs of holding are based on the costs of holding at the new warehouse. Taken into consideration that the company stocks most finished and intermediate products at two different locations. However, costs at each location are similar and therefore this assumption does not impact drastically. The numbers to calculate holding costs are confidential and can therefore not be included in our report. Calculations of the costs leads to the following output of average costs for a module and a membrane per month respectively; are €27.49 and €2.71.

The calculation of holding costs is done according to the formula, leading to €27,- holding per module and almost ten times less for a bundle. While looking at previous production planning files of the company a changeover at spin line 1 leads to a 2- to 3-day production loss. Given the fact that a week has 168 production hours, producing 7 days a week, 24 hours a day. This leads to an average production loss of 60 production hours in which in an optimal situation 178 bundles could be produced. This results in an average of 30 modules lost in production (assumption of an average of 6 bundles per module). Looking at the revenue for one module this means that changeover should be avoided as much as possible until the new factory will allow for continuous production and fewer changeovers. On Spin Line 2 the costs of changeover are neglectable as there is only a small difference and the real spinning process does not differ significantly, resulting in low to no changeover costs.

4.1.14 Recommended Safety Stocks

For the calculation of safety stocks, we assumed the following input numbers:

- A percentage of 95 % is used, making sure the company has a service level of 95 % for both finished goods and intermediate products.
- A Z-score of 1.645.
- Production capacity is operating at its maximum, with no disapproval.
- Only the most frequently sold items are considered as other items, the company already has a year long supply available.

- Lead time for module is 12 days, and lead time for membrane production of dNF is also 12 days, derived from the production process analyses.

As shown in the sales analysis, the deviations in demand are significant. This resulted in high demand volatility. In parallel the company wants to achieve a high service level and avoid stock outs. Due to the high standard deviation, choosing a coverage percentage of 99 % leads to a high increase in costs. The maximum production capacity is higher than the average demand, so solely focusing on averages no extra safety stocks are necessary and production should be able to coop with incoming streams of orders. Therefore a coverage percentage of 95 % is used in this research.

These assumptions were incorporated into our presented linear programming model and integrated into Excel. A screenshot of this model is given in Appendix B.

The numbers of the recommended stock levels, for both module (finished good) and bundle (intermediate product) are incorporated in figures in Power BI. The numbers are presented below in Figure 11 and Figure 12.

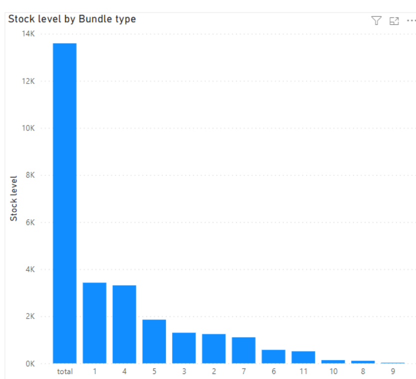

Figure 11: Recommended Stock Levels Bundle.

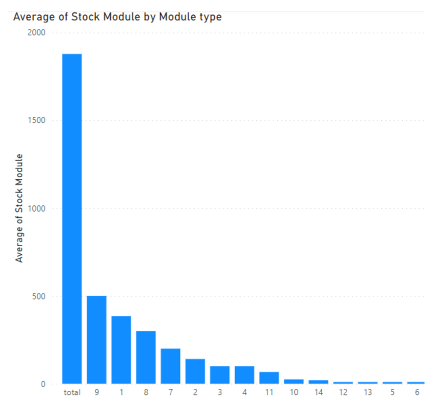

Figure 12: Recommended Stock level Module.

The figures show the number for the 9 different types of bundles used by the company and 14 different types of modules the company sells. This is quite a high number, because for every small differentiation between products a different name and therefore type is used in our calculations. Due to confidentiality, the names of the different bundle and module types are not presented in the figures. Total numbers lead to a recommended level of 13,594 bundles and 1878 modules. This leads to total stock asset values of approximately €- and €- respectively. Due to confidentiality, we cannot present the numbers.

In the current situation with the capacity of only 2 spin lines, production is only possible half of the time, therefore the safety stocks should be doubled at one stock point after the spin production process (membrane production) to cover shortages, looking at the proposed placement of a CODP the most optimal option is doubling the membrane bundle stock. For the other spin line, the company is currently holding stocks for the entire year, reducing changeover as four types of bundles are produced on one spin line, this is the easiest way currently as stock positions are compared to changeover costs relatively cheap, as the changeover results in a 2- to 3-day production loss. Therefore the current method of holding a year of projected demand in stock we assume to be the best choice for the current situation in the calculations of total values the recommended stock levels by the company are incorporated and no new values were computed.

In our rolling forecast, a stock accuracy measure is incorporated. This measure compares actual stock levels, with the recommended stock levels. In our model, the comparison is done with our recommended stock levels, which are all lower or equal to the levels that the company uses. Again accuracy is computed starting from January 2023. Interestingly, all accuracy levels are below 100 %, averaging 80 %. Meaning actual stocks equal 80 % of the recommended stock. This is notable as in the current planning the company uses their own set stock levels, which are higher.

Inventory management also revolves around the management of inflow of raw materials, and supplier relationships. The company currently, uses as described in section 1.2 an Excel system calculating stock levels and re-order levels. This Excel file has a rolling window. Needed materials are derived from the S&OP planning. Recently, recommended stock levels were determined for the most important materials, and are worked on for the remaining materials. Additionally, to reduce the risk of suppliers not being able to deliver, the company is working on a multi-sourcing tactic. This tactic involves the possibility of multiple suppliers for products with high risk and importance for the company. To improve the relationship with suppliers and be able to deliver them expected purchases for a longer period of time. This results in faster delivery and suppliers holding stock for the company, we recommend focusing on the forecast accuracy of the planning and corresponding need for materials. Having an improved forecast accuracy leads to better prediction of purchases, and improving relationships with suppliers. This is discussed more thoroughly in section 4.3.

4.1.15 Impact on Working Capital

To derive the impact of the S&OP processes on working capital all involved current assets and liabilities need to be calculated. As our model operates as a rolling forecast, expected cash flows regarding these are also incorporated. In the previous section, the derivation of holding costs and assets of stock are already presented. The work in progress (WIP) is not explained yet. In this research, we calculate WIP, by taking the difference the between needed stocks of two preceding months and adding the average sales. This results in a value, that is necessary to produce necessary products to achieve recommended stock and meet sales on average at the end of each month.

In Power BI, we constructed some figures for the assets and liabilities, these are presented in Figure 13 and 14:

Figure 13: Current Assets.

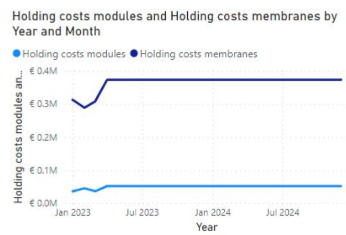

Figure 14: Current Liabilities.

Subtracting current assets and current liabilities leads to an average of €- taking into account recommended stock levels and the average sales per month. This is a positive number representing the impact the S&OP process has on the working capital of the company. Due to confidentiality the number cannot be presented

4.1.16 Conclusion

In summary, we found that the company has high deviations in their forecasted sales. Looking at the forecasts and actuals for the first 6 months of 2023 significant deviations are shown and forecast accuracy was low. Next with an analysis of the production process, we found that placement of a CODP should be possible between membrane and module production. Calculations of the holding cost and recommended stock levels result in lower stock levels than the company uses currently. However, looking at stock accuracy the company did not meet these recommended stock levels in the first months of 2023. Investments for the upcoming period of 12 months are discussed. However, no real big investments were found, therefore investments were not incorporated into our model. It is noted that due to the growth, investments are an ongoing integrated process and smaller investments are done frequently within the company. We combined all cash flow in a rolling forecast model, of which a screenshot is presented in Appendix C, due to confidentiality and the semi-annual numbers not being published yet, some numbers are covered. In this model, numbers marked orange are actuals, and percentages of accuracy are given a green or red colour depending on performance. All other numbers which are forecasts are presented in white.

In the current S&OP process, the company does not incorporate cash flows. We recommend presenting cash flows during the S&OP process. By incorporating calculated cash flows and accuracy measures the company can show how well they reach set goals, regarding stocks and sales and what cash flows should be created with the forecasted amounts.

4.2 Product and Process Innovation

To integrate the product and process innovation into the tactical planning horizon of the company, the impact of the innovation is assessed based on all pillars involved in the integrated planning process. This concerns demand forecasts, production capacity, and supplier capacity, complemented with an assessment of the return of investment. This starts with the construction of a decision tree analysing each decision variable involved in the incorporation of decision-making regarding innovation.

We assume that before an innovation is assessed according to decision tree that there is a technological necessity for the innovation, also we assume that there is enough demand available, and a product is only developed if a demand incentive is available. This assumption mainly focuses on product innovation.

Literature describes two types of decision trees: a fault tree and an event tree, Our research uses the event tree, analysing events and the potential consequences of the events, as this fits bests in assessing innovation for NX Filtration. The following steps are taken to define the nodes in the tree.

1. Define the problem area for which the decision tree is necessary.
2. Draw a decision tree with all possible consequences.
3. Define the input variables with probabilities.
4. Determine and allocate payoffs for each possible outcome.
5. Calculate the expected monetary value, to determine profit per note.

With these inputs a decision tree is constructed, presenting all scenarios regarding the introduction of new product innovations. In the decision tree the net present value is calculated as the payoff allocation for each scenario, which is used to calculate to compute the expected value of investments in the following step. The net present value is chosen as it takes into account that a euro tomorrows is less valuable than a euro today and considers all cash flows coming from the innovation. In NPV merit of innovation is measured as the contribution to the creation of economic value out of the investment[56]. This is done using the following formula by for example Gallo [17]:

$$NPV = \sum_{i=0}^{n} \frac{NCF_t}{(1+r)^t} \tag{23}$$

r :	Discount rate.	
t :	Time periods.	
NCF_t :	Expected net positive cash flow generated by innovation in period t.	€

In this formula, the discount rate is considered equal to the company-wide weighted average costs of capital (WACC). This is done as the company currently does not have a calculated WACC available. To compute the WACC in general the following formula can be used [15]:

$$WACC = \frac{E}{E+D} * R_E + \frac{D}{D+E} * R_D(1-T) \tag{24}$$

With variables defined as follows:

E :	Market value of Equity.	€
D :	Market value of Debt.	€
R_E :	Required rate of return on Equity.	€
R_D :	Cost of Debt.	€
T :	Applicable Tax Rate.	

We used a WACC based on the literature on determining WACC for companies in similar sectors and business environments. According to Žižlavskỳ [56] a typical discount rate for corporate projects ranges from 10 to 15 %, and for high-tech start-ups risk is between 25 and 30 %. Company-wide numbers from PWC show that the average WACC in the industrial goods sector is between 7.6 to 9.5 %. Taking into account that the company is growing rapidly and is still in the early stages of development. A relatively high WACC is assumed, but not as high as in high-tech start-ups, because the company has outgrown the start-up phase and has proven technology, to deliver a functional product with high future demand prospects. Also, considering the fact that the company was listed quite recently and is not making any profit yet, and is therefore operating almost 100 % out of their own equity. Looking at the formula this should this is also an aspect of a high WACC. Therefore the upper limit of the typical corporate discount rate is taken. Meaning that we use for this a WACC of 15%. To determine the incoming cash flows of a new product, forecasts on sales are necessary, as the project limits itself to a time span of 12 months, and cash flows have to be considered for a period of 12 months. To determine the outgoing cash flows of a new product, costs of change in lead time, stock levels of existing products, change in BOM and the replacement of existing products are considered. The research revolves around a time span of 12 months, and the company reviews demand on a monthly basis. We assume a total of 12 periods of 1 month in the computation of the NPV.

The total value of the innovations is determined using the expected current value. This formula combines the probabilities of success the costs and the value of the innovations and corresponding investments, considering the choice of launch and development. It also incorporates the costs of development and commercialisation in the value [29].

$$ECV = ((NPV * p_{CS} - Cc) * p_{TS} - Cd \tag{25}$$

NPV :	Net present value	€
p_{CS}:	Probability of commercial success.	
p_{TS} :	Probability of technical success.	
Cc :	Costs of commercialisation.	€
Cd :	Costs of development.	€

To determine these values, an estimation of the probability of commercial and technical success of each innovation should be made. The determination of the probabilities will be based on the different outputs of the stage gate model.

For this research an, innovation is seen as technically successful when the company has the technical capabilities to design and produce the product. The probability of technical success is based on the probabilities of the failure and risk assessment, part of the Stage Gate model, described in the current state. More particular it is part of Stage 2; conceptualisation of the stage gate model. During this phase, a failure modes and effects analysis (FMEA) of the innovation is made. An overview of this FMEA is given in Appendix D, from this FMEA the risk priority number (RPN) is taken. The RPN consists of three components, occurrence, severity, and detectability; each ranked from 1 to 10 and multiplied by each other to get the final score. This is given for each possible mode of failure in the FMEA. Resulting in a maximal RPN score of maximal 1000. By averaging all RPN scores, and translating this into a probability this results in the following formula:

$$p_{TS} = \frac{\overline{RPN}}{10^3} \tag{26}$$

Success of commercialisation is harder to determine, as the company has few data or frameworks to determine this.

For this research we use a definition from Frattini et al. [16] for commercialisation of innovation: A set of decisions and activities that are necessary to present a new product to its target market and start to generate income from its sale.

Probability of success of commercialisation can be determined in the first stage of the described Stage Gate model. In the Stage Gate model this is defined as the market and competitor review, resulting in the commercial possibilities of the product. Currently the company does not do an extensive market and competitor review yet. Therefore in our research, we make a proposal for the determination of commercialisation. We propose that during the early stages of the Stage Gate process, where the company is focusing on the market and competitor review. A short analysis is done by ranking the innovation in certain dimensions. We suggest to do this according to the following dimensions based on literature from Frattini et al. [16]:

- Timing: Timing of the launch and timing of the announcement.
- Targeting: Responsiveness of the customers to the company's offering.
- Positioning: Particular position for the innovation, concerning competitors and substitute innovations.
- Distribution: Channel of distribution and critical functions of distribution.
- Pricing: Pricing tactics.
- Communication: Type of channels for communication and type of message.
- Whole product configuration: Set of complementary products and services incorporated.
- Partnership and alliances: Availability of external necessary partners and type of agreements with partners.

For each innovation, a ranking from 1-5 is given for each dimension. These rankings are based on each particular innovation where a 1 is the worst-case scenario and a 5 the best-case scenario. In the ranking of all dimensions the ranking is based on the position of the company towards the market and competitors of the innovation are considered. The rankings are averaged to determine the total probability of success for the innovation.

Determination of costs can also be derived from the outputs of the Stage Gate model. However, in the early stages, only an overall budget is derived . This budget does not separate development and commercialisation costs. Therefore a definition making it possible to separate both type of costs is proposed:

- Costs of development: All costs involved in the research and development of the innovation, before starting production.
- Costs of commercialisation: All costs involved in bringing the product to the market, including marketing and launching.

Looking at process innovation a similar model can be applied. Therefore, the Stage Gate model used by the company is used for both products and process innovation, making the inputs available for both product and processes. The main difference in the calculation of a new production process, is the lack of commercialisation. Looking at product process innovation solely, products and product prices should not be changed meaning that costs and probability of commercialisation are not incorporated.

The final step in answering this research question is the derivation of the integration of the decisions regarding NPI in the tactical planning process. With the use of the framework, a suggestion of is given for the incorporation of the NPI in the current process.

4.2.1 Product and Process Decision Making Framework

As described in the current situation the company recently introduced the Stage-Gate model. This model consists of multiple stages in Appendix E the Stage-Gate process is presented. Reviewing costs, budget, and market prospects is part of the business case. However, impact calculations for supply, production, and demand on the overall business processes are not incorporated. As the company is innovating its products and processes constantly, the impact of innovation should be integrated into the planning process. To do so a model is constructed, with as goal a better alignment between the Stage-Gate model and S&OP process.

First, a decision tree is created, the problem area is the introduction of innovation within the tactical planning process of the company. This leads to certain decisions that should be taken regarding the introduction of new products and processes. These decisions are summarised in the decision tree in Figure 15.

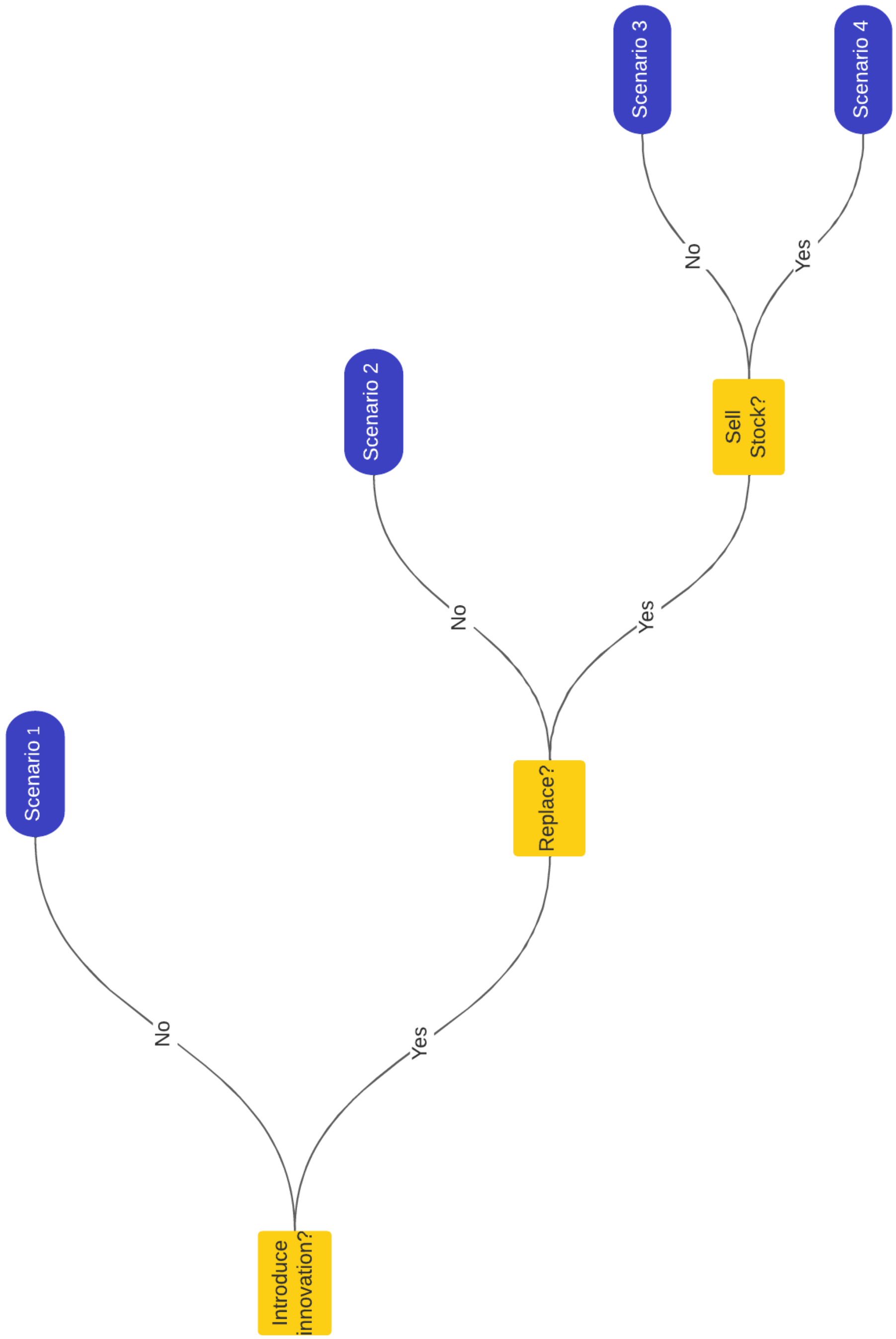

Figure 15: Decision tree introduction of innovation.

In Table 4 a description of all presented Scenarios in the decision tree is given.

Scenario	**Outcome**
Scenario 1	No introduction of innovation.
Scenario 2	Innovation becomes new additional product or process.
Scenario 3	Complete replacement of existing product.
Scenario 4	Replace after stock out of existing product.

Table 4: Scenario description.

Looking at the decision nodes incorporated in the decision tree, the possible decisions the company is facing regarding the introduction of innovation and the impact on the planning process are presented. In the current Stage-Gate model, which the company is using to assist in the execution of projects these decisions are not incorporated. The incorporation of the decision three could assist the company in making decisions regarding the correct way of introducing the innovations. Followed by an incorporation of the impact of those on the planning process. The decision moments are:

- The consideration of whether or not to introduce the innovation.
- The decision between replacement of an existing product or process, or introduction of a new product or process. This is not applicable in all situations as some products do not have the option to replace an existing product. In this case, the NPV of replacement is 0 and the decision of replacement is always No.
- The decision regarding the sale of stock of existing products, if applicable is considered.

For each outcome node presented as a Scenario, the NPV can be determined this is done according to the formulas presented earlier. There are five factors, directly influencing the decisions and therefore the calculations of the NPV of each Scenario. These five factors are all directly related to the current tactical planning process, the S&OP, influencing the inputs and resulting in changes. These five factors and their definitions for this research are formulated as follows:

1. The impact of the innovation on the lead time of current production processes, which is defined as **the impact on lead time**.
2. The losses resulting from high stock development or high stocks of existing products **the impact on stock**.
3. The impact of innovation on the complexity of the BOM **impact on supply**.
4. The impact of innovation on demand of existing and new products, resulting in incoming cash flows **impact on demand**.

5. The influence of innovation on the replacement of existing products the products need to be replaced every few years, the system is build around the existing products and innovations do not always fit, **impact on replacement cycle**.

To determine an NPV an estimate of the WACC is necessary, which is used as the discount rate in the determination. Company wide the WACC is not determined yet, as stated in the methods [56]. As stated earlier the WACC for NX Filtration is set at 15 %.

The determination of the cash flows per month is presented in Table 5.

Determination of NCF.	
Scenario 1	0
Scenario 2	$D_t * (p_{in} - c_{in}) - DI$
Scenario 3	$D_t * (p_{in} - c_{in}) - OI - SI - RI - DI$
Scenario 4	$D_t * (p_{in} - c_{in}) - OI - RI - DI$

Table 5: Cash Flow determination per Scenario.

With variables defined as follows:

D_t : Demand at time t.
p_{in} : Price of innovation.
c_{in} : Costs of innovation.
OI : Cost of impact operations (BOM and lead time).
SI : Cost of impact on stocks.
RI : Cost of impact on the replacement cycle.
DI : Costs of impact on demand on existing products.

We used the following assumptions, to establish a model that computes the outputs for the scenarios with simple input variables making it possible to derive decisions early on in the process. The assumptions are based on available data, desired outputs, and scope of the research:

- Cost of impact on operations, consists of costs of impact on BOM and costs of impact on lead time.
- Lead time growth of 1 day leads to a shrinkage of approximately 4 % of the total output.
- The value of the stock of remaining products is determined by multiplying the number of products by the value of the product.
- Time between replacement of the product is 4 years, every system needs replacement after 4 years.

- A decisions regarding the fit of the existing products need to be made early on in the process, to determine if the innovation fits within existing systems, or if a new system is necessary for the innovation. To determine the impact on replacement.
- The change in the BOM is determined by subtracting the costs of the old BOM from the new BOM.
- The innovation agenda is used as a guideline for the start of production and the start of sale of the product.

All these variables are combined into a model in Excel, assuring the derivation of the different NPV of the different Scenarios. This is presented in Appendix F.

The formula determines the cash flows of the different Scenarios. Looking at the expected profit, by multiplying the expected demand with price by costs. But also looking at the impact the innovation has on the other components of the S&OP cycle. With these cash flows the NPV can be determined according to the formula presented in the methods. In the formulas, the five different types of impact are incorporated. Where the impact of demand is presented in the overall demand and the impact on supply and the impact on lead time are combined in the operational impact.

The determination of the NPV leads to a value for each Scenario. The Scenario with the highest value results in the highest profit for the company. All these variables and formulas are combined into a model in Excel, assuring the derivation of the different NPV of the different Scenarios. In the model data is not incorporated, as this is confidential, giving all scenario outputs the value 0. However, the main goal of the model is to give the company a method to generate different Scenarios inputs for the S&OP derived from data available in the Stage-Gate model.

With the NPV, the determination of the ECV is possible, the determination of the ECV is done using a second decision three. This decision three uses the first decision tree as input, which is shown in the first decision note, if a negative NPV is calculated in early stages development does not take place. This is summarised in a decision tree in Figure 16.

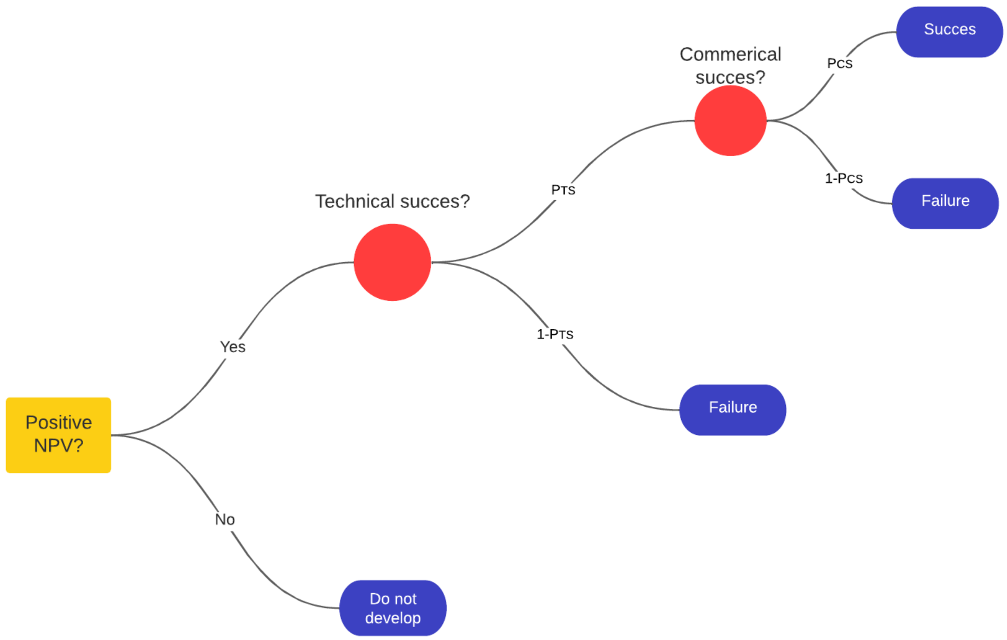

Figure 16: Decision tree ECV.

The model for Scenario derivation of NPV is extended, with the extra variables. Presented earlier. This model is given in Appendix G, again data is not incorporated resulting in all values being 0.

We derived a framework that should help the company to integrate the impact of its innovations within its tactical planning process. Looking at the existing mode of innovation management the company uses to guide their innovations, the Stage-Gate model. In Stage 1 of this model a business case is derived, part of this business case is the derivation of a market and competitor review. With this review, a rough estimation of the impact on demand and sales of the new product can be derived. This main input and the given decisions trees the company can make a fast review of the best decisions regarding innovations in the early stages of development. This makes it possible for the company to decide on the mode of implementation of their innovations: Replacing an existing product or process, introducing a completely new innovation, or not introducing the innovation at all in the early stages of the innovation process. Using these calculations as Scenario calculations in the monthly S&OP meeting makes it possible to see the expected impact of their innovations in early stages. This is of high importance, when looking at the tactical time span, as innovation is an ongoing process impacting the entire supply chain.

In Stage 5 of the Stage-Gate model, the implementation phase. More detailed data regarding forecasted sales of the innovation should be available. This leads to the possibility of more precise Scenario calculations regarding the innovation and makes it easier to incorporate the innovations in the planning. In this stage it is possible to incorporate precise Scenario calculations in the S&OP, giving insights into the changes in the sales and operational process of the company. In this part of the Stage-Gate model, the innovation can also be incorporated short-term planning and should be assessed during weekly operational meetings. In this stage the innovation is taken into operation and is part of the supply chain.

The company uses an innovation agenda to show the progression of the innovations, presenting, which stage they are in. From this agenda, an estimation can be derived regarding when an innovation is sold and marketed. To manage this properly, the agenda should be updated frequently and data should be correct, also indications should be made of when an innovation is transferring from stage to stage early on in the project. Managing the agenda properly is important in, incorporating innovation, without a proper agenda, innovations are incorporated incorrectly in the planning process. Currently, the management of this agenda is not done properly, this is mainly due to the fact that the model was introduced recently and integration is still being worked on. When actual implementation of innovation is approaching, the company has more data is available regarding demand prices and other variables of impact. However, in early stages such as the business case data is not managed properly, making it hard to find, interpret and integrate the data into the system. To achieve better alignment, improved data management is necessary.

4.2.2 Conclusion

The integration of innovation in the S&OP is necessary to achieve a higher level of maturity in the process. The main goal of the introduction of the framework is the implement the outputs of the Stage-Gate model in the S&OP process. The first step in achieving using the correct data and updating regularly, can only be achieved by incorporating the technology department (R&D) into the S&OP process. On top of this, as mentioned earlier data management should be improved, focusing on the outputs of the Stage-Gate model. The decision output of the presented framework influences different aspects of the S&OP directly. After the determination of a decision using the decision tree, the calculated impacts should be integrated and used in capacity and demand planning. An introduction of innovation impacts the following aspects:

- Bill of Materials.
- Production capacity.
- Demand.

- Costs.

Next KPIs regarding innovation should be incorporated to achieve higher levels of maturity in the planning process, this is presented in the next section. Performance measures regarding innovation help in determining when to incorporate the innovation in the process and help monitor the NPI and NPPI pipeline, making sure the company is not surprised by the sudden demand for new products and changes in operations.

With the inclusion of the decision framework, the company should be able to foresee the impact of innovation on production and sales and integrate this into the planning on a tactical time-span. This makes it possible to easily run scenarios regarding innovation, and incorporate outputs in the S&OP cycle. This enables the possibility to incorporate innovation in the planning smoothly and take decisions to manage impact.

4.3 Performance Measurement

Our third step is a recommendation for performance measurement. The S&OP, which is described as the current mode of tactical integrated planning within the company is incomplete and ineffective without a proper performance measurement cycle. In literature, we found that the final cycle of the S&OP process should involve performance measurement and evaluation to make sure the company follows the constructed plan and meets the company's production, capacity, and demand goals. To investigate the best measures for the company, we first generate an insight in the current performance measurement of the company. In section 1.2, we describe the companies performance metrics shortly. To derive the current standings of performance measurement, open interviews and conversations with all employees directly involved within the S&OP cycle are held.

The current situation of the performance is conducted using open interviews and conversations with all employees directly involved within the S&OP cycle. This results in a report, describing the means of measurement and evaluation applied at NX Filtration.

After the analysis of the current performance measurement and evaluation techniques, we construct a framework of KPIs complementing the current S&OP process. The framework is based on a proposed improved S&OP structure from literature integrating performance measures at each step in the process. On top of that, we propose overall performance measures, evaluating the effectiveness and efficiency of the overall business processes as a result of the S&OP integration.

In the current situation of the company, data availability is lagging resulting in difficulties in setting up performance measurement, evaluation, and integration. As time in this research is limited, and data are simply not available to actually integrate all performance measures in the process, we propose the necessary data-gathering methods to integrate and implement the measures.

4.3.1 Proposed Performance Measurement Cycle

First, we present an overview of the company's current standings regarding performance measurement. As mentioned in the current situation the current ERP system that the company uses is Exact Online. This is a relatively simple ERP system, operating in an online environment. Currently, this system is not able to meet all desired capabilities and data requirements for performance measurement within the company. For example, looking at the overall delivery dates, the current system does not record the originally requested delivery dates. The company is currently compensating for this lack of functionality with authority schedules within the system. These schedules assure that not every employee can change delivery dates, making the data more precise. However, currently, it is not possible to save historical data in the system, this results in measurements regarding the on-time delivery performance of the company not being completely reliable looking at original agreements, as some of the dates are changed. This is applicable both to the supply as the delivery of goods. The analysis can only be done on data, which might be adjusted, and not on original data which results in biased outcomes. This is the case for a lot of processes integrated in the ERP system making updated KPI cycles hard to achieve and align.

The company does integrate the monitoring of different aspects of its performance in the current S&OP process. This is done in weekly (sales and production), monthly (finance), or yearly (budgets) meetings, with the use of Power BI dashboards and other measurement tools. However, the alignment of performance and evaluation is not done regularly, or integrated in any system or process. The main evaluation of performance in the company currently focuses on sales, finance, and production. As the company is growing rapidly, and data are not stored and analysed thoroughly also due to the immaturity of the ERP system, some basic measures are not done. On top of that due to the growth and current ramp-up of production, some measurements are not representative of the actual performance of the company.

Regarding the sales performance, a weekly evaluation gives insight into the performance of the company-wide sales, focusing on finance. This involves the comparison of the sales budget with the actual sales, the growth of the sales funnel and the backlog items. Looking at the financial performance a monthly overview is made, focusing on revenue, gross margin, change in inventory, operating expenditures (OPEX), and earnings before interest, tax, depreciation and amortisation (EBITDA). These measures are all evaluated on a year-to-date (YTD), and month-to-date (MTD) basis and evaluated during monthly review meetings. The final main pillar of performance measurement is regarding the production of the company, is done in weekly reports, for both membrane and module production. The main focus is on the number and value of the produced goods, the number of disapproved goods, and the number of products realised compared to the number of products planned.

The goal is to integrate a performance cycle into the S&OP process of the company. As known from the literature a mature S&OP should incorporate a form of performance measurement presentation and an evaluation of the progress regarding the set goals [54]. The main performance measure presented should evaluate performance according to the pillars of the process. From the literature the three measurable pillars of the S&OP process are demand forecasts, supply and production [52].

Looking at the in literature presented stage definition framework of S&OP by Grimson and Pyke [20] the company is currently operating in Stage 2 on most facets. This is the reactive stage in this stage the only type of measurement is the adherence of operations and the sales plan. However, looking at the company's current S&OP even a clear reflection of how well operation meets sales is missing. To mature in Stage 2 a clear representation should be given, of the production capacity in comparison to the sales should be presented. This could be done with for example the measurement of service level. For the company to mature further, the incorporation of forecast accuracy, measurement of product and process innovation, and profitability is necessary. In this section, an overview is given of where to incorporate, which measures within the S&OP cycle.

Baker [6], suggest an order of implementation of the by Grimson and Pyke [20] and Danese et al. [12], presented performance measures necessary in the S&OP cycle.

1. Introduction of demand forecast accuracy.
2. Introduction of service level measures.
3. Introduce materials planning measures.
4. Introduce customer-related measures.
5. Introduce a measure of plan adherence.
6. Introduce new product innovation measures.

Performance measures can be divided into two types: effectiveness measures and efficiency measures. Effectiveness measures asses how well the customer meets customer demand, while efficiency measure, resource utilisation. The importance of these two measures depends on the product-line strategy of the company. Effectiveness measures are most important for a company that competes on innovations and efficiency is most important for a company competing on costs [37]. As the company is competing mainly on their innovation, we focus on the introduction of effectiveness performance measures. The effectiveness of the S&OP process impacts the overall business effectiveness and efficiency as an effective S&OP process should result in the improvement of both effectiveness and efficiency. The efficiency reflects, how well the S&OP process itself is managed [25].

In the theoretical framework, the five steps in a S&OP process are presented[54]. With the help of an existing framework [25], added literature, and insights within the company a framework is constructed suggesting types of performance measurement for each step in S&OP process. This framework is constructed with the assumption that for future S&OP construction, the company uses the five steps from Wallace and Stahl [54], as main process for the S&OP. The framework is presented in Figure 17.

This framework suggests performance measurement at the end of each step of the process, repeating itself monthly. The measurements should be evaluated and used as inputs for each step, resulting in a smooth process, finalised on time. This should result in reviewing, updating, and evaluating the inputs and outputs of the S&OP. Based on the outputs of the S&OP and set threshold by the company, inputs should be incorporated, evaluated and updated resulting in improvement. On top of the proposed measures for each step in the process, the measurement of the overall impact of the integration of the S&OP process in the company is also important. Looking at overall performance and the effect of the S&OP on business processes, the company could introduce measures regarding the return on investments, and the level of customer requirements met [38].

As discussed in section 1.2, the company organises weekly meetings, named SIOP meetings. During these meetings, the planning is discussed in the short-term. To integrate these meetings into the S&OP cycle of the company we advise, using them as performance evaluation meetings. During these meetings, the performance of the company is evaluated with all involved departments and corresponding employees. This will help to make sure that all presented measures are integrated, evaluated, and therefore actually used in the cycle.

Assuming the five steps by Wallace and Stahl [54], and order of implementation by Baker [6], and maturity model by Grimson and Pyke [20] and Danese et al. [12]. An order of introduction and a set of performance measures can be introduced in the company. In the order determination, the quality of data measures is not presented. However, based on the five steps [54] it is proposed that the data quality should be assessed before starting the introduction of new performance measures, as low quality data leads to imprecise performance measures. The framework in Figure 17, presented on page 67, shows where the company should introduce the measures and into which moment of the S&OP cycle the measures should be presented and evaluated. Next, an order of integration of the measures is presented below[12], this order is not coherent with the cycle but is based on the level of importantness, regarding the maturity framework by [20]:

1. **Forecast measures** *(Forecasts):*Forecast accuracy; comparing forecasted revenue on sales, with actual sales. The possible introduction of mean absolute percentage error (MAPE) on forecasts. Forecasts on demand for product innovation.

2. **Inventory measures** *(Capacity adherence)*: Costs of carrying inventory, weeks of inventory on hand, backorder rate and accuracy of actual inventory compared with the recommended inventory levels (Inventory Accuracy).

3. **Service level measures** *(Trade of measures)* : Percentage of customers who do not experience stock-outs, fill rate, on-time in full (OTIF) delivery towards the customer.

4. **Order cycle time** *(Trade of measures)*: Average time between order placement and order delivery.

5. **Capacity and capability adherence** (*Capacity adherence*): Capacity utilisation rate, overall equipment effectiveness (OEE).

6. **Supplier performance**(*Capacity adherence*): confirmed line item performance (CLIP), order fulfilment of the suppliers towards the company.

7. **Financial adherence** (*Planning adherence*): the adherence of financial plan and actuals, for revenue, costs and working capital.

8. **Innovation** (*Forecast and Capacity adherence*): Percentage of sales from new product introductions, NPI and NPPI in Stage 5 (implementation) of Stage-Gate model.

To enhance and integrate the S&OP process in a circular way all measures should be integrated eventually. All presented measures are coupled to one of the 5 categories from Figure 17 However, integrating them in the presented order will result in a smooth integration, focusing on the most important measures at the beginning. The introduction of the measures can follow each other up quickly and can happen simultaneously.

In Appendix H an overview is given of the presented measures. If necessary the needed formula, needed data and where the company can derive the data from is given. To integrate the measures in the S&OP cycle of the company data should be available, stored and managed properly. All data can be gathered in Power BI, presenting updates on the progression according to the cycle. Giving access to involved employees to present their performance and whether they meet up to the cycle and other departments. The goal of this is to achieve improved alignment between departments and coherence of the S&OP cycle within the company.

4.3.2 Conclusion

Our proposed performance measurement framework will result in a higher level of maturity according to the model by Grimson and Pyke [20] and Danese et al. [12]. All performance measures can be combined in a dashboard, and presented during S&OP meetings. During the final executive meeting, the focus should be on presenting the trade of measures and planning adherence. All other measures should be incorporated during the evaluation of the other involved steps. These measures should be evaluated to enhance performance. Looking at the proposed framework at each step the measures should be presented and evaluated, so they can be used as input for the following step. Combining the proposed measures, framework and focus on the integration of the step-wise approach of the S&OP process, leads to a more fluent and efficient S&OP process, at which performance can be evaluated and integration exists in all layers of the company and departments function according to planning, evaluation and measurement of the S&OP.

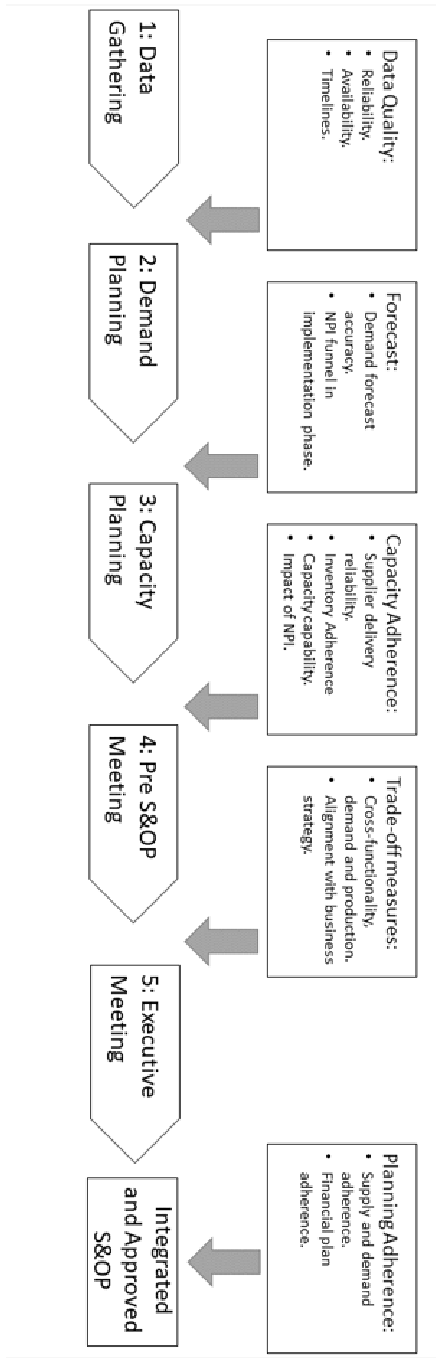

Figure 17: Framework performance measurement S&OP process.

5 Future S&OP Process Framework

In this chapter we combine all results into a control framework, integrating all elements and outputs of the previous chapter. The goal is to present a total structure for the future state of the tactical planning process, which addresses all the key elements from the problem statement of this investigation. This is done using the theoretical framework described; enterprise architecture management (EAM) method. Kreuter et al. [30] developed a five-step model, which uses the EAM as a method to systematically guide the development and implementation of a contextualised S&OP framework. An EAM approach consists of two functions a descriptive and a prescriptive function [19]. The descriptive function provides an overview of the organisational design, capturing layers and elements of the enterprise. This enables the design and analysis of the current organisational situation. The prescriptive functions focus on the development and implementation of the desired organisational design [50].

We focus mainly on the descriptive function and the first step of the prescriptive function as implementation of the framework is outside the scope of this investigation.

To provide a proper step-wise model focusing on S&OP, five steps are necessary. These steps are defined as follows:

1. Analysing the company context.
2. Analysing the initial S&OP design and identifying the context-specific challenges.
3. Developing the adjusted S&OP design.
4. Planning and conducting the implementation of the adjusted S&OP design.
5. Evaluating the implementation results concerning the S&OP effectiveness.

In our research steps 1,2 and 3 are executed. Steps 4 and 5 are the next steps the company should take.

In section 1.2, we researched the context of the company thoroughly. We derive an overview of the current S&OP into a framework, modeling the current state. This framework is adjusted presenting a proposal for an improved overview of the S&OP. In this new framework, all our research outputs are integrated into a control structure. For both structures four layers are presented, the overall S&OP process presented on top, and three layers explaining information flows in the main process: Responsible person/department, business processes, and application.

5.1 Current S&OP structure

In Figure 18 we present a model with the current flows of information regarding the S&OP process of the company. The overall process consists of the four in section 1.2 described steps: Sales budget, MRP module, MRP bundle, and detailed S&OP. The projection mainly elaborates on the preparation phase (MRP Module and MRP Bundle) of the S&OP, as our findings and generated outputs are mainly integrated into this step. Figure 18 shows that data are retrieved from the ERP system and Excel files, which are combined in the S&OP 'Master file'. Only one scenario is run, based on the Sales budget and corresponding Sales forecast plan, focusing on growth. In this scenario, the review and impact of sales on production and procurement are established. These inputs are combined in the S&OP slides, which are distributed in preparation for the final S&OP meeting. The overall process in the current situation consists of the sales budget of which the MRP is derived for modules and bundles, which is translated into a plan. A defined pre-S&OP meeting is missing and only one scenario derived from the budget is run. The missing of the pre-S&OP meeting results in the need for discussion of multiple outputs, impacts, and decisions during the final S&OP meeting. This results in a meeting, where multiple decisions and scenarios still need discussion, and final decisions can not always be made, based on facts and prepared inputs, this results in a time-consuming process. In the current situation the sales budget, and therefore the derived MRPs are derived for a 12-month, time span. In the figure, the discussed SIOP meeting, which is held weekly is not incorporated, as this is not directly part of the S&OP cycle.

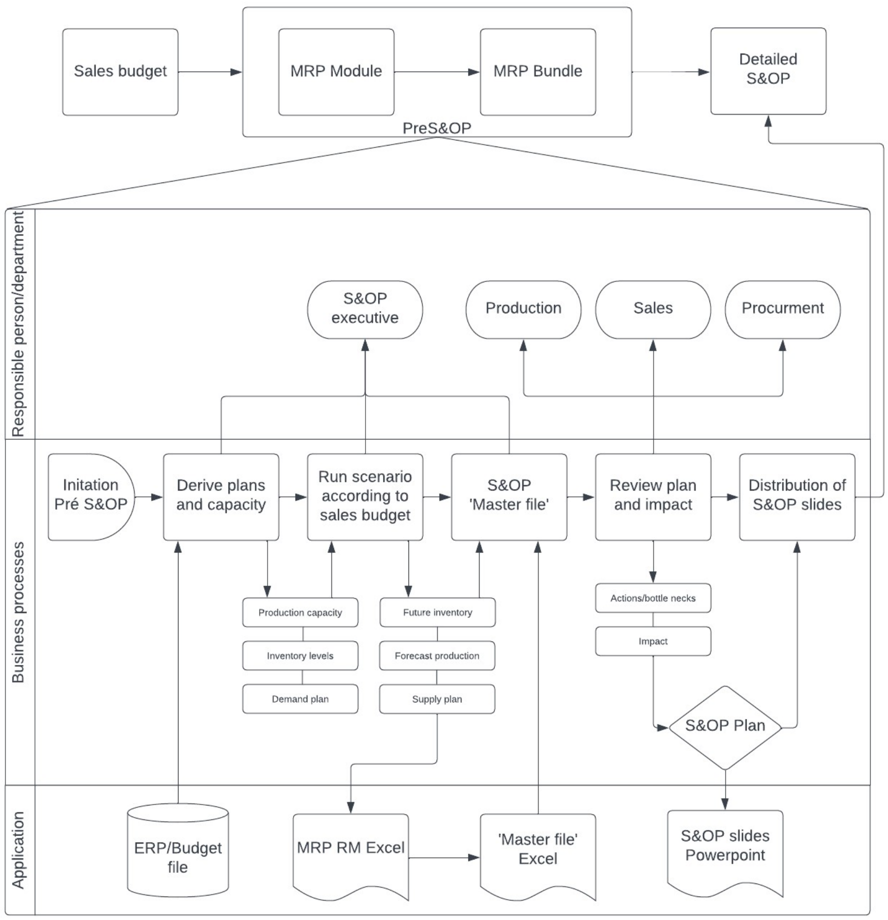

Figure 18: Current situation S&OP.

5.2 Proposed Future S&OP Structure

Based on our findings in this research we developed a new framework, presented in Figure 19. The new framework starts with the overall S&OP cycle, which we made based on the literature presented structure by Wallace and Stahl [54], consisting of the five main steps: Data gathering, Demand planning, Capacity planning, Pre S&OP meeting, and Executive S&OP meeting. Looking at the time span of the cycle, the S&OP process should be operated on a monthly basis, which is already done in the current S&OP process. In this monthly cycle, a week-rhythm is proposed where the 5 steps are executed in a structured and logical sequence. The first step 'gathering of data' should be done in the first week, these data are outputs from the previous S&OP, new information regarding customer orders, and output of the performance evaluation. With these data, by the end of Week 2, an evaluated demand planning should be constructed. This demand planning is based on the established budget at the start of the year. However, the demand planning should be updated and evaluated to the proposed performance measures, new backlog, and hotlisted items. Next, by the end of week three capacity planning should be generated. Currently, capacities are clearly defined, in this step a more precise estimation of current process performance is taken into account, based on an improved estimation of the capacity compared with capability, giving utilisation rates. Next, the pre-S&OP meeting is held, which is discussed more thoroughly in the next alinea.

Within the preparation phase, a clear distinction is made between the actual preparation and the pre-S&OP meeting. During the preparation, the provided demand and capacity planning, by sales and operations are translated into an output file containing: Production capacity, supply capacity, product demand, and current inventory levels. These inputs are used to construct the MRP for raw materials, intermediate goods, and finished products. With these inputs and the MRP file multiple scenarios regarding the S&OP are generated, which can be combined in the Master file. Scenarios give the following output: impact of innovation, corresponding cash flows, future inventory, and impact on the supply chain. For the future inventory recommended stocks should be considered. These scenarios are presented in the pre-S&OP meeting in which the best scenario, with corresponding bottlenecks, actions, and performance evaluation results in a S&OP plan, this distributed and used as input for the final executive meeting. In this executive meeting board members and the supply chain manager attend to approve or disapprove the proposed S&OP plan.

During the preparation phase, it is important to integrate multiple scenarios. In these scenarios the impact of NPI and NPPI we suggest to asses this in the scenarios, according to the proposed decision framework in section 4.2, generating different scenarios. Also, cash flows, part of the presented rolling forecast from section 4.1 should be integrated into the scenarios. This should be implemented in the S&OP output, presenting expected cash flows concerning the S&OP process. For the pre-S&OP meeting, we propose that this meeting is held incorporating representatives from all the figure presented departments, including finance and R&D, which are currently not directly involved. They can evaluate and assess the impact of cash flows and innovation. The output of this pre-S&OP meeting is given in bottlenecks and corresponding actions of the scenarios, whereas bottlenecks are the hurdles and the actions are possible solutions. Also, the outputs for KPIs regarding this step are derived as proposed in section 4.3, with the KPI framework, we suggest focusing on alignment and cross-functionality. These outputs are combined in the S&OP PowerPoint, which is distributed to all employees attending the executive meeting.

In our framework, we also propose the continuous evaluation and measurement of performance. This is the final output of the overall S&OP process and is integrated into all steps. Using this in each step and repeating this constantly, each month results in a circular S&OP process with a closed loop, incorporated in each layer and time step.

The framework gives an overall representation, of how we think the S&OP process should be structured to improve the planning process, addressing the key issues from the problem statement. The framework combines the three main pillars we asses in this research: The incorporation of cash flows, new product and process innovation, and performance measurement and evaluation. These pillars are presented as part of the pre-S&OP meeting and result in the incorporation of key departments, which are currently not part of the cycle. The framework also proposes a circular structure with a closed-loop principle making sure data from previous S&OP cycles are used, to improve each month. All steps are part of the monthly cycle, resulting in a final executive S&OP meeting. We think that with the integration of this framework the alignment between departments involved in the S&OP will improve and overall performance can be tracked better. On top of that by introducing a proper pre-S&OP meeting the final and clear data gathering, demand-, and capacity-planning is organized more professionally involving all relevant departments. The final executive meeting is more structured and makes it possible to just focus on the approval of the S&OP plan and no need for discussion on all aspects as this is already evaluated in the pre-meeting. By incorporating more departments in the pre-meeting, fewer employees need to be attending the final meeting, enabling faster decision-making, based on all inputs.

Our proposed structure is a monthly cycle, each week within the cycle has its own deliverables, goals, and corresponding performance measures. Currently, the company is hosting weekly meetings, which are named SIOP meetings. In these meetings shorter terms, sales, operations, and inventories are discussed, and the ability of the company to meet set goals. To enhance these SIOP meetings within the proposed framework, we suggest using them as weekly performance meetings. The output of the final S&OP executive meeting is a proposed plan for the upcoming 12 months to make sure sales, inventory, and production goals are met, updated at the end of each month. These involve performance measures and corresponding requirement levels. We suggest using the current so-called SIOP meetings to align the tactical plan in the S&OP, with an operational time span of the SIOP, and make sure the goals are met and aligned on a weekly basis, looking only forward for a short period of time.

In summary, the integration of our framework should lead to a more structured S&OP process. With the incorporation of an extensive pre-S&OP, incorporating the following departments: Finance, Sales, Production, Procurement, and R&D. This leads to a better alignment of departments, improving the integration of the S&OP in the company. With the inputs from the pre-S&OP, the final executive S&OP meeting can focus on approving or disapproving proposed scenarios with corresponding bottlenecks and actions. This results in clear decision-making and outputs at the end of the process. Finally the integration of performance measures at each step and using them as inputs for the next monthly results into a circular process, with continuous evaluation. Our Framework will improve the realisation of the strategic goals of the company and help manage the risks on a tactical time span in a controlled way. On top of that the framework should lead to a more efficient process and helps in choosing improved scenarios, not solely focusing on growth but also on optimisation of sale, operations, and alignment between the two.

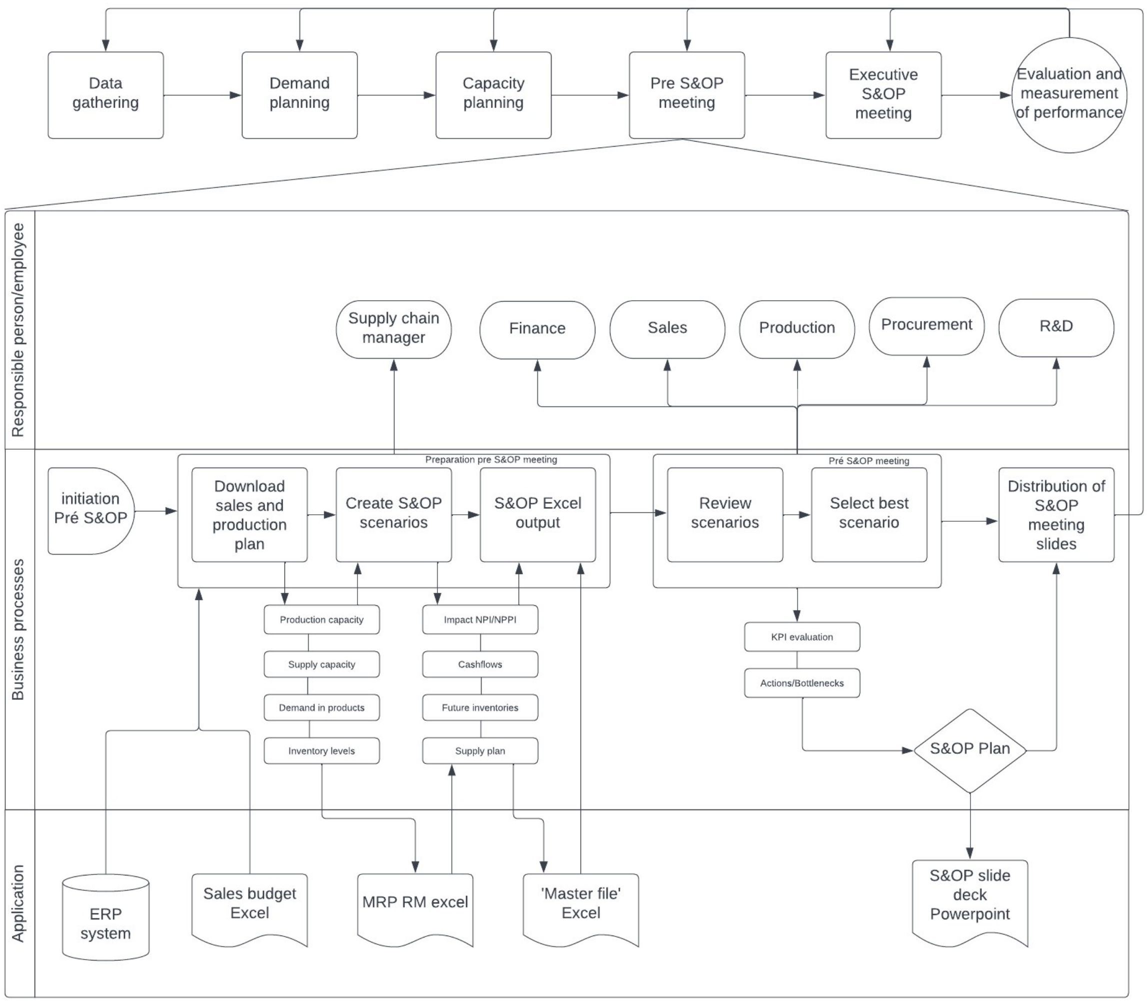

Figure 19: Proposal Future state S&OP process.

6 Discussion

6.1 Contribution

We designed a framework improving tactical planning in order to set the right priorities. In this research, we focus on the coming 12 months and the goal is to reduce risk and uncertainties for the company. The essence of the new integrated process design is addressed in Figure 20. This figure presents the new structure of the planning process incorporating all aspects assessing risk and uncertainties discussed and analysed in this report.

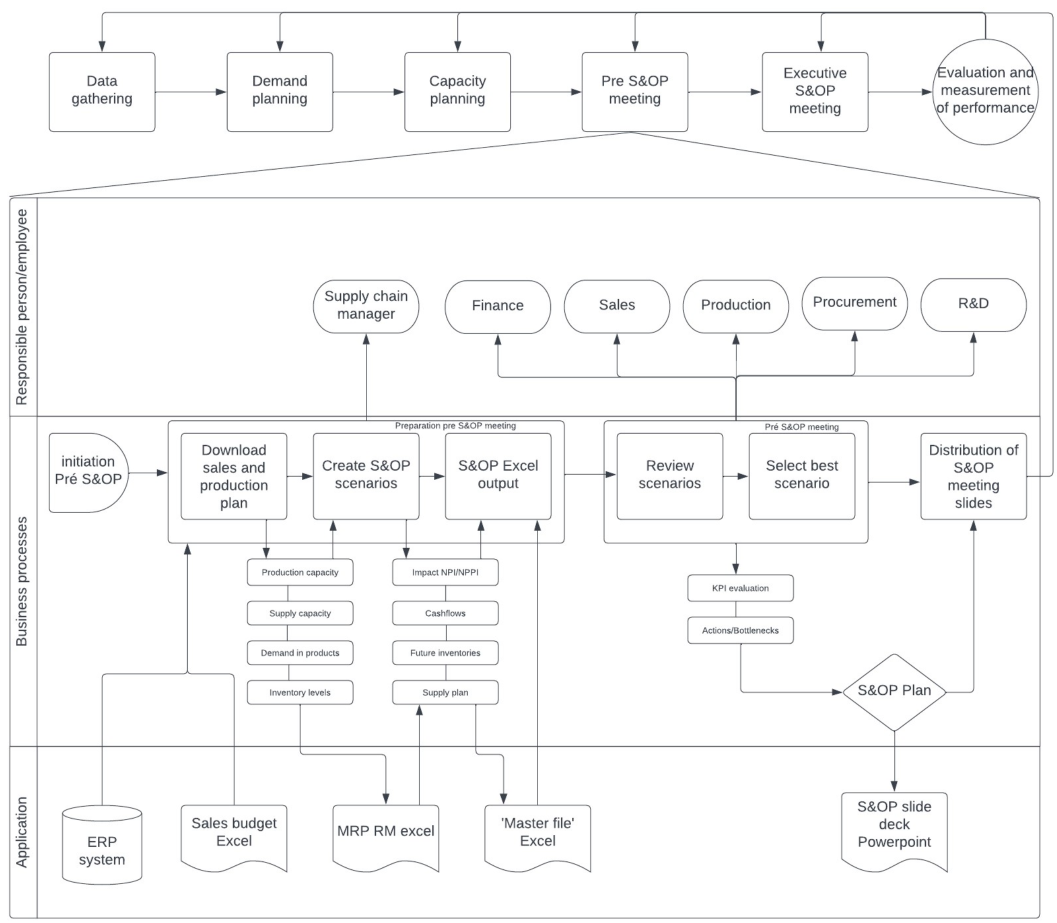

Figure 20: Proposal Future state S&OP process.

To develop our framework, first, the current situation of the company regarding its tactical planning process was examined. This is all summarised in Figure 18. From literature by Wallace and Stahl [54], we found an overall S&OP structure, involving five different steps resulting in an integrated S&OP. This structure is used as the base for the development of our new structure. The five steps are Data gathering, demand planning, capacity planning, pre-S&OP meeting, and the final executive S&OP meeting. The goal of this structure is the improvement of the current S&OP process fundamentally on the following themes, missing in the current setup:

1. Current setup is not cross-functional and lacks structured involvement of different departments.
2. Current setup has no clear representation of impact on cash flows.
3. Current setup does not include the impact of decisions regarding innovation.
4. Current setup has no closed loop between forecast, and realisation, measured through KPIs and a performance management system.
5. Current setup has no structured scenario planning and selection process.

We discuss the following key elements of the tactical planning structure:

- High deviations in the sales budget and forecast accuracy.
- CODP placement, optimal stock levels, and the impact on corresponding cash flows.
- Involvement of product and process innovation in the planning cycle.
- Incorporation of a performance management system connected to the tactical planning process.

Looking at the sales and demand planning of the company, the current situation presents high monthly deviations and relatively low forecast accuracy. Looking at the future growth prospects sales are expected to be subject to changes and therefore hard to predict. Therefore, the incorporation of forecast accuracy and delivery performance is necessary to build a closed loop in the demand planning process and improve forecasts enabling smooth stable growth.

The company's production process is divided into two different steps, membrane, and module production, which are operated at two different locations. Both production processes are executed sequentially, with stable lead times, meaning that a decrease in individual process steps will result in an overall lead time reduction. However, analysing the realised output of the factory with planned output, significant differences are visible. Especially the output of membrane production has proven to be unpredictable. Looking at the order cycle time; the time between order entry and order delivery and comparing this with the production lead time, a customer order decoupling point is advised between membrane and module production. Through this decoupling point, the instability in the output of the membrane department is compensated, enabling stable delivery performance to the customer. Currently, this is hard to achieve, due to uncertainties and the fast pace of change. However, the company is building a new factory in which, we propose to incorporate a decoupling point.

We analysed the cash impact related to stocks as part of improving the planning process, an estimate is made of the costs of holding stocks. This analysis resulted in holding costs for both membrane and module production, of €2,71,- and €27,45,- respectively. Comparing this with the changeover costs, it can be concluded that holding costs are relatively low, and therefore changing production lines should be avoided as much as possible. In the new factory, which the company is building, more spin lines are available. This creates the possibility to operate in more product-specific set-ups limiting changeover and therefore reducing changeover costs. Based on holding costs and changeover costs optimal inventory levels are determined using a linear programming method. The outputs focus on a 95 % coverage percentage, avoiding stock-outs 95% of the time. Cash flows related to inventory management, are included in a rolling forecast, and figures.

We propose a rolling forecast, incorporating most cash flows related to the company's S&OP. With the knowledge of our recommended stock levels and actual stocks for the past months, the number of products that need to be produced during that month can be calculated. We presented this as the needed WIP. Next, we computed the impact of the S&OP variables on the working capital. This is done by combining all current assets and liabilities, combined presented as the impact on working capital. Finally, some forecast accuracy measures are included, for stock and sales. For sales, these numbers clearly show that in the first months of 2023, the accuracy was low, as expected deviations in sales were very high and the low accuracy shows that at the moment it is still hard to predict sales. Looking at the stock accuracy an interesting thing occurs, the stock accuracy compares our calculated recommended stock levels in this report with the actual stock levels, for the past months. Even though our recommend stock levels are lower than the recommended stock levels that the company currently uses the actual stock accuracy is not reaching 100 % in any month. Meaning that at the end of each month, the stock levels were always lower than the recommended levels. Finally, the mean absolute percentage error of the forecasts is given, this clearly shows that for the first couple of months, forecast accuracy was very low.

The next element we designed and proposed in the new planning structure, is the incorporation of innovation and the impact on the planning process, this is done using a decision framework. This framework is based on the impact of five variables, impacted by the introduction of innovation. The five variables are:

- Impact on lead time.
- Impact on stock.
- Impact on supply and BOM.
- Impact on demand.
- Impact on the replacement cycle.

With the inclusion of these impact variables, we suggest a decision tree analysis in which, with basic data regarding innovation the expected current value can be derived to make a decision regarding the best mode of integration of the innovation. The framework suggests a method using net present value, for evaluating multiple scenarios regarding these impacts. This is followed by a method for calculating the expected current value of the innovation. Recently the company introduced the Stage-Gate model to guide innovation throughout the organisation. Our framework makes it possible to derive decisions regarding innovation based on the outputs of the Stage-Gate model. To integrate our decision framework into the S&OP cycle of the company we suggest using multiple scenarios, during the pre-S&OP stage and assessing the impact of the innovations. This is presented in Figure 20, as the impact NPI/NPPI.

In the following step, we present a proposal for performance measurement, to assess the risks and uncertainties in the planning process. Performance measurement should be done regarding multiple factors, to enable a more effective planning system. The suggested performance measurement framework, which we based on the five steps from the literature by Wallace and Stahl [54], suggests performance measures at the end of each step, which are used as input for the following step. This is followed by a list of overall performance measures at the end of the process, that should be incorporated to establish an ongoing cycle each month. With these performance measures the S&OP process becomes circular, using monthly performance outputs as inputs for the next month and so on.

Uncertainties are possible to predict however, future decisions and development have high unpredictability. Especially looking at the situation of the company, experiencing hypergrowth and expanding operationally with the new factory. Building buffers, and protection against the risk of growth or high fluctuations in demand results in less risk focusing on customer order fulfilment, however, this leads to high costs for the company and impacts the balance sheet negatively. Therefore, our framework presents a structure for the future S&OP process of the company. This framework focuses on the integration of the S&OP as a monthly repeated process looking 12 months forward with a structured underlying weekly cycle in five steps. Our framework integrates three missing pillars; cash flows, innovation, and performance measurement. We recommend the introduction of a pre-S&OP meeting and the inclusion of calculations regarding multiple scenarios. Looking at the key problem statements in this research we focus on cash flows, the introduction of innovation, and the evaluation using performance measures. This can only be accomplished by incorporating, departments in the preparation phase of the S&OP that are currently not structurally included: R&D and Finance. During the final executive S&OP meeting, only a limited number of employees can be included, approving or disapproving decisions from the pre-S&OP. In the situation of hypergrowth, structuring the tactical planning is essential to realise the strategic goals set by the company, our framework is an essential step in managing the related risk in a controlled way.

6.2 Impact

In literature, five stages of maturity regarding the S&OP process are given by Grimson and Pyke [20]. Looking at the current situation the company is at Stage 2 of this maturity model. Our model can support reaching a higher level of maturity within this model, as our framework uses pillars derived from the maturity model. Improving the S&OP process leads to a higher maturity of the company's business processes, which is necessary to achieve the structured growth of the company.

Our proposed S&OP framework makes it possible to integrate the S&OP with more business processes and departments. In the current situation not all departments are involved, and therefore do not operate coherently. Our new structure suggests the structured inclusion of more departments, starting as early as the data-gathering phase. The structure helps with integrating more scenarios making it possible for the company to operate an improved scenario compared to the current situation. Our recommended incorporation of the decision framework regarding innovation and the incorporation of R&D into the process leads to better alignment of innovation in the process. This results in the company is prepared for innovation and improvement in decision-making regarding the incorporation of innovation in the S&OP. Followed by the incorporation of finance, integrating cash flows shows the impact of the planning on cash, and for example, the working capital of the company. Making it possible to align finance, with sales and operations more efficiently. On top of that, the new structure leads to the establishment of a cyclical S&OP. This cycle leads to a higher level of integration, performance monitoring, and improvement of processes in the company.

In the entire process, we propose involving more employees and departments in a structured way, helping to establish scenarios, impact assessments, and defining actions on addressed bottlenecks. Out of these scenarios and impact assessments, a choice can be made for the best scenario in the final executive meeting, focusing on decision-making based on prepared scenarios, which are outputs of the pre-S&OP meeting. The involvement of multiple departments should in general lead to a better alignment of departments and processes within the company.

Finally, the integration of performance measurement and evaluation makes it possible to improve at each step in the overall S&OP process. Evaluating and measuring performance at the end of each step leads to the improvement of inputs for the following step. This improves the accuracy of inputs and enables to possibility of updating and reviewing data during the process. The evaluation and presentation of performance measures during the final executive S&OP meeting, and at the end of the process using this as input for the next month leads to a circular S&OP process, improving the planning process each month. Incorporating measures and evaluating them, also supports the growth process and makes it possible to tackle bottlenecks early on.

We created a tactical planning framework, using different relevant elements from existing literature. As this research is done in a very rare situation of hypergrowth, this created specific demands on the study and created some new insights and outcomes, which are not always presented in the existing literature. Our findings add the following new elements to the literature:

1. Structuring tactical planning in a situation of hypergrowth.
2. Connecting S&OP with inventory management, CODP placement, and cash flows.
3. Connecting the Stage-Gate model, for innovation management with the S&OP cycle.

Our research is performed in a company that currently experiences hypergrowth, based on a technological competitive advantage. This situation is uncommon, demanding a different approach regarding the tactical planning process. We addressed this through the incorporation of sales forecast learning loops, which are input to the S&OP process. Also, the incorporation of a circular performance measurement cycle should result in better alignment of planning and growth, and more agile decision-making when and where necessary.

Literature suggests multiple strategies for managing inventory and its costs [3]. In our research this is linked to tactical planning adding customer order decoupling points, determination of improved stock levels, and corresponding cash flows. In this way, our research developed a more advanced solution to inventory management on the tactical time span but also connects planning to the cash projection of the company.

Existing literature offers multiple solutions for including product and process innovation into a S&OP process [4]. In most cases, existing methods come down to involving best guess impacts of new products and processes. We developed a model connecting existing innovation management with tactical planning. This adds a more accurate and more agile method of incorporating NPIs and NPPIs into the tactical planning process than the current literature does.

Overall it can be concluded that with our proposed new structure, the tactical planning of the company can be matured significantly, increasing the likelihood of meeting the strategic goals. Our structure, recommendations, and elements derived from literature are key elements of the success of this approach.

6.3 Limitations

Looking at the limitations of this research, the main issues revolve around the lack of data. Due to the current situation of hypergrowth and the fact that the company has only been operational since 2016, there is a limited amount of historical data available. On top of that, the data available are measured imprecisely or are hard to derive from the system. Due to the immaturity of some processes, relevant data are scattered around the company and are hard to integrate into the S&OP process. The current IT landscape of the company is very limited, only supporting one level in the product structure, with limited functionality, and has no advanced data retrieval options. Due to the current status of the ERP system and information-sharing modes, it is impossible to reach higher levels of maturity regarding the S&OP, within the current IT landscape. Currently, the company is planning on professionalising its IT landscape, which should result in better availability of data.

Looking at the Stage-Gate model of the company used to guide innovation, data are not always available resulting in limitations or even missing steps in some stages. This Stage-Gate model is an important input for the derivation of decisions regarding innovation. The lack of data results in the fact that our research cannot present an application of the decision tree framework entirely. However, the company is working on professionalisation at the moment, and more and more data will become available and can be tracked in the near future. Therefore the integration is expected to be possible in the near future. A lack of data could lead to the need for adjustment in the framework, as cash flows, the impact of innovation, and scenarios are harder to predict. Next to that the lack of data results in the necessity of assumptions in multiple areas of the research, necessary to derive models. However, this may lead to minor mistakes and therefore, potentially lead to sub-optimal solutions in implementation.

Calculations of stocks are done for the current situation. However, due to the growth and building of the new factory, these calculations are only accurate for a relatively short period of time. The proposed model is scalable and can be modified easily for future situations when sales and capacity increase.

The impact of investments, besides the building of the factory, building inventory buffers and improving capacities limited cash is available. Investments are part of the future agenda however, within the time span of 12 months no additional investments are planned yet. This results in the decision-making regarding investments not being integrated into our research. However, smaller investments are an ongoing process in the company that needs to be assessed in the S&OP. For example, the hiring of new employees is done at a rapid pace to enable growth. To track decisions regarding investments a similar approach as the framework regarding innovation is advised, assessing investment based on net present value. Looking at the current situation, innovation is an ongoing process, looking at both products and processes, therefore should be treated as an investment to enable thoughtful decisions also looking at the expected generation of cash flows.

The company derives budget files based on knowledge and expectations, estimating the expected demand and corresponding sales forecasts. These budgets are determined at the start of the year and are updated quarterly, however, no exact forecasts are made for 2024 yet. Therefore the time span for the demand is not 12 months at every time of the year. Manually, a forecast is constructed based on the exponential smoothing of available data. This forecast is however less accurate, also because seasonality is not incorporated, as this was almost impossible to derive from the available data. The method of forecasting used in this research can be overruled when the 12 months rolling budget process becomes available.

The building of the new factory, which will be operational in 2024 results in many future uncertainties, that are hard to track. This will impact the tactical planning process of the company drastically as exact operational capabilities are not known yet. Capacities are known; however the actual performance and capabilities cannot be investigated yet as the building of the factory is still an ongoing process and no data on operational performance, regarding the new factory are available. we propose structured S&OP in such a manner that integration is possible in both the current situation and in the new version of the company. This is also one of the reasons that a closed-loop approach is designed in the new structure, making the process a repeating cycle each month using outputs from previous periods as inputs for determinations of new plans and consensus.

In this research, we used exponential smoothing as a method to forecast sales for 2024. However, due to the expectations of hypergrowth, this method is probably not the best estimate. As the company is growing rapidly, even higher numbers of forecasted sales could be expected. The company will make an actual more thorough forecast for 2024 in the near future, which can replace our derived numbers.

Due to the listing of the company, a lot of data are confidential and therefore cannot be made public. This did not affect the research. However, this resulted in some difficulties in writing our report as not all derived models and calculations can be incorporated. This results in not being able to present all data and outputs, as thoroughly as everything is derived and presented to the company. However looking at the derivation of our framework, this is more general and can be presented in the report entirely. Our framework presents a comprehensive and extensive overview of what and which form of the process should be integrated in the future.

Considering our proposed decision framework regarding innovation, the goal of the framework is the improving the cohesion between the current Stage-Gate model and the tactical planning process. Stage-Gate was also only recently introduced as an innovation management tool within the company. This results in the model not being integrated entirely yet, and data management not being how it should be. This means that to integrate the decision framework improvement of management of the Stage-Gate model is necessary, outputs of each stage should be documented and stored properly and should be easy to find within the company and its IT landscape.

Finally, as mentioned earlier, in summary, it can be stated that the main limitation comes from the availability and accuracy of data. This is mostly related to the fact that the company only exists for 7 years and its fast-growing character. The company is working on the professionalisation and tracking of data, so serious improvement is expected in the near future. A factor is the ERP system of the company. This system is immature, lacks functionality, and has no advanced options for data extraction. To enable proper performance measurement the company should strive towards an integrative and consistent mode of data measurement providing inputs. Especially looking at the expected growth, management of data will be challenging for the company. A more mature ERP system is a costly and time-consuming investment but is certainly advised for the company to invest in the coming years. The current ERP system has its limitations, however, the company is working on professionalization, with for example the implementation of earlier mentioned WMS and CRM systems, tackling limitations and maturing the IT landscape.

6.4 Recommendations for the Company

The key recommendation of this thesis for the company is to fully implement the proposed tactical planning structure, as displayed in Figure 20.

The key to the success of our proposed process is the structured involvement and alignment of all departments in a weekly rhythm. This enables an integrated view of the tactical plan, which comes together in a structured and organised way. Meaning that not only the key executive S&OP meeting taking place each month needs to be continued. But also the incorporation of the extensive pre-S&OP meeting structure, where scenarios, actions, and bottlenecks are discussed. On top of this, the S&OP process should be an ongoing cycle, with weekly steps returning each month and outputs from previous months being used as inputs for the upcoming month. This is to make sure the planning is always available on time and updated every month in a closed-loop principle.

Next to this new tactical planning framework, we also suggest some key elements for success for the company to plan and execute on a tactical level. These key elements are:

1. Introduction of a Customer Order Decoupling point between membrane and module production
2. Improvement of stock levels, based on determined holding- and changeover costs and clear cash impacts regarding the S&OP.
3. Inclusion of innovation in the tactical plan process, based on a data drive decision framework.
4. Integration of a performance management cycle, which is presented with clear performance metrics. to make sure there is a closed loop from planning to execution (plan-do-check-act) and to monitor the impact of S&OP on business processes.
5. Integration of a forecast accuracy process, to measure and improve forecast, stabilise sales, and use the results in the S&OP cycle to create continuous learning loops.

With our proposed key elements, the company can mature its position regarding the professionalisation of the tactical planning process. With a clear structure and follow-up loops monthly. As stated above, the structure of meetings, repeating monthly is crucial to get this process in place. We, therefore, advise making the Supply Chain manager process owner of this process and creating and managing the 4 weekly steps, which come together in the executive meeting, where the key decisions are taken by executive management.

Next to installing this process, we recommend to the company to further professionalise the quality and availability of data. We also present this as an important step in the performance measurement cycle within the S&OP structure. This has to do with building a historical data set, with closed learning loops to improve the quality of data and corresponding processes continuously. For the future we also recommend to the company implement a more professional IT landscape, with more advanced planning tools, enabling multi-level product structures and more advanced data extraction methods. Company-wide there is awareness of the immaturity of the IT landscape and the need for change in the future. However, we recommend doing this as fast as possible, as the complexity of the implementation will significantly increase with the growing size of the company.

For a professionalised integration of the impact of innovation we recommend to professionalise the Stage-Gate model, and integrating this as a company-wide innovation management tool. The model was recently introduced, and integration is not finalised completely. However, to make sure innovation can be integrated within the S&OP model, the Stage-Gate model should be matured. This results in the possibility to track the progress of innovation and calculate the impacts. This can be achieved by better data management and prioritising a proper meeting and documentation at the end of each stage before progression. The company is working on the professionalisation regarding this model, however looking at current innovation on the agenda, data are hard to find and use within the company.

Finally, we present a recommendation regarding the sales budget of the company. Currently, the company uses a sales budget derived at the start of the year, forecasting the sales for the upcoming 12 months, and updating on actuals quarterly. However, this sales budget is not updated each month, resulting in missing data in some S&OP cycles, making it not possible to look forward to 12 months at each time point. This creates the risk of not taking necessary decisions timely. To help with this problem, we recommend expanding the period of the sales budget or updating the budget more regularly. The company is currently already working on expanding the period of their tactical planning aiming to forecast for the upcoming 18 months in the future. On top of that, looking at the low forecast accuracy and high deviations in the current sales forecast, we recommend measuring forecast accuracy thoroughly and using outputs to stabilise demand forecasts.

6.5 Further research

We used existing literature and new insights to design a more advanced tactical planning process for one particular company. What made it especially challenging is that NX Filtration still is a young company, facing hypergrowth in the coming years. This creates additional challenges in dealing with uncertainties and data availability. We recommend performing more research on tactical planning systems in hypergrowth situations and the influence of hypergrowth on the planning cycle in the S&OP process.

Next, it is also advised to perform further research on scenario planning connected to the tactical planning process in a hypergrowth situation. In our proposed structure, it is recommended to run multiple scenarios and assess their impact in the pre-S&OP meetings. However, it is not investigated, which types of scenarios are important and the number of scenarios that should be run to find the best outputs. Also, the research could be done regarding scenarios assessing growth more thoroughly. We recommend the company, to investigate, which scenarios should be run exactly and incorporate them accordingly.

The third piece of advice for further research is to investigate the relationship between the tactical planning process and the performance management system of the company in a hypergrowth situation. Hypergrowth puts specific demands and uncertainties on the planning and performance cycle of companies, which requires more investigation. The fact that existing performance is currently changing in a hyper-growth situation makes this specifically difficult.

In our research, an approximation is made for the sales forecast for 2024, this is done using exponential smoothing, however, looking at the expected hypergrowth this method could be underestimating the sales for the company. Currently, the company uses a different method of sales forecasting, however, sales are still prone to high deviations and accuracy in forecasts were low. Therefore, further research could be done in finding a better method for forecasting sales and stabilising demand expectations.

In this report, we did not incorporate research regarding the effect of the maturity of the S&OP process on the alignment and structure of the involved departments within the company. The framework suggests that the integration and implementation of our new structure lead to better alignment. However, the actual effects of alignment are not researched. We recommend investigating this thoroughly during the implementation and afterwards. On top of that to achieve a better alignment, changes within departments have to be made. For the company, it is important to research how to redesign departments to better align with the new structure.

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A List of Abbreviations and Acronyms

Abbreviation	**Meaning**
BOM	Bill of Materials.
CODP	Customer Order Decoupling Point.
CLIP	Confirmed Line Item Performance.
CRM	Customer Relationship Management.
dNF	Direct Nanofiltration.
EBITDA	Earnings Before Interest, Tax, Depreciation, and Amortisation.
ERP	Enterprise Resource Planning.
FG	Finished Goods.
IP	Intermediate Products.
MAPE	Mean Absolute Percentage Error.
MTD	Month to Date.
MRP	Materials Resource Planning.
NCF	Net Cash Flow.
NPI	New Product Introduction.
NPPI	New Production Process Introduction.
NPV	Net Present Value.
OEE	Overall Equipment Effectiveness.
OPEX	Operational Expenditures.
OTIF	On Time In Full.
PERT	Program Evaluation and Review Technique.
RLIP	Requested Line Item Performance.
RM	Raw Materials.
ROI	Return On Investment.
SIOP	Sales Inventory Operations Planning.
S&OP	Sales and Operations Planning.
UF	Ultrafiltration.
WIP	Work in Progress.
YTD	Year to Date.

B Screenshot Inventory model

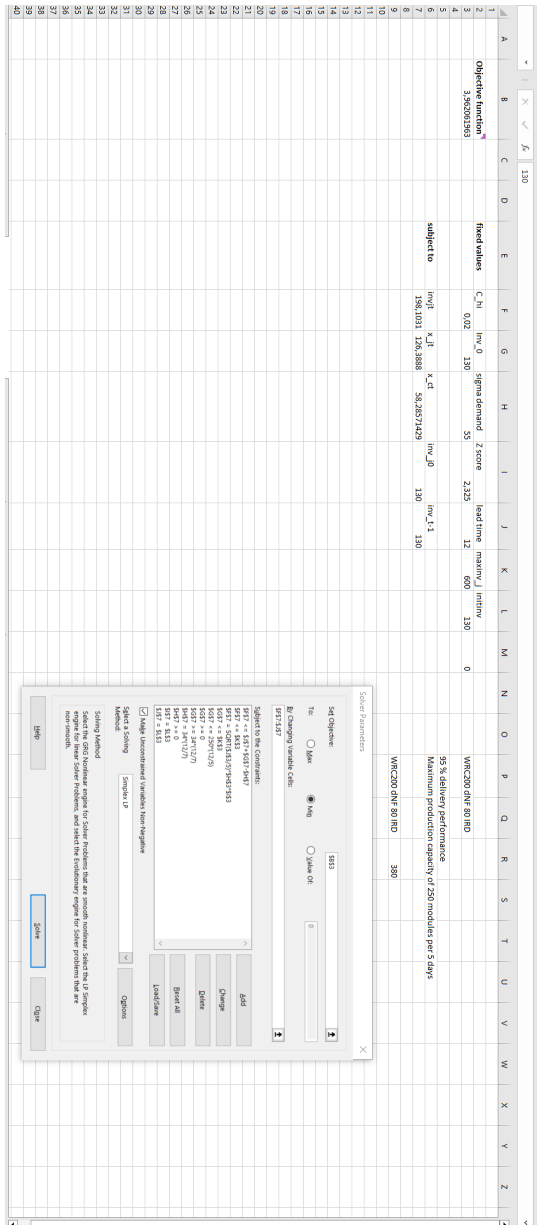

Figure 21: Excel model inventory management.

C Rolling Forecast Model

Due to confidentiality, this figure cannot be presented in this version of the report.

D FMEA Framework

Process Step / Function	Requirement	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential Cause(s) of Failure	Current Process Controls Prevention	Occurence	Controls Detection	Detection	RPN	Recommended Action. RPN > 125, action required	Responsibility & Target Completion Date	Action Results: Actions Taken Completion Date	Severity	Occurrence	Detection	RPN

Figure 22: FMEA template.

E Stage Gate Process

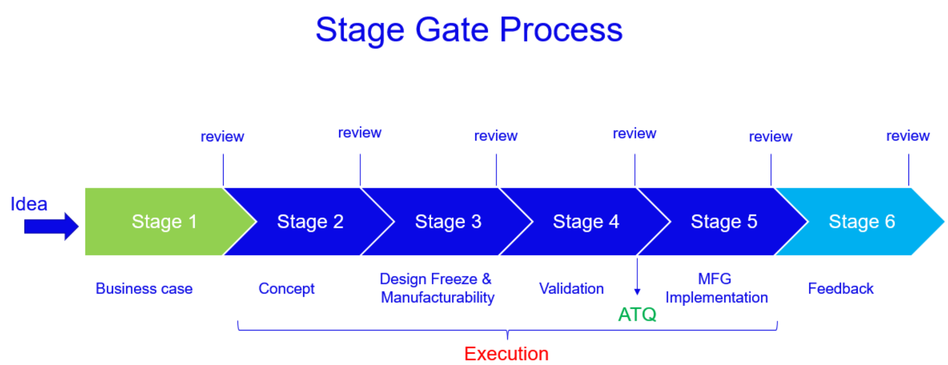

Figure 23: Stage gate model.

F NPV model

Time period	CF Dt	OI	SI	RI	DI	BI	LI	Dt	p	c	SVt	PSt	Replacement?	ECR	Te	BOMO	BOMN
1	0	0	0	0		0	0										
2	0	0	0	0		0	0										
3	0	0	0	0		0	0										
4	0	0	0	0		0	0										
5	0	0	0	0		0	0										
6	0	0	0	0		0	0										
7	0	0	0	0		0	0										
8	0	0	0	0		0	0										
9	0	0	0	0		0	0										
10	0	0	0	0		0	0										
11	0	0	0	0		0	0										
12	0	0	0	0		0	0										
		WACC	0,015														

Figure 24: Input number determination NPV.

Discounted Cashflows				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0

Figure 25: Output Table Discounted Cash Flows.

Variables	Definition	Note
CF Dt	Revenue from innovation	
OI	Cost impact of innovation on operations	
SI	Costs of impact on stocks	
RI	Cost of impact on replacement cycle	
DI	of other products	
Dt	Demand of innovation	
Discounted	Cash flow discounted	
p	Selling price of innovation	
c	Production costs of innovation	
BI	Costs of impact of innovation	
LI	Costs of impact on lead time	
SVt	Number of products on stock at time t	
Replacement?	Replacement necessary at time t?	Answer yes or no
ECR	Expected extra costs of replacment	
Te	Extra lead time, compared to existing products	In number of days
BOMO	Price of BOM of existing product	
BOMN	Price of BOM with innovaiton	
Pst	Value of product on stock	

Figure 26: Variable Definition NPV.

Output NPV Scenarios			
Scenario 1	Scenario 2	Scenario 3	Scenario 4
0	0	0	0

Figure 27: Output NPV.

G ECV Model

Scores determination Pcs							
Timing	Targeting	Positioning	Distribution	Pricing	Communicatio	Whole product configuration	Partnerships and alliances

Figure 28: Inputs probability of Commercial Success.

Extra input variables	Number
Pcs	0
Cc	
Pts	0
Cd	
RPN	

Figure 29: Extra inputs ECV.

Variables	Definition	Note
Pcs	Probability of commercial succes	
Cc	Costs of commericalisation	
Pts	Probability of technical succes	
Cd	Cost of development	
RPN	Risk priority number	

Figure 30: Variable definition ECV.

Output ECV Scenarios			
Scenario 1	Scenario 2	Scenario 3	Scenario 4
0	0	0	0

Figure 31: Output ECV.

H Formula and Data Performance Measurement

KPI	Data	Derive from
Forecast Accuracy.	Actual Sales, Sales Forecast	Budget File, Salesforce(CRM).
MAPE.	Actual Sales, Sales forecasts, 12 months.	Budget File, Salesforce(CRM).
Forecast on innovation demand.	Impact of innovations in final stage, NPI pipeline.	Stage Gate output, impact calculations.
Costs of carrying inventory.	Costs per item, number of items.	Exact online(ERP), holding costs from report.
Weeks of inventory on hand Backorder rate	Recommended inventory, average sales. Orders delivered too late, total number of orders.	Calculated recommended stock levels, Sales budget. Exact online (ERP).
Inventory Accuracy	Recommended inventory, actual inventory.	Calculated recommended stock levels, Excel(MRP, Exact online (ERP).
Percentage of customer who do not experience stock out.	Customers served too late, total number of customers.	Salesforce (CRM), Exact online (ERP).
Fill rate.	Total number of order delivered on-time, total number of orders.	Exact online (ERP).
OTIF.	Orders delivered on-time, orders delivered in-full, total number of orders (towards customer).	Exact online (ERP).
Order cycle time.	Delivery date, order entry date, total number of orders.	Salesforce (CRM).
Capacity utilisation rate.	Actual production, theoretical maximal potential.	Weekly production report, Exact online(ERP).
OEE.	Availabity, performance and quality of production process.	Weekly production report, Exact online(ERP).
CLIP.	Weekly orders, backlog, orders delivered, excess deliveries (towards suppliers).	Salesforce(CRM), Excel (MRP), Exact online (ERP).
Planned vs. Actual(finance).	Forecastsed and actual costs, revenue and working capital.	Balance sheet, budgets.

Percentage of sales from new product introductions.	Total number of Sales, sales from NPI.	Salesforce (CRM), Stage gate.
NPI and NPPI in Stage 5.	NPI, impact of NPPI	Proposed innovation analysis, stage gate model.

Table 6: Data derivation KPI.