Improving the MRP of Nedap Retail

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Preface

This research contains the bachelor's thesis "Improving the MRP of Nedap Retail" to complete my bachelor program Industrial Engineering and Management at the University of Twente.

There are a number of people I would like to thank for contributing to this research. I want to thank the operations team of Nedap Retail for making me feel at ease and involving me in their work. Especially, I would like to thank Bart, Marita and Angelique for making me understand the working of the MRP and having useful discussions about the improvement of the MRP.

Finally, I would like to thank my supervisors from the University of Twente, Matthieu van der Heijden and Petra Hoffmann for their guidance during my bachelor thesis. Their feedback provided valuable additions to the research.

I hope you will enjoy reading.

Martijn Remmelink,

Enschede, September 2018

Management summary

Introduction

This research takes place at Nedap Retail. Nedap Retail provides solutions for the retailing industry, applying RF(ID) technology to optimize in-store stock levels, reduce store losses and increase sales. The antennas of Nedap Retail can for example be found at the entrances of adidas and River Island.

In 2016, the main part of the production was outsourced to East- European countries. This increased the replenishment lead time for most products from 7 weeks to 12 or 28 weeks depending on the product and the manufacturer. The increase of the replenishment lead time made it necessary to place replenishment orders earlier, as Nedap Retail is using a make to stock replenishment policy. To help the purchasers place the replenishment orders on the right moment, Nedap Retail uses the ERP-package Navision 2016. As the standard MRP in Navision 2016 did not generate planning suggestions on the right moments, Nedap programmed additional features in Navision to optimize the working of the MRP. The working of these features is documented poorly which result in an unclear purchasing process which consumes on average 12 hours a week. The purchasing process is desired to consume less than 6 hours a week.

Approach

To understand why the purchasing process currently takes double as much time as desired, first the current working of the MRP in Navision needs to be understood. This was investigated by observing the purchasers and sales employees when they were entering purchase or sales orders in Navision and interviewing them. To validate and test the outcomes of the interviews there is a test-environment in Navision to simulate the working of the MRP. The outcome of the investigation of the working of the MRP in Navision is a process flow and an Excel model. The process flow depicts the relations between the actions the purchasers, sales people and Navision do to come up with the planning suggestions. In the Excel model it is possible to simulate the MRP, this makes it possible to explain the different specific features which are implemented specially for Nedap to the people working with the MRP.

Based on the interviews it was possible to determine the reasons why the purchasing process is currently consuming too much time. After the problems were determined, solutions for the moments Navision does not generate the desired planning suggestions are conducted based on a literature study. The solutions are implemented in the Excel model and tested with historical data.

Findings

- The available to promise period (ATP-period) was not changed after the outsourcing of the production. The available to promise period is currently standard 8 weeks. This results in a gap of 5 to 21 weeks in which Navision suggest placing replenishment orders which is not possible.
- The safety stock is built up manually, which consumes on average one hour per week.
- The purchasers are changing the sales forecast in Navision manually to let Navision come up with good planning suggestions, taking on average 8 hours a week and making the MRP hard to understand.
- Clear instructions for the use of the MRP are missing, which makes the operations employees partly understand the working of the MRP. This results in miscommunication and unnecessary faults.

Recommendations

The simulation shows that the amount of planning suggestions will be reduced with 72% if the solutions are implemented, automatically making the flex-inventory redundant. This would reduce the time the purchasers need to handle the planning suggestions to approximately 3,5 hours a week. Besides the reduction of the time needed to handle the planning suggestions, the MRP is easier to understand for other employees than the purchasers. To get this better situation, I recommend Nedap Retail to implement the following points:

- Change the available to promise period from 7 weeks + safety lead time to replenishment lead time + safety lead time.
- Let the sales forecast automatically increase if the demand is higher than forecasted in a week outside the ATP-period. This will make sure roll-outs will be processed in the right way in the MRP.
- Let the forecast be placed back to the original week if a sales order is deleted which caused a movement of the forecast earlier.
- Make an extra option in the transfer order screen which makes it possible for the transfer order to be handled as a sales order in the MRP.
- Change the moment Navision is triggered to place planning suggestions: Let Navision react on the moment the suggested projected inventory comes below zero within the ATP-period and let Navision react on the moment the suggested projected inventory comes below the safety stock quantity outside the ATP-period.
- Create a new planning flexibility which makes it only possible for Navision to re-schedule the purchase orders to an earlier moment and let the purchase orders automatically get this planning flexibility when the purchase order comes within the ATP-period.
- Document the changes which are made in the MRP of Navision from now on, which makes it easier for new employees to understand the working of the MRP in Navision.

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Reader' s guide

Chapter 1: Introduction

In this chapter will be explained what type of business Nedap Retail is and what the context of the problem is. After the reader understands the context, the research scope and methodology will be explained.

Chapter 2: Current situation

To understand the problems Nedap Retail currently encounters, first the core of the current working of Navision will be explained. Then, the advantages and disadvantages of the current way of working of the operations process will be explained. At the end of the chapter, the findings will be summarized.

Chapter 3: Theoretical framework

In this chapter, the basic principles of material requirements planning (MRP) will be explained. After the MRP is explained, the points where Navision is not performing in the desired way will be compared to the standard Navision settings and the way other ERP-packages handle with these points.

Chapter 4: Applicable solutions

Based on the problems described in chapter 2 and the theoretical background in chapter 3, solutions will be generated to improve the current working of the MRP in Navision. The solutions will be programmed in an Excel VBA model to test the consequences of the solution.

Chapter 5: Validation of the solutions

In chapter 5, firstly the way the process flows are extracted from Navision will be explained. Secondly, the implementation of the process flow in an Excel VBA model will be explained. Thirdly, the way the solutions discussed in chapter 4 are tested in the Excel model will be discussed.

Chapter 6: Impact

The impact of the solutions explained in chapter 4 will be discussed in this chapter. This will be done based on the impact effort matrix, as not every solution will be easy to implement.

Chapter 7: Implementation

The way the solutions need to be implemented will be discussed. This will make sure that the solutions are interpreted in the right way by the programmers and the operations employees.

Chapter 8: Conclusion, recommendations and discussion

In this chapter the outcomes of the bachelor assignment will be discussed.

Definitions

Available to promise (ATP): The available to promise is the amount of products sales may sell to the customers at a moment. The ATP is based on the number of products which are expected to be in inventory.

ATP-period: The ATP-period is the period in which sales may not sell more products than the products which are expected to be in inventory. Outside the ATP-period sales may sell as much products as they want, as is assumed the manufacturers are able to produce and deliver a new batch of products.

Flex-inventory: The flex-inventory is the safety stock policy which is specially designed for Nedap in Navision. The flex-inventory is built up manually, making it possible to increase the safety stock level outside the ATP-period.

Lot-for-lot replenishment strategy: The Lot-for-Lot replenishment strategy has another meaning in Navision compared to the literature. The Lot-for-lot replenishment strategy in Navision can be compared to the forecast-based planning method in other ERP-systems. If the inventory is expected to come below the safety stock level based on the sales forecast, a new replenishment order is desired. If the inventory would come below the safety stock level based on the sales forecast over 8 weeks and the lead time is 4 weeks, a replenishment order will be placed over 4 weeks.

Navision: Navision refers to Microsoft dynamics Navision 2016. This is the ERP-package which is currently used at Nedap Retail. An ERP-package combines the purchasing, sales and invoicing processes in one program.

Re-order point replenishment strategy: In the re-order point replenishment strategy, a replenishment order is placed when the inventory comes below the re-order point. The re-order point is based on the safety stock and the expected lead time demand.

Replenishment planning suggestion: The replenishment planning suggestions are the planning suggestions Navision generates to place new replenishment orders. These planning suggestions are visible in the purchasing forecast for the manufacturers

Re-scheduling planning suggestion: The re-scheduling planning suggestions are the planning suggestions in Navision which propose to re-schedule an

existing purchase order. These planning suggestions are not visible in the external forecast.

The Automove function:

The Automove function makes sure the amount of planning suggestions during the ATP-period is reduced, through moving sales forecast from a week where there is sold less than expected to a week where there is sold more than forecasted.

1. Introduction

1.1 Nedap

Nedap was founded in 1929 in Amsterdam, it was one of the first companies which was working with Bakelite, a synthetic plastic which was widely used by the manufacturing of electronical products. In 1947 it moved to Groenlo and in the same year it was listed on the Amsterdam Stock Exchange. Since the start in Groenlo, Nedap has developed and produced a lot of electronical products, resulting in 11 market groups nowadays. Every market group is specialized in a certain application of the technologies that are developed, but generally they are all applying RF(ID) and NFC technologies or planning/controlling business processes. Nedap has nine offices around the world and business partners in more than 100 countries.

1.2 Nedap Retail

Nedap Retail is the market group where the bachelor assignment takes place. As the name already reveals, Nedap Retail is working on solutions for the Retail industry. The antennas that are developed at Nedap Retail can be found at food stores like Kaufland and Aldi, as by the clothing shops like adidas and G-star. These antennas track if there are no products leaving the shop without paying, by scanning the clothes on RF(ID) chips. As these RF(ID) chips need to be in the products, Nedap Retail also provides other solutions that make it easy to count the products and have a very precise overview of the products available in the shop. At Nedap Retail are almost 100 people working, in three main divisions: Sales, Operations and Research and Development.

1.3 Context of the problem

In 2016, the main part of the production of Nedap was outsourced to manufacturers in the east of Europe. Only the products that are too risky to outsource and the products that are almost never produced are still produced in Groenlo. The supply chain is showed in figure 1. In green, the manufacturers are depicted. The manufacturers in the row closest to DSV are the manufacturers where Nedap is placing its orders. All these manufacturers have again suppliers which deliver the spare parts for the products. The manufacturers all have a make to order policy. DSV is depicted in yellow in figure 1, this is the warehouse in the Netherlands. In this bachelor assignment, we will focus on the replenishment of DSV. In DSV Nedap wants to have all products on inventory, as they want to fulfil demand as fast as possible. In orange are the customers depicted. The end customers order the products at the Nedap office closest to them, the Nedap office than orders the products at DSV. For DSV, most sales orders are placed for a moment within the upcoming three weeks. As the replenishment lead time is for the most products 12 to 28 weeks, Nedap Retail uses a make to stock replenishment policy for the regular demand to make sure the demand can be fulfilled in time. However, if there are roll-outs, a make to order replenishment policy is used as Nedap would otherwise need a lot more safety stock.

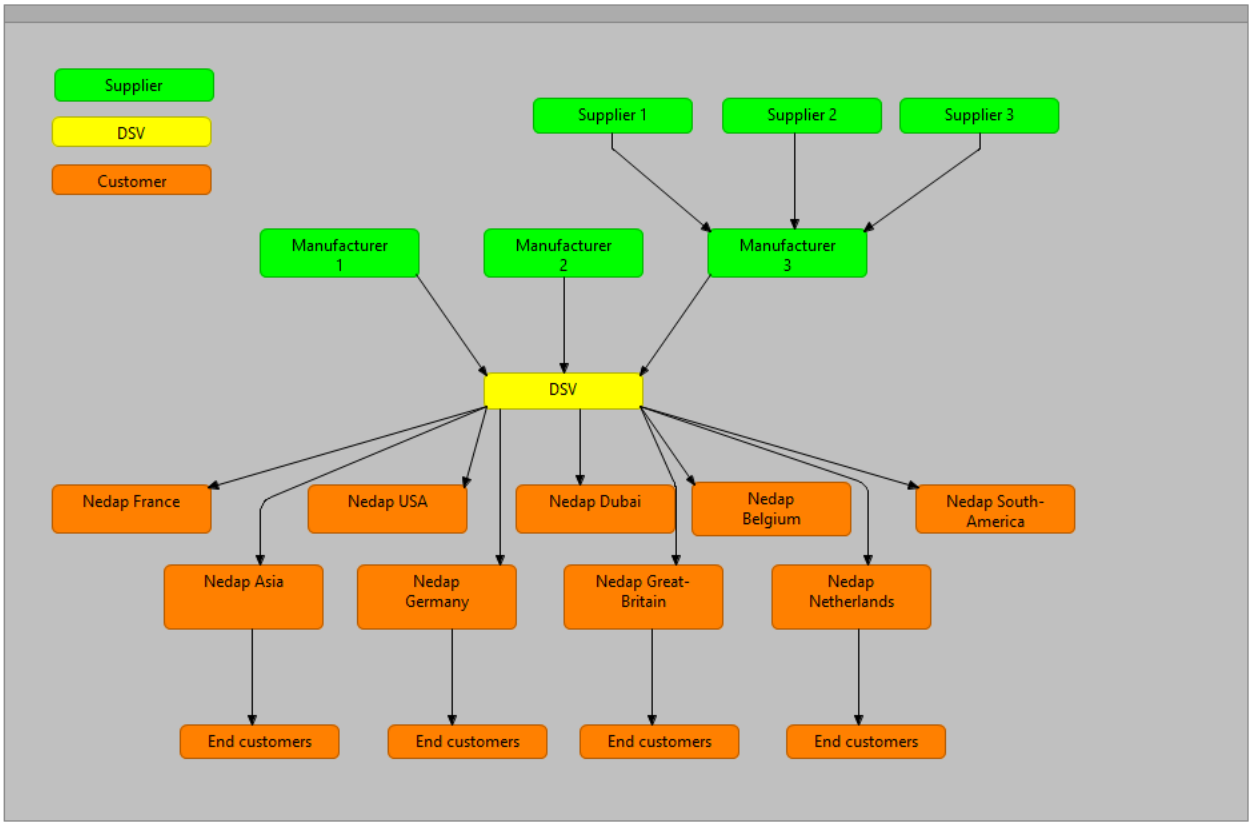


Figure 1: Supply chain of Nedap Retail

Outsourcing the manufacturing gave some challenges:

- The new manufacturers had to learn the production of all the products. In the beginning a lot of products from the new manufacturers did not reach the quality levels Nedap expected.
- The new manufacturers encountered problems with purchasing the spare parts at their suppliers. The manufacturers sometimes purchased the spare parts at other suppliers than Nedap did. The manufacturer's suppliers have other lead times and did sometimes not expect the amount that was desired, which increased the time it took the manufacturer to produce the products.
- The time between placing an order by the manufacturer and receiving the products increased significantly. When the production was in the Netherlands, enough spare parts where in inventory to produce and deliver the products to the end-customer within 7 weeks for almost all products. After the outsourcing, it takes some products 28 weeks before a product can be delivered to DSV.
- A lot of production knowledge was no longer available. Back in the Netherlands, some products were produced and tested by the same employees since the launch of the product. These people changed their way of working and developed their own testing procedures based on the changes in the products, but these changes were often documented poorly.

To make sure there were enough products in inventory to cover the longer lead-time demand, the inventory levels were increased before the outsourcing. Replenishment orders were placed by the new manufacturers and purchase forecast were send. The new manufacturers were not always able to deliver

the desired amounts, as they were not always able to get all the components in time and did not always reach the Nedap quality standards. If the products were not delivered in time, the sales forecast was moved forward. This was firstly done because this is necessary to let Navision make the right planning suggestions and secondly this was done as it was assumed the main part of the not fulfilled sales forecast would be sold as soon as the products were available. However, customers often went to the competitors or chose compatible products. This effect doubled the inventory within half a year.

Now the manufacturers are getting more reliable and the quality of the products reaches the Nedap standards, it is possible to look to a more efficient purchasing policy. Nedap Retail changed in 2017 to the newest Navision ERP system at that moment: Microsoft Navision 2016. Nedap Retail expected this system would solve most of the irritations in the old system, but at the purchasing site, the process was still working the same. Navision gives a planning suggestion based on three or four indicators. For the products with a re-order point replenishment policy these are:

- The sales orders
- The scheduled receipts
- The re-order point

For the products with a lot-for-lot replenishment policy the indicators are:

- The sales forecasts
- The sales orders
- The scheduled receipts
- The safety stock level

As these indicators are indicated by different people and these people are already doing the same steps for a couple of years, there is no clear overview of the way the different indicators affect each other and how Navision exactly determines the planning suggestions. As described above, with the improved manufacturer reliability, the operations process is again working as it was expected to work before they started with the outsourcing of the production.

In this operations process, there is still a lot of work done manually to make sure Navision processes the right planning suggestions. The replenishment and re-scheduling planning suggestions both need to be corrected, as these often appear on moments these planning suggestions cannot be accepted. If the planning suggestions are not corrected, these will be visible in the external forecast for the manufacturers and new planning suggestions will be generated based on the assumption that earlier planning suggestions are accepted. To improve the planning suggestions Navision generates, some special features are developed, which will be explained in chapter 2. A good working of the operations process in Navision becomes more important, as Nedap wants to automate the sales order placing process in the future.

1.4 Research objectives and questions

As described above, it is currently time consuming to let Navision make the right planning suggestions. The aim of the research is to get a better insight in the working of the operations processes in Navision and come up with a proposal for a better working of the MRP in Navision. Currently, it takes on average 12 hours per week to correct the planning suggestions and place the purchase orders. The goal of the

research is to reduce the time it takes to correct the planning suggestions and place the purchase orders to 6 hours a week.

1.4.1 Research scope

As 10 weeks is too short to analyze the complete supply chain, the scope of the research needs to be reduced.

- The scope of the research will be limited to the operations process in Groenlo, which is the purchasing and sales process for the DSV warehouse. All the other business locations will be called customers, as they order from DSV.
- Nothing will be changed on the way DSV works, as DSV is an extern company that only lays the products of Nedap on inventory and ships the products when Nedap gives a message.
- It will not be possible to change the way the manufacturers work. The lead times the manufacturers give will be used.
- The way sales receives orders will not be changed, the only thing that is possible to change in the sales process is the amount of products sales may promise to the customers. With sales are the people meant that are entering the orders in Navision, not the people that are promoting the products by the end-customers.
- The solution must lay within the possibilities of Navision. Nedap uses Navision in all market groups, changing this is not desirable and would be too expensive. However, it is possible to build in new functions or change existing functions in Navision.

1.4.2 Research questions

The core problem of this research is: **It takes Nedap Retail's purchasing department on average 12 hours a week to correct the planning suggestions Navision generates, which is desired to be less than 6 hours.**

To solve this problem, first a detailed overview of the current situation needs to be made. This overview must include the working of Navision, the way operations determines it forecasts, the way sales processes sales orders and the considerations purchasing makes to place an order by the manufacturers. Secondly, literature will be used to search for comparable situations. Thirdly, the most applicable solutions will be chosen and fourthly, the best situation will be tested in Navision and will be recommended. This process will be worked out in the following six research questions:

1. How does the MRP within Navision currently work for end-products with a re-order point and products that are ordered based on a forecast?

This question will be answered by observing and questioning the purchasing and sales people. It will also be possible to work in the test-environment of Navision, which will make it possible to validate if the observations are interpreted in the right way. By understanding the working of Navision, it will be possible to think in the possibilities Navision gives, as that will be an important constraint in solving the research problem. The output of this question will be a process flow with a detailed description of the sales and purchasing processes for the products with a re-order point and the products with a sales forecast. After analyzing the current way of working, the pros and cons of the current way of working will be derived. The pros and cons will be determined based on the experiences with Navision and the interviews with the sales and purchasing department. After understanding the pros and cons it will be

clear where the improvements can take place and how the problems relate to each other. After completely understanding the current situation, it will be possible to look to solutions.

2. Does the MRP in Navision work different from the literature about MRP and differ from the MRP in other ERP-packages?

This question will be answered by a literature study. In the literature study will be searched for the basic working of a MRP system and the found literature will be compared with the working of Navision and other ERP-packages.

3. Which solutions will solve the problems of Nedap Retail's purchasing department regarding the working of the MRP and the planning suggestions?

Solutions will be generated based on the problems explained in the first research question and the findings of the literature study of the second research question. After the possible solutions are determined, these will be discussed with the purchasers, sales people and the programmers of application management to make sure the solutions can also be implemented in Navision.

4. Is the way the research is conducted valid?

In this research question the validity of the research will be discussed. This will be done to make sure that the research is conducted in a valid way. As the solutions are tested in an Excel VBA model, it is important to know how the Excel model was generated.

5. What is the estimated impact of the solution?

The solutions will be placed on the impact-effort matrix, which will give insight in the effectiveness of the different solutions. The advantages and disadvantages of the different solutions are summarized.

6. How can the solution be implemented in the current purchasing process?

To make sure that the solution can be implemented in the way that it is foreseen in this research, an implementation plan will be made. This will make sure that the programmers can implement the solution if this is not already possible and that the purchasers understand the consequences of the solution in their way of working.

1.5 Research methodology

To make sure that the research is conducted in a reliable and valid way, it is important to look to the consequences of the way the research is conducted. The idea of a reliable research is that another researcher will get the same outcome if he conducts the research in the same way. The idea of a valid research is that it is credible and believable. If the data is valid, it must be reliable, but a reliable data set does not automatically have to be valid.

1.5.1 Validity

Validity can be divided in internal and external validity. Internal validity is about the accuracy, reliability, utility and quality of the process (Cooper and Schindler, 2014). In conducting a research, it would come up with questions like, was the decision maker influenced on forehand? Is the researcher manipulated during the research process? Are the process steps executed in the right order? Those questions are hard to measure but are important to determine if the research is valid (McDermott, 2011). To generate

external validity, the outcome of the research needs to be applicable on other situations and then generate the same outcome.

In this research, we will mainly focus on the internal validity. If another student would have done the same research, this student must have generated the same outcome as is proposed in this research if he follows the same steps as are conducted now.

1.5.2 Reliability

When conducting experiments, the experiment is reliable if it under the same conditions always generates the same outcome (Golafshani (2003)). In Navision this would for instance mean that if a situation is tested, it would generate the same output if the conditions are the same on another moment. For Navision this might not be a problem, as Navision runs on mathematical rules. Knowing this, it is important that the researcher is aware of the situation he is conducting the experiments in. When for example only setting the planning-flexibility on in a purchase order, Navision generates complete other planning suggestions than when this option is not enabled.

1.5.3 The data

The dataset which is provided for this research is from 16 October 2017 until 29 June 2018. This is more than half a year of data which can be used to obtain parameters and simulate solutions. The data set is reliable, as it depicts the real situation in that period. The validity of the data set is less, as in this period the manufacturers were often not able to deliver in time, which resulted in delayed deliveries and lost sales. However, if Navision can provide the right planning suggestions based on an unstable period, it will provide good planning suggestions in a stable period.

1.5.4 The interviews

Interviews will be conducted with people from sales, purchasing and application management. To make sure all the influenced people are heard, interviews will be conducted with all the people which are directly placing sales and purchase orders in Navision. The findings of the interviews will be discussed with the other people working in Navision, to validate if a problem is encountered by one person or more people.

2. Current situation

2.1 Product types

Nedap Retail makes a distinction between A, B and C products. A and B products use a lot-for-lot replenishment policy and C products use a re-order point replenishment policy. The lot-for-lot replenishment policy uses sales forecasts to determine when a new purchase order is needed. If based on the forecast the inventory drops below zero in a week, a planning suggestion will appear in the week the order needs to be placed. This week is determined by the time it takes the manufacturer to produce the products and the safety lead time.

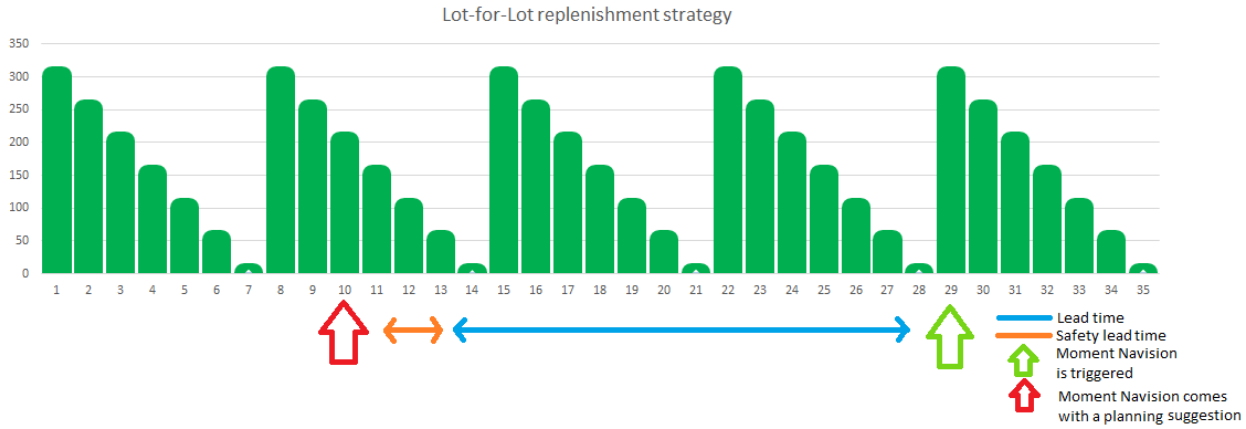


Figure 2: Lot-for-Lot replenishment policy

In figure 2, the optimal lot-for-lot replenishment graph is showed. The products are every time received when the inventory is likely to drop below zero. If the inventory drops below zero in week 29, Navision will give a planning suggestion in week 10. Navision will give this planning suggestion based on the lead time (depicted in blue) and the safety lead time (depicted in orange). The lead time is the time the manufacturer needs to produce and deliver the orders to DSV. The safety lead time is used to cover the time it takes DSV to make the products ready for shipment to the end-customer. The green arrow depicts the moment Navision is triggered to place a replenishment order, the red arrow depicts the moment Navision will come up with a planning suggestion.

In the re-order point replenishment policy, a planning suggestion will appear in the week the inventory comes below the re-order point. This is depicted in figure 3, the re-order point in this example is 300 products. When the inventory comes below the 300 products in week 5, purchasing gets a planning suggestion to place a new order. If purchasing accepts this message, the products will be received in week 14. Again, the blue line depicts the manufacturer's lead time, the orange line depicts the safety lead time, the green arrow depicts the moment Navision is triggered to place a replenishment order and the red arrow depicts the moment Navision will come up with a planning suggestion.

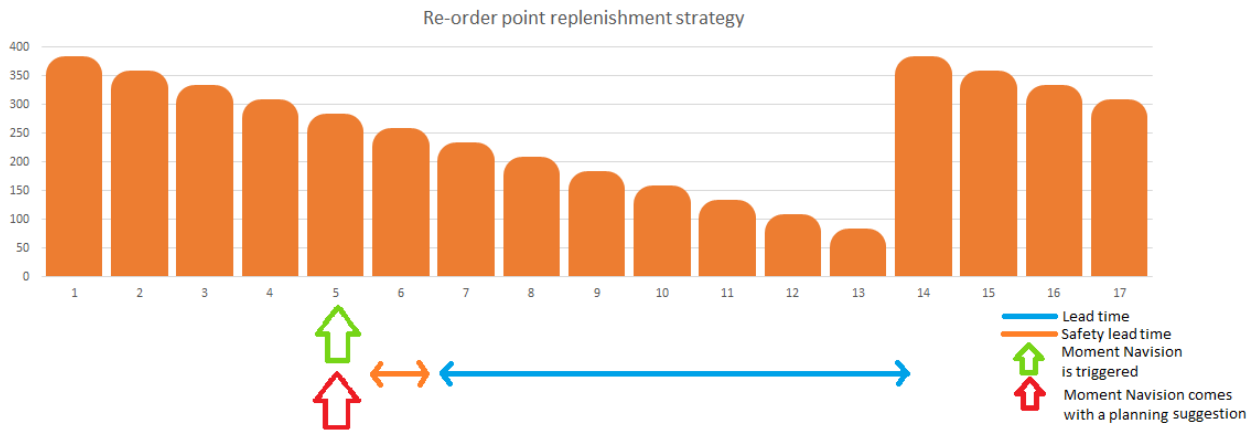


Figure 3: Re-order point replenishment policy

The A and B products are the products with a high or unstable demand. For these products, a forecast with the expected purchase orders is sent to the manufacturers every week, with the intention manufacturers can already buy the long lead time components, eventually even in bigger amounts because they can see that Nedap forecasts to place more purchase orders in the upcoming year. The products with a re-order point are the products that are already sold for a period, the demand is quite stable and the prices are relatively low. In table 1, an overview is given of the different product types with the replenishment policy and a formula of how the forecast or the re-order point is determined.

Product type	**Replenishment policy**	**Description**	**Formula**
A	Lot-for-Lot	Forecast is based on past sales, already announced roll outs and customer forecasts.	$Forecast_{week} = 0{,}5 * \frac{Total\ sales\ last\ 26\ weeks}{26\ weeks} + 0{,}5 * \frac{\sum customer\ sales\ forecasts}{13\ weeks} + \frac{Roll\ outs\ in\ upcomming\ 13\ weeks}{13\ weeks}$
B	Lot-for-Lot	Forecast is based on past sales and already placed orders.	$Forecast_{week} = \frac{Total\ sales\ last\ 26\ weeks}{26\ weeks} + \frac{Roll\ outs\ in\ upcomming\ 13\ weeks}{13\ weeks}$
C	Re-order point	Re-order point is based on the expected lead time demand + a factor to cover lead time delays and unexpected demand.	$Reorder\ point = \frac{Total\ sales\ last\ 26\ weeks}{26\ weeks} * Lead\ Time + safety\ stock$

Table 1: Product types

2.2 Navision

In the product card in Navision, all the product specific information can be found and changed. In Appendix 1, all the possible fields that can be changed regarding the replenishment strategy are explained. After filling in the product card and entering the start inventory, Navision will calculate the MRP card. As the calculations in the MRP card differ per replenishment strategy, an extensive process flow is made for the products with a re-order point (Appendix 2) and the products with a Lot-for-Lot replenishment strategy (Appendix 3). In Navision is a distinction made between the MRP sales sees and

the MRP purchasing sees. In the MRP of sales are the planning suggestions not visible, whereas purchasing can choose to see the planning suggestions or not.

2.3 Process flow

In the process flow in figure 4, a simplified version of the process flows in Appendix 2 and 3 is given. This process flow focusses on the key process in Navision. For purchasing, the planning suggestions are the most important trigger to place new orders. For Sales the available to promise (ATP) is the most important indicator when placing sales orders. The green blocks are only important for the products with a Lot-for-Lot replenishment policy, these blocks are 0 in the products with a re-order point replenishment policy. Every block has a number, every number is explained below the figure.

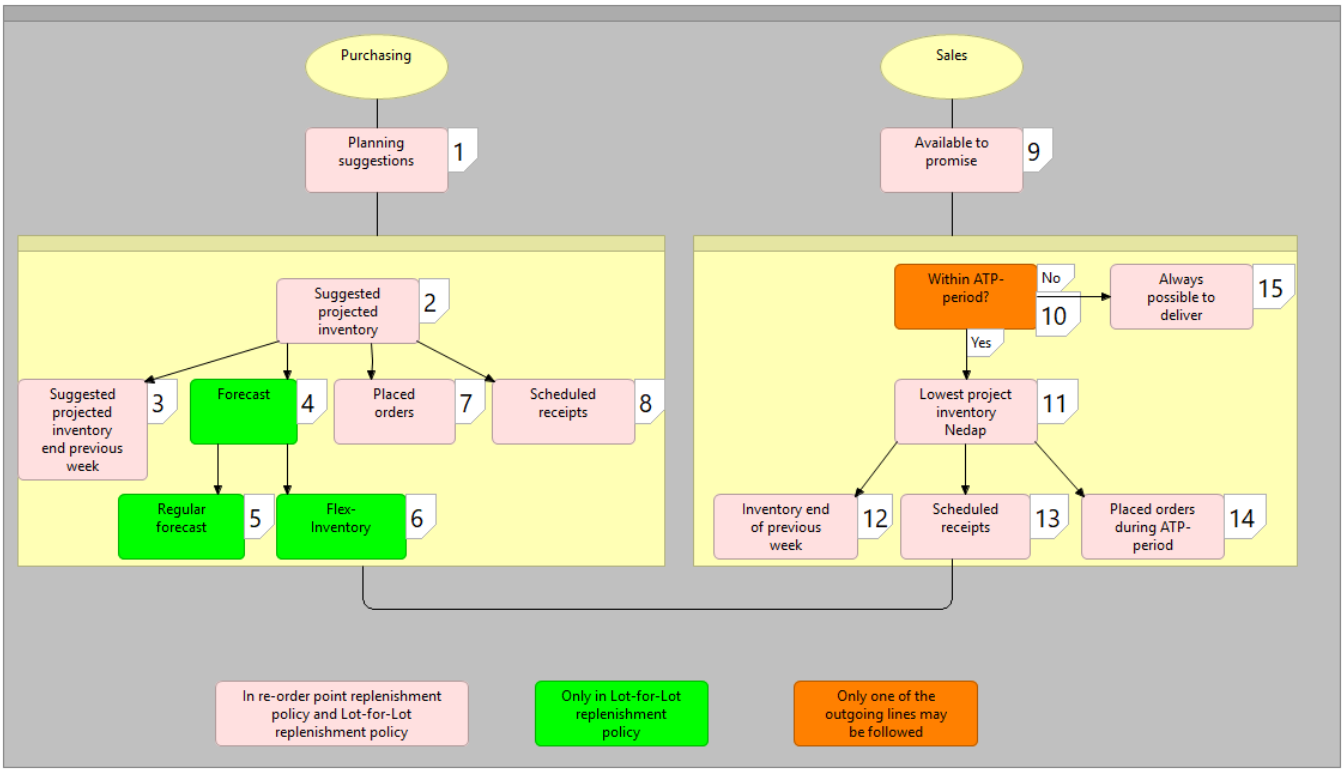


Figure 4: Simplified process flow

1. Planning suggestions

The planning suggestions are the messages the purchaser receives from Navision. The planning suggestion contains a product number, an order date and a suggested order amount. The suggested order amount is per product determined by the minimal order quantity (MOQ) and the order multiple. If for a product the MOQ is 6, the order multiple is 3 and the expected demand is 8, Navision will give a planning suggestion of 9 to cover the demand. The planning suggestions are generated based on the suggested projected inventory. In the re-order point replenishment policy, a planning suggestion will appear if the suggested projected inventory comes below the re-order point. In the Lot-for-Lot replenishment policy, the planning suggestions will appear if the suggested projected inventory comes below zero.

2. Suggested projected inventory

The suggested projected inventory for the products with a re-order point replenishment policy is calculated based on the suggested projected inventory at the end of the previous week, added up with the scheduled receipts and decreased with the placed orders. In the Lot-for-Lot replenishment policy, the suggested projected inventory is calculated based on the suggested projected inventory at the end of the previous week, added up with the scheduled receipts and decreased with the placed orders and the remaining forecast for this week. This remaining forecast is calculated through deleting the placed orders from the sales forecast until the remaining forecast is 0. Purchasing can choose to see the planning suggestions or not. If the planning suggestions are visible, Navision will automatically include them when calculating the suggested projected inventory, the planning suggestions are added up by the initial suggested projected inventory.

3. Suggested projected inventory end of the previous week.

The suggested projected inventory at the end of the previous week is taken to calculate the suggested projected inventory for the current week. This process goes back until the first-time products were received. So, if the suggested projected inventory at the end of the previous week is 100 and this week the sales forecast is 40, the suggested projected inventory for this week is 60.

4. Forecast

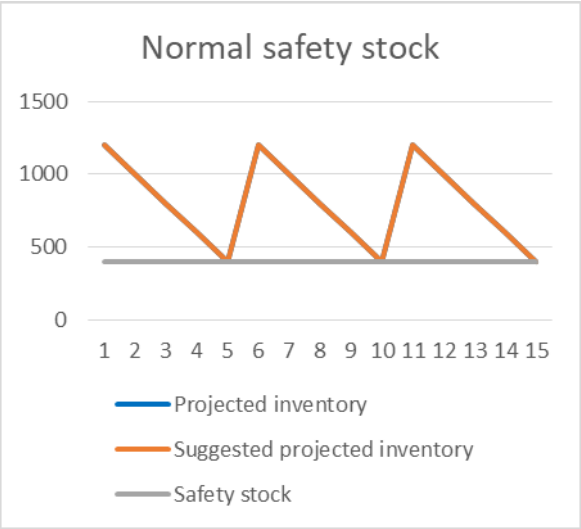
The forecast is only filled in the MRP card in the Lot-for-Lot replenishment policy. The forecast is the main generator of the planning suggestions in this replenishment policy, as the moment the purchaser receives the planning suggestion is based on the moment the suggested projected inventory is likely to come below zero (see figure 2). The forecast is built up from flex-inventory and regular forecast. Navision is able to move with the forecast of other weeks if the demand is higher than expected in a week. This is done automatically within the ATP-period with the Automove function, the Automove function will be explained in section 2.5.

5. Regular forecast

The regular forecast is the sales forecast described in table 1. All the regular forecasts are updated quarterly, but during the quarters the Automove function and the purchasers are able to change the sales forecast if necessary.

6. Flex-inventory

The flex-inventory is the desired safety stock level in the Lot-for-Lot replenishment strategy. As the flex-inventory is in Navision part of the forecast, it influences the suggested projected inventory and so the planning suggestions. In a standard situation, the flex-inventory operates the same as a standard safety stock level. This is demonstrated in figure 5 and 6.



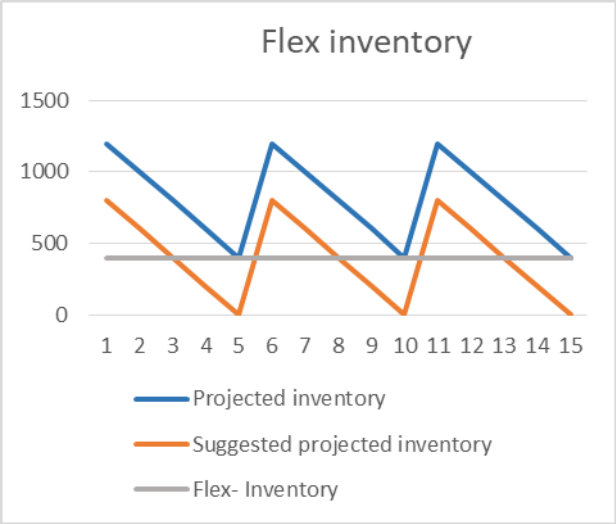


Figure 5: Normal safety stock

Figure 6: Flex-Inventory

In figure 5, a standard safety stock policy is displayed. Navision will react if the suggested projected inventory is lower than the safety stock quantity, in this case this happens when the inventory comes below 400. The projected inventory is in this case the same as the suggested projected inventory. In figure 6, the flex-inventory is showed. The flex-inventory lowers the suggested projected inventory and instead of re-ordering when the suggested projected inventory reaches the safety stock quantity, Navision plans to re-order when the suggested projected inventory is zero. In a standard situation, the inventory follows the same pattern, as can be seen in figure 5 and 6. In both situations, Navision wants to replenish in week 5 and week 10. However, the flex-inventory is built up in the sales forecast and the forecast can be moved (section 2.5). This movement let the flex-inventory level automatically decrease which prevents Navision from generating planning suggestions on the moment the suggested projected inventory comes below the desired safety stock level. If the flex-inventory level is decreased, the purchasers will mention this and will complement the flex-inventory level to the desired level in a week outside the ATP-period.

The flex-inventory is part of the forecast, if the flex-inventory is on the desired level, the forecast in the current week is flex-inventory + regular forecast. The remaining forecast is determined by the forecast decreased by the placed orders. At the end of the week, there are three options:

- There is no remaining forecast: If there is no remaining forecast, all the flex-inventory is used. The flex-inventory in the next week is 0, unless there is placed new flex-inventory in the next week.
- There is remaining forecast, the remaining forecast is lower than the desired flex-inventory level: The remaining forecast will be moved to the next week. The flex-inventory level will be lower than the desired flex-inventory level, unless there is placed new flex-inventory in the next week.
- There is remaining forecasts, the remaining forecast equals or is higher than the desired flex-inventory level: The flex-inventory is moved to the next week, the rest of the remaining forecast is deleted.

If there was already flex-inventory placed in the next week, this will be added to the moved flex-inventory of the previous week. On Monday morning, a purchaser checks all the flex-inventory levels. There are three possible situations the purchaser can occur:

- The flex-inventory is higher than the desired flex-inventory level: The purchaser will remove the redundant flex-inventory and if there is already placed extra flex-inventory in the following weeks, the purchaser will delete these as well.
- The flex-inventory equals the desired flex-inventory level: The purchaser looks if there is placed extra flex-inventory in the upcomming weeks and deletes it if it is available.
- The flex-inventory is below the desired flex-inventory level: The purchaser will check why the flex-inventory is below the desired flex-inventory level and place new flex-inventory outside the ATP-period.

Building up the flex-inventory in the forecast makes sure the replenishment of the flex-inventory takes place outside the ATP period. With the Monday morning check, the purchaser will directly mention if Navision did not work in the expected way, as this is often visible in the flex-inventory. An overview of the actions is displayed in figure 7.

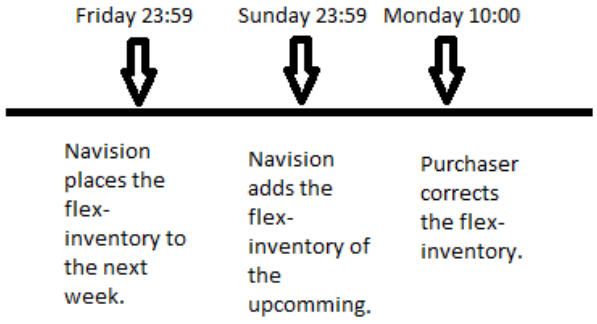


Figure 7: timeline flex-inventory

7. Placed orders

The placed orders are the customer orders. After an order is placed in Navision, the products can no longer be delivered to another customer. Within the ATP period, the placed orders have a major role in determining the ATP. This is explained by point 14: placed orders during the ATP. The major part of the customers want their products within three weeks from of the moment they place the order.

8. Scheduled receipts

The scheduled receipts are the planning suggestions which are accepted. These purchase orders are placed and are scheduled to be receipt in a certain week. The scheduled receipts increase the inventory and so the suggested projected inventory. From of the moment the scheduled receipts are standing in the MRP-card, these are assumed to be available to be sold.

9. Available to promise

The available to promise (ATP) is the key indicator for sales. If sales receives a sales order, they first look if it is possible to deliver this order based on the ATP. If the ATP becomes green after filling in the product number, the amount and the desired date, the sales order can be accepted. If it turns red, the

amount of available products is lower than the desired amount. The sales person then needs to contact purchasing to check if it is possible to receive a purchase order earlier and otherwise the sales person has to negotiate with the customer.

10. Within the ATP-period?

The ATP-period is the period where it is in most cases not possible to change existing purchase orders and place new purchase orders. Basically, it means that it is not possible for sales to sell more products than the products that are in inventory plus the products that are already ordered and expected to be deliverd during the ATP-period. The ATP-period is currently 7 weeks replenishment lead time + 1 week safety time.

11. Lowest projected inventory Nedap

Within the ATP-period, the ATP is determined by the lowest projected inventory Nedap (PIN). The PIN starts with the inventory at the end of the previous week. It then calculated for the current week the available products. This is done by taking the PIN of the end of the previous week adding it up by the scheduled receipts of the current week and decreasing it with the placed orders of the current week. The ATP within the ATP-period is the lowest PIN until the next scheduled receipt. However, if the scheduled receipts are all sold, the lowest PIN of the ATP-period will be taken. This process is depicted in figure 8 and figure 9. In figure 8 the lowest PIN of the ATP is 10 in week 8, this means that there are only 10 products left when all the placed orders are fulfilled, so in this situation may sales not place a sales order with an amount bigger than 10 during the ATP-period. In figure 9, the lowest PIN is reached in week 3. In week 1 untill 3 the ATP is 68, as there are still 68 products available to sell. In week 4, a purchase order is received, the purchase order is partly consumed in week 4 and 5 which makes the next lowest PIN 136 products. In week 6 is again a purchase order received, this order again increases te PIN and the next lowest point within the ATP-period is 210 in the last week of the ATP-period.

Week	Scheduled Receipts	Placed orders	PIN	ATP
0			100	
1	300	152	248	10
2		135	113	10
3		45	68	10
4	300	93	275	10
5		139	136	10
6	100	167	69	10
7		54	15	10
8		5	10	10
9	200	87	123	123
10		65	58	58

ATP-periode

Lowest PIN

Figure 8: ATP if all scheduled receipts are sold.

Week	Scheduled Receipts	Placed orders	PIN	ATP
0			100	
1	300	152	248	68
2		135	113	68
3		45	68	68
4	300	93	275	136
5		139	136	136
6	200	67	269	210
7		54	215	210
8		5	210	210
9	200	87	323	323
10		65	258	258

ATP-periode

Lowest PIN

Second lowest PIN

Third lowest pin

Figure 9: ATP if not all scheduled receipts are sold.

12. Inventory end of previous week

The inventory at the end of the previous week is the start inventory in the new week. The role of the inventory at the end of the previous week is showed in figure 8 and 9. The inventory at the end of the previous week is needed to calculate the values of the new week. In figure 8 this is for example visible in

the calculation of the PIN of week 1: 100 (Inventory end of week 0) + 300 (Scheduled receipts week 1) – 152 (placed orders of week 1) = 248 (PIN end of week 1).

13. Scheduled receipts

The scheduled receipts are the placed purchase orders which are expected to be delivered in the week the scheduled receipts stands. If in a week stands a scheduled receipt, the products are expected to be available to be sold in that week. The scheduled receipts increase the PIN.

14. Placed orders during ATP-period

The placed orders during the ATP-period are the sales orders placed in the weeks of the ATP period. The placed orders during the ATP-period are influencing the ATP. This is visible in figure 8, the PIN in week 8 is the lowest due to all the sales orders in the ATP-period. When sales gets a new sales order in week 4, the purchaser may sell a maximum of 10 products, however there are still 275 products in inventory in that week.

15. Always possible to deliver

Outside the ATP-period, the ATP will always becomes green, even if the ATP is negative after entering the order. The idea is that manufacturers will be able to deliver new products directly outside the ATP-period. The ATP of a week outside the ATP-period equals the PIN of that week.

2.4 Planning flexibility

Within Navision, there are some features which make sure Navision generates the planning suggestions for the right week. The first option which will be explained is the planning flexibility in the purchase order. If the planning flexibility in the purchase order is turned on, Navision is able to move with the purchase order. Navision has the opportunity to place re-scheduling planning suggestions to replace a purchasing order to another week. This mechanism can for example be handy if the the sales are lower than forecasted, the suggested projected inventory will be higher and replenishment orders are needed later. Navision will then propose to reschedule the order to a later moment, so there is no unnescesary inventory. In case the sales are higher than forecasted, Navision can propose to reschedule a purchase order to an earlier moment, so the demand can be fulfilled. The rescheduling period determines the period in which a order may be moved. If the rescheduling period is 5 weeks and the planning flexibility in the purchase order is on, Navision may propose to reschule the purchase order to a maximum of 5 weeks earlier or 5 weeks later than the initial delivery date.

2.5 Automove

The Automove function replaces sales forecast when there is sold more than forecasted in a week within the ATP-period, making sure the suggested projected inventory does not come below zero. As soon as a new sales order is placed, which makes the amount of sales of a product exceed the sales forecast for that week, Navision starts to look if there is remaining sales forecast in the current week, then the second week and so on until the sales forecast equals the amount of sales or until the remaining forecast is zero in every week of the ATP-period. This process is demonstrated in figure 10 and 11. In figure 10, the optimal MRP card is shown if there is no safety stock. Week 33 is the last week of the ATP-period, which means a new purchase order can be placed for week 34. As can be seen, the suggested projected inventory is 0 at the end of the ATP period if the forecast is sold. If in week 29 an order is placed with an amount of 30, the available on date and the remaining forecast will both decrease with 30. The forecast

and suggested projected inventory will stay the same. Figure 10 is a screenshot from Navision, in Navision are all the indicators which decrease the inventory negative such as the forecast and the gross requirements. All the indicators which increase the inventory are positive, for example the scheduled receipts.

Description	Available on date	Forecast	Remaining Forecast	Gross Requirement	Suggested Projected Inventory
Week 27	350	-50	-50		300
Week 28	350	-50	-50		250
Week 29	350	-50	-50		200
Week 30	350	-50	-50		150
Week 31	350	-50	-50		100
Week 32	350	-50	-50		50
Week 33	350	-50	-50		0

Figure 10: Standard situation Automove.

If in week 29 an order is placed with a bigger amount than the forecasted 50, for example 70, the forecast in week 29 will be increased with 20 products and the forecast in week 27 will be decreased with 20. The suggested projected inventory will increase in week 27 with 20 as these products will be in inventory in this week. In week 29 the suggested projected inventory will stay the same, this situation is visualized in figure 11. As in the explanation of the flex-inventory, the main reason for the Automove function is avoiding planning suggestions within the ATP-period.

Description	Available on date	Forecast	Remaining Forecast	Gross Requirement	Suggested Projected Inventory
Week 27	280	-30	-30		320
Week 28	280	-50	-50		270
Week 29	280	-70		-70	200
Week 30	280	-50	-50		150
Week 31	280	-50	-50		100
Week 32	280	-50	-50		50
Week 33	280	-50	-50		0

Figure 11: Automove moves the forecast from week 27 to week 30.

2.6 Pros and cons of the current situation

Now the basic working of the MRP in Navision is explained, the pros and cons of this system will be explained. First 3 advantages of the current way of working will be explained and then 6 disadvantages of the current way of working will be explained. After this section, the findings will be summarized in section 2.7.

2.6.1 Pros

- Navision currently is programmed in such a way, the planning suggestion will appear as much as possible outside the ATP-period. To ensure the planning suggestion appear outside the ATP-period, the Automove function and the flex-inventory are invented. As long as the demand follows the forecast, no sales orders are cancelled, or purchase orders are delayed, the current way of working works well.

- As the current system is already running a year, the purchasers learned how to influence the system to let it generate the right planning suggestions. The forecast can for example be increased or decreased per week and this also holds for the flex-inventory. The purchasers are also aware of the way manufacturers react on the purchase forecast which are sent to the manufacturers. For some manufacturers, this significantly reduces the replenishment time, as they are able to buy the long lead time components. However, this really depends on the manufacturer and the product. Some manufacturers are supplying the same products for a period and so have good experiences with the purchasing forecast that are send. For other products the forecast changes regularly and so do the manufacturers wait until the real order is placed.
- Sales is currently satisfied with the product availability. Compared to the previous quarter, almost all the demand can be fulfilled in time. If this is not the case, sales gets a clear message with the reason and the new expected delivery date.

2.6.2 Cons

In this section, the main problems with the current way of working will be discussed. An extensive description of the cons can be found in appendix 4. After the explanation of the cons, an overview of the people affected by the cons is given.

1. The ATP-period is not the same as the replenishment lead time.

The ATP-period currently equals 7 weeks + the safety lead time for all the products. This is a left-over from before the outsourcing of the production, as it was possible to manufacture a new batch of products within 7 weeks. In the current situation, the replenishment lead times differ per manufacturer and sometimes even per product. In some cases, the replenishment lead times equal 28 weeks, which creates a gap of 21 weeks in which sales has the possibility to sell more products than that there are available.

2. Keeping the flex-inventory on the desired level is time consuming

The flex-inventory needs to be corrected weekly due to the consumption of the flex-inventory. If there are more sales orders in a week than forecasted, Navision will start with the consumption of the flex-inventory. When the purchaser checks the flex-inventory levels on Monday, the purchaser will mention the change in flex-inventory and will add new flex inventory in a week outside the ATP-period. The flex-inventory will be added in a week outside the ATP-period because the new added flex-inventory will decrease the suggested projected inventory and would otherwise possibly create new planning suggestions. This process is visualized in figure 12a and 12b.

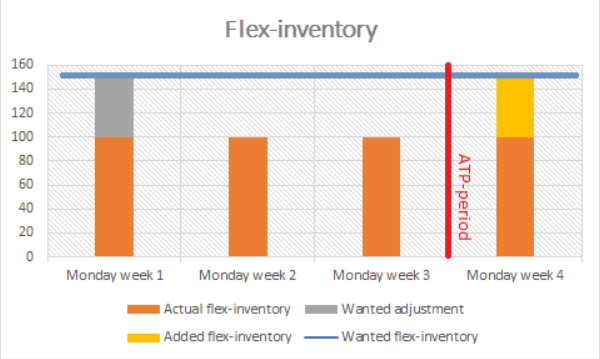


Figure 12a: Flex-inventory shortage

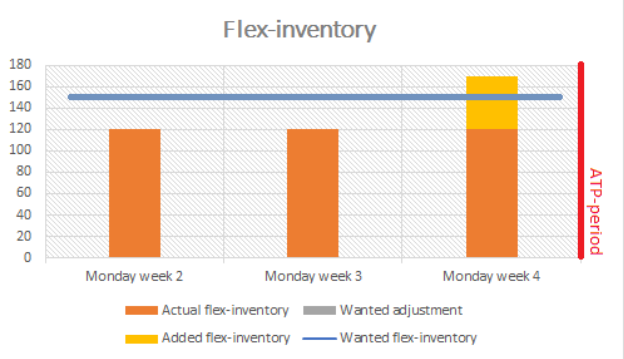


Figure 12b: Flex-inventory overflow

In figure 12a and 12b, two examples of the development of the flex-inventory of a product is displayed. The forecast is rarely exact the number of products that are needed. If there are sold more products than forecasted, the flex-inventory is consumed. In those cases, a purchaser will on Monday morning see the change and increase the flex-inventory in the first week outside the ATP-period. In this case, the flex-inventory is always added three weeks after the inventory came below the desired flex-inventory level. The gap is showed in grey, the adjustment in yellow in figure 12a. In figure 12b, it is visible that not all the sales forecast was sold in week 1. The remaining sales forecast will be added to the flex-inventory until the flex-inventory is filled. As can be seen, the added flex-inventory in week 4 comes now above the desired flex-inventory level. The purchaser will mention this on Monday week 2 and decrease the amount of added flex-inventory in week 4.

In a period of 32 weeks, starting in week 37 2017 and ending in week 17 2018, there was at least 979 times an adjustment needed. On average this are 30 adjustments per week, which cost at least 2 minutes per adjustment. Looking to the total number of products with a Lot-for-Lot replenishment policy, which is 94, this means that every week almost 1/3 of the products needs an adjustment. The calculation of this number can be found in Appendix 5.

3. Navision places planning suggestions during the replenishment lead time.

During the replenishment lead time, it is assumed it is not possible to receive a purchase order which was not ordered before the start of the replenishment lead time. Replacing a purchase order which is already within the replenishment lead time to another moment is also not possible. Currently, Navision does not make a difference between the planning suggestions within the replenishment lead time and the planning suggestions outside the replenishment lead time. As the replenishment suggestions are also send to the manufacturers as the purchase forecast, the replenishment suggestions need to be deleted by the purchasers through deleting and adding sales forecast. If the replenishment planning suggestions are not deleted, these will also influence the rest of the planning suggestions for the product, as Navision assumes all the planning suggestions will be accepted when calculating new planning suggestions.

To reduce the amount of re-scheduling suggestions, the planning flexibility in the purchase orders is currently in most cases turned off. In a sample of 110 purchase orders, the planning flexibility was turned off in 96 orders, which indicates that this is done frequently to reduce the amount of rescheduling suggestions. The consequence of this action is that Navision will also not give a rescheduling suggestion outside the replenishment lead time, when the planning flexibility can improve the inventory position.

4. Navision does not place moved sales forecast back when a sales order is deleted.

If for a sales order in a certain week the forecast is moved, the forecast will not be placed back when the sales order is cancelled. As the remaining forecast is deleted at the end of the week, Navision will not anticipate on the expected demand in the weeks after the week the sales forecast was moved to. This results in planning suggestions which occur too late, resulting in more chance on a stockout. This process is displayed in figure 13, 14 and 15.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory
Inventory	32	32		32			32
Week 26	120	120		88	-75	-75	45
Week 27	120	120			-15	-15	30
Week 28	150	150		30	-15	-15	45
Week 29	150	150			-15	-15	30
Week 30	180	180		30	-15	-15	45
Week 31	180	180			-15	-15	30
Week 32	210	210		30	-15	-15	45
Week 33	210	210			-15	-15	30

Figure 13: standard situation

In figure 13 a standard situation is showed. Forecast is available in the current and upcoming weeks and no sales orders are available. As can be seen in the rightest column, the suggested projected inventory is every week added up with the scheduled receipts and decreased by the forecast.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory
Inventory		32		32			32
Week 26		120		88			120
Week 28		150		30			150
Week 30		180		30			180
Week 31		0	-180		-180		0
Week 32	30	30		30			30
Week 33	30	30					30

Figure 14: Big order in week 31

In figure 14, a big order is placed in week 31. As can be seen, the forecast in week 26, 27, 28, 29, 30, 32 and 33 is moved to week 31. In the rightest column the suggested projected inventory is visible. Based on this number, Navision will make the planning suggestions. As can be seen, the suggested projected inventory is added up with the scheduled receipts as there is no more forecast available. In week 31, all the suggested projected inventory is used.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory
Inventory	32	32		32			32
Week 26	120	120		88			120
Week 28	150	150		30			150
Week 30	180	180		30			180
Week 31	180	180			-180	-180	0
Week 32	210	210		30			30
Week 33	210	210					30

Figure 15: Order in week 31 is deleted

Now in figure 15, the order in week 31 is deleted. The remaining forecast is the same as the forecast, as there are no other sales orders in week 31. The forecast is not placed back to the original weeks, which will generate problems in the weeks after week 31. In week 32, only the flex-inventory will be remaining from the forecast in week 31. Navision will not anticipate on the demand after week 31 and so will generate the planning suggestions for this product too late.

5. The forecast may not be changed within the replenishment lead time.

When the forecast is changed on short term, Navision will generate planning suggestions within the replenishment lead time. This makes it impossible to change the forecast on short term, even when it is known the sales will be higher or lower than earlier forecasted. Especially when the sales are lower than forecasted, this will lead to a fast increase of the products in inventory. In case of higher sales than forecasted this leads to less problems, as a frequent shortage in the flex-inventory will be mentioned and the forecast will be added up to complement the flex-inventory.

6. There is a lack of knowledge about the way Navision processes sales and purchase orders by the operations people.

The operations people are not always aware of the consequences of their action in Navision. If sales makes a typing mistake in the sales order, this can have major consequences in Navision, even if the sales order is corrected. The forecaster is not always aware of the consequences replaced forecast can have. The lack of insight is firstly created by changing from one ERP system to another ERP system. In the last 8 years, the ERP system has changed minimal 3 times. However, the changes between the systems were not always big, the working of the MRP card was every time slightly different. When changing from ERP system, every part of the operations team got its own explanation of the functions which were relevant for them. Sales learned how to place sales orders, purchasing learned how to place purchase orders and influence the system and the forecaster learned how to retrieve the information from Navision to generate a new forecast.

Secondly, the lack of insight is created by adding new features to ‘optimize’ the working of Navision. These features are often explained to the people which are directly working with them, but not always to everyone who is influenced by them. The features are added in time, which makes the system more and more complex.

Thirdly, the changes in the systems are documented poorly. The last document found about the working of for example the available to promise is written in 2013. Other important features like the working of

the Automove function and the flex-inventory are never documented, as these are programmed specially for Nedap.

2.7 Findings

From the cons, it can be derived that the current working of Navision is not optimal. The ATP-period remains from before the outsourcing and Navision suggests placing purchase orders within a period the manufacturers are not able to produce new batches. Even if a planning suggestion is not accepted, it still needs to be resolved as the planning suggestions are sent as purchase forecast to the manufacturers. The purchasing process currently takes on average 12 hours a week, where on average eight hours are used for correcting the planning suggestions, one hour for correcting the flex-inventory and three hours for placing purchase orders. The time purchasing uses for correcting the planning suggestions is desired to be less than 1 hour a week. Correcting the planning suggestions is experienced as extra work, which reduces the time the purchasers have for their other tasks. Thereby is a correction of for example the forecast in Navision a solution on short term to delete a planning suggestion, but will a correction often generate problems on long term, as Navision does not calculate with the real data after an adjustment. Not all the cons influence the whole operations team directly, to get insight in who is affected by which con an overview is provided in table 2. In the table, there are three stakeholders. Sales are the people inserting the sales orders in Navision, purchasing are the people placing the purchase orders and the operations manager is the one responsible for the whole operations process. The operations manager also determines the sales forecasts.

Stakeholder↓ Con→	1	2	3	4	5	6
Sales	X			X		
Purchasing	X	X	X	X		X
Operations manager		X		X	X	X

Cons			
1	ATP-period	4	Automove
2	Flex-inventory	5	Changing forecast
3	Planning suggestions	6	Lack of knowledge

Table 2: Who is affected by which con?

Based on the findings a couple of improvements can directly be mentioned. A change of the ATP-period is a logical result of the outsourcing of the production. As the replenishment lead times per product are already available, changing the formula of the ATP-period to replenishment lead time + safety time will be easy to implement. However, a change of the ATP-period will also implicate that the Automove function may use more weeks to move with the forecast, resulting in more problems with con 4. The lack of knowledge about the working of Navision could be improved by giving presentations about the working of the MRP and by documenting changes in the working of Navision extensively.

The problems with the flex-inventory, with changing the forecast and with the planning suggestions are correlating. The flex-inventory is used instead of a standard safety stock policy to reduce the amount of planning suggestions, the forecast may not be changed during the replenishment lead time to reduce the amount of planning suggestions and still there are too much planning suggestions.

To come to a solution, extra information is needed about the planning logic in other ERP-packages. The working of the MRP in Navision will be compared to the MRP in other ERP-packages, especially the way the safety stock is implemented in other ERP-packages and the way other ERP-package handle the planning suggestions during the ATP-period will be investigated.

3. Theoretical framework

As explained in chapter 2, the current planning logic is complex and does not work in the desired way. To come to a solution, literature will be used to look to other ways to organize the working of the MRP. In section 3.1 the basic MRP will be explained, in section 3.2 safety stock in ERP-packages will be explained, in section 3.3 the ATP-period of Navision is compared to the ATP-period in other ERP-packages and in section 3.4 this theory will be summarized and applied on Nedap Retail.

3.1 Material requirements planning

The standard MRP comes from the manufacturers. If a product is built from 10 components, these 10 components may have different lead times. If the manufacturer wants to produce a new batch, all the components need to be available to finish the product (Slack & Stuart & Johnston (2010)). In figure 15, a basic MRP card is showed. In this example is assumed that there are no components in inventory and that all the components are used once in the product. In week 13, the manufacturer wants to produce a new batch of a product. As the manufacturer does not want to have unnecessary inventory, he orders all the components to be in stock at the start of the week he wants to produce in. This means that the manufacturer needs to order component 4 at last at the start of week 8, component 5 in week 6 and so on.

Product 1								
Week	6	7	8	9	10	11	12	13
Planned production								300
Component 1 (3 weeks LT)					300			
Component 2 (4 weeks LT)				300				
Component 3 (3 weeks LT)					300			
Component 4 (5 weeks LT)			300					
Component 5 (7 weeks LT)	300							
Component 6 (4 weeks LT)				300				
Component 7 (2 weeks LT)						300		
Component 8 (1 week LT)							300	
Component 9 (3 weeks LT)					300			
Component 10 (2 weeks LT)						300		

Figure 16: the standard MRP

In figure 16 is the MRP simplified, in reality there are more factors which influence the moment an order needs to be placed.

- Components often have a minimum order quantity (MOQ). This creates extra inventory which needs to be considered when placing the next order.
- Components are used for more than one product, which makes it unclear which amount belongs to which order.
- Safety stock is needed to cover unexpected demand and lead time delays.

The MRP card even becomes more complex, when customers expect their products on shorter term than the lead time of the components. In those cases, it becomes interesting to have a make to stock production strategy instead of a make to order production strategy (Zuyderduyn (2011)). In a make to stock policy, the risks for the manufacturer are higher, as the manufacturer needs to have more finished

products in inventory. Firstly, when there are more products in inventory, the inventory costs will increase. Secondly, there is a risk that the inventory will be damaged or stolen during the time it is in inventory. Thirdly, there is a risk the products will not be sold. This can be caused by the development of better products or competitors who can sell the products for lower prices.

3.2 MRP in ERP-packages

The make to stock replenishment policy is based on sales forecast is in ERP-packages called as the lot-for-lot replenishment strategy (Shtub & Karni (2010)). In this lot-for-lot replenishment policy, replenishment triggers are based on the moment the inventory level is expected to come below the safety stock quantity. If the inventory comes below the safety stock quantity based on the sales forecast about 10 weeks and the lead time is 6 weeks, the ERP-package will come up with a replenishment suggestion about 4 weeks (Shtub & Karni (2010)). Depending on the ERP-package, there are plenty of indicators which make it possible to let the MRP come up with the right replenishment suggestions and is it also possible to implement new features.

The biggest problem experienced with the MRP in ERP-packages is that the implementation often fails (Ghosh (2012)). The reason for this is according to Ghosh two fault, firstly the MRP works incorrect and secondly the people who are working with the MRP do insufficient understand the working of the system. The incorrect working of the MRP is in most cases a consequence of the special needs of the company. The top 10 most used ERP-packages all have a working MRP which are all working slightly different, however not every MRP does perfectly fit for the company specific needs. In the situations where the MRP is not working well, the suppliers of the ERP-packages emphasize that it is possible to adjust the MRP to the company specific needs. Furthermore, are companies often not capable of expressing their actual needs in the right way to the ERP-suppliers, generating sub-optimal solutions. The training of the people working with the ERP-package does cost a lot of time, time which companies preferably spend on other tasks. This causes the problem the employees often insufficiently understand the working of the ERP-package and so the MRP. Another reason for the failure of the MRP in ERP-packages is that there are often conflicting interest within the organizations (Barker & Frolick (2003)). On the sales side other information is needed compared to the purchasers. For example do the sales people want to see the number of products which are available to be sold on a certain point in time, whereas the purchasers want to know when a replenishment order is needed (Surbhi (2014)).

3.2 Safety stock in ERP-packages

Navision describes the standard safety stock quantity as (Navision (2016)): ‘The safety stock quantity defines a quantity of stock that you want to have in inventory to protect against fluctuations in demand and supply during the replenishment lead time for the item. Although a safety stock quantity is set aside to compensate for fluctuations, the planning system may consume from it to meet a demand that could otherwise not be fulfilled on its due date. In that case, the planning system ensures that the safety stock is replaced by suggesting an exception supply order to replenish the safety stock quantity on the date that it is consumed. This planning line displays an exception warning to explain that the safety stock has been partly or fully consumed and must be replenished.’

In other ERP-packages, like SAP, Oracle and Sage the definition of the safety stock is comparable. This suggests the standard safety stock level built in Navision does not differ from other packages.

3.3 Replenishment triggers during the ATP-period

The ATP-period defines a period in which there is a limited supply of products (Oracle (2005)). Within this period, the available to promise (ATP) equals the products which are in inventory and are not already reserved for another customer. Outside the ATP period it is assumed there is an infinite supply possible. This definition is widely used in ERP-systems, for instance in SAP, Oracle as in Microsoft Dynamics.

The MRP is preferred to be frozen within the ATP-period (Shtub, Karni (2010)). The frozen planning period is an interval in time in the planning horizon during which a company does not change it supply plan for a product, regardless of events or changes that occur (Snapp (2010)). The frozen period stabilizes the ordering process. As within the frozen period the orders cannot be changed, the manufacturer knows for sure the order will be sold on the arranged date. On the other side, is the customer obligated to buy the order as soon as it is within the ATP-period, which makes it impossible to decrease or increase the order when the demand changes (Thomas, Lamouri & Genin (2007)).

However, a frozen period is not recommended for products with a high standard deviation in the demand (SAP (2010)). The frozen period is not recommended, as the frozen period 'freezes' the whole period and so makes it also impossible to change for instance the sales forecast in this period. For these products is it recommended to check the MRP also during the ATP-period, to make sure there are enough products available. In the newest versions of Navision, the frozen period is not even available, as it caused more problems than it solved. The main problem of the frozen period in the older versions was that it just froze the weeks, without changing anything. So, as soon a week came within the frozen period, all the planning suggestions were nor deleted or accepted and were no longer visible in the planning suggestions screen, resulting in new planning suggestions based on the assumption the old planning suggestions were accepted, which was not the case (Schofield (2016)).

3.4 Applying the theory on Nedap Retail

Comparing the theory of the MRP with the MRP in Navision, the working is comparable. Also, the basic working of the MRP in Navision is comparable to the working of the MRP in other ERP-packages. The reason the MRP in Navision is not working for Nedap seems to be caused by the specific wishes of Nedap Retail.

According to the literature, it is better to freeze the ATP-period. However, it is according to SAP not preferable to freeze the ATP-period if there is a high standard deviation in demand, which is definitely the case by Nedap Retail. Also in earlier versions of Navision, this option was available in Navision, but as it caused more problems than it solved, it was not implemented in the newest versions of Navision.

The standard safety stock policy available in Navision is comparable to the standard safety stock policy in other ERP-packages. There is no literature available about the standard safety stock policy in combination with the problems Nedap experienced with this function, so it seems like this function works well for other companies.

In chapter 4 the literature will be used to come up with a better version of the frozen period to let the amount of planning suggestions during the ATP-period decrease and make it possible to use the standard safety stock policy available in Navision.

4. Applicable solutions

Based on the literature it can be concluded that the specific problems Nedap Retail experiences with for instance the safety stock are not common. As other ERP-packages use the same basic planning logic as Navision does and this planning logic is also supported by literature, it can be concluded that the way Nedap Retail has implemented Navision is not how it is meant to be used.

4.1 The ATP-period

The ATP-period of 7 weeks + the safety time remains from before the outsourcing of the production. After the outsourcing, the lead times differ per manufacturer and sometimes even per product. The replenishment lead times are mostly 12 to 28 weeks, which is much longer than the current 7 weeks. It is better to adjust the ATP-period to the replenishment lead time per product + the safety lead time per product. The replenishment lead times are already available in Navision, but it is currently not used for the ATP-period. The increase of the ATP-period has as consequence that the period in which the Automove function (explained section 2.5) is activated is longer.

4.2 Automove

If the lot-for-lot replenishment policy is used, Automove will make sure the forecast follows the pattern of the actual demand. In figure 17 and 18 the situation is showed in case there is an order in week 5 which takes the total available inventory. In figure 17 all the sales forecast is moved to week 5, which is visible as the suggested projected inventory (SPI) does not decrease in the weeks 1 to 4 and the weeks 5 to 8. This is realistic, as the ATP is zero as there is no more available inventory to sell in this period. As the SPI is zero, the flex-inventory is used and a replenishment order will be placed directly outside the ATP-period. In figure 19 Automove is not activated, Navision decreases the suggested projected inventory every week with the forecast. In week 5 is again a big order of 400 products placed, which decreases the suggested projected inventory again with 400. However, in weeks 1 to 4 and the weeks 5 to 8 it is not possible to place new sales orders as the ATP is 0.

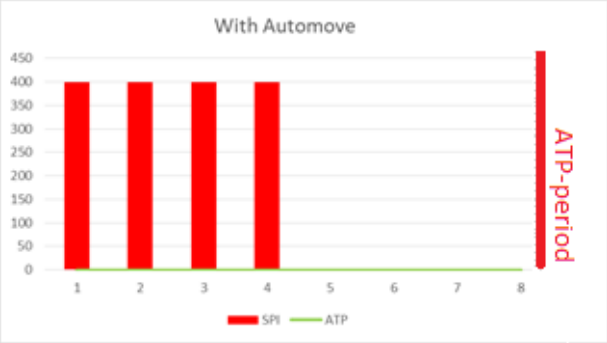


Figure 17: Situation with Automove.

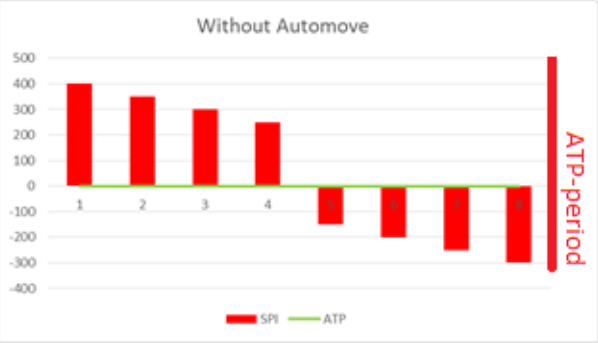


Figure 18: Situation without Automove.

New planning suggestions will occur based on the suggested projected inventory. In the situations in figure 17 and 18 it is assumed the flex-inventory is already consumed. Planning suggestions in figure 17 will occur directly outside the ATP-period, as the adjustments of the flex-inventory will trigger Navision to place a new replenishment order. In figure 18 a planning suggestion will occur in week 5, however this demand cannot be fulfilled as it is within the ATP-period.

It is not recommendable to delete the Automove function, as it will make Navision suggest the sales in this week do not influence the sales of the upcoming weeks, which is not the case. The solution in section 4.3 will reduce the problems which are currently experienced with the Automove function. It is recommendable to explain the exact working of the Automove function to all the operations people, as this will make them better understand what Automove does and why it is implemented.

4.3 Placing moved forecast back when a sales order is deleted

When a sales order is placed which makes it necessary for Navision to move with the sales forecast, the movement of the forecast is linked to the sales order. Currently, when the sales order is deleted, the link with the moved forecast is also deleted, which makes the moved forecast regular forecast in the week the sales order was standing. As the moved forecast is already linked to the sales order, it is possible to place the forecast back when the order is deleted. This solution improves the current situation, as it is no longer possible that a cancelation of a big order results in a lot of sales forecast which is deleted. However, the solution needs to be interpreted well by the people adjusting the sales orders. When the date of the sales order is changed in the sales order, this does not generate a problem. Navision will move the forecast from the old week to the new week. If sales first deletes the old order and then places a new order, a part of the old forecast may be thrown away as it cannot be placed back in the past, which will result in other forecast which is consumed. This is not desired, as moving with new forecast will result in planning suggestions which occur too late.

4.4 Replace Automove by an automatic increase of the forecast outside the ATP-period

The movement with the forecast outside the ATP-period is not desirable, as it is possible to place replenishment orders if a big sales order is placed in this period. Deleting the Automove function outside the ATP-period will not directly generate problems, as the planning suggestion will react on the new demand and enough products will be in inventory when the sales orders needs to be delivered. As soon as the order comes within the ATP-period, Navision does not react on this order, as it was already placed which is good. When the sales order is replaced to another week, for instance if the customer is not ready to place the antennas, Navision will handle this order as a ‘new’ order. This means that Navision will start moving with the forecast, while this is not necessary as the purchaser already anticipated on the sales order before. To solve this problem, the forecast needs to equal the demand if the demand is higher than forecasted in a week outside the ATP-period.

4.5 Make it possible for transfer orders to be handled as sales orders in the MRP.

The transfer orders are currently not considered as sales orders in the MRP, however a part of the transfer orders are sales orders for DSV. To tackle this problem, a new button needs to be included in the transfer order screen. This button needs to give the possibility to let the transfer order be handled as a sales order in the MRP-card.

4.6 Safety stock

The reason why Nedap Retail is currently using the flex-inventory instead of a normal safety stock policy, is because a normal safety stock policy would create planning suggestions during the replenishment lead time. So, to replace the flex-inventory by a normal safety stock policy, firstly it needs to be impossible for Navision to place replenishment suggestions during the (adjusted) ATP-period. As the purchasers need to be informed when there is a problem with the available inventory during the ATP-period, the re-scheduling suggestions are still desired. These re-scheduling suggestions need to occur when the suggested projected inventory comes below 0. This is the case when the (forecasted) demand cannot be

fulfilled. To get the re-scheduling suggestions only on the moment the suggested projected inventory is below 0, a new type of planning flexibility need to be implemented. The new function will be called ‘earlier’ and is a combination of the planning flexibility functions ‘none’ and ‘unlimited’. The ‘earlier’ function only needs to propose to reschedule if the purchase order needs to be rescheduled to an earlier moment. The rescheduling period needs to be unlimited instead of the current 5 weeks, as this will make sure Navision comes up with a re-scheduling suggestion as soon as there are purchase orders placed. The moment the planning suggestions need to occur are visualized in figure 19.

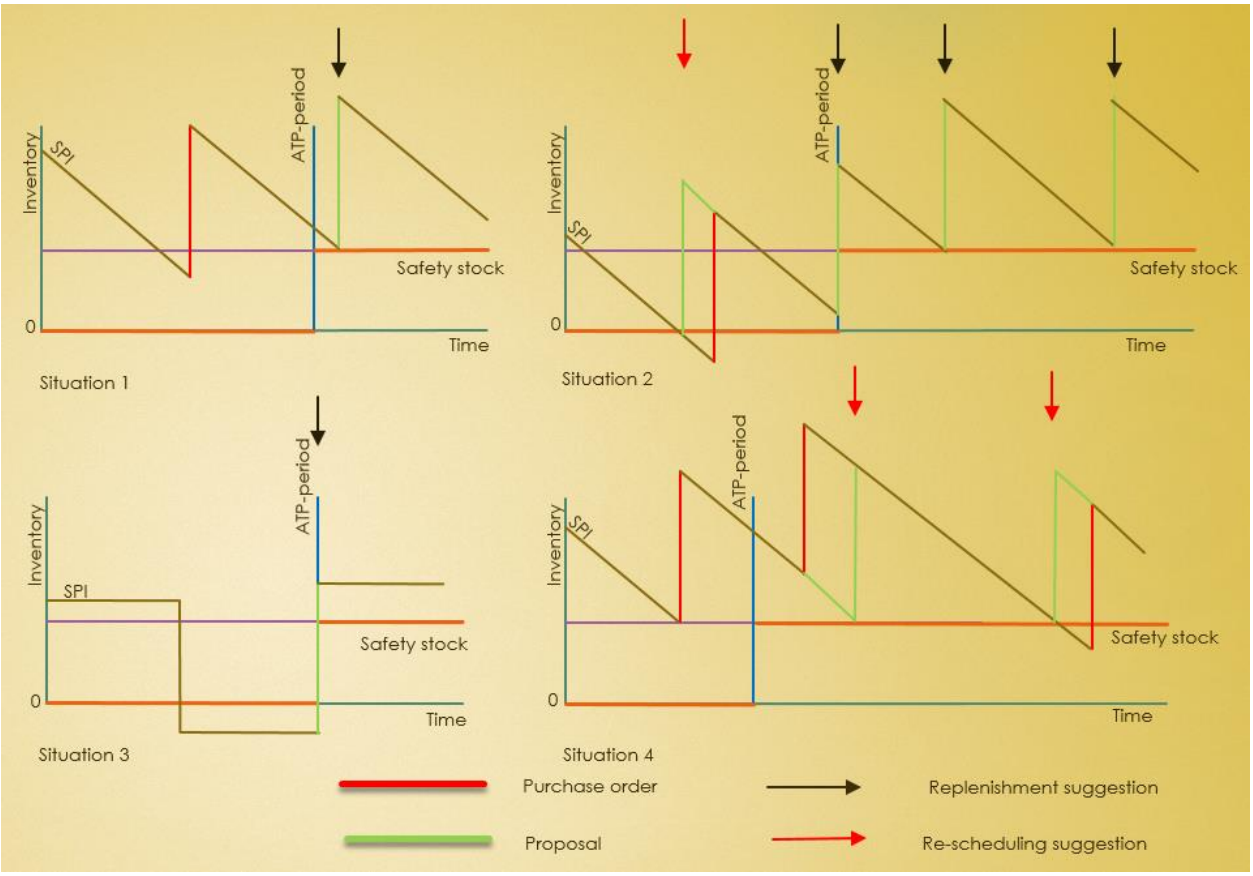


Figure 19: The moments Navision comes up with planning suggestions in the new situation

In figure 19 are 4 situations visualized. In situation 1, the safety stock is consumed during the ATP-period. As the suggested projected inventory does not come below zero, there are no problems and thus does Navision not propose to re-schedule the purchase order. Outside the ATP-period Navision reacts on the moment the suggested projected inventory comes below the safety stock quantity by giving a replenishment suggestion. In situation 2, the suggested projected inventory comes below 0, which means that there is more (expected) demand than that there is inventory available. In this case purchasers have to react and so they will get a re-scheduling suggestion. Outside the ATP-period, Navision reacts in the same way as in situation 1. In situation 3, no purchase orders are available to re-schedule, but the suggested projected inventory comes below 0. The purchasers will now be triggered by the replenishment planning suggestion which is placed directly outside the ATP-period. This situation can only occur when sales does ignore the ATP. In situation 4, the situation outside the ATP-period is visualized if there are already purchase orders placed. It would be better to receive the first purchase

order outside the ATP-period later, as the suggested projected inventory does not reach the safety stock quantity. The second purchase order could better be received earlier, as the suggested projected inventory comes below the safety stock quantity.

4.7 Applicability

To make sure the solutions work in Navision and would not generate other problems, the solutions are tested in the test-environment of Navision and when this was not possible programmed in a simplified Excel VBA model. The solutions which could be tested in the test-environment, are the solutions which can be implemented by only changing the settings. The solutions which are tested in Excel are the solutions which need extra code.

The change of the ATP-period could be tested in the test-environment of Navision. The ATP reacts on the change in ATP-period, which solves the problem at the sales side. In the MRP card is also visible that the Automove function is linked to the ATP-period, which makes it possible for Navision to move with the forecast of more weeks.

To test the impact of the Automove function, the Automove function was turned off in the simplified Excel model. The Excel model was tested in multiple situations and it could be concluded that a model without Automove would not make Navision better (explained in section 4.2). The outcome of this simulation is further explained in Appendix 6.

The impact of replacing moved forecast back could not be tested in a valid way in Navision nor the Excel model. To make sure the solution works, the working of the Automove function was investigated extensively and the solution is discussed with all the people involved.

During the bachelor assignment, the Automove function was already turned off outside the current ATP-period in the test-environment in Navision. This solution already improves the working of the MRP in Navision, but as it still causes problems when the sales order date is changed, it is necessary that the forecast equals the demand if the demand is higher than forecasted in a week outside the ATP-period.

Replacing the way transfer orders influence the MRP by the way normal orders go through the MRP was not specially tested, as the working of the transfer orders and the sales orders in the MRP are already known. The situations where a change is desired were discussed with the purchasers, as they currently handle the transfer orders.

The change of the safety stock policy, with all the implications for Navision, were investigated extensively. The current working of the available safety stock quantity field was tested in the test-environment in Navision. Then solutions for the problems with the functions were programmed in the Excel model. The solution was adjusted until there were no negative implications left. This solution was simulated and discussed with all the people involved. The way the simulation was performed is explained in Appendix 6.

4.8 Conclusions

- Changing the ATP-period to the replenishment period + safety time will solve the problems at the sales side.
- The Automove function cannot be deleted.
- If a sales order is deleted and for this sales order sales forecast is moved, the sales forecast need to be placed back to the original week.

- The sales forecast needs to equal the demand if the demand is bigger than the sales forecast in a week outside the ATP-period.
- There needs to be the possibility to handle transfer orders as sales orders in the MRP.
- The moments planning suggestions occur need to be changed, to change the safety-stock policy and reduce the amount of planning suggestions significantly.

5. Validation

In this chapter, the validity of the research will be discussed. As explained in section 1.5.1 there are some places were the validity of the research may be questionable. In this chapter we will first discuss the way process flows of the lot-for-lot replenishment policy and the re-order point replenishment policy are made. In section 5.2 the way the process flow of the lot-for-lot replenishment strategy was translated to an excel model will be discussed and in 5.3 the way the impact of the solution was determined will be discussed.

5.1 Validity of the process flows

A clear overview of the working of Navision was not available at the start of the bachelor assignment. The last documentation with explanation of parts of the process were from the previous ERP-packet. As understanding the current planning logic is essential to come with an improvement plan, first the current situation was visualized in two process flows (Appendix 2 and 3).

To determine the way Navision determines the ATP and the planning suggestions, a product without forecast, sales orders and purchases orders was taken. This product was first set to a product with a re-order point replenishment strategy. Firstly, sales orders were inserted to see which columns react on a change. Based on this information, a first overview of the mathematical rules of the re-order point replenishment strategy was made. Secondly, purchase orders were added and again all the columns of the MRP-card were added to determine which columns react on a received purchase order. Thirdly, the parameters visible in appendix 1 were changed to see the effect of the different boxes. Lastly, the process flow was explained to a purchaser to see if situations or options were missing.

The same process was used to determine the working of the lot-for-lot replenishment policy in Navision, but then the flex-inventory and the forecast were also added. Through constantly checking the changes in the MRP card, all the changes were mentioned and a clear overview of all the actions could be given. As the formulas in appendix 2 and 3 give the same output as Navision does, it can be assumed the formulas are valid.

5.2 Validity of the Excel model

The MRP of Navision was re-built in Excel VBA based on the process flow of the lot-for-lot replenishment policy. The model made it possible to simulate the working of the MRP in Navision, complemented with graphs which gave more insight in the problems experienced. Later on, this model was adjusted to simulate the working of the solutions.

To make sure the Excel model generates the same results as the MRP in Navision, a lot of situations were inserted in both models and checked if they generated the same outcomes. It was not possible to make a distinction between the replenishment planning suggestions and the re-scheduling planning suggestions in the Excel VBA model, as both suggestions are triggered by the moment the suggested projected inventory comes below the safety stock quantity. This does not directly cause a problem as both types of planning suggestions are currently handled in the same way, but this also makes it impossible to simulate the situation if the planning flexibility is turned off in the purchase orders. As turning the planning flexibility off in purchase orders is not desired, this will not generate problems for the simulations.

5.3 Validity of the effect of the improvement steps.

Navision and Excel both are Microsoft products, which makes the coding languages in VBA for Excel and C/AL for Navision look on each other. C/AL of Navision even gives more possibilities than VBA, which makes the changes in the VBA code also possible in Navision. However, a working VBA model will not automatically be valid in Navision, as the Excel model only visualizes the MRP-card and not the processes which happen based on the MRP-card in Navision. If excel does not give the desired results after programming the solution, this will also hold for Navision. But if a solution works in Excel, this does not automatically mean this does also work in Navision.

The simulation was used to test the impact of deleting the Automove function and used to test the impact of the new moments Navision needs to give planning suggestions. The simulation was as most as possible conducted with historical data of the period 18-09-2017 until 27-7-2018. The original inserted forecast, sales orders, flex-inventory and purchase orders were known, making the start-inventory and the manual changes in the sales forecast the only unknown factors. As the start-inventory was unknown, the simulations were conducted with 6 start-inventories to check if the start inventory would have a lot of impact on the amount of planning suggestions. The manual changes in the sales forecast cannot be tracked, but as these are not done in any of the simulations, the outcome of the simulation is valid.

As it is not possible to measure the impact of the solutions in sections 4.1, 4.3, 4.4 and 4,5 in a valid way, the impact of these solutions will not be measured in time. The solution in section 4.1 (change of ATP-period) cannot be measured in a valid way, as it is hard to track how often this really let to problems. The sales employees currently open an extra window to check if it will generate problems if the ATP is below zero or they ask the purchasers. The solution on its own will reduce the time the purchasers and sales need, but it will not directly contribute to solving the problem with the planning suggestions. However, this solution is essential to let the solution in section 4.6 succeed. The moments the solutions in sections 4.3, 4.4 and 4.5 are needed do not enough occur to make a valid estimation of the time it will reduce. For these solutions holds that the impact is big if the situations are not handled in the right way. If for instance the solution in section 4.4 is not implemented and a big order is changed within the ATP-period, this can result in wrong planning suggestions, resulting in a lot of products in inventory which costs a lot of money.

6. Impact

In this chapter, the impact of the solutions will be discussed. Some solutions will have little effect and will be easy to implement others will have a lot of effect but are hard to implement. To visualize the impact of the solutions, an impact matrix will be used.

6.1 The impact-effort matrix

In an impact matrix, the y-axis visualizes the impact of a solution and the x-axis visualizes how much effort is needed to implement the solution (Gray (2010)). On the impact axis, the solutions will get a value based of the expected impact for sales, purchasing and the inventory manager. They rated every solution with a number between 1 and 10, where 10 means a lot of impact and 1 means little impact. As all the stakeholders have their own interests, all the stakeholders are assumed to be equally important. The difference in impact is for example clear in case of the solution for the transfer orders, as sales does not handle these orders the solution has no impact on them. On the effort axis, the expected effort needed to implement the solution is rated with a number between 1 and 10.

Impact	Change ATP-period	Change forecast outside ATP-period	Placing forecast back	Transfer orders	Safety stock
Number	1	2	3	4	5
Sales	8	4	2	1	1
Purchasing	2	4	6	4	10
Inventory Manager	2	1	8	6	10
Average	4	3	5,33	3,67	7

Table 3: Impact table

Effort	Change ATP-period	Change forecast outside ATP-period	Placing forecast back	Transfer orders	Safety stock
Number	1	2	3	4	5
Operations	1	1	2	3	3
Programmer	5	2	5	4	10
Average	3	1,5	3,5	3,5	6,5

Table 4: Effort table

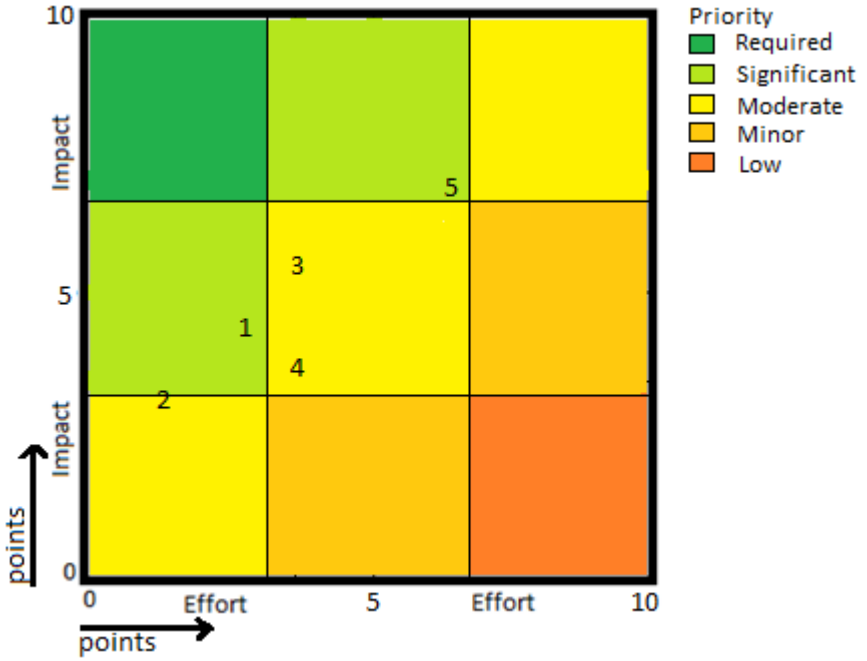


Figure 20: Impact-effort matrix

In figure 20 are the outcomes of table 3 and 4 visualized on the impact-effort matrix. Based on the impact-effort matrix it can be concluded that solutions 1 and 5 need to be implemented first, followed by 2, 3 and lastly 4.

6.2 Impact and effort per solution

Solution 1: Change the ATP-period to the replenishment lead time + the safety lead time

The impact of solution 1 is visible on the sales side, as sales can no longer promise customers products that cannot be delivered based on the ATP. The impact on the purchasers will be minimal, for them it is less likely they find planning suggestions which cannot be fulfilled within the period Navision proposes to place a replenishment order. As sales is currently extra alert when placing sales orders outside the ATP-period, but inside the replenishment lead time, this solution will not significantly influence the amount of planning suggestions on its own. However, this solution is needed to let the other solutions succeed.

Solution 2: Let the forecast equal the demand if the demand is higher than the forecast outside the ATP-period.

This solution improves the working of the MRP and makes sure no new planning suggestions will occur if the sales order date is changed. As this situation hardly never occurs, the impact is low.

Solution 3: Placing sales forecast back when a sales order is changed or deleted.

This solution has impact on the product availability and makes sure the forecast does not expire but goes back to the original week. This will make sure Navision anticipates on the inserted sales forecast if a sales order is cancelled. This solution will not decrease the amount of planning suggestions but makes sure the planning suggestions occur on the right moment.

Solution 4: Make it possible to let transfer orders count as sales orders in the MRP.

The impact of this solution is comparable to the impact of solution 3 but did not cause a lot of irritation yet. As sales does not handle the transfer orders, they rated the impact with a one. The impact for the inventory manager is lower than in solution 3, as this problem is currently handled in a good way by the purchasers. The solution will not reduce the amount of planning suggestions but will reduce the time the purchasers spend on their purchasing tasks.

Solution 5: Replacing the flex-inventory by a standard safety stock policy.

Making this change possible, the moment Navision generates planning suggestions needs to be changed. This will make sure the amount of planning suggestions will be reduced from on average 228 per week to on average 64 per week. With this solution the correction of the flex-inventory is also no longer needed. The amount of planning suggestions was measured in a simulation in Excel. Based on historical data 4 scenarios were simulated with historical data. As the historical start-inventory could not be retrieved, every scenario was simulated with 6 start inventories. An extensive explanation of the simulation can be found in appendix 6. The outcomes of the simulations are displayed in figure 21. Simulation 1 shows the current situation, simulation 2 shows the current situation without the Automove function, simulation 3 shows the current situation with the standard built in safety stock function instead of the flex-inventory and simulation 4 shows solution 5.

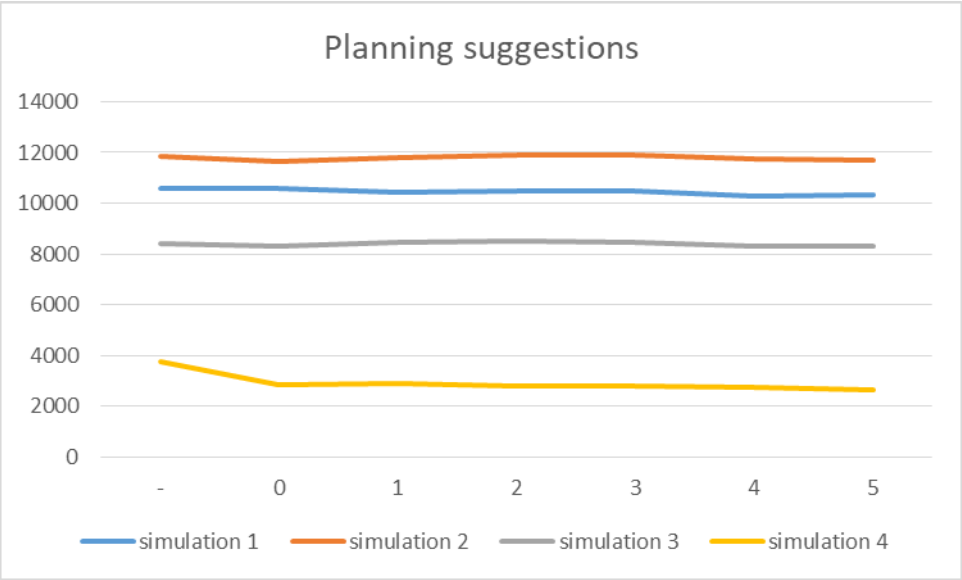


Figure 21: Number of planning suggestions per simulation

It can be concluded that solution 1,2,3 and 4 improve the working of the MRP, where solution 5 improves the problems with the planning suggestions. The effort which is needed for solution 5 is quite high, as multiple changes need to be made in the way Navision determines its planning suggestions, where the other solutions can be implemented by just adding or changing a little bit of code.

7. Implementation

In this chapter, the implementation of the solutions will be discussed. The implementation of the 6 solutions will be discussed one by one. First the solution will be summarized, then the changes in Navision will be discussed for the Programmer and lastly the implications for the operations team will be explained.

7.1 ATP period becomes replenishment lead time + safety time

1.1 Summary

Currently, the ATP-period equals 7 weeks + the safety time. The 7 weeks still remain from before the outsourcing of the production, as it was possible to manufacture a new batch of products within 7 weeks. In the current situations the replenishment lead time mostly equals 12 weeks, which creates a gap of 5 weeks in which Sales has the possibility to sell more products than available. If the ATP-period becomes the replenishment lead time + safety time, this gap will no longer exist. The safety time will not be changed compared to the original situation.

7.1.2 Navision

Currently, the formula for the ATP-period equals CW (current week) + 7 weeks. In the improved situation the formula for the ATP-period needs to be: CW + Replenishment lead time. The replenishment lead time is already available in Navision as the preferred vendor lead time.

However, it is possible to change the ATP-period manually, automating this process is preferable as it reduces the possibility that the change in ATP-period is forgotten when the replenishment time increases or decreases.

7.1.3 Operations

The solution makes it impossible for sales to place an order bigger than the ATP in the weeks outside the ATP-period but inside the replenishment lead time without getting a warning.

The solution increases the period in which Navision is able to move with the forecast. This means that the consequences of a wrong movement can be even bigger than these are currently. The safety lead times need to equal the actual safety lead times. For the products from some manufacturers the safety lead time is longer than the 1 week which is currently used.

At the purchasing side, the change in ATP-period will not have consequences, as they are already receiving their planning suggestions based on the replenishment lead time + the safety lead time.

7.2 Replace the flex-inventory by a standard safety stock policy

7.2.1 Summary

The flex-inventory is currently used to avoid planning suggestions during the ATP-period. So, if a standard safety stock policy is desired, Navision must accept the consumption of the safety stock and need to place the replenishment suggestions from of the moment it is possible to place replenishment orders. During the ATP-period are only the rescheduling suggestions desired which make sure the suggested projected inventory does not come below 0, as this are the moments it is not possible to deliver the (expected) demand.

7.2.2 Navision

1. Let Navision generate planning suggestions during the ATP-period on the moment the suggested projected inventory comes below 0 and let it generate planning suggestions outside the ATP-period based on the safety stock quantity.

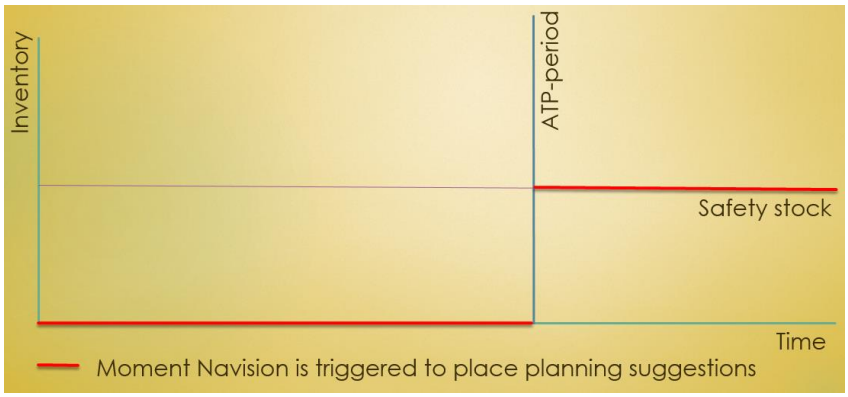


Figure 22: Trigger moment

2. Create a new planning flexibility function: 'earlier'. This function needs the same code as the 'unlimited' function, but then without the possibility to suggest placing the purchase order to a later moment. So, the 'earlier' function only may suggest replacing the purchase order to an earlier moment.

3. Let the purchase orders automatically get the planning flexibility 'earlier' when the purchase order enters the ATP-period.

4. Let Navision start with placing replenishment suggestions outside the ATP-period. So, within the ATP-period only the re-scheduling planning suggestions are desired. Outside the ATP-period, the replenishment planning suggestions and the re-scheduling planning suggestions are desired.

5. Let the rescheduling period of all the retail products be unlimited instead of 5 weeks. This makes sure Navision can propose to reschedule every purchase order if this is necessary.

7.2.3 Operations

For the products with a lot-for-lot replenishment policy:

The safety stock quantity field needs to be filled in with the value of the desired flex-inventory amount in the stockkeeping-unit card. Thereafter, the desired flex-inventory amount needs to be set to 0 as the flex-inventory would otherwise be complemented with the remaining forecast at the end of the week. All the existing flex-inventory also needs to be deleted.

For the products with a re-order point replenishment policy:

In the stockkeeping-unit card, the re-order point replenishment policy needs to be set to lot-for-lot replenishment policy. The re-order point needs to be filled in, in the safety stock quantity field and the re-order point needs to be set to 0.

7.3 Let the forecast equal the demand, if there is more demand than forecasted outside the ATP-period.

7.3.1 Summary

Currently, if there are more sales orders placed in a week outside the ATP-period than forecasted, the forecast does not equal the demand. Earlier, this was issue was solved by moving forecast from the ATP-period to the week outside the ATP-period. The movement of the forecast was not desired, as a big order outside the ATP-period does not influence the ATP within the ATP-period. In the current situation, if the placed sales order outside the ATP-period is changed inside the ATP-period, Navision will recalculate the order and move with the forecast. This is not desired as the purchasers already anticipated on this sales order and so it is not needed to move with the forecast.

7.3.2 Navision

If the demand is higher than forecasted in a week outside the ATP-period, the forecast should equal the demand. In VBA the code would be:

```
If week > ATP-period then
        If demand > forecast then
                Forecast = demand
        End if
End if
```

7.3.3 Operations

A situation where this caused a problem will probably not have occurred yet. The reason this solution is needed is something to keep in mind when changing orders until it is implemented.

7.4 Place moved forecast back when a sales order is deleted

7.4.1 Summary

Currently, when the forecast is moved for a sales order, the forecast is not placed back when the sales order is deleted or changed. As soon as the week the forecast is standing in belongs to the past, the forecast is deleted, as it is not possible to sell in the past. However, if the sales order is deleted, the reserved products become available and the original forecasted demand can be sold. As the forecast is not placed back, the suggested projected inventory does not calculate with the original demand and the planning suggestions will appear too late.

7.4.2 Navision

When the forecast is moved, this movement is linked to a sales order. This makes it possible to place the forecast back when a sales order is deleted. If the week the forecast was standing in before the movement of the forecast belongs to the past, the forecast still needs to be deleted.

7.4.3 Operations

For sales this means that changing the sales order dates does not badly influence the MRP. However, if a big order is deleted, this still needs to be communicated with purchasing as purchasing possibly needs to change the purchase orders. For sales it is also important that a change in date or quantity is changed in the same sales order, as the forecast would otherwise possibly be deleted and new forecast could be consumed. Purchasing no longer needs to replace the forecast manually if a sales order is deleted.

7.5 Make it possible for transfer order to consume forecast

7.5.1 Summary

In the current situation, transfer orders do not consume sales forecast. For the transfer orders from DSV to Nedap this is good, as these are only at Nedap to be tested and will be available to be sold afterwards. However, for the transfer orders for APAC this is not desired, as this is real demand and needs to decrease the remaining forecast. To solve this issue, it would be better if the transfer order would standard consume the forecast and have the possibility to turn this off when placing a transfer order from for example DSV to Nedap.

7.5.2 Navision

Add an extra column in the transfer order order-line with a checkbox, just as the 'configurated' and 'build in' columns. When nothing is changed to the checkbox when the transfer order is placed, the transfer order needs to be handled as a sales order in the MRP, if the checkbox is changed, the transfer order needs to be handled in the MRP as it is handled now.

7.5.3 Operations

The forecast no longer needs to be decreased manually when a transfer order for APAC is placed. If a transfer order is placed to deliver products from DSV to Nedap, the person entering this order needs to (un)check the new checkbox. This depends on the way the programmers implement the solution.

8. Conclusion, recommendations and discussion

This chapter intends to give an overview of the findings and the solutions of the bachelor assignment. The chapter will start with the findings followed by the solutions in section 8.1. In section 8.2 the recommendations for Nedap retail will be discussed.

8.1 Findings and solutions

To improve the working of the MRP, first it needed to be clear where and when in the operations process Navision did not generate the expected results. An overview of the working of the MRP was not available, which made it hard to allocate the problems. After the working of the MRP was observed, the situations in which the MRP did not generate the expected outcomes could be linked to each other, resulting in three main problems:

1. The ATP-period was not changed after the outsourcing of the production. This results in a gap where Navision believes it is possible to place a replenishment order however this is not possible.
2. The replenishment planning suggestions during the replenishment lead time are not desired, as manufacturers receive these planning suggestions as purchase forecast. Manufacturers are not able to fulfill demand within this period, which can let them react wrongly on the planning suggestions. To make sure the planning suggestions appear outside the ATP-period, functions as Automove and the Flex-inventory were invented by Nedap. These functions both do not always work in the desired way, which makes the purchasing process more time consuming than it needs to be.
3. The operations people are not always aware of the exact working of the MRP in Navision, which made them not oversee the consequences of their actions in Navision.

Finding 1 is easy to improve, as the replenishment times are already available in Navision. The ATP-period and the replenishment lead time need to be linked to each other, the new formula for the ATP-period would then become: Replenishment lead time + the safety lead time.

Finding 2 is harder to improve, changing the Automove function or the Flex-inventory needs a change in Navision to let it succeed. Outside the ATP-period, the Automove function can be replaced by an automatic increase of the forecast if there is a bigger sales order than forecasted. Inside the ATP-period it is not recommendable to delete the Automove function as this function prevents the MRP from forecasting more sales than it is possible to sell.

Replacing the flex-inventory by a standard safety stock needs a change in the way Navision is currently working. A standard safety stock will generate planning suggestions on the moment the suggested projected inventory comes below the safety stock quantity, not taking the ATP-period into account. These same undesired planning suggestions currently occur within the ATP-period if the forecast or the flex-inventory is changed.

Finding 3 can be solved by explaining the consequences of changes in Navision to all the people involved in the operations process. Especially the impact sales has on the working of the MRP needs more attention, as this will make the sales people better understand when a change in a sales order needs to be communicated to the purchasers. The explanation of the MRP can be easily done based on the Excel model, as the Excel model makes it possible to visualize the consequences of a changed or deleted sales order.

8.2 Recommendations

Based on the analyses of the data and the interviews with the purchasers it can be concluded that the 12 hours the purchasers need to do the purchasing tasks can be roughly divided in 1 hour increasing or decreasing the flex-inventory and 11 hours handling the planning suggestions. The simulation shows that the amount of planning suggestions will be reduced with 72% if the solutions are implemented, which automatically make the flex-inventory redundant. This would reduce the time the purchasers need to handle the planning suggestions to approximately 3,5 hours a week. Besides the reduction of the time needed to handle the planning suggestions, the MRP is easier to understand for other employees than the purchasers. To get this better situation, I recommend Nedap Retail to implement the following points:

- Change the ATP-period from 7 weeks + safety lead time to replenishment lead time + safety lead time.
- Let the sales forecast automatically increase if the demand is higher than forecasted in a week outside the ATP-period.
- Let the forecast be placed back to the original week if a sales order is deleted who earlier caused a movement of the forecast.
- Make an extra option in the transfer order who makes it possible for the transfer order to be handled as a sales order in the MRP.
- Change the moment Navision is triggered to place planning suggestions: Let Navision react on the moment the suggested projected inventory comes below zero within the ATP-period and let Navision react on the moment the suggested projected inventory comes below the safety stock quantity outside the ATP-period.
- Create a new planning flexibility which makes it only possible for Navision to re-schedule the purchase orders to an earlier moment and let the purchase orders automatically get this planning flexibility when the purchase order comes within the ATP-period.
- Document the changes which are made in the MRP of Navision from now on, which makes it easier for new employees to understand the working of the MRP in Navision.

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Appendix 1: Parameters in Navision

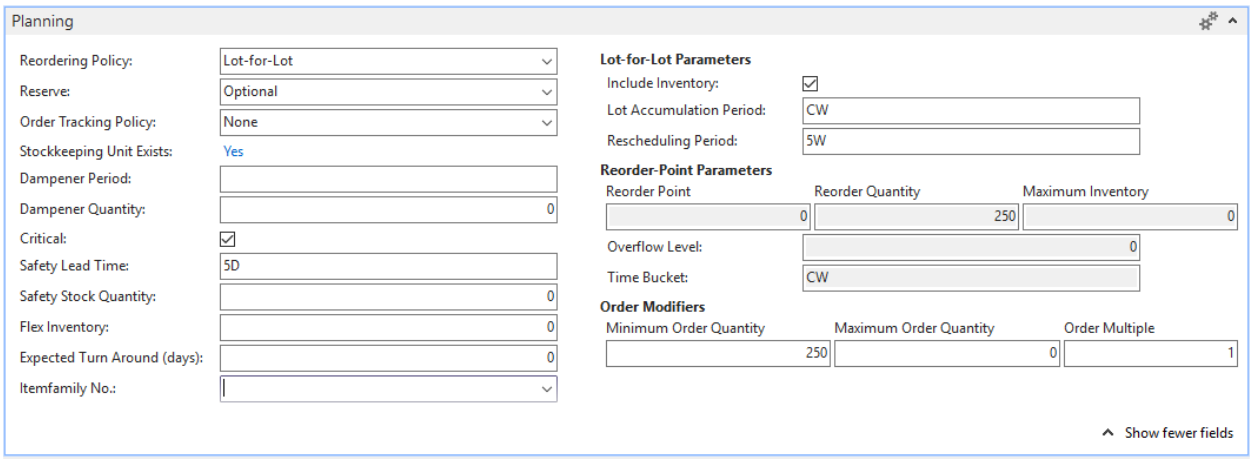


Figure 23: Planning parameters

Reordering policy:

- Fixed reorder point: If the inventory drops below the reorder point, Navision automatically gives a new action message.
- Maximum quantity: Maximum Order Quantity <= Maximum Inventory
- Order: If a sales order is received, the product is purchased by the vendor.
- Lot-for-Lot: Same as Order, but uses planning. This makes it possible to use a forecast to predict when a new purchase order has to be delivered to fulfill the customer demand.

Reserve:

- Never: Not possible to reserve
- Optional: Products can be reserved, but not necessary.
- Always: Products need a reservation (Important in the Order Reordering policy)

Dampener period: Specifies a period of time during which you do not want the planning system to propose to reschedule existing supply orders forward. If the lot accumulation period is less than the dampener period, then the dampener period is dynamically set to equal the lot accumulation period. This is not shown in the value that you enter in the Dampener Period field. The dampener period limits the system's sensitivity by insignificant rescheduling suggestions for existing supply to a later date if that new date is within the dampener period. The dampener period function is only initiated if the supply can be rescheduled to a later date and not if the supply can be rescheduled to an earlier date.

Dampener Quantity: Specifies a dampener quantity to block insignificant change suggestions for an existing supply if the quantity by which the supply would change is lower than the dampener quantity. If the suggested change in quantity is higher than the dampener quantity, then the suggestion is not blocked.

Safety lead time: Specifies the time needed to prepare the purchase order to go to the end-customer. For Nedap this means that the preffered vendor lead time is the time it takes the manufacturer to manufacter the order and ship the products to DSV and the safety lead time is the time DSV needs to prepare the products to be shipped to the customer.

Safety Stock quantity: When the inventory comes below the safety stock quantity, Navision will propose to place a replenishment order.

Flex Inventory: The Flex Inventory is another type of safety stock. This type of flex-inventory is built up in the forecast and so decreases the suggested projected inventory. The safety stock quantity or the flex-

inventory level need to be filled in, when filling in both these will complement each other. The flex-inventory can be controlled manually in the production forecast screen.
Lot Accumulation Period: Adds up all the forecast in a certain period. Most used is Current Week (CW), there is only one purchase order placed for this period. This option can only be changed using the lot-for-lot reordening policy.
Rescheduling Period: Defines a period within which any suggestion to change a supply date always consists of a Reschedule action and **never** consists of a Cancel + New action.
Reorder Point: If the inventory comes below this point, a planning suggestions will appear.
Reorder Quantity: The amount that is reordered if the reorder point is reached.
Maximum Inventory: The maximum amount of products that may lay in inventory. Important if the reordering policy is maximum quantity.
Overflow level: The amount of products which are available – maximum inventory

- Maximum order quantity: *Overflow Level = Maximum Inventory +* (*Minimum Order Quantity. + rounded up to nearest order multiple*)
- Fixed reorder point: *Overflow Level = Reorder Quantity + Reorder Point +* (*Minimum Order Quantity + rounded up to nearest order multiple*)

Time Bucket: If the reordering policy is not lot-for-lot, it is also possible to look to a period to accumulate the sales orders.
Minimum Order Quantity: The minimum amount that need to be ordered.

Purchasing
Planning flexibility: When the planningsflexibility is unlimited, Navision may propose to re-schedule the purchase order. When there is no planningsflexibility, Navision will not give any suggestion to change the placed purchase order.
Reservation: A reservation can be placed for a sales order. This makes sure a purchase orders can not be sold to another customer, and will generate a new planning suggestion based on the expected demand. This can be usefull in the re-order point replenishment policy, as it is than possible to include expected demand in the MRP card. In the Lot-for-Lot replenishment policy this option is less helpful , as the planning suggestions automatically occur when the suggested projected inventory is lower than 0.

Appendix 2: Process flow re-order point replenishment policy

In the process flow is assumed that the process starts within a product that is already sold for some time, so there is already some inventory or scheduled receipts are nearby. The process flow depicts the standard situation, where an order is placed based on the ATP. In some cases big orders are expected, for example if a customer already announced a roll out for a specific country. In those cases purchasing can place an order independent of the planning suggestions. After sales places an order and the inventory comes below the re-order point, purchasing gets a message in Navision. Purchasing will then check if the planning suggestion can be accepted, or that it is better to wait a couple of weeks. Every time a change is made in Navision, Navision will update the MRP card. Not all fields are directly updated, for instance the planning suggestions are only calculated every night or when someone calculates a regenerative plan manually.

Sales

The sales process starts with an order that is received from a customer. This order contains a product number, an amount and a desired delivery date. Sales places a sales order in Navision, Navision then directly shows if it is possible to place the order or not. When the ATP becomes green, sales checks if the order can cause problems for other customers, this is not being done by specific rules but mainly on knowledge about the products. For little amounts this is almost never a problem, but big orders may cause a problem if there is already a big order near outside the ATP-period, which is not taken into account in the ATP. When there are no problems, the order is placed, otherwise sales contacts purchasing to check what the possibilities are. A solution could be that purchasing contacts the manufacturer to ask if it is possible to deliver earlier or place an extra order. If purchasing thinks that it is possible, the order will be placed, otherwise the order will come in the same process as an order that cannot be placed based on the ATP.

When an order cannot be placed based on the ATP, sales will first check if the customer does also accept a comparable product or can receive the products on a later moment. If the customer agrees with the other product, the process will start over again. However, sales will this time check the ATP before they propose it to the customer, which will mostly result in an order that is directly placed. If the customer does not agree with the other option, sales will negotiate with purchasing to see what the possibilities are. If the customer accepts the proposal, the order is placed, otherwise sales will again look to the possibilities depending on the importance of the customer. If a solution is found, the order will be placed, otherwise the customer will go to a competitor.

Customers want to change their orders sometimes. It could be that shops will open later or that a customer wants the antenna in more stores than was initially the plan. In those cases, sales looks to the possibilities and change the order if it is possible. These changes can have major effects on the purchasing process, if for instance already a sales order was placed a couple of weeks ago and purchasing already placed a purchase order by the manufacturer. It can be hard to delete this order as the manufacturer already ordered the spare parts.

Purchasing

Purchasing enters the orders for the products with a re-order point always on Friday morning. Purchasing receipts all the planning suggestions in Navision, for the products where the inventory will come below the re-order point. By purchasing, all the planning suggestions are checked, so not only the

planning suggestions that really have to be placed in the current week. If the inventory is likely to come below the re-order point about three weeks due to the orders that are already placed, purchasing will evaluate this product and mostly already place the order as the manufacturer then knows that the products are desired. Manufacturers can in those cases already order the components with long lead times, which will make it sometimes possible to deliver the products earlier if this improves the inventory position.

The purchasing department is also responsible for the re-order point. This point is determined based on the lead time of the product, the previous sales, the manufacturer's reliability and the price of the product. If the re-order points are changed, a regenerative plan is calculated and new planning suggestions will appear if new orders need to be placed or existing orders need to be cancelled or rescheduled.

If a purchase order is delayed, this will often directly influence the sales orders that are already placed. Purchasing contacts sales, so they can inform the customer if necessary and purchasing changes the receipt date in Navision. After the changes are made, a regenerative plan is calculated to make sure the changes are adopted in the right way.

If a sales order's amount or date is changed, purchasing checks what the consequences are for the placed purchase orders. In some cases, it is possible to change the delivery date of a purchase order, which can automatically be calculated if purchasing had set the planning flexibility in the purchase order to unlimited, otherwise this has to be calculated manually. After the changes are made, purchasing runs a regenerative plan to update the system.

Navision

As soon as a sales or purchase order is placed, Navision recalculates the number of available products. It also updates the columns that are important for the calculation of the amount and date of the planning suggestion. Important is that Navision is programmed in such a way, that in the MRP card everything that lowers the inventory is automatically negative and everything that increases the inventory is positive. After a sales or purchase order is placed, Navision starts with the current inventory and all the scheduled receipts and the gross requirements. It than calculates the first week, then the second week and so on until all the lines are filled. With this way of working, Navision makes sure that old planning suggestions, deleted or added sales orders and deleted or added purchase orders are processed in the right way. In the following list, all the formulas that are used to calculate the columns as explained.

Gross Requirement(G): Sales Orders, sales orders will always be negative, as they lower the inventory. In the following equations, the G will often be added, as this is what Navision does however this may seam contradictory. In those cases it is important to remember that 1 + -1 = 0 and 1 - -1 = 2.
Scheduled Receipt (S): Incoming Products, these are possitive, as they increase the inventory.
Projected Inventory (PI): The projected inventory gives the exact inventory.

- Projected Inventory privious week – Gross Requirements + Scheduled Receipts
  $PI_t = PI_{t-1} + G + S$

Suggested Projected Inventory(**SPI**)**:** The expected inventory level

- $SPI = SPI_{t-1} + RQ$

Action Message Qty. .(AMQ): If the Suggested Projected Inventory is lower than the reorderpoint the Action Message Qty. gives the amount of products that need to be deliverd to fullfil demand. The AMQ is

received in the week the inventory comes below the re-order point. The AMQ's are the planning suggestions.
AMQ = The minimum order quantity rounded to the first order multiple.
Remaining Quantity (Base) (RQ): The amount of products which are over in a certain week. This number will be used to calculate the suggested projected inventory.

- Remaining Quantity = Scheduled Receipts. + Gross Requirement + Action Message Qty
- RQ = S + G + AMQ

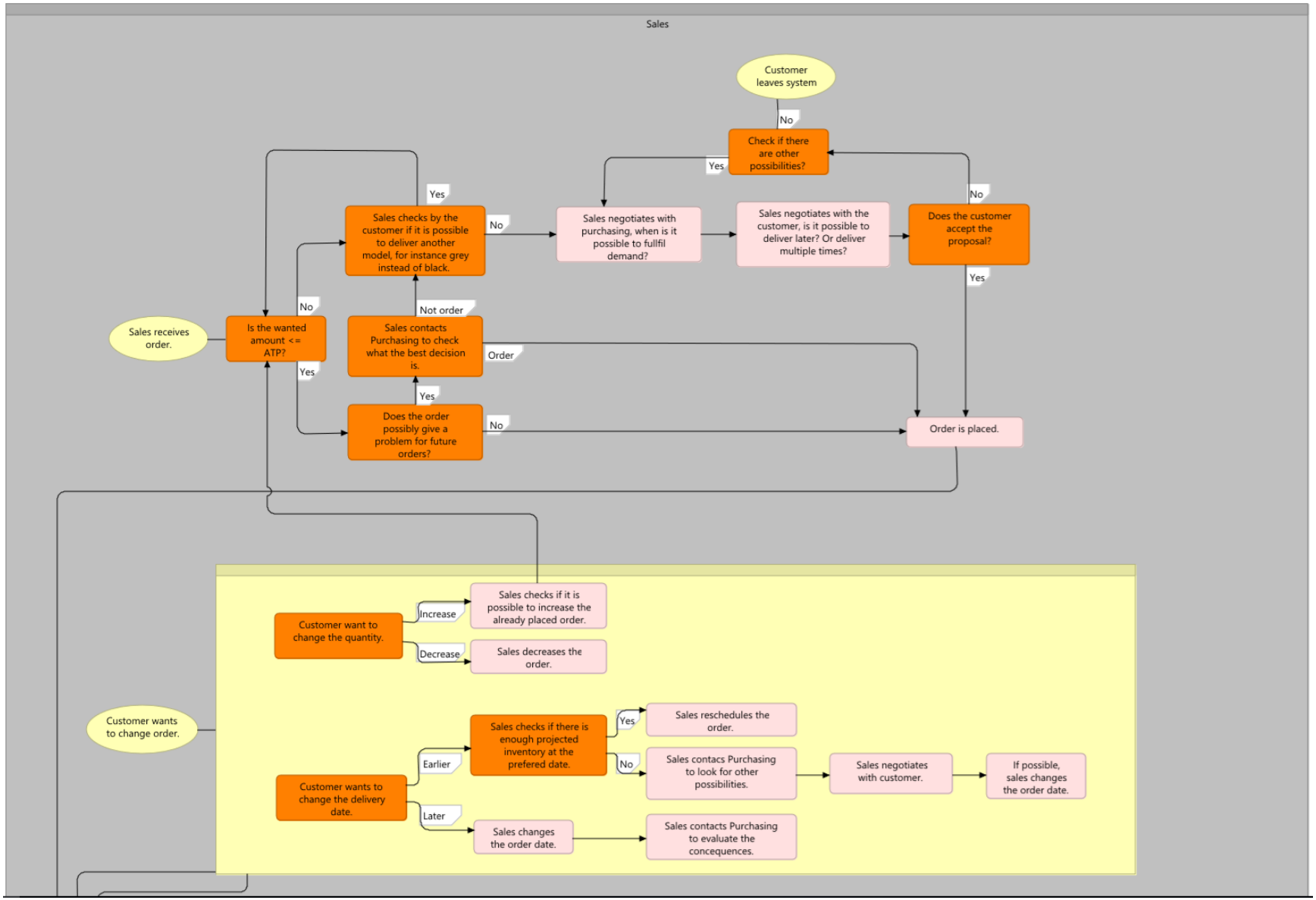
Safety Stock Quantity: (SSQ) Filled in the stockkeeping unit.
Projected Inventory Nedap (PIN): The PI if the AMQ's are taken into account. For sales, the AMQ is not taken into account, purchasing has to decide if the AMQ is accepted or not.

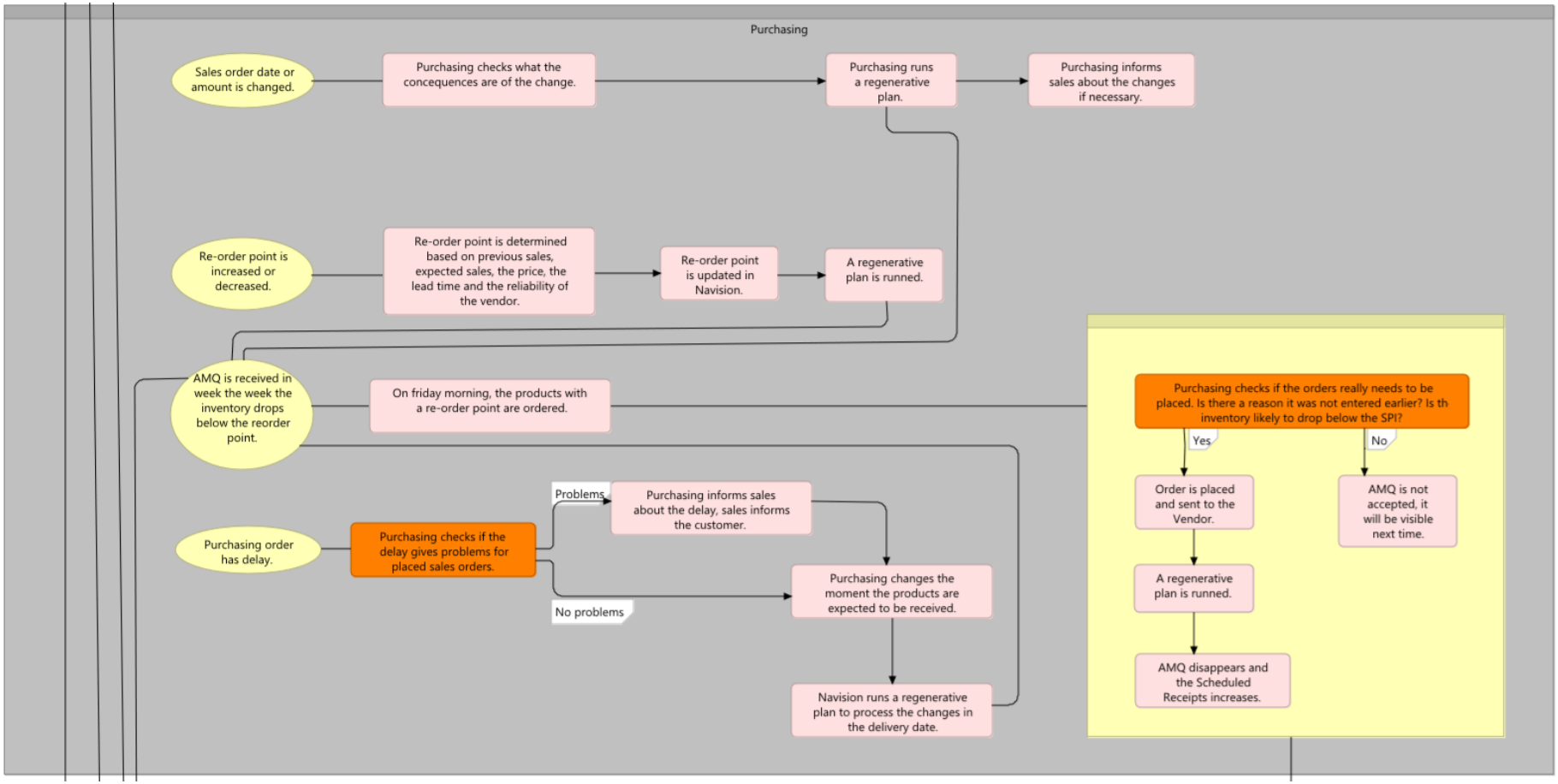
- $PIN_t = PIN_{t-1} + G + S + AMQ$

Available on Date (AoD): The remaining amount of products that can be sold to the customers. The AoD looks to the lowest inventory point until the next delivery, as long as that delivery is not already consumed. The idea behind the AoD is that it is possible to have a PIN of 200 in week 5 and the first delivery in week 7. In that case, based on the PIN these 200 products are available and so could be sold to the customers. The PIN does not take the upcomming orders into account, if there is a order of 200 in week 6, the PIN will still be 200 in week 5 and will be 0 in week 6. As it is not possible to assign the same products to multiple customers, the AoD makes sure that in week 1-6 the AoD will be 0 if the order in week 6 is placed. Outside the ATP period, the AoD = PIN.

- AoD_t = Lowest PIN until next delivery, this holds inside the ATP period
- AoD_t = PIN, this holds outside the ATP period

In the current situation, the SSQ is always 0 as this option is not used. In the process flow on the next page, the yellow circles adress an starting-situation. The orange blocks are the places where a decision is made, these are the so called if-blocks. The pink blocks are the situations where no decision need to be made, if there is leaving more than one line, both lines need to be followed. In those cases more than one task need to be performed. The lines between the orange and pink blocks all contain a clear arrow in which order the blocks need to be read. The lines between the yellow activities and boxes do not contain an arrow, as this is technically not possible. The yellow circles on the left side all mention the start of an activity, yellow and white boxes all contain a sperate process, these are added to make it more clear which action belong to each other.


Sales
Customer leaves system
No
Check if there are other possibilities?
Yes
No
Yes
Sales checks by the customer if it is possible to deliver another model, for instance grey instead of black.
No
Sales negotiates with purchasing, when is it possible to fullfil demand?
Sales negotiates with the customer, is it possible to deliver later? Or deliver multiple times?
Does the customer accept the proposal?
Yes
No
Not order
Sales receives order.
Is the wanted amount <= ATP?
Sales contacts Purchasing to check what the best decision is.
Order
Yes
Yes
Does the order possibly give a problem for future orders?
No
Order is placed.
Customer want to change the quantity.
Increase
Sales checks if it is possible to increase the already placed order.
Decrease
Sales decreases the order.
Customer wants to change order.
Sales checks if there is enough projected inventory at the prefered date.
Yes
Sales reschedules the order.
No
Earlier
Sales contacs Purchasing to look for other possibilities.
Sales negotiates with customer.
If possible, sales changes the order date.
Customer wants to change the delivery date.
Later
Sales changes the order date.
Sales contacts Purchasing to evaluate the concequences.


Purchasing
Sales order date or amount is changed.
Purchasing checks what the concequences are of the change.
Purchasing runs a regenerative plan.
Purchasing informs sales about the changes if necessary.
Re-order point is increased or decreased.
Re-order point is determined based on previous sales, expected sales, the price, the lead time and the reliability of the vendor.
Re-order point is updated in Navision.
A regenerative plan is runned.
AMQ is received in week the week the inventory drops below the reorder point.
On friday morning, the products with a re-order point are ordered.
Purchasing checks if the orders really needs to be placed. Is there a reason it was not entered earlier? Is th inventory likely to drop below the SPI?
Yes
No
Order is placed and sent to the Vendor.
AMQ is not accepted, it will be visible next time.
A regenerative plan is runned.
AMQ disappears and the Scheduled Receipts increases.
Problems
Purchasing informs sales about the delay, sales informs the customer.
Purchasing order has delay.
Purchasing checks if the delay gives problems for placed sales orders.
Purchasing changes the moment the products are expected to be received.
No problems
Navision runs a regenerative plan to process the changes in the delivery date.

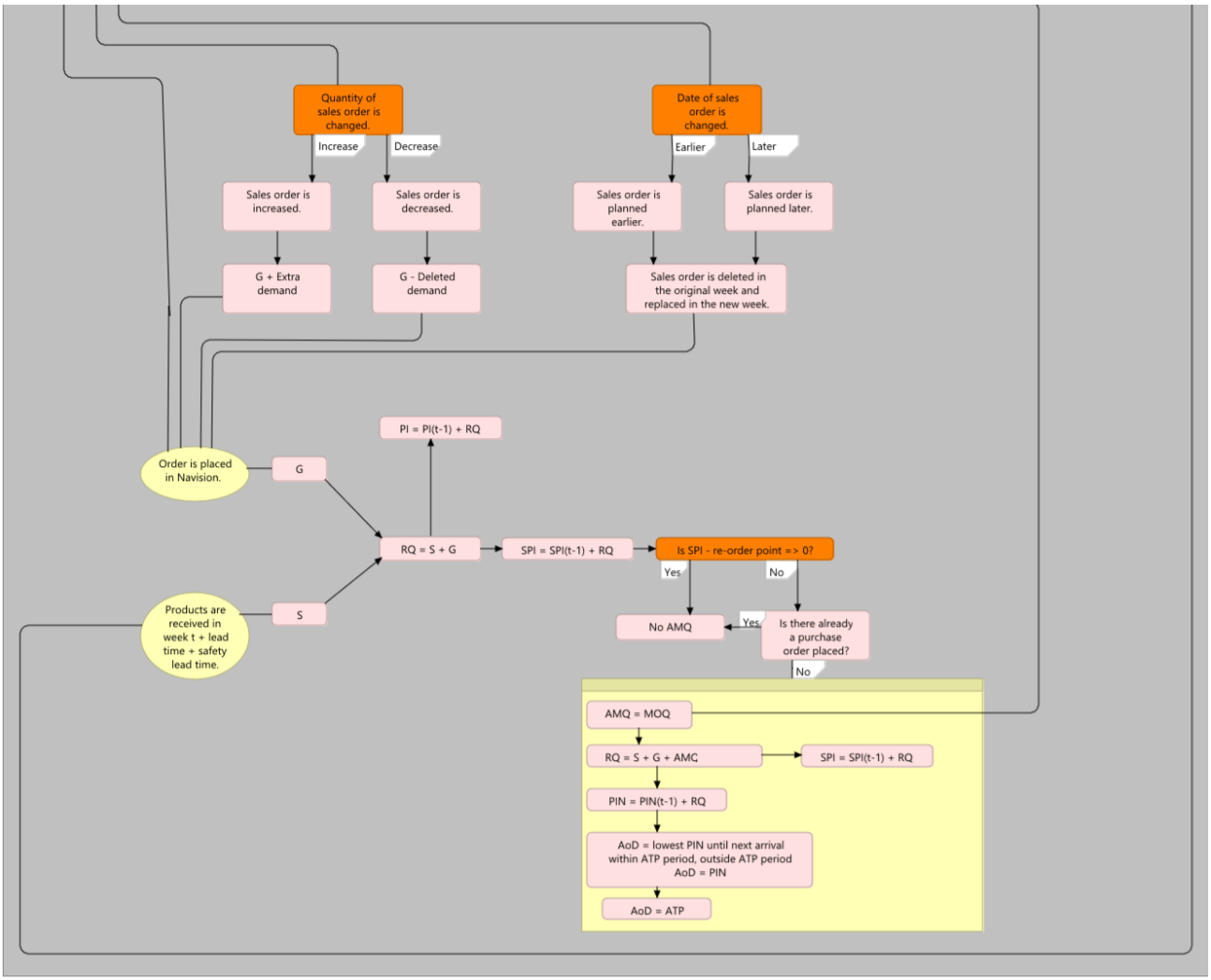


Figure 24: Re-order point replenishment policy

Appendix 3: Process flow Lot-for-Lot replenishment policy

Sales

Compared to the sales process in the re-order point replenishment policy (appendix 2), there are almost no changes. The purchasers must be extra alert if they delete or change a sales order, as the forecast is not placed back automatically if it was moved for the order.

Purchasing

In the purchasing process are compared to the re-order point replenishment more tasks needed. Determining the re-order point is no longer necessary and a replenishment order will no longer be done on the moment the inventory level comes below the re-order point. In the Lot-for-Lot replenishment strategy the forecast and flex-inventory are added. The flex-inventory also needs to be checked and corrected manually every week.

Navision

Within Navision, the forecast and remaining forecast columns are filled. These columns are influencing other important columns as the suggested projected inventory and the available to promise. The Automove function is also activated and the differences between ordering in or outside the ATP-period are becoming clearer.

Gross Requirement (G): Sales Orders, sales orders will always be negative, as they lower the inventory. In the following equations, the G will often be added, as this is what Navision does however this may seam contradictory. In those cases it is important to remember that 1 + -1 = 0 and 1 - -1 = 2.
Scheduled Receipt (S): Placed orders, these are possitive, as they increase the inventory.
Projected Inventory (PI): Independent of the forecasts, projected inventory gives the exact inventory.

- Projected inventory = Projected Inventory privious week + Gross Requirements + Scheduled Receipts
- $PI_t = PI_{t-1} + G + S$

Forecast (F): The forecasted demand, the forecasted demand lowers the inventory, so this one is negative in Navision. The forecast is the sum of the general forecast and the flex-safety stock. The forecast will be moved within the ATP period, if there is a bigger order than the remaining forecast in a week. The remaining forecast in other weeks of the ATP period will be added in the week the forecast is needed. Navision will first check if there is remaining forecast in the first week of the ATP, than the second week up to the last week of the ATP until all the remaining forecast is used. If all the remaining forecast is used and the forecast for the order is still not filled completely, the forecast will get the value of the original forecast + all the remaining forecast of the ATP period. If the RF is placed in another week, the forecast in that week will be lowered with the consumed RF.
Remaining Forecast (RF): The remaining amount of products that is expected to be sold in a week.

- Remaning Forecast = Forecast – Gross requirements if F => G
- RF = F - G if F => G
- Remaining Forecast = 0 if F < G
- RF = 0 if F < G

Forecasted Projected Inventory (FPI): The inventory if the sales forecast is taken into account.

- Forecasted Projected Inventory = Forecasted Projected Inventory previous week + Gross requirements + Scheduled Receipts + Remaining Forecast
- $FPI_t = FPI_{t-1} + G + S + RF$

Action Message Qty. (AMQ): If the Suggested Projected Inventory is lower than the Safety Stock Quantity the Action Message Qty. gives the amount of products that need to be deliverd to fullfil demand or hold the safety stock.
If the SPI < SSQ: AMQ = |SSQ – SPI| rounded to the minimum order quantity, rounded to the first order multiple if it is < MOQ otherwise rounded to the MOQ + the a order multiple rounded to a order multiple.
Remaining Quantity (Base) (RQ): The amount of products which are over in a certain week. This number will be used to calculate the suggested projected inventory.

- Remaining Quantity = Scheduled Receipts. + Gross Requirement + Remaining Forecast + Action Message Qty
- RQ = S + G + RF + AMQ

Suggested Projected Inventory (SPI): The inventory if the forecasts and Action Message Qty. are taken into account.

- $SPI = SPI_{t-1} + RQ$

Rem. Forecast Cumm. (RFC): Cummulative remaining forecasts. If in a week comes an big order, and the remaining cummulative forecast is bigger, the order could be delivered if there are no other customers.

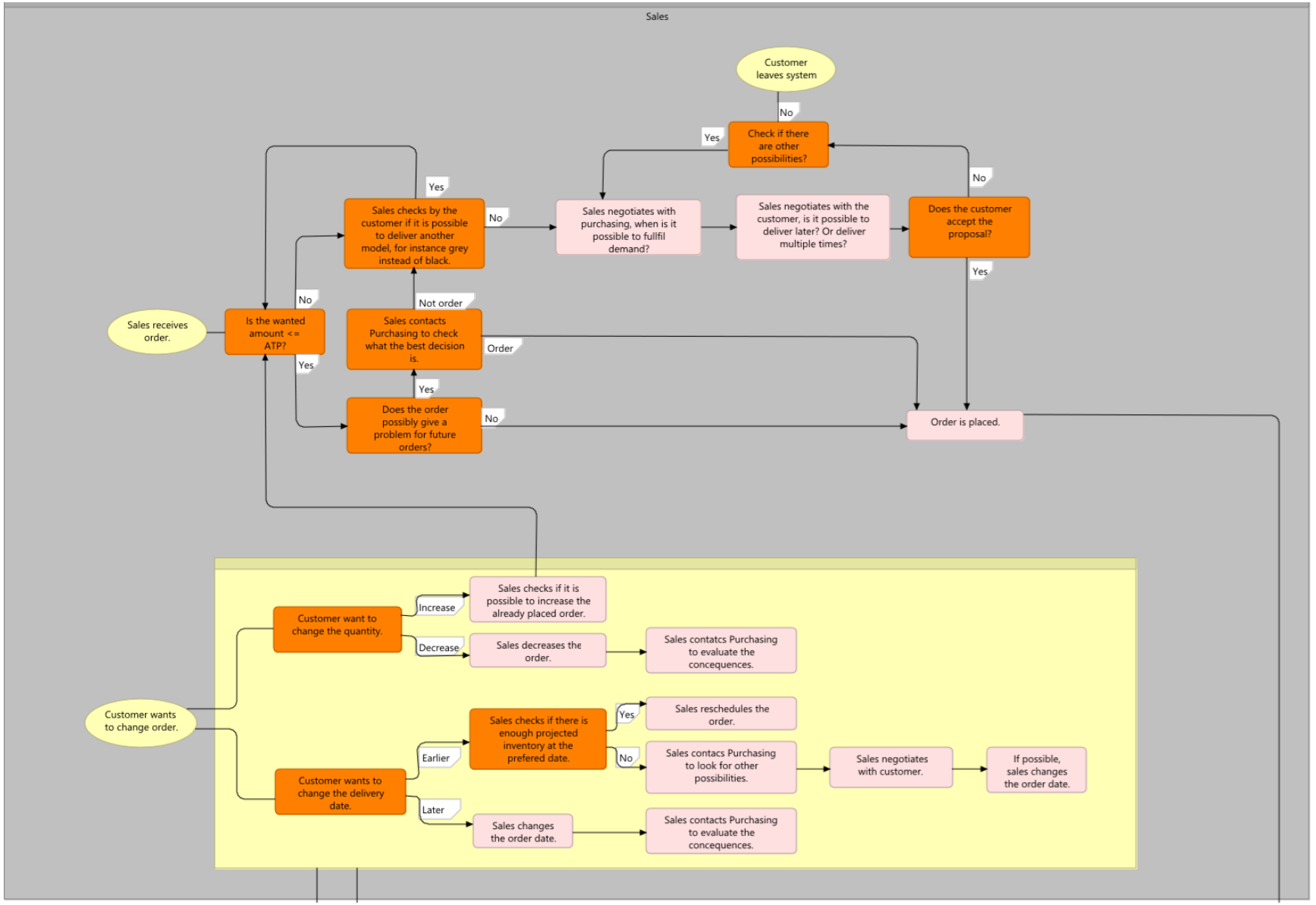
- RFC = $\sum_{t=0}^{T} RF$

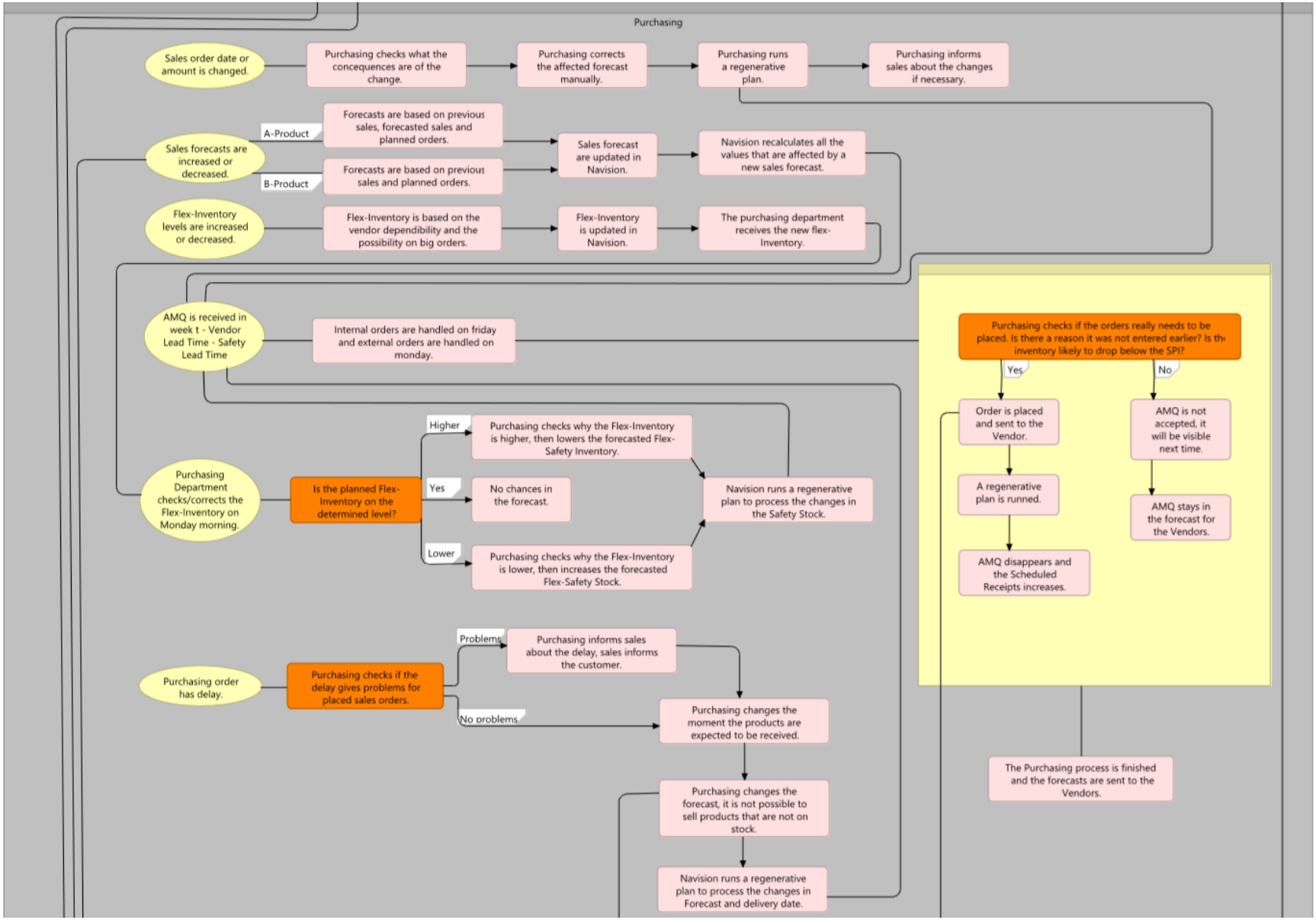
Safety Stock (SS): Determined with the flex-inventory.
Safety Stock Quantity (SSQ): Filled-in in the stockkeeping unit.
Projected Inventory Nedap (PIN): The PI if the AMQ's are taken into account. For sales, the AMQ is not taken into account, purchasing has to decide if the AMQ is accepted or not.

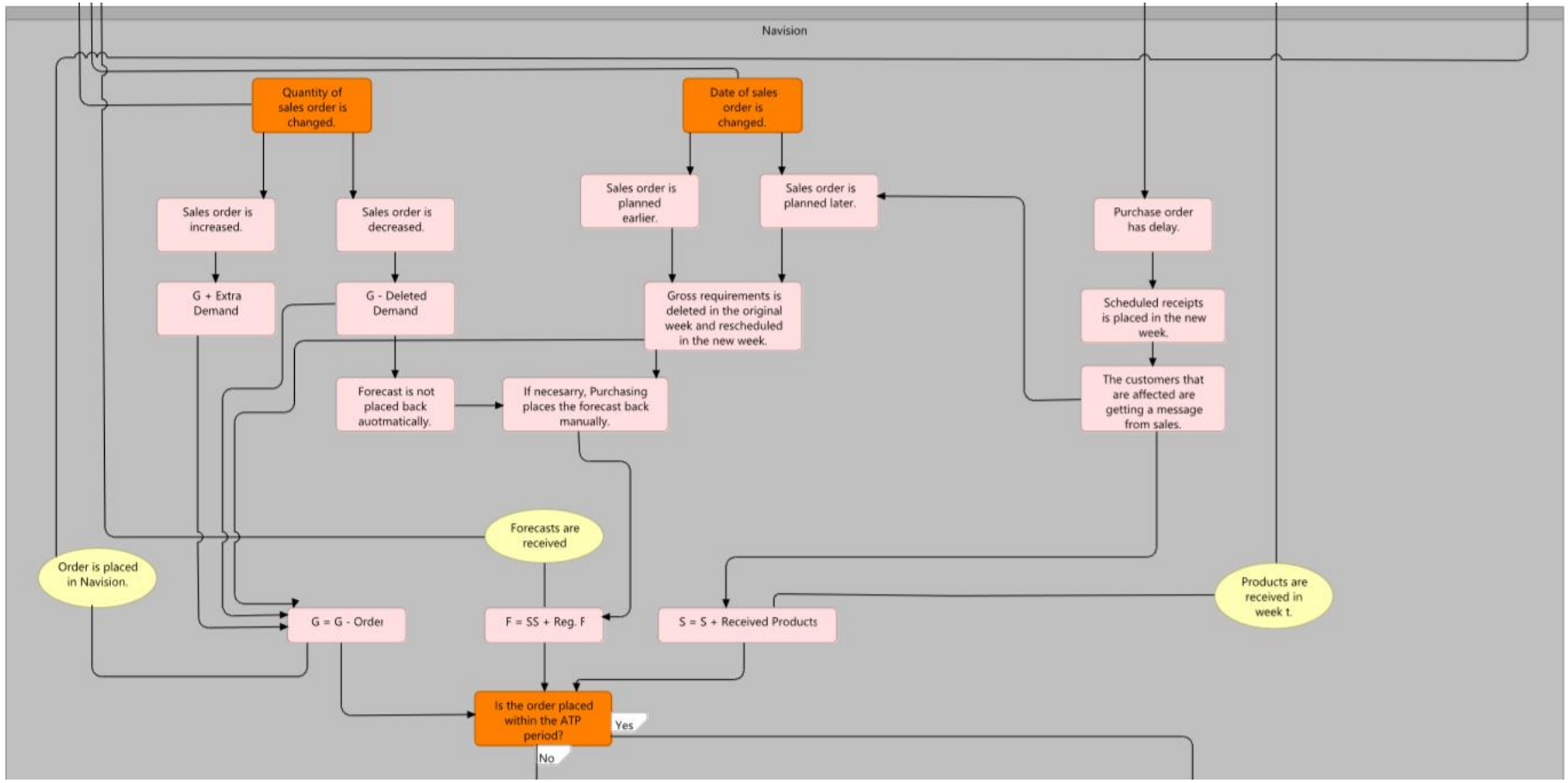
- $PIN_t = PIN_{t-1} + G + S + AMQ$

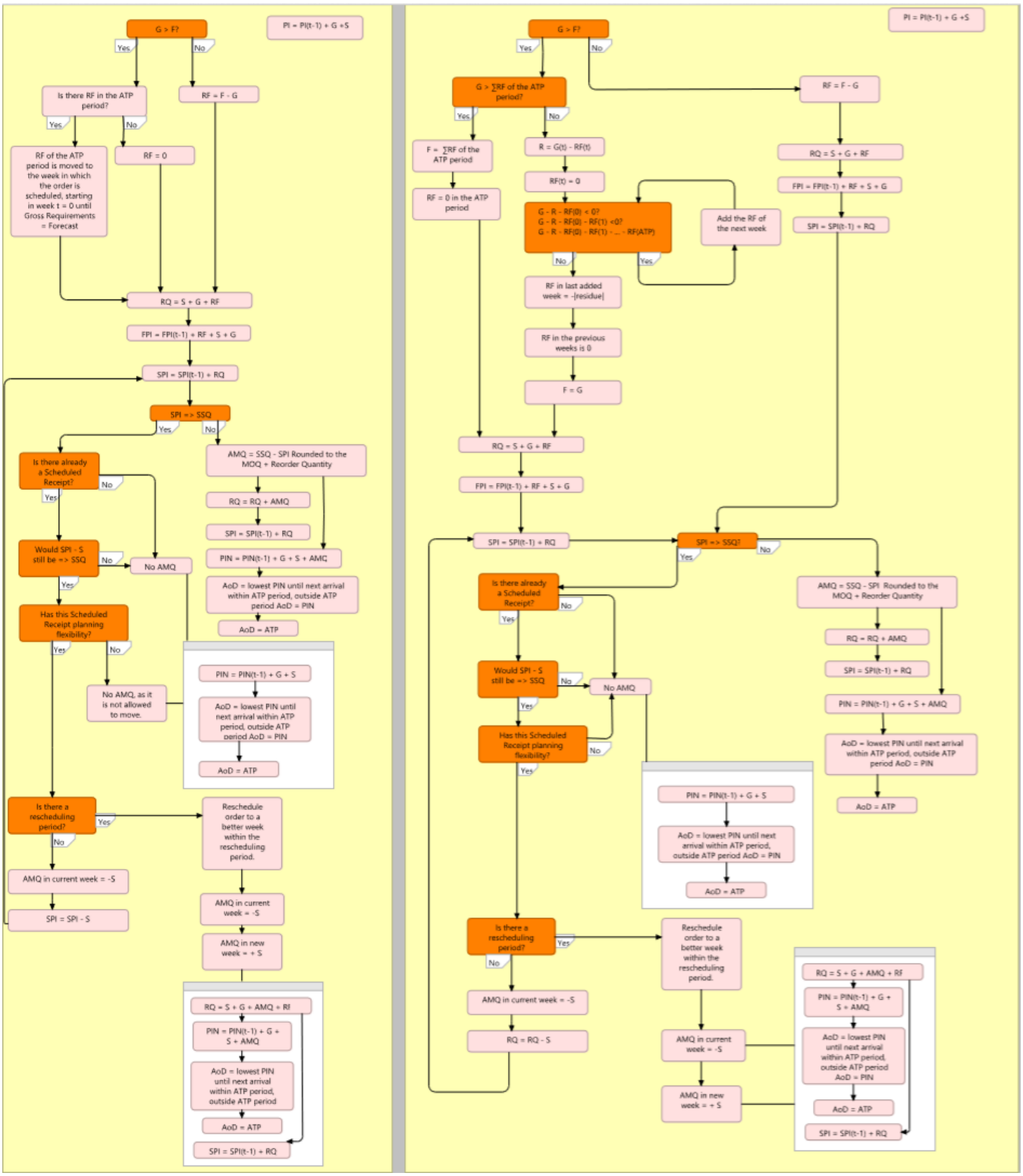
Available on Date (AoD): The remaining amount of products which can be sold to the customer. Wihtin the ATP-period the AoD looks to the lowest PIN until the next purchase order is received. Outside the ATP-period, the AoD equals the PIN.

- AoD_t = Lowest PIN until next delivery (Inside the ATP period)
- AoD_t = PIN (Outside the ATP period)


Sales
Customer leaves system
No
Yes
Check if there are other possibilities?
Yes
Sales checks by the customer if it is possible to deliver another model, for instance grey instead of black.
No
Sales negotiates with purchasing, when is it possible to fullfil demand?
Sales negotiates with the customer, is it possible to deliver later? Or deliver multiple times?
No
Does the customer accept the proposal?
Yes
No
Not order
Sales receives order.
Is the wanted amount <= ATP?
Sales contacts Purchasing to check what the best decision is.
Order
Yes
Yes
Does the order possibly give a problem for future orders?
No
Order is placed.
Customer want to change the quantity.
Increase
Sales checks if it is possible to increase the already placed order.
Decrease
Sales decreases the order.
Sales contatcs Purchasing to evaluate the concequences.
Customer wants to change order.
Sales checks if there is enough projected inventory at the prefered date.
Yes
Sales reschedules the order.
Earlier
No
Sales contacs Purchasing to look for other possibilities.
Sales negotiates with customer.
If possible, sales changes the order date.
Customer wants to change the delivery date.
Later
Sales changes the order date.
Sales contacts Purchasing to evaluate the concequences.


Purchasing
Sales order date or amount is changed.
Purchasing checks what the concequences are of the change.
Purchasing corrects the affected forecast manually.
Purchasing runs a regenerative plan.
Purchasing informs sales about the changes if necessary.
Sales forecasts are increased or decreased.
A-Product
Forecasts are based on previous sales, forecasted sales and planned orders.
B-Product
Forecasts are based on previous sales and planned orders.
Sales forecast are updated in Navision.
Navision recalculates all the values that are affected by a new sales forecast.
Flex-Inventory levels are increased or decreased.
Flex-Inventory is based on the vendor dependibility and the possibility on big orders.
Flex-Inventory is updated in Navision.
The purchasing department receives the new flex-Inventory.
AMQ is received in week t - Vendor Lead Time - Safety Lead Time
Internal orders are handled on friday and external orders are handled on monday.
Purchasing checks if the orders really needs to be placed. Is there a reason it was not entered earlier? Is the inventory likely to drop below the SPI?
Yes
No
Order is placed and sent to the Vendor.
A regenerative plan is runned.
AMQ disappears and the Scheduled Receipts increases.
AMQ is not accepted, it will be visible next time.
AMQ stays in the forecast for the Vendors.
Purchasing Department checks/corrects the Flex-Inventory on Monday morning.
Is the planned Flex-Inventory on the determined level?
Higher
Purchasing checks why the Flex-Inventory is higher, then lowers the forecasted Flex-Safety Inventory.
Yes
No chances in the forecast.
Lower
Purchasing checks why the Flex-Inventory is lower, then increases the forecasted Flex-Safety Stock.
Navision runs a regenerative plan to process the changes in the Safety Stock.
Purchasing order has delay.
Purchasing checks if the delay gives problems for placed sales orders.
Problems
Purchasing informs sales about the delay, sales informs the customer.
No problems
Purchasing changes the moment the products are expected to be received.
Purchasing changes the forecast, it is not possible to sell products that are not on stock.
Navision runs a regenerative plan to process the changes in Forecast and delivery date.
The Purchasing process is finished and the forecasts are sent to the Vendors.


Navision
Quantity of sales order is changed.
Date of sales order is changed.
Sales order is increased.
Sales order is decreased.
Sales order is planned earlier.
Sales order is planned later.
Purchase order has delay.
G + Extra Demand
G - Deleted Demand
Gross requirements is deleted in the original week and rescheduled in the new week.
Scheduled receipts is placed in the new week.
Forecast is not placed back auotmatically.
If necesarry, Purchasing places the forecast back manually.
The customers that are affected are getting a message from sales.
Forecasts are received
Order is placed in Navision.
Products are received in week t.
G = G - Order
F = SS + Reg. F
S = S + Received Products
Is the order placed within the ATP period?
Yes
No


G > F?
Yes
No
Is there RF in the ATP period?
RF = F - G
RF = 0
RF of the ATP period is moved to the week in which the order is scheduled, starting in week t = 0 until Gross Requirements = Forecast
PI = PI(t-1) + G +S
RQ = S + G + RF
FPI = FPI(t-1) + RF + S + G
SPI = SPI(t-1) + RQ
SPI => SSQ
Is there already a Scheduled Receipt?
Would SPI - S still be => SSQ
No AMQ
Has this Scheduled Receipt planning flexibility?
No AMQ, as it is not allowed to move.
AMQ = SSQ - SPI Rounded to the MOQ + Reorder Quantity
RQ = RQ + AMQ
SPI = SPI(t-1) + RQ
PIN = PIN(t-1) + G + S + AMQ
AoD = lowest PIN until next arrival within ATP period, outside ATP period AoD = PIN
AoD = ATP
PIN = PIN(t-1) + G + S
AoD = lowest PIN until next arrival within ATP period, outside ATP period AoD = PIN
AoD = ATP
Is there a rescheduling period?
Reschedule order to a better week within the rescheduling period.
AMQ in current week = -S
SPI = SPI - S
AMQ in current week = -S
AMQ in new week = + S
RQ = S + G + AMQ + RF
PIN = PIN(t-1) + G + S + AMQ
AoD = lowest PIN until next arrival within ATP period, outside ATP period
AoD = ATP
SPI = SPI(t-1) + RQ
G > ∑RF of the ATP period?
F = ∑RF of the ATP period
RF = 0 in the ATP period
R = G(t) - RF(t)
RF(t) = 0
G - R - RF(0) < 0?
G - R - RF(0) - RF(1) <0?
G - R - RF(0) - RF(1) - ... - RF(ATP)
Add the RF of the next week
RF in last added week = -|residue|
RF in the previous weeks is 0
F = G
RF = F - G
RQ = S + G + RF
FPI = FPI(t-1) + RF + S + G
SPI = SPI(t-1) + RQ
SPI => SSQ?
Is there already a Scheduled Receipt?
Would SPI - S still be => SSQ
No AMQ
Has this Scheduled Receipt planning flexibility?
AMQ = SSQ - SPI Rounded to the MOQ + Reorder Quantity
RQ = RQ + AMQ
SPI = SPI(t-1) + RQ
PIN = PIN(t-1) + G + S + AMQ
AoD = lowest PIN until next arrival within ATP period, outside ATP period AoD = PIN
AoD = ATP
PIN = PIN(t-1) + G + S
AoD = lowest PIN until next arrival within ATP period, outside ATP period AoD = PIN
AoD = ATP
Is there a rescheduling period?
Reschedule order to a better week within the rescheduling period.
AMQ in current week = -S
RQ = RQ - S
AMQ in current week = -S
AMQ in new week = + S
RQ = S + G + AMQ + RF
PIN = PIN(t-1) + G + S + AMQ
AoD = lowest PIN until next arrival within ATP period, outside ATP period AoD = PIN
AoD = ATP
SPI = SPI(t-1) + RQ

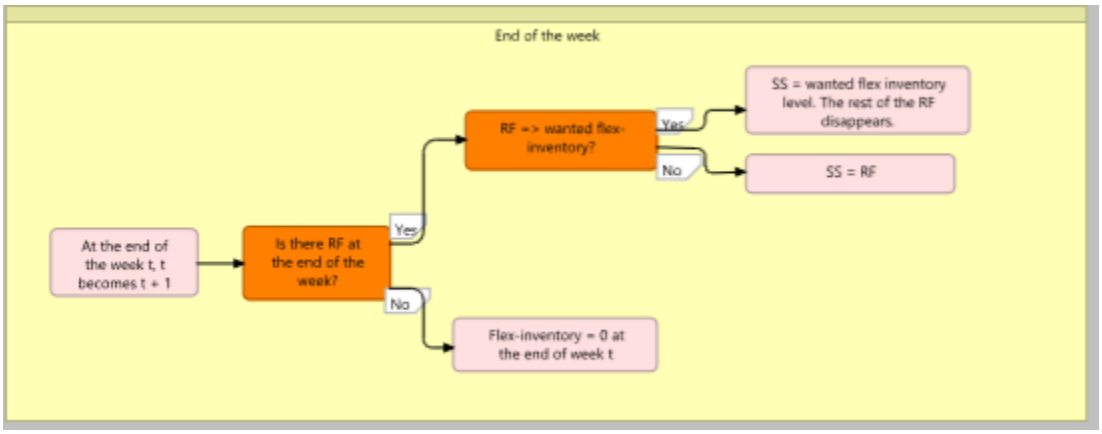


Figure 25: Lot-for-Lot replenishment policy

Appendix 4: Disadvantages of the current system

1. The ATP-period is not the same as the replenishment lead time.

The ATP-period is currently standard 7 weeks + the safety time. This remains from before the outsourcing of the production. Before the outsourcing, it was mostly possible to reschedule the production in such a way a new batch could always be produced within 7 weeks. In the new situation it sometimes takes manufacturers 28 weeks to produce a new batch of products. In those cases there is a gap of 21 weeks, in which Navision thinks it is possible to deliver and this is not possible in reality. The replenishment times the manufacturer gives are available in Navision, but these are not used yet. A situation that could now possibly occur, is that an order is placed outside the ATP period, but inside the replenishment lead time of a significant amount. As long as this amount is lower than the ATP the sales person will not see a problem, the order turns green and no problems occur. But, if another quite large order is placed afterwards within the ATP-period and this order is also lower than the ATP at that moment, the order will become green again. The sales person will possibly not check further as everything seems good, but the order outside the ATP can no longer be delivered. This situation is demonstrated below. In figure 26 the start situation is demonstrated. The purchaser will see the available on date column as ATP in the sales screen. As can be seen, the available on date column is still completely green.

Period Start	Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt
	Inventory	32	32		**32**
9-7-2018	Week 28	62	62		**30**
23-7-2018	Week 30	92	92		**30**
30-7-2018	Week 31	92	92		
6-8-2018	Week 32	122	122		**30**
13-8-2018	Week 33	122	122		
20-8-2018	Week 34	152	152		**30**
27-8-2018	Week 35	152	152		
3-9-2018	Week 36	182	182		**30**
10-9-2018	Week 37	182	182		

Figure 26: The start situation

Now a big order is placed outside the ATP period. As is visible in figure 27, the available on date column is still completely green. It is also showed that Navision does not take the orders outside the ATP-period (the in blue colloured weeks) into account when determining the available on date column within the ATP-period. The available on date changes is decreased from of the week the order is desired. In this situation, there is still no problem, as there are enough products in inventory to cover the demand. It is even possible to sell 42 extra products in the previous weeks.

Period Start	Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt
	Inventory	32	32		**32**
25-6-2018	Week 26	32	32		
2-7-2018	Week 27	32	32		
9-7-2018	Week 28	62	62		**30**
16-7-2018	Week 29	62	62		
23-7-2018	Week 30	92	92		**30**
30-7-2018	Week 31	92	92		
6-8-2018	Week 32	122	122		**30**
13-8-2018	Week 33	122	122		
20-8-2018	Week 34	152	152		**30**
27-8-2018	Week 35	42	42	**-110**	
3-9-2018	Week 36	72	72		**30**
10-9-2018	Week 37	72	72		

Figure 27: A big sales order is received for week 35.

Now another order is placed inside the ATP period. This order is possible as 80 is lower than the 92 which are available as is visible in the previous situation. Now, a problem occurs in week 35: Navision thinks that it is possible to deliver as it is outside the ATP period, however it is not possible to deliver as it is still within the replenishment lead time (indicated in the first column in red). In week 35, too less products will be on stock to fulfill demand and still it is possible to place extra orders in week 28 till week 34 as the available on date is still green. Navision will generate a planning suggestion for week 35, however purchasing is not able to accept this suggestion as it is inside the replenishment lead time.

Period Start	Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt
	Inventory	12	32		**32**
9-7-2018	Week 28	12	62		**30**
23-7-2018	Week 30	12	12	**-80**	**30**
30-7-2018	Week 31	12	12		
6-8-2018	Week 32	42	42		**30**
13-8-2018	Week 33	42	42		
20-8-2018	Week 34	72	72		**30**
27-8-2018	Week 35	*-38*	*-38*	**-110**	
3-9-2018	Week 36	*-8*	*-8*		**30**
10-9-2018	Week 37	*-8*	*-8*		

Figure 28: A new sales order is received in week 30.

2. The planning flexibility in the purchase orders is often turned off.

The planning flexibility in the purchase orders is often turned off, as it is often not desired that Navision comes up with re-scheduling planning suggestions. Turning the planning flexibility of makes it impossible for Navision to send rescheduling suggestions for a placed order. The consequence of turning the planning flexibility off, is that it possible that there is unnecessary inventory if an expected order is cancelled. In the short-term, the planning flexibility is not desired, as it is mostly not possible to reschedule purchase orders. Manufacturers expect a certain order in a week and will adjust their

production schedule to the expected delivery date, which makes them inflexible on short term. For placed orders outside the ATP-period the planning flexibility is desired, as it may improve the inventory position in the future.

3. The flex-inventory is time consuming

The Automove function is explained in section 2.5. This function combined with the flex-inventory gives a lot of work for the purchasers. If there are more sales orders in a week than forecasted, Navision will start with adding the forecast up with the remaining forecast (including the flex-inventory) of the current week. This process continues until all the remaining forecast is used during the ATP-period. When the purchaser checks the flex-inventory levels on Monday, it will add new flex inventory in a week outside the ATP-period. This process is visualized in figure 29.

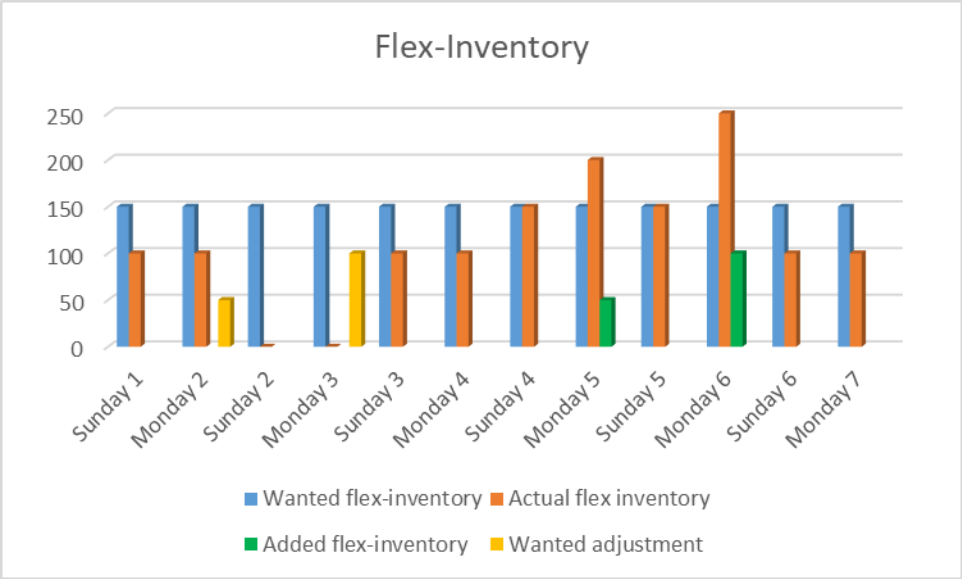


Figure 29: The problem with the flex-inventory

In figure 29, an example of the development of the flex-inventory of a product is displayed. The forecasts are rarely exact the number of products that are needed. If there are sold more products than forecasted, the flex-inventory decreases. This is what happens in week 1, 2 and 6. In those cases, a purchaser will on Monday morning see the change and increase the flex-inventory in the week outside the ATP-period weeks. In this case, the flex-inventory is always added three weeks after the inventory has dropped below the desired flex-inventory level. The gap is showed in yellow, the adjustment in green in the figure above. The added flex-inventory will be visible in the forecast. If there is some remaining forecast in a week, like in week 3, 4 and 5 this remaining forecast will be added to the flex-inventory until the flex-inventory is filled. However, if the flex-inventory is completely filled on Sunday and there is new flex-inventory added in the next week, the added flex-inventory will be deleted on Monday. This is what happens on Monday week 5, the flex-inventory is already filled by the remaining forecast, but there is still some added flex-inventory from week 1 which is no longer desired. Probably, the purchaser will then also delete the added flex-inventory in the next week, which would delete the green bar on Monday week 6. This system, where every week the flex-inventory is corrected manually is time consuming.

In a period of 32 weeks, starting in week 37 2017 and ending in week 17 2018, there was at least 979 times an adjustment needed. On average this are 30 adjustments per week, which cost at least 2 minutes per adjustment. Looking to the total number of products with a Lot-for-Lot replenishment policy, which is 90, this means that every week almost 1/3 of the products needs an adjustment. The calculation of this number can be found in Appendix 5.

4. The Automove function also moves with the forecast for orders outside the ATP-period.

The Automove function also works outside the ATP-period. So, if a big order is placed over half a year, the remaining forecast of the ATP-period will be used to complement the forecast in the week of the big order. This is not desired, as this would suggest that there will be no more sales orders during the weeks where the remaining forecast is used. However, the available to promise will not change if the remaining forecast is moved. This will give sales the opportunity to sell products, while Navision will not anticipate on this demand and the planning suggestions will come too late.

5. Navision does not place moved forecast back when a sales order is deleted.

If for a big order in a certain week the forecast is moved, the forecast will not be placed back when the order is cancelled. This is displayed in figures 28, 29 and 30.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory
Inventory	32	32		32			32
Week 26	120	120		88	-75	-75	45
Week 27	120	120			-15	-15	30
Week 28	150	150		30	-15	-15	45
Week 29	150	150			-15	-15	30
Week 30	180	180		30	-15	-15	45
Week 31	180	180			-15	-15	30
Week 32	210	210		30	-15	-15	45
Week 33	210	210			-15	-15	30

Figure 30: standard situation

In figure 30 a standard situation is showed. Forecast is available in the current and upcoming weeks and no sales orders are available. As can be seen in the rightest column, the suggested projected inventory is every week added up with the scheduled receipts and decreased by the forecast.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory
Inventory		32		32			32
Week 26		120		88			120
Week 28		150		30			150
Week 30		180		30			180
Week 31		0	-180		-180		0
Week 32	30	30		30			30
Week 33	30	30					30

Figure 31: Big order in week 31

In figure 31, a big order is placed in week 31. As can be seen, the forecast in week 26, 27, 28, 29, 30, 32 and 33 is moved to week 31. In the rightest column the suggested projected inventory is visible. Based on this number, Navision will make the planning suggestions. As can be seen, the suggested projected inventory is added up with the scheduled receipts as there is no more forecast available. In week 31, all the suggested projected inventory is used.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory
Inventory	32	32		32			32
Week 26	120	120		88			120
Week 28	150	150		30			150
Week 30	180	180		30			180
Week 31	180	180			-180	-180	0
Week 32	210	210		30			30
Week 33	210	210					30

Figure 32: Order in week 31 is deleted

Now, the order in week 31 is deleted. The remaining forecast is the same as the forecast, as there are no other sales orders in week 31. The forecast is not placed back to the original weeks, which will generate problems in the weeks after week 31. In week 32, the forecast will equal the flex-inventory. If we assume, the flex-inventory is 15, the forecasted demand in week 32 can be covered. In week 33, there will be no forecast, but it is possible to sell products, as the ATP is positive. The suggested projected inventory is not prepared on extra demand and will give a planning suggestion later than needed.

6. Navision places planning suggestions within the ATP-period.

In the ATP-period, it is impossible to receive orders which are not ordered before the ATP-period started. So, if the ATP-period is 7 weeks, the purchaser had to place an order minimal 7 weeks ago to receive the orders in this week. Navision does not calculate with these 7 weeks when it determines its planning suggestions. If the situation changes, for instance if the forecast increases or sales are cancelled, Navision will recalculate the suggested projected inventory and if it is better to change or place an order Navision will propose this. This proposal is used when Navision calculates new planning suggestions for the same product. So, if Navision proposes a new order in week 3, it will calculate the next planning suggestion based on this first planning suggestion. For the purchaser, this is confusing and it is frustrating that this planning suggestion will appear until the week where the planning suggestion occurred belongs to the past. To deal with this situation, the purchasers currently move the forecast in such a way, the planning suggestion will disappear. However, this is time consuming and gives a wrong overview of the actual situation. This situation is showed in figure 33, where the forecast is increased significantly compared to the previous situation.

Description	Available on date	Planned Inventory...	Gross Requirement	Scheduled Receipt	Forecast	Remaining Forecast	Suggested Projected Inventory	Action Message Qty.
Inventory	32	32		32			32	
Week 26	102	102		88	-100	-100	2	-18
Week 27	202	202			-100	-100	2	100
Week 28	302	302		30	-100	-100	2	70
Week 29	402	402			-100	-100	2	100
Week 30	502	502		30	-100	-100	2	70
Week 31	602	602			-100	-100	2	100
Week 32	702	702		30	-100	-100	2	70
Week 33	802	802			-100	-100	2	100

Figure 33: Sales forecast increased with 85 products a week.

7. Big orders in the re-order point replenishment policy.

In the products with a re-order point replenishment policy, the planning suggestions are completely based on the placed sales orders. The re-order points are based on the expected lead time demand and a safety factor to cover unexpected demand and delays in lead time. If a big order is placed, for example if there is a roll-out in a country, the available inventory can be sold completely, which can result in a long period without inventory.

This problem can also occur in the products with a Lot-for-Lot replenishment policy, as the ATP can be sold completely. However, replenishment orders of these products are placed forward, which will reduce the time the product is out of stock.

8. Delayed purchase orders

If an order is delayed, currently the forecast is moved forward to the next week, as the forecasted demand will probably be sold when the products arrive. Moving the forecast will let the suggested projected inventory remaining the same, this is desired as planning suggestions during the ATP-period are not desired. However, not all the forecasted demand will be sold. Purchasing will inform sales about the delay and sales will inform the customers. This will result in customers choosing other available products, which decreases the number of products of the delayed product which will be sold. Moving the forecast forward as this is currently done generates a fast increase of the inventory, as planning suggestions will be generated based on the original forecast.

9. The forecast may not be changed on short term.

As explained in con 6, if the forecast is changed on short term, this can result in new planning suggestions. As the planning suggestions are not desired during the ATP-period, forecast may not be changed on short term, even if it is known the sales will increase or decrease.

10. Transfer orders in the MRP

Transfer orders currently do not consume forecast, however the transfer orders to APAC are for DSV customers and so is the forecast manually decreased if a transfer order is placed. This process is time consuming and manually changing the MRP is not desirable as there is a greater change on mistakes. Not all transfer orders need to be handled as a standard sales order in the MRP, such as the transfer orders from DSV to Nedap and back. These orders will come back to DSV and so is it better to change the forecast manually.

11. Within operations, the different departments do often not realize the consequences of certain actions.

The operations people are not always aware of the consequences of their action in Navision. If sales makes a typing mistake in the sales order, this can have major consequences in Navision, even if the sales order is corrected. The forecaster is not always aware of the consequences replaced forecast can have. The lack of insight is firstly created by changing from ERP system to ERP system. In the last 8 years, the ERP system has changed minimal 3 times. However, the changes between the systems were not always big, the working of the MRP card was every time slightly different. When changing from ERP system, every part of the operations team got its own explanation of the functions which were relevant for them. Sales learned how to place sales orders, purchasing learned how to place purchase orders and influence the system and the forecaster learned how to retrieve the information from Navision to generate a new forecast.

Secondly, the lack of insight is created by adding new features to 'optimize' the working of Navision. These features are often explained to the people which are directly working with them, but not always to everyone who is influenced by them. The features are added in time, which makes the system more and more complex.

Thirdly, the changes in the systems are documented poorly. The last document found about the working of for example the available to promise is written in 2013. Other important features like the working of the Automove function and the flex-inventory are never documented, as these are programmed specially for Nedap.

Appendix 5: Calculation average number of flex-inventory adjustments per week.

The desired flex-inventory levels are hard to retrieve, as these are not saved in Navision and are also not saved externally. However, it is possible to see the actual flex-inventory levels in a period of 32 weeks, starting in week 37 2017 and ending in week 17 2018. These actual flex-inventory levels show a certain pattern, as certain numbers keep coming back. Taking a specific product, in 30 of the 32 weeks the actual flex-inventory was 50, in the other two weeks the actual flex-inventory was 0. It can be assumed, the desired flex-inventory level was 50.

The modus is calculated for every product. So, it is possible to see in how many weeks the inventory was on the modus level. This number is 1370, but by analyzing the data, this did not seem realistic. In some products it is visible that the flex-inventory was increased significantly in week 9. So, the modus per product was divided in two, one is the modus in the weeks until week 9 and the other is the modus from the weeks from of week 9.

Then a loop was built in VBA, which looked to the changes in the actual flex-inventory. If the inventory changed compared to the upcoming week, the counter goes + 1. Only if the inventory goes back to the desired inventory level, this was not counted, as this change will be made earlier. So, if the inventory in the previous week was on the desired level, then an adjustment will be made in this week and the inventory would be on the desired level again in the upcoming week. This would be counted as 1 adjustment, as the purchaser will only 1 time make an adjustment.

After running the code, the counter gets a value of 979 adjustments. This value gives an indication, as it does not exactly gives the number of adjustments. In some cases, the flex-inventory is multiple weeks the same amount, but is this not the desired flex-inventory level. In the situation described before, the inventory in two other weeks is 0. As these two weeks are after each other, this will not be counted as an adjustment, however the purchaser will check it both times as the flex-inventory is below the desired flex-inventory level.

The code is written in Excel VBA, the code is visible in figure 34.

```
Sub Count2()
Dim x, y, z, a As Integer 'x = row, y = column, z = counter

Cells(3, 4) = 0                                    'Make sure cell is zero
a = 0                                              'Make sure a is zero
For x = 8 To 98                                    'In rows 8 until 98, the data is collected
    For y = 9 To 41                                'In columns 9 to 41, the data is collected
       If Cells(x, y) = Cells(x, (y + 1)) Then     'Is there a change between the current week and the next week?
       a = a                                       'If there is no difference, the counter will not be added.
       Else
        If Cells(x, (y + 1)) = Cells(x, 49) Then   'In cell(x,49) the first modus is available
        a = a
        Else
         If Cells(x, (y + 1)) = Cells(x, 50) Then  'In cell(x,50) the second modus is available
         a = a
         Else
         a = a + 1                                 'If the value between two weeks is different and the next week the value does not equal the modus, counter + 1
         End If
        End If
       End If
    Next y
Next x


Cells(3, 4) = a                                    'After the loop, the value of the counter is added in cell(3,4)

End Sub
```

Figure 34: Code in VBA

Appendix 6: Simulation

Preparation

To simulate the reality, an Excel VBA model was conducted from the process flow in appendix 3. The Excel model only visualizes the working of the MRP in Navision. The model is able to conduct the planning suggestions on the same moments Navision conducts the planning suggestions. A limitation of the model is that it is not able to distinguish re-scheduling planning suggestions and replenishment planning suggestions. However, this will not cause problems in the simulation, as the re-scheduling planning suggestions and the replenishment planning suggestions are handled in the same way.

To test the simulation on all the 94 products with a lot-for-lot replenishment strategy and almost a year of historical data, the model needs to automate the flex-inventory process, as performing the steps manually would cost a lot of time. The planning suggestions will also need to be checked and accepted automatically. In reality, the planning suggestions are mostly worked away by replacing forecast to another week, but in the model the result is the same: The planning suggestion will disappear.

To visualize the reality, the sales and purchasing information per product per week were retrieved from Navision for a period of 46 weeks starting in week 37 2017 and ending in week 30 2018. The forecast and flex-inventory were also retrieved from Navision. This data visualizes the values which were standing in Navision at the end of the week. This data does not visualize the 'real' situation as Navision is able to move with the forecast, which results in weeks with zero forecast and weeks with a lot of forecast. To validate the forecast, the original inserted forecasts in week 34 2017 are set beside the forecast retrieved from Navision. The forecast of Navision is set beside the forecast of week 34 and on the places it was clear the forecast was changed, the forecast inserted in week 34 was adjusted. This generates a forecast which approximately generates the original forecasts. The flex-inventory was determined by taking the modus of the historical flex-inventories per product. As retrieving the original inventory position per product at the start of week 37 2017 is not possible, the simulation will run for different start inventory positions. The flex-inventory is the desired safety stock level, so it can be assumed that if the flex-inventory level was equal to the desired flex-inventory level, the start inventory would be the flex-inventory plus a couple of weeks of forecast. The simulated start inventories are: no start inventory, flex-inventory in week 37 + 1-week forecast, +2 weeks forecast, +3 weeks forecast, +4 weeks forecast, + 5 weeks forecast.

To visualize the reality, the forecast is inserted for 15 weeks from of the current week. This is done, as the planning suggestions outside the 15 weeks are not corrected or accepted. The sales orders will be inserted 3 weeks from the current week. This makes it possible to simulate the way the sales orders influence the model. For the amount of planning suggestions it does not make a difference if the sales order is inserted within 1,2,3 or 4 weeks from of the current week. The purchase orders will be inserted for the first 12 weeks, as these orders should already be placed and so no new planning suggestions should be needed.

Simulation

To test the working of the model, first the steps are executed manually for the first three products. Manually the data was inserted and the number of planning suggestions was determined. The code was adjusted until the amount of planning suggestions which were determined manually equaled the amount of planning suggestions the Excel model counted. Then three runs were simulated with the

same data and the same parameters, to make sure the simulation would give the same output every time. This is important as there are no random variables, which should mean the output should always be the same. Then the model could be used to test the amount of planning suggestions which would be generated.

Start inventory	-	0	1	2	3	4	5
Number of planning suggestions	10598	10598	10442	10477	10498	10300	10352
Flex-inventory adjustments	1078	1078	1078	1078	1078	1078	1078

Table 5: Simulation 1 The current situation.

Start inventory	-	0	1	2	3	4	5
Number of planning suggestions	11847	11662	11782	11876	11891	11767	11681
Flex-inventory adjustments	1809	1809	1809	1809	1809	1809	1809

Table 6: Simulation 2 The current situation without Automove.

Start inventory	-	0	1	2	3	4	5
Number of planning suggestions	8427	8315	8444	8483	8457	8318	8298
Flex-inventory adjustments	0	0	0	0	0	0	0

Table 7: Simulation 3 Current situation with a safety stock quantity instead of the flex-inventory.

Start inventory	-	0	1	2	3	4	5
Number of planning suggestions	3756	2856	2898	2783	2814	2718	2621
Flex-inventory adjustments	0	0	0	0	0	0	0

Table 8: Simulation 4 Safety stock quantity instead of flex-inventory, with Automove, with new planning flexibility.

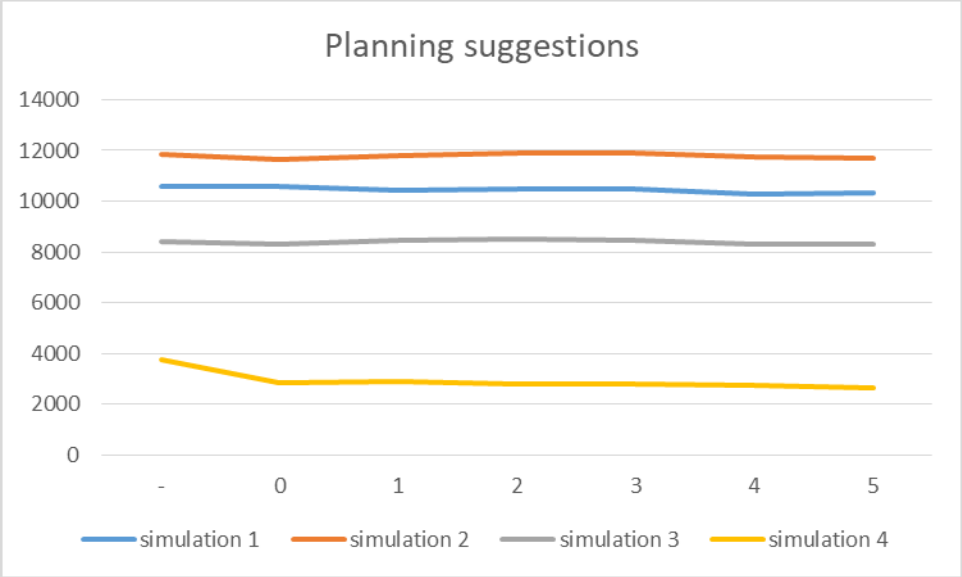


Figure 35: Outcomes of the simulations

Analyses

Simulation 1: The current situation

The first simulation shows the start situation. The number of planning suggestions equals on average 10466/46 ≈ 228 planning suggestions per week. This means the purchaser spends on average 3 minutes per planning suggestion. An important note to the number of planning suggestions is that this number assumes that the planning flexibility is in every purchase order 'unlimited', which is rarely the case. However, the 'none' option makes it necessary to lower or higher the sales forecast to let the planning suggestions disappear, which is much more time consuming than just accepting or neglecting the planning suggestion. Another important note is that the model assumes the planning suggestions are always accepted, this is in reality not always the case as it is in those cases also possible to order in one of the upcoming weeks, which lets the planning suggestion appear multiple weeks and so would increase the number of planning suggestions. These notes hold for every simulation, which makes it possible to compare the different simulations with each other.

The flex-inventory was adjusted 1078 times, which is in line with the outcomes of appendix 5. In the simulation was a change in desired flex-inventory level not taken into account, as the modes of the different weeks was taken to determine the desired flex-inventory level. In reality, this would have increased the amount of adjustments, furthermore would the flex-inventory be more often used to change the moment planning suggestions appear.

Simulation 2: Deleting the Automove function

The second simulation shows the same simulation as in simulation 1, but then without the Automove function. As can be seen in table 6, the amount of planning suggestions is even higher than in simulation 1. This suggests that the demand in a week is negatively correlated with the demand in upcoming weeks. If the demand in this week is higher than forecasted, it is likely that the demand is lower than forecasted in upcoming weeks. This is not strange, as the sales forecast is quarterly determined and then equally spread over the weeks in the upcoming quarter, as it is not known in which week the sales orders will be placed and the manufacturers expect a weekly update of the purchase forecast.

The number of flex-inventory adjustments is also significantly higher than in simulation 1. If in simulation 1 a big sales order was placed, the sales forecast of the ATP-period would be used through the Automove function. In the weeks the forecast was used, no remaining forecast would be available, and so would the flex-inventory not be complemented, until the week there was remaining forecast available. In the weeks the flex-inventory is not complemented, only one adjustment is needed to let the amount of flex-inventory sum up to the desired amount of flex-inventory. In this simulation, the forecast was not moved, which let the remaining from of the first week after the big order complement the flex-inventory. Then the manually inserted adjustment need to be decreased, which let the number of adjustments go up fast.

Simulation 3: Safety stock quantity instead of flex-inventory

In this simulation is the flex-inventory replaced by a standard safety stock level, further are all the settings the same as in simulation 1. The amount of planning suggestions is consistently lower compared to the first simulation. This seems like a good result, but it actually makes the situation for the planners even worst. The main part of the replenishment suggestions come within the replenishment lead time,

the only way the purchasers can let the planning suggestion disappear is by lowering the safety stock level manually, which is even more work than complementing the flex-inventory.

The amount of flex-inventory adjustments is logically 0, as the flex-inventory was not used.

Simulation 4: A new planning flexibility 'earlier'

In this simulation, simulation 3 was further extended. The amount of planning suggestions within the ATP-period did make this situation sub-optimal, so now may Navision only propose to reschedule existing purchase orders to an earlier moment when the suggested projected inventory comes below zero within the ATP-period, outside the ATP-period everything stays the same as in simulation 3. The amount of planning suggestions is reduced to 2920 on average. As a planning suggestion is assumed to cost the purchaser 3 minutes, the time needed per week is: 190 minutes.