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Proposing Inventory Management Framework for Make-to-Stock (MTS) Products

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In the summer of 2016, one sunny day, I came to Metropolia for the interview to this program. One interviewer asked me “why should we admit you?”. The immediate answer hit me was “if I am not admitted this year, I will be back next year”. I am still very glad that I was accepted and given the chance to experience this wonderful journey.

Today I almost reach the end of this journey and I wonder, without the help and support from people around me, how I can reach the finish line. Therefore, for those who helped me and worked together with me to make this happen, I have few words for you here.

To my employer, I am grateful for having the luxury to be away from work for the school. To my colleagues, I thank all of you for substituting me during my absence as well as sharing your knowledge for my thesis work. I also want to thank my boss Jukka for choosing this “boring” but solid thesis topic and providing supports in many subtle ways, and my colleague Antti for attending to my non-stop questions.

Recalling the past one year, it was filled with happy memories, thanks to my amazing classmates and instructors. Many of you have shown me good examples of team spirit, leadership, dedication and perfection. My instructor Juha Haimala, who talks little, but often made us laugh with good jokes. I want to thank you for giving the right direction of my thesis without much nonsense. Not to forget Zinaida Grabovskaia, one marvelous person, words probably cannot describe how thankful I am for the efforts you have put in.

Last but not the least, to my husband Jari. Thank you for believing that I can do this, and constantly reminding me to stay focused.

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This thesis focuses on a holistic approach to inventory management for the case company, which aims to balance the needs of reducing inventory and increasing service level. As approaches focus purely on reducing inventory come with trade-offs and result in sub-optimization. Keeping inventory as low as possible without sacrificing customer service is one key business challenge not limited to the case company.

The study adopted the case study research approach. The study on the case company was based on the data collected through interviewing key stakeholders, examining internal documentations as well as information from ERP system. To find the best practices for the case company, extensive search among the academic articles and books was undertaken and summarized as a conceptual framework, which was integrated with the results from the current state analysis and turned into a practical proposal for the case company.

The outcome of the study is a proposed inventory management framework for make-to-stock products. The framework is a three-step approach: categorize inventory, select type of inventory control system (ICS) and define replenishment process (a.k.a. settings of ICS). The proposal is detailed to the mathematical formulas for optimizing re-order point, and safety stock based on service level for instance. Moreover, the proposal introduces ways to incorporate the concept to SAP system.

This thesis facilitates the decision-making on refining the inventory management. It sets an example for companies that desire a cost-effective total solution for managing inventory.

Keywords	Category management, inventory control system, re-order point, safety stock, demand forecasting, ABC analysis, SAP

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1 Introduction

Inventory counts for a significant part of total assets of a company, in some cases, the largest. Companies are holding inventories in order to have enough stock to fulfill sales orders, and insufficient inventory can cause the loss of sales and it is expensive. On the other hand, excess inventory takes up unnecessary space in the warehouse, and most importantly, ties up monetary assets, lowers profit and cash flow. Finding the right balance of inventory level that can minimize inventory value and maintain a healthy level of customer service is one key challenge to many businesses. This thesis examines inventory status of the case company, identifies issues and proposes an inventory management framework that minimizes inventory value without sacrificing service level.

1.1 Business Context

The case company of this thesis is a Finnish manufacturer and supplier of kitchen equipment, serving restaurants and professional kitchens. Currently the company is the market leader in the region and one of the leading brands in Europe. Sales offices are located mainly in Finland, Sweden, Norway, the Baltic States, and some in Benelux countries.

The company has two primary business units: manufacturing and wholesale unit. The wholesale unit buys and sells finished products from vendors around the world, including its own manufacturing unit. This thesis study focuses on the inventory of wholesale unit only.

Despite the various sales office locations in Europe, the inventory of the wholesale unit is centralized in one single location in Finland, where the headquarters is. This central warehouse supplies goods and fulfill orders for all sales offices. The replenishment of inventory is centrally managed by the headquarters. In the central warehouse, the inventory is made of two types: *make-to-order (MTO) products and make-to-stock (MTS)* products. MTS products are stored in the warehouse and often available for immediate fulfillment, while MTO products are ordered only after a customer order is received. The amount of MTS products directly affects the value of inventory. This study focuses on MTS products only.

1.2 Business Challenge, Objective and Outcome

Make-to-stock (MTS) products account for thousands of SKUs with excess inventory value in the central warehouse. There is a need to investigate into current inventory management of MTS products and look for ways to reduce the number of SKUs as well as the amount of total inventory value, in order to free up working capital and lower inventory holding costs.

The objective of this thesis is to find a way to minimize inventory value of the make-to-stock products for the wholesale unit in the case company, while maintaining predefined service level as the form of stock availability. The expected outcome is an inventory management framework for make-to-stock (MTS) products, which avoids sub-optimization and achieves the balance between lowering inventory level and improving or maintaining service level.

1.3 Thesis Outline

To achieve the business objective, firstly, the best practices from existing literatures were studied, as inventory management is a classic management topic, the best practices are available to tackle various inventory related problems. Secondly, after forming the conceptual framework of the best practice, the study investigated into the current practice of inventory management in the case company, to understand what work well and what not. What work well are to be maintained, while what work not well are to be improved with the existing knowledge. Thirdly, the proposal was built to answer the questions how to integrate the best practice into current practice. Finally, to become a practical and valuable solution for the case company, the proposal was evaluated and validated by the key stakeholders.

Following the logic, this study was written in seven sections: Section 1, Introduction briefed the background and challenges of the case company, as well as the objective and outcome of this thesis study. Section 2, Method and Material explained how this study was done in steps. Section 3, Best Practices from Literatures introduced the inventory management framework consisting of three sub-subjects: category management, inventory control system and replenishment process. Section 4, Current State Analysis revealed the current practice from the same sub-subjects and finalized with strengths and weaknesses. Section 5, Proposal introduced the initial proposal and explained how it was built. Section 6, Validation tested the ideas of proposal and demonstrated whether the proposal worked to achieve the objective. Section 7, Conclusions, as the final step, summarized the study and provided suggestions for the implementation.

1.4 Key Concepts

ABC Analysis	An inventory management technique that is used to categorize a large number of products into predefined categories. Inventory review system or policy is assigned to different categories based on ABC categorization or classification.
Continuous review system	Known as fixed point reorder system. A replenishment order is placed at a specific stock level. (Rushton 2011)
Inventory management	A key element of logistics and supply chain management. Inventory management decides on when to order, how much to order and how much stock to maintain. (Murphy and Wood 2014)
Inventory review system	Knows also as inventory review policy or inventory control system, is a way of tracking inventories. Periodic and continuous reviews are the two main methods. (smallbusiness.chron.com)
Make-to-order product	Opposite to make-to-stock product, make-to-order product is not produced unless someone orders it. It is often referred to a pull-type production. (lean-manufacturing-japan.com)
Make-to-stock product	a type of products that are produced based on demand forecasts, it is often regarded as push-type production. MTS products are kept in stock to prevent stockout. Amount of MTS can be minimized by accurate demand forecast. (lean-manufacturing-japan.com)
Max-min inventory control system	An inventory control system that control quantities in stock stay within a predefined range. (USAID Deliver 2011)

Periodic review system	An inventory control method that examines stock level at regular intervals
Safety stock	is the term to describe the extra stock built to minimize the risk of supply and demand deficits due to inaccurate demand forecast, it is one way to prevent out of stock, is also called buffer stock, commonly exists in manufacturing companies.

2 Method and Material

This section addresses the research method and material used during the study. This section starts with the overview of the research approach and research design, followed by the description of data collection and data analysis.

2.1 Research Approach

For this study, the case study was selected as the research approach. Case study is described as “an empirical inquiry that investigates a contemporary phenomenon with it real-life context, especially when the boundaries between the phenomenon and the context are not clearly evident” (Yin 2009:13-14). A case study tends to clarify on a decision, *why* it is taken, *how* to implement and *what* results to expect (Schramm 1971). Woodside and Wilson (2003) describe the case study research as “an inquiry focusing on describing, understanding, predicting, and/or controlling” the individual or a phenomenon (Woodside and Wilson 2003: 494).

The nature of case study allows the use of evidences from different sources, which paints a richer picture of an issue compared to other single methods (Dubé & Paré 2003). Additionally, multiple data collection techniques can be used, for example, interviews and company documentation (Dubé & Paré 2003).

In most of the cases, case study research selects a variety of research methods, mostly relying on either qualitative or mixed research methods. Qualitative method studies a subject in depth through texts collected from interviews, workshops, observations and documents. In qualitative research, researcher aims to gain a holistic view of the context, and understand problems from the inside (Miles and Huberman 1994). On the contrary, quantitative approach typically focuses on collection of numbers and statistical analysis. This method includes facts, figures and calculations, therefore particularly good for studying large sample. It provides reliable, stable relationships between variables. A researcher typically uses quantitative approach to observe patterns, trends in the data.

In this study, the approach corresponds to these ideas of a case study, with high inventory value being the contemporary phenomenon in the case company, on which the researcher conducted investigation and decided on the ways to reduce inventory, planed implementation and illustrated the expected results. In this study, the case study approach supports combination of qualitative and elements of numerical calculations.

In this study, the methods used include mixed qualitative research with numerical calculation elements. This study uses qualitative method to understand processes that affect inventory in depth, to trace the causes of high inventory value. In addition, the researcher analyzed numerical data, such as SKUs, inventory value, lead time, safety stock and past consumptions.

2.2 Research Design

Research design is made of the steps for conducting the study, as visualized in Figure 1. The white boxes contain the titles of the steps as well as the lists of main points, the green boxes include the sets of data collected from each step and the methods used for the data collection, while the orange boxes illustrate the outcome of each step.

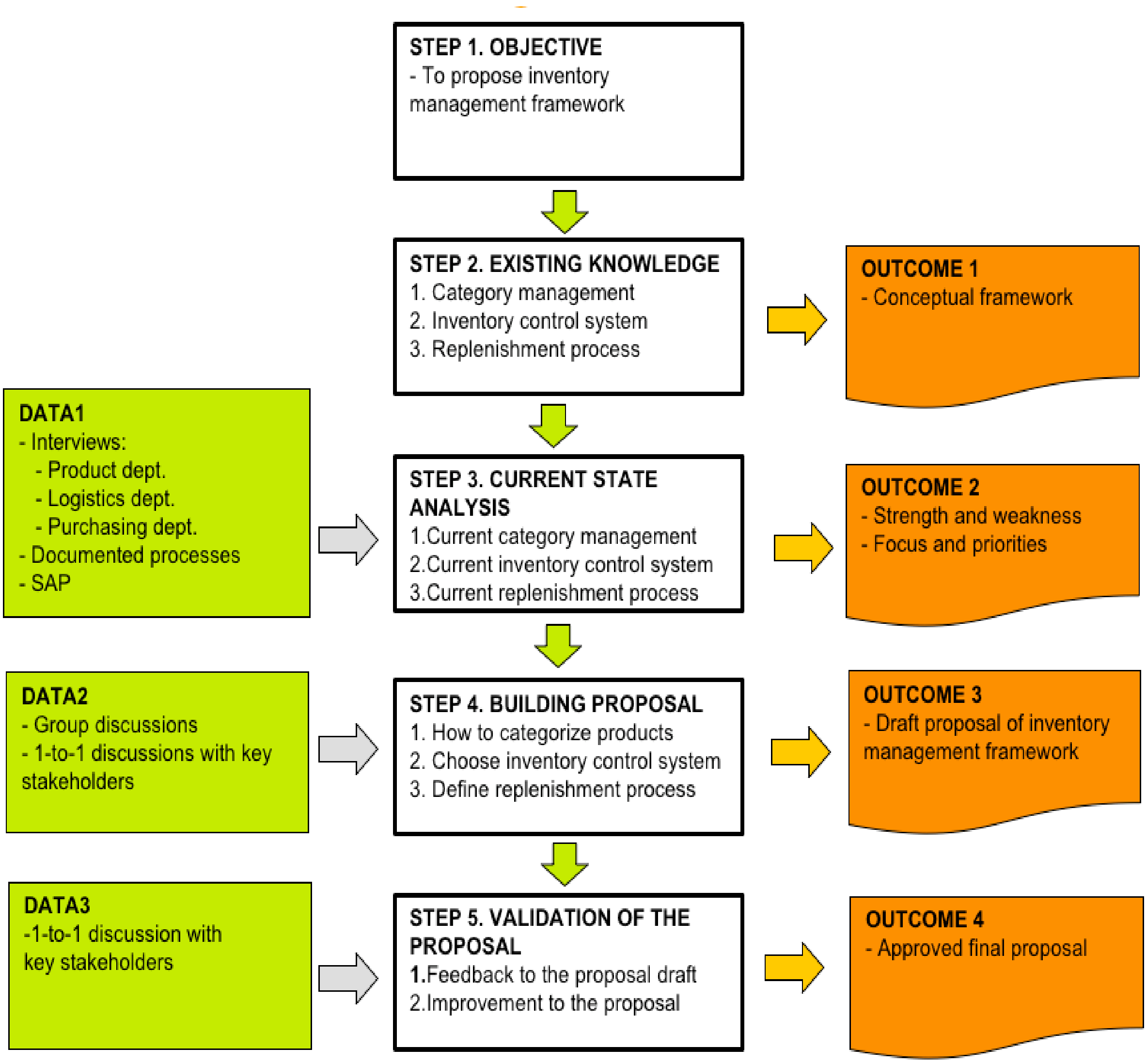


Figure 1. Research design of this study.

As seen from Figure 1, step 1 defines the objective, which is the direction for the study. The business challenge of the case company was some substantial amount of working capital being tied up to the inventory, thus the objective of this study was to find a solution to tackle this challenge and improve the situation.

After defining the objective, Step 2 studied the best practices for reducing the inventory from existing literatures related to three subjects: category management, inventory control system and replenishment process. The outcome of Step 2 is the conceptual framework. Following the same logic of Step 2, Step 3 analyzed the current inventory management of MTS products from the three subjects, the current category management, the current inventory control system, and the current replenishment process. The outcome of Step 3 is the strengths and weaknesses of the current state. Step 4 focuses on building the draft proposal that transforms the weaknesses of the current state with the ideas from the conceptual framework. In the final Step 5, the draft proposal was adjusted according to the input from the stakeholders, and was tested. After the validation of the proposal, the initial proposal was accepted as the final proposal.

2.3 Data Collection and Analysis

There were three types of data collection utilized in this study. Data 1 collected and analyzed the data relevant to the current processes, which provided in-depth understanding of the current category, purchasing and replenishment processes that enabled further analysis. Analysis of Data 1 resulted in strengths and weaknesses of the current inventory management, as well as the focus and priority for improvements. Data 2 collected ideas on improvements from internal participants in the research. The draft of the proposal was built based on the outcomes of integrating Data 2 and the conceptual framework. Finally, Data 3 was collected from the evaluations and feedback by the stakeholders before the proposal was approved for implementation. Table 1 below provides an overview of the Data collections 1-3.

Table 1. Overview of data collections 1-3.

Data	Data Source	Data Type	Purpose of Analysis
Data 1 (current state)	ERP system	Inventory matrix of current stock quantity, SKU, safety stock, lead time, consumption	To identify what inventory are, how much they are, and whether the amount justifies the lead time and consumption
	Interviews	Processes, pratices, strength and weakness	To understand the current processes in depth from different people and angles.
	Documentation s	Processes, memos, user manuals	To identify the current practices in black and white.
Data 2 (draft proposal)	Group discussions	Written ideas on improvement	To build proposal that bridges conceptual framework and real-life ideas
Data 3 (validation on proposal)	One-to-one discussion	Written testing results of the propsal	To prove the feasibility of the proposal.

As seen from Table 1, Data 1, 2, 3 were collected from different sources with different contents and for specific purposes. However, the amount of details in Table 1 is not sufficient for reproducing this case study. Therefore, Table 2 shows the details of all three data collections and explains how they were collected.

Table 2. Details of data 1-3 collections.

Data Source	Function	Participants	Topics Discussed	Data / Duration	Document Name, Location
Date 1					
Interview	Logistics & Purchasing	Logistics manager	1. Type of inventories 2. Scope of make-to-stock (MTS) products 3. General purchasing process	11.10.2016	Fieldnote 1, Appendix 1
Interview	Management	Director	1. MTS product classification process 2. Safety stock management process 3. Existing process or method to reduce inventory, pros and cons 4. Current MRP process, pros	18.1.2017	Fieldnote 2, Appendix 2
Interview	Purchasing	Purchasers	Purchasing process: 1. Pros and cons of current purchasing process 2. Current practices to reduce inventory 3. Challenges to reduce inventory	30.1.2017	Fieldnote 3, Appendix 4
Interview	Management	Director	Demand forecasting processs	22.3.2017	Field note 4, Appendix 5
Data 2					
Group discussion	Purchasing	Purchasers	1. Feedback on draft proposal 2. Improvement ideas	10/04/2017 30 mins	Fieldnote 5, Appendix 7
One to one discussion	Logistics & Purchasing	Logistics manager	1. Feedback on draft proposal 2. Improvement ideas	11/04/2017 30mins	Fieldnote 6, Appendix 8
Group discussion	Management	Director and Logistics Manager	1. Feedback on draft proposal 2. Improvement ideas 3. Implementation in ERP	18/04/2017 60mins	Fieldnote 7, Appendix 9
Data 3					
One to one discussion	Top management	Director of the Business Unit	1. Final validation of proposal	13/04/2017 45mins	Fieldnote 8, Appendix 10

Table 2 above lists the data sources, participants and their functions, as well as the topics discussed in each data collection round. It also indicates the date and duration for each data collection event. The purpose of these details of data collection is to allow other researchers to reproduce the research in the same way, if needed, by other researchers.

Data 1 was collected during of the current state analysis corresponding to each stage in the research design. The purpose of Data 1 was to understand the current inventory category management, inventory control system and replenishment process. These processes affect the level of inventory, for example, category management defines how the products are categorized, the inventory control system determines how often inventory should be reviewed and replenished, while the replenishment process determines exactly when to place a new order, how much to order and how much safety stock to maintain. Thus collected, Data 1 helps identify the processes that cause excess inventory and points to the narrowed research focus and priority for improvement.

As seen from Table 2, Data 1 consists of the interviews with logistics, purchasing and management. Logistics manager is responsible for logistics and purchasing. He was interviewed on the types of inventories, scope of make-to-stock product and purchasing process as well, the interview was done through email on 11-10-2016 by email in Finnish (Appendix 1). A director from senior management was interviewed on 18-01-2017 by email, who was former purchasing manager and product manager, he was interviewed on current product classification, safety stock management, methods that have been used to reduce inventory and current replenishment process (Appendix 2). The same director was later interviewed on 22-03-2017 by email, the topic was demand forecasting process documented, his response was recorded as field note 4 at Appendix 5. Additionally, all four purchasers from purchasing department were interviewed on purchasing process and current practices that are being used to reduce inventory, as the purchasers use ERP system to generate purchase orders, they decide what to purchase, how much to purchase, when to purchase, thus their decisions directly impact inventory value. The interview with the purchasers was organized on 30-01-2017 by Google Form and recorded at Appendix 4.

In addition to the interviews, a few internal documents were also collected. The overview of the internal documents used for Data collections 1-2 is shown in Table 3 below.

Table 3. Overview of the internal documents used for data collections 1-2.

Data Source	Name of the document	Description	Location
Document	Doc. Wholesale Inventory Product Control	Inventory products control manual	Appendix 3
Document	Doc. Current Purchasing Process	Documented purchasing process	Appendix 6
Document	Doc. List of MTS products	MTS product Excel list: SKUs, ABC indicators, current stock, cost, price, lead time, safety stock, MOQ, past consumptions	Not documented in Appendix

As seen from Table 3, the document called ‘Doc. Wholesale inventory product control’ was provided by the director during the interview. This document contains the information about the current inventory categories and the explanation of each category, as well as the roles and responsibilities for inventory controlling parameters, such as ABC indicators and safety stock. Doc. ‘Current purchasing process’ was retrieved from logistics work manual, which outlines the workflow of the purchasing department. This document was originally written in Finnish, to serve this study paper, it was translated to English. Doc.’List of MTS products’ was extracted from the ERP system to excel. The list includes details of each stock keep unit (SKU), such as ABC category, safety stock, re-order point (ROP), past consumptions and value of the stock. This list was used firstly for initial analyzing of the current inventory situation, secondly for new ABC analysis, computing the optimized level of safety stock, ROP and order cycle etc. However, the full list is not attached to this thesis due to confidentiality.

As shown in Table 2 earlier, in the proposal building stage, Data 2 was collected through group discussions and one-to-one discussions, which were documented as field notes. The purpose of Data 2 collection was to collect feedback and improvement ideas for the draft proposal. Group discussion with purchasers were conducted on 10-04-2017 for 30mins and documented as filed note 5 in Appendix 7, the draft proposal was introduced to three purchasers, who later returned feedback on the proposal and suggested improvement ideas. A one-to-one discussion was arranged with the logistics manager, to whom the draft proposal was presented, the discussion was documented as field note 6 in Appendix 8. Finally, a group discussion involving a senior management and logistics manager was arranged on 18-04-2017 for one hour, where the director shared his feedback on the draft proposal, his experiences with similar projects and concerns over implementation in ERP system. With the feedback and improvement ideas collection from Data 2, the draft proposal was refined and developed into the final proposal.

Lastly, Data 3 was collected from one-to-one discussion with the director of the business unit. The printed proposal along with the testing results were presented and discussed. The purpose of the discussion was to review the proposal in alignment with the objective of the company and discuss about the feasibility. This discussion lasted about 45 minutes on 13-04-2017 and it was documented as Field note 8 in Appendix 10. After this, the proposal is ready for implementation.

3 Best Practice of Inventory Management for MTS Items

This section discusses available knowledge and key concepts related to managing excess inventory and looks for best practice to reduce inventory value while maintaining stock availability.

3.1 Introduction to the Problem of Managing Excess Inventory

As mentioned in previous sections, one business challenge that many businesses face is excess inventory. Excess inventory is an indicator of improperly functioning inventory management. Inventory management is not an isolated function, it is a key component of logistics and supply chain management (Murphy and Wood 2014). Other logistics functions as well as costs are affected by inventory management in many ways and vice versa (Rushton et al. 2011: 177). Refining inventory management requires a process that balances inventory relevant functions to prevent sub-optimization, and eventually land in a cost-effective total solution (Rushton et al. 2011). Therefore, it is important to review those areas that may affect this balance (Rushton et al. 2011).

Inventory means stocks of products that are maintained to mainly satisfy customer demands. (Murphy and Wood 2014) Excess inventory opposite of inventory shortage, occurs when the amount of stocks ordered are more than actual demand, due to inaccurate demand forecasting.

Inventory management is a key element of logistics and supply chain management. Inventory management decides on when to order, how much to order and how much stock to maintain (Murphy and Wood 2014).

Inventory control is about ensuring enough inventory to fulfill customer demand. Inventory control system monitors and records inventory levels for decision making concerning it. Inventory control system decides when to order and how much to order. The two main types of inventory control system are periodic review and continuous review (Russell and Taylor, 2011: 559).

To identify those areas that affect the balance between inventory and inventory relevant functions, first and foremost is to understand the purpose of inventory. The most common purpose of keeping inventory is to satisfy customer demand patterns (Murphy and Wood 2014). In a holistic view, customer demand is fulfilled through collaborative planning, forecasting and replenishment (CPFR) combining multiple trading partners, as shown in Figure 2 below.

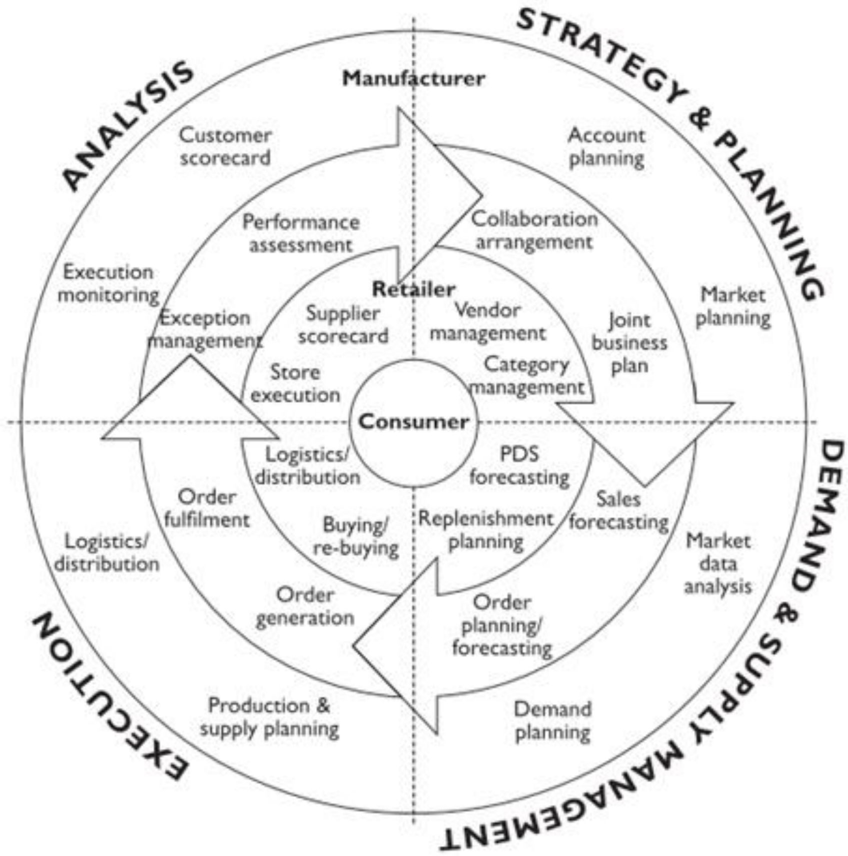


Figure 2. CPFR model (Rushton et al. 2011: 207).

CPFR model in Figure 2 involves the manufacturer, retailer and consumer or end customer as the center. In CPFR model, the areas that correlate to inventory management are category management, forecasting and replenishment planning. As such, category management is part of strategy planning, followed by forecasting and replenishment planning as parts of management. (Rushton et al. 2011: 206)

Next, this section discusses three main subjects, first is the category management, which explains why inventory should be categorized and how to categorize them. Second is the inventory control system, which introduces different types of inventory control systems that are suitable for different inventory categories. Third is the inventory replenishment process, which is divided into demand forecasting, when and how much to replenish inventory, as well as safety stock. Finally, a conceptual framework with key steps to reduce inventory value is presented.

3.2 Category Management for Inventory Control

As for inventory planning, “one size fits all” approach may lead to either higher cost or lower availability due to the requirements for products vary from one to another (Rushton et al. 2011). Category management is a mean that categorizes products with similar characteristics into groups for better inventory control and management (Rushton et al. 2011).

Described by (O’Brien 2009: 2), “category management is the practice of segmenting that main areas of organizational spend on bought-in goods and services into discrete groups of products and services according to the function of those goods and services”. Category management organizes procurement sources to maximize the leverage of purchasing decisions (CIPS 2010). Similarly, category management is referred to a model that allocates resources into logically grouped products or services for more effective management (whatis.techtarget.com). It is a strategic approach that requires involvement of not only purchasing, but also stakeholders and across business functions to be successful (O’Brien 2009).

In terms of inventory control and management, Rushton et al. (2011) suggests products to be categorized by their selling profile. Thus, despite of being different types of products, SKUs with same order or usage patterns may be categorized into same groups or “families”. For instance, typically SKUs can be categorized into four main groups, namely vital expensive, desirable and expensive, vital and inexpensive and desirable and cheap. Table 4 explains this categorization suggested by Rushton et al. 2011 with A, B, C, D indicators.

Table 4. Inventory ABCD groups (Rushton et al. 2011: 205).

A. Vital and expensive products need to be closely monitored and controlled. Sources of supply should be reliable and quality of delivery should be good and steady. Continuous review inventory policy is generally suitable for this category.
B. Desirable and expensive products should be maintained at minimum inventory level. Continuous review inventory policy is applicable for this category.
C. Vital and inexpensive products may be held at maximum inventory level and be monitored closely. Sources of supply should be also reliable as vital and expensive products with consistently goods delivery performance. For this category, it is appropriate to apply a weekly periodic review inventory policy.

D. Desirable and cheap products should be ordered or purchased least frequent over the year. They should be applied monthly periodic review inventory policy. Inventory should be at maximum level.

ABC categorization, as shown in Table 4, is a tool for category management that is used to classify items into groups by their characteristics. ABC analysis corresponds to the idea of category management that inventories are not equal, therefore should be managed in different ways, for instance, a company does not keep slow movers in all warehouses (Murphy and Wood 2014). ABC analysis is also known as Pareto analysis. According to 80/20 rule, often 20% of products account for approximately 80% of total inventory throughput, while 80% of products amount for only 20% total inventory throughout (Rushton et al. 2011: 104). When inventory are classified as A, B and C, most of the management efforts are allocated to A, least to C, and B are in between (Ravinder & Misra 2014). By using ABC analysis, managers can tailor inventory control system for different inventory categories, in order to keep relevant inventory costs well under control (Douissa and Jabeur 2016).

In addition, one and most commonly used criterion for ABC analysis is dollar value. By value criterion, A products are highest in value, C products are least in value and B are in between. Other criteria include lead time, importance, scarcity, substitutability, numbers of supply sources, modes of transportation, obsolescence and so on (Ravinder & Misra 2014). Combination of several criteria are also used to evaluate items overall performance in a multi-criteria framework, items are first evaluated by different criteria with weights given to those criteria, then sorted by descending order of weighted score (Douissa and Jabeur 2016). For example, multi-criteria ABC analysis can be used to categorize products by demand as one criterion and cost as the second criterion, products that fall into both top 80% of demand and top 80% of cost can be considered as A, while products fall into top 20% of demand but 80% of cost are considered as B etc.

Summing up, the aim of product or inventory categorization is to determine the appropriate inventory control systems for different categories. Inventory control systems are discussed in detail in the next section.

3.3 Types of Inventory Control Systems

After inventory or product categorization, the next question is how each category of inventory should be managed. Inventory control system serves this purpose, it regulates when to place new orders, how much to order and how much inventory to maintain in order to avoid either shortage or overstocking (USAID Deliver 2011). Another purpose of selecting inventory control system is to find the balance between stock holding cost and certain customer service level (Rushton et al. 2011). Holding too little inventory risks losing sales, too much inventory ties up financial capital and waste storage space. Moreover, excess much inventory covers numerous problems, such as products deterioration, product outdating and obsoleting, poor sales (Rushton et al. 2011).

There are a number of different inventory control systems, periodic review and continuous review are the two major ones (Rushton et al. 2011: 180). In periodic review system, inventory is reviewed only at fixed time intervals, a fixed inventory level is predefined, a replenishment order is placed to bring inventory back to a predefined level, due to existing inventory varies, size of a new order is not fixed (Rushton et al. 2011). On the contrary, in continuous review system also known as fixed point reorder system, there is no fixed review time or time interval, inventory is reviewed continuously, time to place an order depends whether inventory reach a fixed level or point, size of order is fixed (Rushton et al. 2011). Figure 3 illustrates the periodic review system.

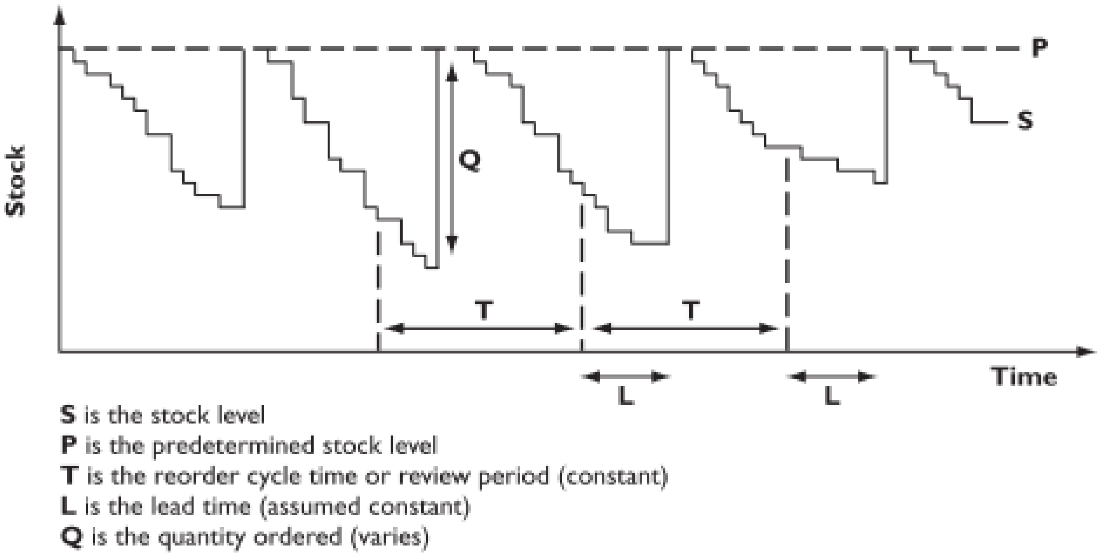


Figure 3. Periodic review (Rushton et al. 2011: 180).

In Figure 3, in the period review system, on top of the chart, P is the predetermined or predefined stock level, T is the review time interval or order cycle, a new order is placed at beginning of the review cycle, the next order is placed at end of the review cycle. As shown in Figure 4, Q, the order quantity varies in different review cycles (Rushton et al. 2011).

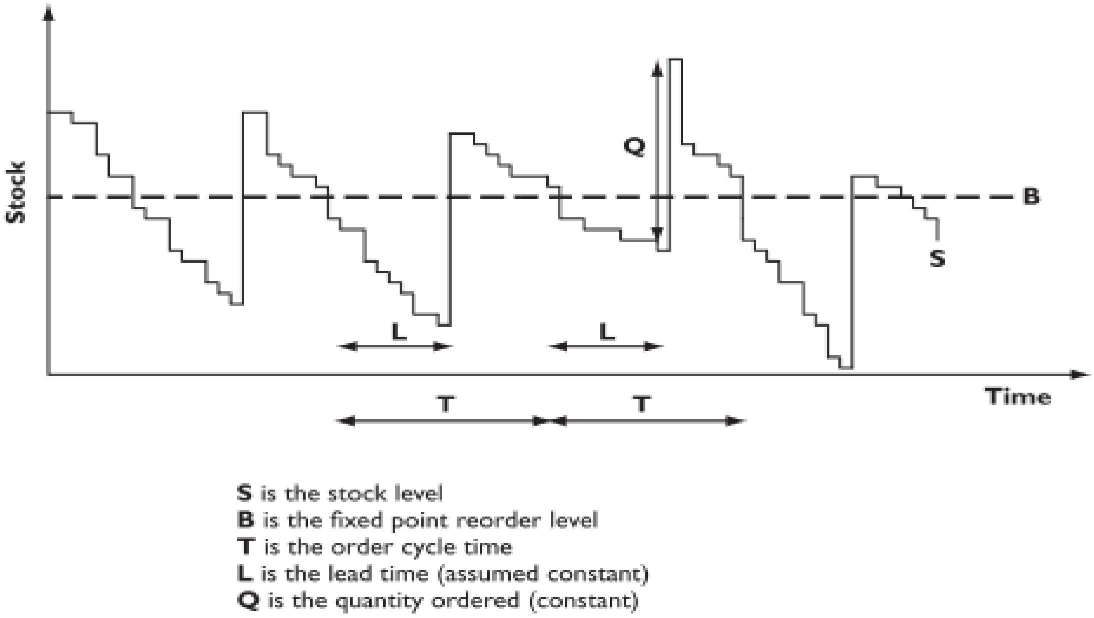


Figure 4. Continuous review (Rushton et al. 2011: 180).

Figure 4 shows continuous review system or fixed point reorder system. The horizontal and fixed line B is the fixed reorder level, once the stock S reaches level B, a new order is triggered, and order quantity Q is fixed (Rushton et al. 2011).

As seen from Figures 3 and 4, periodic review and continuous review differ, periodic review examines inventory in a fixed time interval while continuous review does so without a fixed time interval but at a fixed level of inventory. In periodic review, inventories are examined less often, making the system more reluctant towards changes. To protect against sudden fluctuation in demand, higher safety stock is likely needed. In continuous review, since inventory is reviewed almost constantly, makes the system react agilely to changes, however a re-order-point (ROP) needs to be predefined and constantly reviewed. Within a company, it is common that both systems are used (Murphy and Wood 2014)

Similarly, yet differently, USAID Delivery 2011 suggests the most successful inventory control system for health commodity, namely max-min system. However, the approach is not limited to health commodity and it is useful for any logistics practitioners. Here the max-min inventory control systems come in three types: forced-ordering system, continuous system and standard system. The basic difference is the how a new order is triggered. In forced-ordering system, a new order is triggered at end of review period. In the continuous system, a new order is triggered when inventory reach at a minimum level, same as a re-order point. In standard system, a new order is triggered at end of review period when minimum inventory level or re-order point is reached. Both the forced-ordering system and the standard system can be considered as a periodic review, while the continuous system is the same as a continuous review system as illustrated in Table 5 below.

Table 5. Comparison of inventory control systems.

Inventory control systems Rushton et al. 2011	**Max-min inventory control systems** (USAID Deliver 2011: 57)	**Features**
Periodic review	-Forced-ordering system -Standard system	- ROP or MIN not required - ROP or MIN required
Continuous review	-Continuous review	- ROP or MIN required

Table 5 shows the relation of the terms used to describe different types of inventory control systems (based on Rushton 2011 and USAID 2011). Based on this comparison, the forced-order system and the standard system suggested by USAID 211 can be considered as a sub-category of the periodic review system suggested by Rushton et al. 2011. Therefore, despite the differences in terminology, inventory control systems are mainly divided into two types: periodic review and continuous review. Whereas periodic review is divided further into forced-ordering system if ROP is not required, and standard system if ROP is required. Eventually, there are three types of inventory control systems to choose from.

Depends on inventory classification, specific inventory control system is to be assigned to each category of inventory. After determining the inventory control systems for different inventory groups or categories, the next step is the setting of the inventory control system.

3.4 Inventory Replenishment Process

Inventory replenishment process requires the setting of inventory control system.
The setting of the inventory control system is a quantification exercise. The quantification exercise is done by forecasting and followed by supply planning (USAID Deliver 2011: 67). To quantify when to order and how much to order the new stock, forecasting is the first step.

3.4.1 Demand Forecasting

Demand forecasting is the estimation of future requirements for a SKU or product to fulfil customer needs. Thus, demand forecasting helps determine when to stock and how much to stock. The more accurate demand forecasting is, the less chance there is to have too little or too much stock (Rushton et al. 2011: 187).

For demand forecasting, the types of demand need to be taken into account. Independent demand and depend demand are two different types of demand. Next, demand of finished goods and spare parts is typically independent, while that of manufacturing items is dependent. Uses and demand patterns of both independent and dependent demand are different. Understanding the difference helps forecast demand (Muller 2011). Independent demand comes directly from customers and is affected by market conditions instead of a firm's internal operations, demand of one product does not have impact on others, because of that, max-min inventory control system works for independent demand. Inventory management for products with independent demand is customer oriented, therefore, the formulation of re-order point aims to maintain high customer service level and lower operational expenses (Muller 2011). On the other hand, dependent demand is associated from one to the others, inventory control for products with depend demand aims to support the master production plan, material requirement planning (MRP) is therefore appropriate for dependent demand (Muller 2011).

Several methods are used for demand forecasting. *Judgmental methods* are suitable for new products without historical demand data or with very limited data. This method is based on personal opinions such as sales and marketing, purchasing or customers, therefore it is subjective. *Causal methods* are used for products, of which the demands depend on other factors, for example, promotions, legislation, or seasonality and weather. *Regression analysis* is mainly used for this method. *Projective methods*, are the forecasting techniques that analyze historical consumption data to project demands in the future, without considering future events, therefore, the methods are suitable for existing products. In addition, two main methods for projective forecasting are moving average and *exponential smoothing*. Moving average is the simplest one, exponential smoothing is more complicated but react much faster to changes in demand (Rushton et al. 2011).

Demand can change over time in three main patterns: *trend line, seasonal fluctuation, random fluctuation.* Trend line shows upward or downward trend over a period. Seasonal fluctuation reflects a same fluctuation every year. Random fluctuation does not follow any pattern and happen at any time. A good inventory control system take demand patterns carefully into demand forecasting along with the forecasting methods (Rushton et al. 2011: 189).

The results of demand forecasting directly affect the following supply planning, therefore Rushton et al. 2011 suggests adopting methodical approach for demand forecasting, in order to generate sensible results for the supply planning.

3.4.2 When to Order

Determining when to replenish or place a new order depends on the chosen inventory control system whether the system is periodic review or continuous review. The difference is the trigger of a new order.

In a periodic review system, there are three possible triggers: review period, re-order point (ROP) or MIN, and Emergency Order Point (EOP). The *first trigger*, review period, is how often to review inventories (Sezen 2006). The rules for defining appropriate review period are not certain; however, one general guideline is by demand variability, shorter review period is preferred for products with highly variable demand to reduce the risk of stock shortage and sales lost, thus, longer review period is applicable for products with more stable and lower demand (Sezen 2006: 369). Another rule for setting review period is to use reporting period as review periods, such as monthly or quarterly, and set lead time shorter than the review period, if the lead time is longer than review period, a new order is placed before the arrival of previous order (USAID Deliver 2011). Muller (2011: 121) suggests a formula to calculate the review period:

review intervals = total yearly purchase / discount quantity.

The *second trigger*, re-order point(ROP), is the same as the minimum level of max-min inventory control system, ROP and MIN are interchangeable (Muller 2011). As described earlier, periodic review comes with two types, namely forecast-ordering and standard system. Forced-ordering system does not require ROP, a new order is placed at end of a review period, while standard system requires ROP, a new order is only placed if inventory reaches ROP (USAID Deliver 2011). The calculation for ROP or

MIN (standard system): ROP or MIN= (Demand x lead time) + Safety stock + review period stock level.

The *third trigger*, emergency order point (EOP), is the inventory level that triggers an emergency order, EOP sets to be lower than ROP or MIN and cannot be equal to MIN due to MIN includes safety stock, EOP can be reached at any time during review period (USAID Deliver 2011: 57). EOP is used as an alert to prevent shortage due to sudden demand surge since inventories are not reviewed continuously (USAID Deliver 2011). Commonly, an order can be fulfilled faster than usual in urgent situation, which is called emergency lead time. The formula for EOP is: "Emergency order point ≥ longest emergency lead time", which shows that emergency order point must not be less than longest emergency lead time (USAID Deliver 2011).

Whereas, in continuous review systems, the trigger for ordering is ROP or MIN. Inventory is assessed every time a stock is issued, when stock level fall below ROP or MIN, a new order is placed to replenish inventory to a predetermined MAX level (USAID Deliver 2011). The calculation for ROP or MIN is ROP or MIN=Demand x lead time + safety stock. EOP is not required in this case, because there is no fixed review period or order cycle, a new order can be issued whenever it is needed (USAID Deliver 2011).

In summary, in a continuous review system, ROP or MIN needs to be defined, whilst in a periodic review system, three triggers to be defined are the review period, ROP or MIN and EOP.

3.4.3 How Much to Order

Regardless of the inventory control system, the calculation of order quantity is the same (USAID Deliver 2011: 58):

Order quantity=max quantity-stock on hand-quantity on hand order

Business practice suggests that "the max stock level is the level of stock above which inventory levels should not rise, under normal conditions. The max stock level is set as a number of months of stock, it indicates how long supplies will last" (USAID Deliver 2011: 43). Max quantity is converted by multiplying max stock level and demand. Since demand varies from time to time, max quantity also varies, but max stock level is fixed (USAID Deliver 2011).

To calculate max stock level, ROP or MIN stock level and review period stock level are needed. The formula for MAX stock level is (USAID Deliver 2011: 67):

MAX stock level ≥ ROP or MIN stock level + review period stock level

In summary, there are two steps to calculate the order amount. Step 1 is to define the max stock level. Step 2 is to define the order quantity by subtracting the stock on hand and the open order (ordered but not arrived yet).

However, knowing when to order and how much order is not enough. When demand fluctuates, safety stock is needed to prevent a sudden shortage. The next section introduces the techniques for calculating safety stock found from the existing knowledge.

3.4.4 Safety Stock

Safety stock is the inventory that prevents stock shortages (King 2011: 33). Safety stock is known as buffer stock shown in Figure 5, is a type of stock used to protect against unexpected events such as delivery delays and demand surge. Safety stock can be expressed in both ways, either a number of months in terms of supply or a quantity (USAID Deliver 2011)

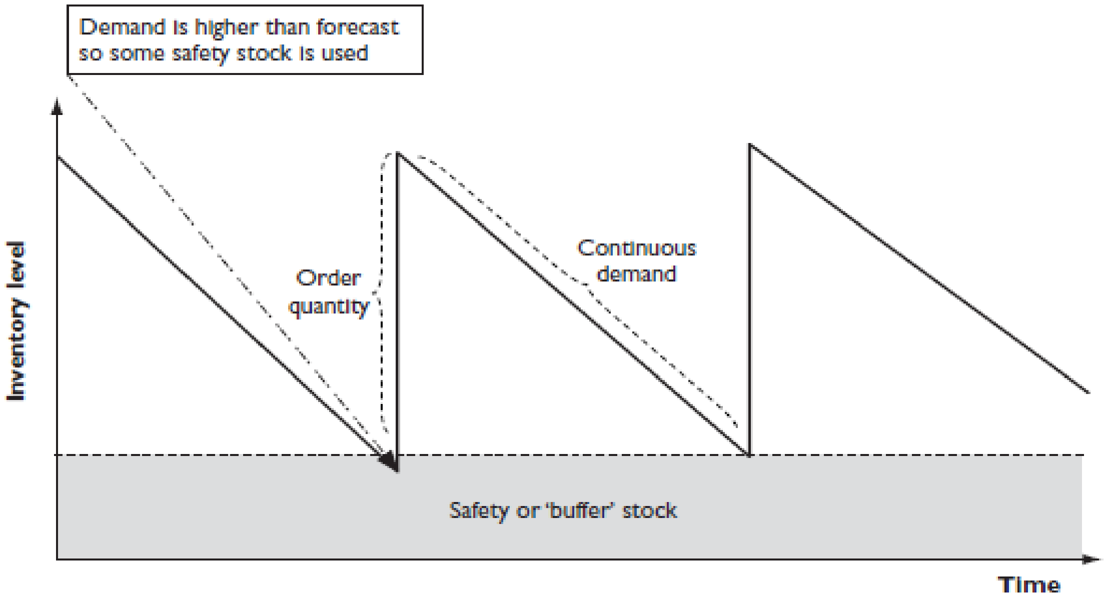


Figure 5. Inventory level with safety stock (Rushton et al. 2011: 176).

Figure 5 illustrates that, despite the demand forecasting is in place, when the replenishment lead time and order quantity remain the same, the sudden demand increase requires the use of safety stock (Rushton et al. 2011).

Safety stock is one of the most critical measures of inventory control system (Thomopoulos 2015). Often, in real life, safety stock is set by hunches or based on a portion of cycle stock, although it is easy to set up, such setting generally result in poor performance (King 2011). The reason for keeping the safety stock is the demand uncertainty. Safety stock can be lower if demand is stable. However, if too much safety stock ties up working capital, then too little safety stock may not be able to offer enough protection against unexpected demand increase. Thus, setting an appropriate safety stock level is important (USAID Deliver 2011). As a rule of thumb, safety stock should not be lower than half of review period stock level, or (USAID Deliver 2011: 66):

safety stock level >= ½ review period level

Additionally, there are two more mathematical calculations of safety stock, either by service level or percent fill. Service level is the probability of not-out-of-stock. Percent fill refers to the ratio of demand filled over the total demand (Thomopoulos 2015: 9). King (2011) adopts the calculation by service level and suggests that proper mathematical approaches balance the needs between maximizing the customer service and minimizing the inventory cost. However, even with safety stock in place, stock-out cannot be completely eliminated, only the majority of them (King 2011).

Depends on variability either in demand or lead time, King (2011) introduce two formulas for safety stock calculation.

Variability in demand means only demand fluctuates, safety stock is meant for protecting fluctuations in demand. Below is the formula for safety stock in this case (King 2011: 34):

$$Safety\ stock = Z\ x\ \sqrt{\frac{LT}{DP}}\ x\ \sigma_D$$

Z=z-score
LT=total lead time
DP=demand period
σ_D=standard deviation of demand.

In the above formula, LT stands for total lead time from placing a new order to receiving of the goods, DP means demand period that is used to report demand, for example, if demand is reported every month, then demand period is one month. σ_D is the standard deviation of the demand. Whereas Z-score is a statistical Figure for the service standard score, there is a standard Z-score for each desired service level as shown in below Figure 6.

Desired cycle service level	Z-score
84	1
85	1.04
90	1.28
95	1.65
97	1.88
98	2.05
99	2.33
99.9	3.09

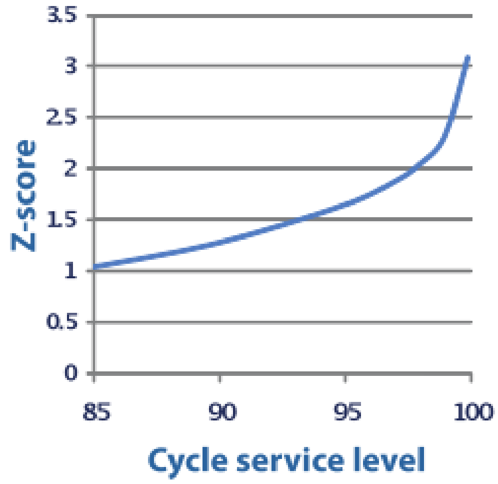


Figure 6. Desired service level and z-score (King 2011: 34).

Figure 6 illustrates the nonlinear relationship between desired service level and Z-score. The higher the service level, the higher the z-score. Typically, the service level is desired between 90-98, 100 is unachievable (King 2011). Moreover, different Z-score can be set for different types of products for strategic planning (King 2011).

Variability in *lead time* means lead time is not stable and changes over time. In this case, the formula of safety stock becomes (King 2011: 34):

$$Safety\ stock = Z\ x\ \sigma_{LT} x D_{avg}$$

σ_{LT} = standard deviation of lead time

D_{avg}=average demand.

When variability exists in both *demand and lead time* independently, then (King 2011: 34):

$$safety\ stock = Z\ x\ \sqrt{\left(\frac{LT}{DP} x {\sigma_D}^2\right) + (\sigma_{LT} x D_{avg})^2}$$

If demand and lead vary dependently, then (King 2011: 34):

$$safety\ stock = \left(Zx\sqrt{\frac{LT}{DP}}x\ \sigma_D\right) + (Z\ x\ \sigma_{LT}\ x\ \ D_{avg})$$

In summary, safety stock is one of the most important settings in inventory management. According to existing literatures, general guideline suggested by USAID (2011) and Muller (2011) can be used for simple calculation of safety stock when more information is not available. In addition, more mathematical approach suggested by King (2011) is useful for sophisticated calculation when more information is available.

3.5 Conceptual Framework of This Thesis

The conceptual framework is the summary of the best practices found in existing literatures. It provides the theoretical approach to solve a problem or improve something. The conceptual framework of this thesis is to improve the current inventory management, in order to reduce the level of inventory without sacrificing service level.

This framework is outlined in three main subjects, with category management highlighted in blue, inventory control system in yellow and replenishment process in grey. These three subjects imply a three-step sequential approach to inventory management. Each step is provided with methods, tools and sources of literatures, as shown in Table 6 below.

Table 6. Conceptual framework for Inventory Management of MTS products.

1. Category Management	2. Inventory Control System	3. Replenishment process			
		3.1. Demand Forecasting	3.2. When to order	3.3. How much to order	3.4. Safety Stock
Types of Product Category: 1. Vital & Expensive 2. Desirable & expensive 3. Vital & inexpensive 4. Desirable & cheap 5. Common usage spares (Rushton et al.2011) **Method:** ABC analysis in multi-criteria framework (Douissa and Jabeur, 2016)	**Types of ICS System:** 1. Continuous review system 2. Periodic review system: forced-ordering or standard (Rushton et al. 2011) (USAID Deliver 2011)	**Type of Demands:** 1. Independent demand (customer oriented) 2. Dependent demand (manufacturing oriented) (Müller, 2011) **Methods:** 1. Judgemental methods (new products) 2. Causal methods (dependent demand) 3. Projective methods including moving avearge & exponential smoothing (products with historic data available) (Rushton et al. 2011)	**Scenario 1:** continuous review To define ROP or MIN ROP or MIN=lead time stock level + safety stock level (F1) **Scenario 2:** periodic review To define review period Review cycle=Annual purchase qty /discount qty (F2) To define ROP or MIN ROP or MIN= (Demand x lead time) + Safety stock + review period stock (F3) To define EOP Emergency order point ≥ longest emergency lead time (F4) (USAID Deliver 2011)	**Step 1.** define Max Max stock level >=min stock+review period stock (F5) **Step 2.** define order quantity Order quantity= Max stock quantity – stock on hand- Open order (F6) (USAID Deliver 2011)	**General guideline:** Safety stock ≥ ½ review period demand (F7) (USAID Deliver 2011) or Safety stock ≥ ½ lead time demand (F8) (Muller 2011) **More sophisticated:** Variability in demand Safety stock=$Z \times \sqrt{LT/DP} \times \sigma_D$ (F9) (King, 2011)

As seen from Table 6, reducing inventory value requires balancing the level of inventory and customer service level to avoid sub-optimization. Inspired by CPFR model in (Rushton et al. 2011: 206), a holistic approach is adopted in this conceptual framework to find the balance between the level of inventory and customer service level. This involves three steps, Step 1. Categorize product, Step 2. Choose inventory control system for each category, Stage 3. Define replenishment process. Step 1 and Step 2 belongs to the scope of strategy planning, whereas Step 3 is under the scope of management and implementation according to Rushton et al. (2011).

Step 1, categorize produce based on the ideas from category management. Category management suggests that inventory should be classified by different characteristics, one-size fit all approach is the cause of excess inventory. In this step, firstly, the *types of product category* introduced by Rushton et al. (2011) are listed although many other classifications are also available. Secondly, a method for classification is recommended. This method is introduced by Douissa and Jabeur (2016), the idea is based on classic ABC analysis with the use of multi-criteria. According to this approach, for example, *vital* and *expensive* can be identified as two criteria, where vital is about demand, expensive is about value or cost. Both criteria are used for ABC analysis.

Step 2, choose inventory control system following inventory categorization. In this step, the types of inventory control system are listed. According to Rushton et al. (2011), two main types are continuous review and periodic review. Additionally, USAID (2011) introduces two periodic review systems: forced-ordering and standard. Continuous review is recommended to vital & expensive products while periodic review is suitable for desirable & inexpensive products (Rushton et al. 2011).

Step 3, define replenishment process, is the step of setting inventory control system. In this step, the four sub-steps are demand forecasting, *when* to order, *how much* to order and safety stock. To forecast demand, the first step is to identify the demand type, whether it is independent or dependent, independent demand is customer oriented and usually for finished products, dependent demand is manufacturing oriented and often related to raw materials as suggested Muller (2011). There are three methods for demand forecasting depending on products. *Judgement method* is used for new products without historical data, *causal method* is used for dependent demand, for existing products with historical data, *projective method* is used, which includes two main methods: moving average and exponential smoothing as suggested by Rushton et al. (2011). Supply planning follows the demand forecasting. *When* to order depends on the chosen inventory control system in two scenarios. Required settings are listed for each scenario. To determine *how much* to order, step 1 is required to define max stock level, followed by step 2 to define order quantity using simple equation. The last setting is *safety stock*, both general guideline and more sophisticated calculation can be used.

Based on the theoretical study, the conceptual framework of this thesis is formulated as the sequenced of steps to create an inventory management framework. Based on the selected suggestions from literature and best practice, it provides a comprehensive guideline for managers how inventory is supposed to managed strategically and differently.

With the conceptual framework in place, the next section reviews how the case company manages the inventory of MTS products. According the logic of the conceptual framework, the current state analysis was conducted from the same three angles: category management, inventory control system and replenishment process. The theoretical approach identified in this framework coupled with the findings from the current state analysis leads to the proposal building that should fit the context and challenge of the case company.

4 Analysis of Current MTS Products Inventory Management in The Case Company

This section reports on the results of the current state analysis (CSA). First, it focuses on the current inventory management. Second, it examines the current types of inventory control system. Third, it analyzes the current replenishment process. Lastly, it points to the strengths and weaknesses in the current practices.

4.1 Overview of the CSA Stage

Following the same logic as indicated in the conceptual framework, this section investigates the current state of inventory management of the case company for make-to-stock(MTS) products. It was done by conducting interviews, reviewing internal documents as well as information extracted from the ERP system.

The current state analysis starts by describing the current inventory management and explaining how inventory is currently categorized. It was done by interviewing logistics manager and a director who was previously product manager.

Next, the analysis focuses on the current types of inventory control system and reveals what system is being applied to different categories. It was done by interviewing mainly the same director who also designed the inventory categorization and control system.

After that, the analysis concentrates on the current replenishment process and investigates how inventory is being replenished, what are the triggers for new orders, how the order amount is determined and the current setting of safety stock. It was done by mainly interviewing purchasers who are responsible for issuing purchase orders and replenishing stocks.

Last, the strengths and weaknesses are analyzed and summarized from the key findings, to identify the focus for proposal building in the next step.

4.2 Current Inventory Category Management

According to doc. 'Wholesale inventory product control' (Table 7 / Appendix 3), the wholesale unit of the case company has two main types of products, one is make-to-order products and the other is make-to-stock products. Make-to-order products are labeled as ZM02, make-to-stock products are labeled as ZM01. Since this thesis focuses on make-to-stock products, therefore ZM01 was be further investigated.

Table 7. Doc.wholesale inventory product control (English translation).

Logistics / Purchasers control	AMG / Product Managers Control
MPR Group -ZM01=make-to-stock product -ZM02=make-to-order product **Safety Stock** -Desired available quantity in warehouse for inventory product **Minimum lot size** -Order requisition amount -ZM01 = make to stock -ZM02 = make to order **Planned delivery time** -Total delivery time from order issue to goods receipt Goods receipt time = GR time -Warehouse reserved unloading time	**A-product** -Always ZM01 -Safety stock always >0 -A product availability to be monitored -AMG meeting or product managers decide on A products **B-product=optional product** -Usually ZM02, can be also ZM01 -Safety stock by default is 0, minimum lot size can de due to logistics reasons. -AMG decides on B selection **C product=project product** -Wholesale purchase make-to-order products from group suppliers. -Can be inventory product exceptionally (for example, big chain customer's orders)

Updated on 06.03.2017

As shown in Table 7, *ZM01=make-to-stock products* are classified by ABC indicators. Features of A, B, C products are listed. Presently, A product has always safety stock, and availability is closely monitored. B product has no safety stock, or safety stock equals zero, it might be stored in stock due to minimum lot size. C product means project product, it is kept in stock for special reason. It appears that B and C products are necessarily kept in stock, while only A is required to be in stock since safety stock is always above zero.

To further clarify what are considered as make-to-stock or stock product, the aftersales director and logistics manager were interviewed. The statement below illustrates some of their points.

> *"Inventory product is only ZM01 A products and safety stock should be always in place. ZM01 B are those products we keep in stock for reasons such as bulk purchase, delivery time constraint etc, but they are not inventory product in that sense, we don't promise our customers that they are available in our warehouse. Thus, inventory product is only ZM01 A"* (Appendix 1, Logistics Manager).

> *"When considering the ABC classification, it is always a promise to the end user. If the class is A it means that the product is stocked and should be always available"* (Appendix 2, Aftersales Director)

As both described, the inventory products are in fact only A products and only A products are required to be available in warehouse as a commitment to customers.

To find out how the inventory classification is configured, the ERP system was examined. Figure 7 shows an example of the configuration in the ERP system, MRP group is used to separate make-to-stock and make-to-order products, MRP group is accompanied by ABC indicator.

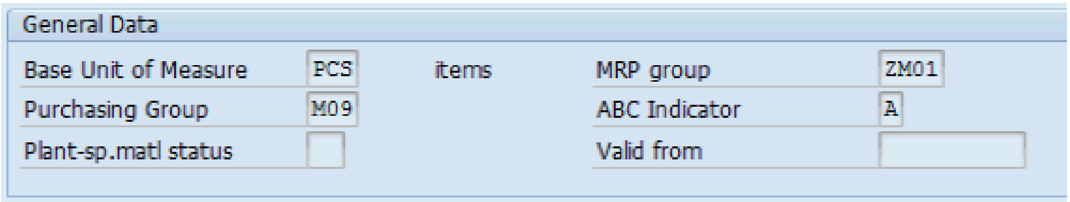


Figure 7. Configuration of product classification in the EPR system.

As seen from Figure 7, this is an example of make-to-stock product, with MRP group set as ZM01 and ABC indicator set as A.

In summary, the case company currently categorizes inventory into two main types, make-to-order and make-to-stock. Make-to-stock products are further classified by ABC indicator, A means always available in stock, B and C are not required to be in stock as A, B and C appear in stock for special reasons. Therefore, the current criterion of ABC classification is availability of stock, without considering demand and stock value.

4.3 Current Inventory Control System

Current inventory control system studied what the current inventory control system includes, whether a continuous review or a periodic review is adopted or none, as well as what are the relevant settings that relate to the system. To find out these details, two steps were taken. First, MRP setting in ERP system were examined. Importantly, the MRP setting regulates how the inventory of a material is reviewed. Second, the key person involved in ERP systems was interviewed to explain the inventory control settings or MPR settings in the language of the ERP system.

Firstly, Figure 8 shows the screenshot of the current MRP settings of a material in ERP system. It provides an example of how MRP settings are configured for all materials at the current state. MRP type defines the material replenishment method, which corresponds to the inventory control system. PD is the material MRP type applied to all materials, which is described as MRP vaguely.

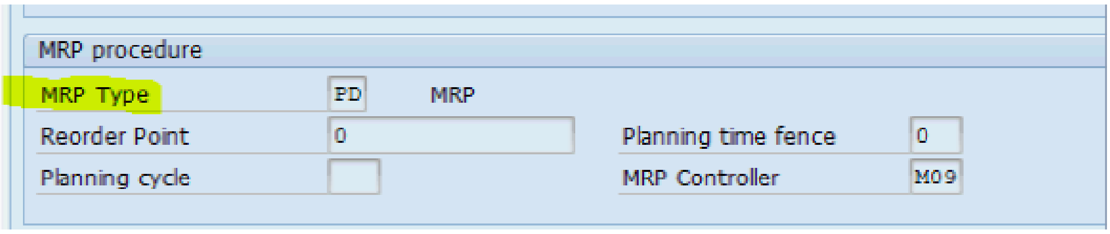


Figure 8. MPR procedure in ERP system.

As seen from Figure 8, the reorder point, the planning time fence, and the planning cycle are left blank. Both the reorder point and the planning cycle are the elements of the periodic review. MRP setting indicates materials are at least not reviewed periodically. To examine it further, the stock requirement list was studied, as shown in Figure 9.

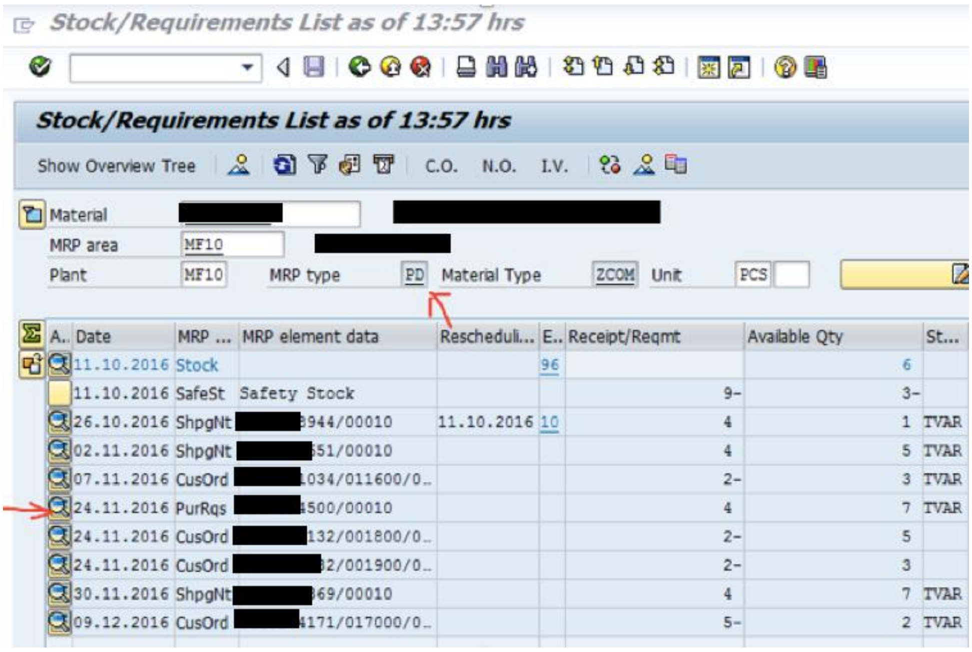


Figure 9. Stock requirement list in the ERP system.

Figure 9 illustrates how the ERP system automatically triggers the replenishment. In the stock requirement list, the current stock is 6, safety stock 9, the purchase order quantity 8 (4+4), the upcoming customer order 2 pieces, a purchase requisition of 4pcs is triggered on 24.11.2016 which means 4pieces needs to be in warehouse on that date, since the next two customer orders require 4 pieces, which would reduce stock to below the safety stock level 9. With MRP running every hour on daily basis, after each run, a new purchase requisition is trigger. Therefore, the current inventory review policy that regulated by MRP type PD is, in fact, a continuous review. This is also further proven by purchasers via interviews, as described by one purchaser:

> *“The current replenishment process is semi-automatic. SAP automatically generate purchase request when safety stock falls short” (Appendix 4, Purchaser)*

Secondly, the key person involved in the ERP system development was interviewed, on how MRP type PD works and why it is chosen. As he said:

> *“I do not know the other MRP-types, they are not in use in the company, but in some other Group companies. This is one part of the 'complicated process' I mentioned in previous email. I think that there would be plenty of options for doing automated or semi-automated material procurement in MRP but the problem was that none of the consultants ever showed us how they are working so we are using the one we chose in the start, which means PD that is working related to Safety stock, Minimum order lot and Planned Delivery Time” (Appendix 2, Aftersales director)*

Apparently, the MRP type is not fully explored and utilized due to complexity of the ERP system, this also explains why other MRP relevant such as reorder point and planning cycle are left untouched.

In summary, the currently inventory review is controlled by the MRP procedure in the ERP system. Based on the settings and observation of the replenishment pattern, a continuous review is applied to all products.

4.4 Current Replenishment Process

The replenishment process starts with demand forecasting followed by supply planning. Hence, in the case company, the current demand forecasting was examined first, the current supply planning was examined later.

4.4.1 Current Demand Forecasting

The inventory level of Make-to-stock(MTS) products is determined based on the anticipated demand, the anticipation is done by demand forecasting. To understand how the case company practices demand forecasting, a key stakeholder was interviewed. According to the interview with the key stakeholder (Field note 4, Appendix 5), there is no demand forecasting process in place.

> *"No, we do not have any external or automated demand forecasting process. The process is fully related to purchase person being active and following the trends and open orders in SAP. For many of our products the demand is so unstable and fluctuating that it might not even work with an automate - but then again I guess there could well be a hundred or even more articles that have a quite constant flow and could be forecasted better than today" (Appendix 5, Aftersales director)*

As explained in Appendix 5, the demand forecasting process does not exist in the company, it is not needed in EPR system due to the high fluctuation of demand in general. However, the answer implies that the demand forecasting in the ERP system is feasible for the products with stable demand and should be applied. Furthermore, demand forecasting is currently done by individual purchasers manually, without a process.

The next question is the types of demand, in other words, whether the demand for a product depends on the others. *"Our demand is almost fully independent" (Appendix 5, Aftersales director)* in the business unit, all products are purchased and sell to customers without the manufacturing process.

In the case company, the old and new products are adopted different methods of demand forecasting. For completely new products, the method is by experience or by hunch:

> *“If the product is something we do not previously have, then the forecast is based on hunch/experience, normally that of the product manager. “(Appendix 5, Aftersales director)*

For the old or existing products, demand can be forecasted by historical data of past consumption, the data is available in the ERP system. In the case company, the past consumption data has been used to adjust the level of safety stock, this has been done several times before, according to the interview at Appendix 5.

> *“Yes, we have done it several times in bigger 'runs' with excel (I did it when I was responsible of purchase). But according to our instructions, this is also a process that should be done by purchase persons as part of their normal work. The consumption levels should be checked regularly and safety stocks / minimum order quantities adjusted accordingly.” (Appendix 5, Aftersales director)*

However, the EPR system does not utilize demand forecasting for purchase requisition. According to the purchasers:

> *“The current system does not automatically calculate the average demand of items based on the history data when creating the purchase requisitions.” (Appendix 4, Purchaser)*

In summary, in the case company, the demand forecasting process is not a clearly defined process, it is rather a manual process in the control of individual purchasers. Nevertheless, several findings are discovered. First, the demands of most products are highly unstable, it makes demand forecasting less sensible and close to impossible. Second, all products are finished products, demand of such are independent. Third, demand forecasting for old products have been done by the past consumption, that for new products have been done by hunch.

4.4.2 Current Supply Planning

Presently, the supply planning consists of three key settings. These settings are when to order, how much to order and level of safety stock. The current doc. ‘Purchasing Process’ (Appendix 6) only mentions the roles and responsibilities of parties involved in the whole purchasing process, and it does not address when to order and how much to order nor safety stock in details. Therefore, the ERP system was examined and the interviews were conducted to find out the answers.

A. When to order

As discussed in the section on the current inventory control system, only continuous review is adopted in the case company, that means the ERP system monitors stock level of all products in the same continuous way. In the ERP system, MRP runs every hour, during each MRP run, stock level, planned and firmed customer orders are re-counted. New purchase requisitions are triggered after each MRP run. That said, multiple purchase requisitions are literally generated every hour, forcing purchasers to manually combine several purchase requisitions into one. This means “when to order” is preliminarily triggered by the ERP system but purchasers are given the flexibility to decide when to order.

> *“A new purchase request is generated whenever safety stock falls short, which leads to multiple separate purchase requests, purchaser needs to manually consolidate these purchase requests. “ (Appendix 4, Purchaser)*

To understand the configuration of the current order trigger, namely “when to order”, the setting in ERP system was inspected further. The result is shown in Figure 10.

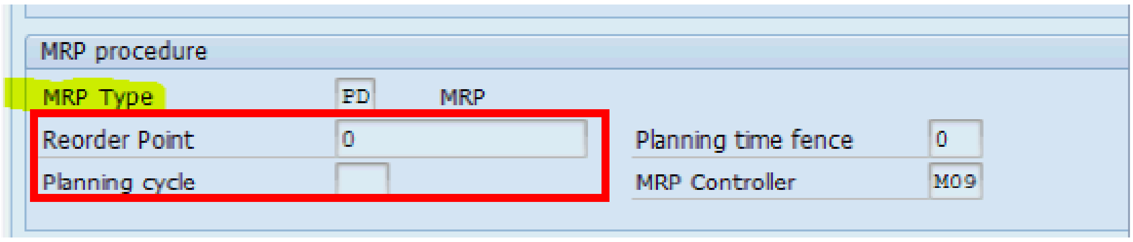


Figure 10. MRP procedure ROP & planning cycle in the EPR system.

Reorder point is the essential element of continuous review, but as seen from Figure 10, the re-order point is indeed not configured. In addition, the planning cycle, as an element of periodic review, does exist but is not configured.

B. How much to order

Presently, the amount of a new purchase requisition is determined by the ERP system, based on this formula:

order amount = safety stock level – (current stock + receipt quantity – issue quantity).

These elements in the formula are highlighted in the same colors in Figure 11.

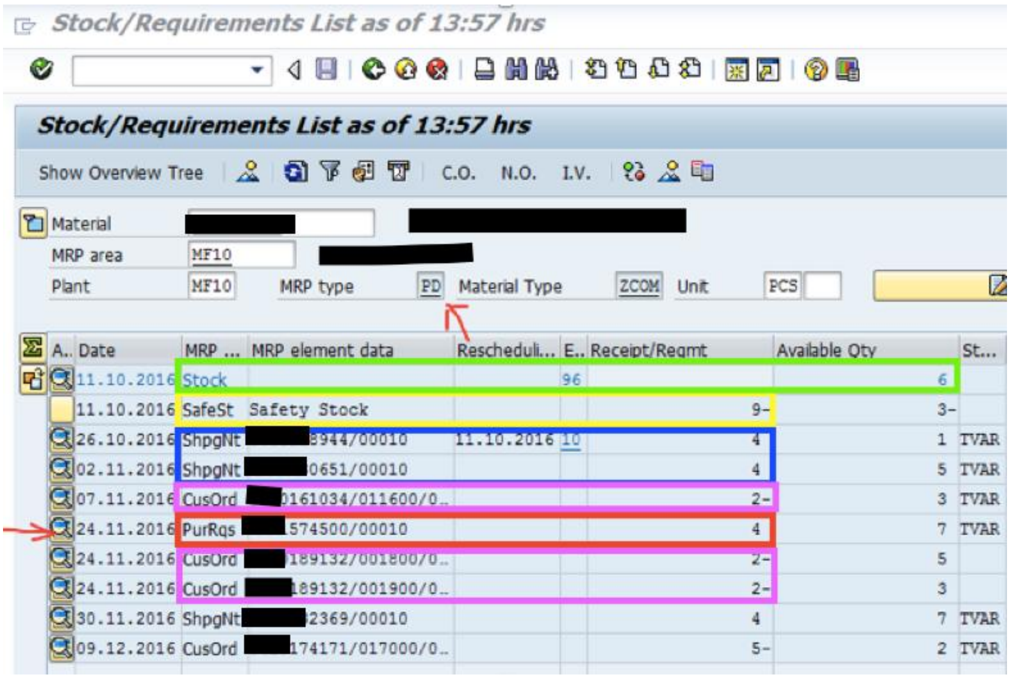


Figure 11. Stock requirement list from ERP system.

Figure 11 is an example of stock requirement after one MRP run, where PurRqs is the order quantity counted by the ERP system based on the formula mentioned above. the example in Figure 11 shows that the net requirement is only 1 piece, but why PurRqs is 4 pieces, because the calculation of order quantity takes in account minimum order quantity as well.

Figure 12 shows that settings of the minimum order level or reorder point and the maximum stock level are both available in the EPR system. However, these settings are not used for all products.

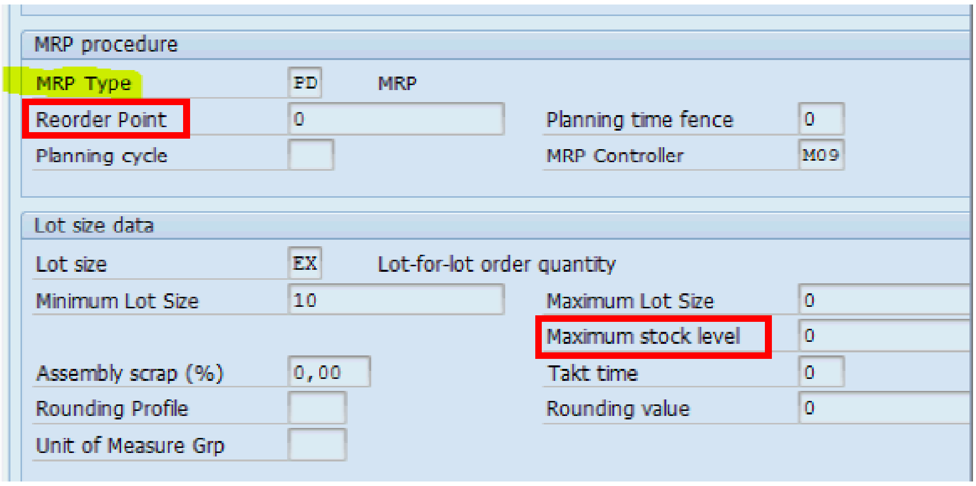


Figure 12. Reorder point & max stock level setting in the ERP system.

Hence, the current replenishment process does not consider min-max stock level to count order amount.

C. Safety stock

Safety stock is determined and managed by purchasers (Field note 2, Appendix 2). Safety stock was once used as an important method to reduce inventory value according to the management, however, the process is not documented (Field note 2, Appendix 2). To find out how safety stock is currently being calculated, four purchasers were interviewed. Their answers are listed in Table 8 below (Field note 3, Appendix 4)

Table 8. Calculation of safety stock in the case company.

How do you calculate the amount of safety stock?
Answer 1: 1-2 x monthly consumption Answer 2: (Max consumption-average consumption) * lead time Answer 3: Generally average monthly consumption multiplied 1- 1,5 with some exception, subject to delivery time or some other special agreement. Answer 4: In general, the average demand for a period of approximately one month. There are also exceptions (for example for expensive units or units with a very short lead time).

As shown in Table 8, the answers from fours purchasers vary. Purchaser 1 thinks safety stock should be 1 to 2 times of monthly consumption. Purchaser 2 thinks safety stock should equal to lead time (in days) multiplied by the difference between maximum daily consumption and average daily consumption. Purchaser 3 thinks safety stock should be 1 or 1,5 times of average monthly consumption subject to delivery time and other factors. Similarly, purchaser 4 thinks safety stock should be equal to nearly one month consumption. Additionally, there is no procedure stating how often safety stock should be updated, purchasers update safety stock one in a while (Field note 3, Appendix 4)

In summary, the replenishment process does exist and is documented in the case company, however, it addresses only the key role and responsibilities of parties involved in the process, it does not address how the process should be done. Furthermore, ERP system automatically triggers new purchase requisitions through the hourly MPR run. When to order or the trigger for new orders is when safety stock falls below the predefined level. The amount to order is the amount needed to bring safety stock back the predefined level. While the level of safety stock is set differently by purchasers. Lastly, despite the automated purchase requisition in the ERP system, purchasers still can make decisions on when to order and how much to order.

4.5 Summary of Strengths and Weaknesses

The analysis ends with the strengths and weaknesses from the key findings of the current inventory management practices. The results of analysis are summarized in Table 9, where strengths are highlighted in green and weaknesses are in red. The results are categorized in three different subjects on the left, namely the inventory category management, the inventory control system and the current replenishment process, according to the same logic suggested by the conceptual framework of this study.

Table 9. Summary of strengths and weaknesses of the current state.

	Strengths	Weaknesses
Inventory Category Management	-Inventories are in fact categorized	-All A products are treated equally regarldess consumption or cost, not further classified
Inventory Control System	-ERP allows continuous review for all products on daily basis -ERP triggers new purchases automatically -ERP settings for continuous review & periodic review are available	-Continuous review applied for all products -Periodic review is not adopted.
Replenishment Process	-Past consumption data is available -Freedom to adjust order amount -Semi-automatic purchase -Safety stocks are updated sometimes	-ERP demand forecasting is not explored and utilized. -New purchase order is not fully automated -No standard process nor guideline for safety stock setting or management

As seen in Table 9, there are strengths and weaknesses in each subject area. First of all, inventories are currently categorized and ABC indicators are used. However, A products, referring to the real make-to-stock products, are not further classified. The only criterion for being A product is availability, if a product needs to be available always in stock, it is A product. With over one thousand products are categorized as A product, further classification is needed but lacking.

Secondly, ERP plays important role in inventory control. The EPR system review inventory in real time, with hourly MRP run. As a result, the new purchase requisitions are triggered automatically. Although ERP system currently practices continuous review, the periodic review settings are also available in the system. The problem with the current inventory control is that, the continuous review is applied to all MTS products, for example, a cheap and low demand product is replenished as frequent as an expensive and high product. Multiple small orders without consolidation cause ordering costs to rise. Whereas period review with fixed time interval, is not in use.

Finally, a few strengths are observed from the current replenishment process. For instance, the new purchase requisition is triggered automatically by ERP, the new purchase requisitions inform purchasers what need to replenish, moreover, purchasers are able to make manual adjustment on new orders and consolidate several purchase requisitions as well. The current replenishment process appears to be a semi-automatic. Purchasers to decide what to order, when to order and how much to order, and customize the purchase order. Data of the past consumption is available and accessible in the ERP system. Safety stock is not set and forgotten, in fact, each purchaser keeps track past consumption and adjust safety stock from time to time, which is good.

Nevertheless, weaknesses also exist in the current replenishment process. For example, demand forecasting is not utilized to calculate the order amount. As a result, purchasers use past consumption to manually forecast future demand while making the new purchase order. That said, making of purchase order involves several manual decisions and yet automated through the settings in the ERP system. Finally, the standardized safety stock calculation is lacking.

To sum up, the analysis of strengths and weaknesses identified the focus and priority of proposal building. A customized proposal is presented in the next section, combining the results of this current state analysis and the conceptual framework.

5 Proposal of Inventory Management Framework for MTS products

This section introduces the draft proposal that is built in co-creation with the stakeholders based on the conceptual framework (in Section 3), the analysis of the current state (in Section 4) and the input from the stakeholders (in Section 5, below). Firstly, *overview of the draft proposal stages* is introduced, it gives the ideas how the proposal was built by steps. Secondly, inputs from stakeholders during proposal building are addressed. Thirdly, the draft proposal is presented. Fourthly, the draft proposal is explained in detail by its three key elements: categorization of inventories, selection of inventory control system and specification of replenishment parameters. The last section emphasizes on the transformation that the draft proposal will bring to the case company.

5.1 Overview of Draft Proposal Stages

This draft proposal is created based on (a) suggestions from existing knowledge for reducing inventory level, (b) the results from the current state analysis of the inventory management practice in the case company, and (c) the summary of the input from the stakeholders on improvements, as illustrated in Figure 13.

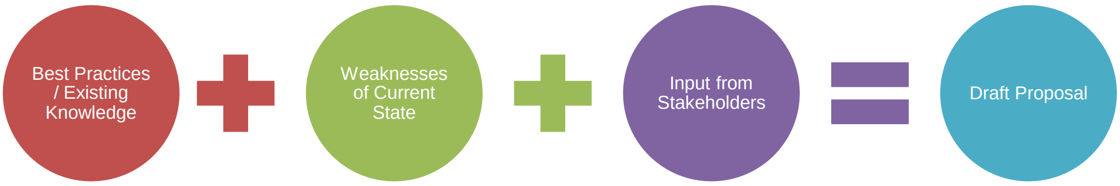


Figure 13. Draft proposal building stages.

As seen from Figure 13, the draft proposal building was done in three stages. *First*, the best practices summarized in conceptual framework were reviewed. *Second*, weaknesses of current states were analyzed. *Third*, input from stakeholders was collected as Data 2. The draft proposal is the outcome of these three stages that combines the key points from each stage. The draft proposal integrates theoretic ideas and current practices in the case company. The purpose of the draft proposal is to eliminate the weaknesses from the current state and even turn them into strengths. After all, the proposal is the guideline on how to apply the existing knowledge into the real-world scenario.

Furthermore, since the case company is using SAP as the ERP system, any proposal needs to take SAP into consideration. Therefore, in addition to the existing knowledge from literatures, the relevant SAP settings and SAP documentation were studied, in order to make the proposal workable in the ERP environment. The terminologies in the conceptual framework were found their corresponding terms in SAP system, which are the critical bridging elements from the theory to the current state. However, due to the complexity of the SAP system, implementation purely based on SAP system may not be sufficient, therefore, in addition to approach via SAP, alternative "manual" approach without using SAP is also proposed.

5.2 Input from the Stakeholders (Data 2)

When the initial ideas of the proposal were formed after reviewing the best practices and weaknesses of the current state, the discussions with internal stakeholders were arranged to gather input for improvements. The contents of the discussion were recorded as Data 2. The draft proposal was co-created together with the input from the stakeholders.

First, the initial idea was presented to purchasers, as purchasers are making purchase orders and actively monitor inventory level. Three purchasers were participated in the discussion and shared their thoughts. Their inputs are generally positive:

> *"This proposal is a complete one, I don't have anything to add, it is good" Purchaser 1 (Appendix 7, Purchaser 1).*
> *"The ABC analysis idea is classic, it should be done this way, we tried it before, didn't know why we didn't adopt this method" Purchaser 2 (Appendix 7, Purchaser 2).*
> *"The idea is clear, logical, useful and feasible as well. Well studied" Purchaser 3 (Appendix 7, Purchaser 3).*

Next, the logistics manager, who oversees inventory level, mentioned in the discussion "I cannot make comment on that, I need to talk to the manager who is familiar with SAP. I will arrange a meeting for that. My concern is how the new ABC categorization will affect our current operation" (Appendix 8, Logistics manager)

Finally, in the group discussion with aftersales director along with logistics manager, a constructive input was given in a summary below:

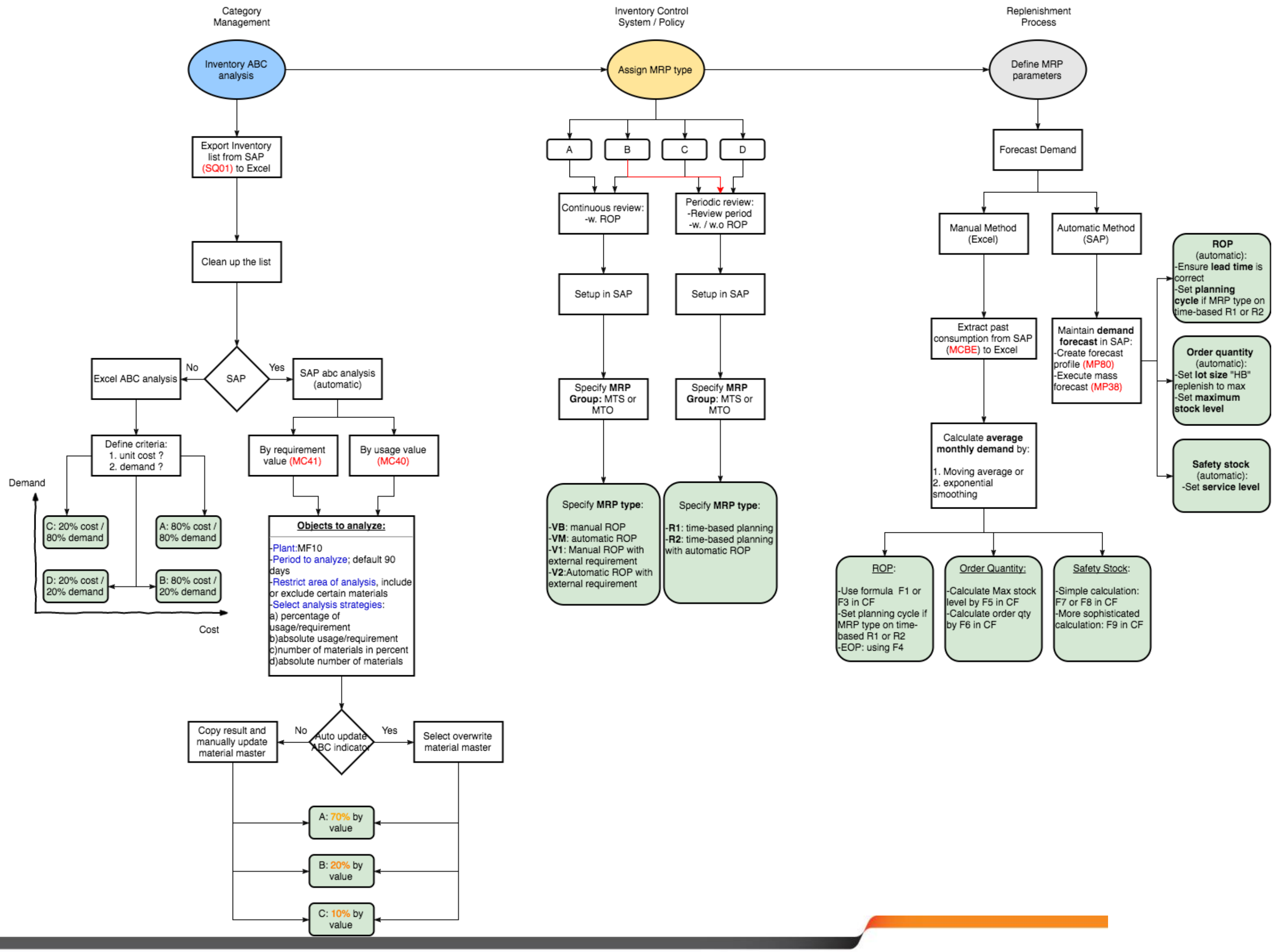
> *"We have a mixed-used of ABC indicator in the company, the present ABC is not only an inventory control indicator but also indicator for sales, your proposal needs to consider the impact of ABC classification on sales organization. Overall goods proposal. 100% feasible. Need to consider those products that will probably not work with this framework. The idea can be tested in SAP testing environment, but real-world changes will not be reflected. I would suggest starting with piloting on a few less impactful products in real SAP environment and observe what happens. The framework sounds beneficial to other business units especially for products with stable demand." by (Appendix 9, Aftersales director)*

As seen from the inputs above, the participants have expressed acknowledgement of the proposed idea. The concern is mainly on how the new inventory categorization affects the whole operation. Their input and concerns were taken into consideration and helped complete the proposal building. The following session introduces the proposal draft.

5.3 Proposal Draft

Below Flow Chart 1 presents the draft proposal of inventory management framework for make-to-stock products. On the top are the three theoretic subjects from conceptual framework. The three bubbles in blue, yellow and grey are the corresponding practical terms in SAP language, they represent the major steps. White boxes describe actions. The green boxes are the final outcomes of each step. The red texts are SAP transaction code to open certain transaction. The bolded texts are SAP terms or emphasized texts. The orange texts are nominal values.

Flow Chart 1. Draft proposal of inventory management framework for make-to-stock products.



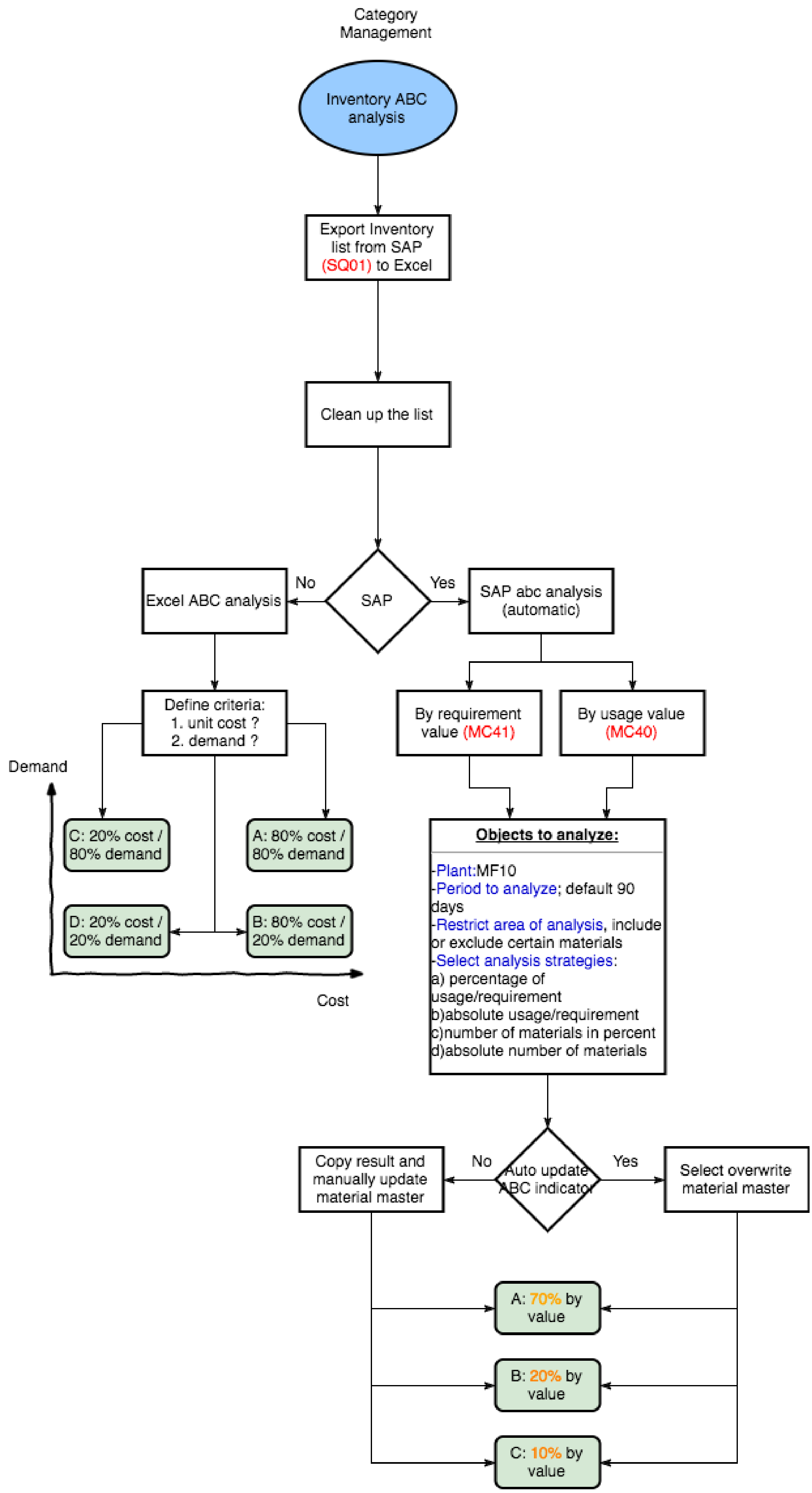
As seen in Flow Chart 1, the entire draft proposal consists of three main steps. Step 1, in blue bubble, is to categorize product by ABC analysis, ABC analysis is the method used in category management for inventory classification. The outcome of step 1 is new ABC indicators for all make-to-stock products. Following the outcome of step 1, Step 2, colored in yellow bubble, is to assign MRP type to each category, MRP type is the SAP term similar as inventory control system or policy in theory. The outcome of step 2 is MRP types being assigned to different categories.

Step 3, in grey bubble, is to define MRP parameters, MRP parameters are the configurations that define replenishment process in SAP, the outcomes of which are the reorder point (ROP), order quantity and safety stock. The details of each step were explained in the following sections.

5.4 Categorization of Inventories

As the first step of the draft proposal, the concept of inventory categorization refers to the theory in chapter 3.2, category management for inventory control. Flow Chart 2 outlines the actions for categorizing inventories.

Flow Chart 2. Step 1 - inventory ABC analysis in the proposal.



Step 1, as show in Flow Chart 2, inventory ABC analysis starts from exporting inventory list from SAP to excel. This inventory list is to include all finished product SKUs (material type: ZCOM) in the specific Plant (MF10). This step serves two purposes. The first purpose is to facilitate list cleanup in the immediate next step. The second purpose is to use the list for manual ABC analysis using EXCEL method. This step is done by using SAP transaction code SQ01 (highlighted in red).

Step 2, after exporting inventory list to excel, is to clean up the list. The purpose is to correct all wrongly classified products, eliminate obsolete products and testing products, and eventually only the real MTS (make-to-stock) products should remain in the list. One good example is seen from Figure 14.

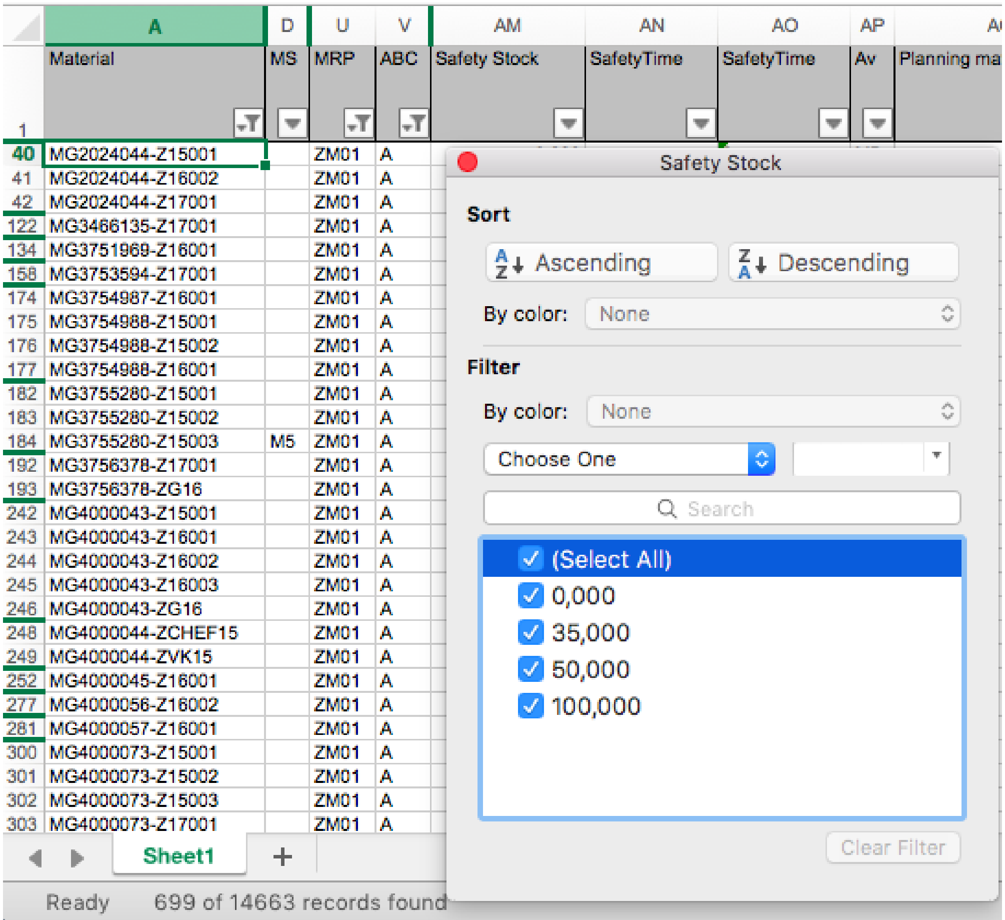


Figure 14. Testing products marked as MTS A products.

As seen from Figure 14, total 699 testing products with “Z” suffix are categorized currently as MTS A products, 3 of such are given safety stock, which implies the necessity to clean up the product list before proceeding further.

Step 3, a decision needs to be made on whether ABC analysis is done by Excel or SAP. *In Excel*, ABC analysis can be done by first defining weighing criteria. The flexibility of Excel makes multi-criteria ABC analysis possible, a good choice of the criterion is both unit cost and demand, and 80%/20% as class boundary. As the result of excel analysis, A products account for 80% cost and 80% demand, thus are the most important, requires attention as frequent as possible. B products are secondary, accounting for 80% cost but 20% demand. C products forms 80% demand but 20% cost. The least important D products make up only 20% demand and 20% cost. The percentage for class boundary is flexible and adjustable. After grouping products into A, B, C or D, the new *ABC indicator* is to be mass input into material master in SAP.

In SAP, the ABC analysis can be carried out with existing ABC analysis transactions. Two SAP transactions are available for this purpose, one is MC41 and the other is MC40. These two transactions differ in terms of analysis criterion. The criterion for MC41 is requirement value, that for MC40 is usage value. Requirement value is the value of *future* valuated requirements within a period. The usage value is the value of average *past* consumption within a period. After deciding on which criterion to use, the next step is to restrict objects to analyze, the available options are plant, period to analyze, restricted area, and analysis strategies. There are four analysis strategies or class boundaries to choose from: a) percentage b) absolute value c) number of materials in percentage d) absolute number of materials. Running ABC analysis generates a list of products with new ABC indicators. If auto update ABC indicators is selected, material master is overwritten, otherwise, the result can be exported to excel for manual adjustment before updating material master.

The outcome of this step is the new inventory categories with new ABC indicators, whether the ABC analysis is done in Excel or SAP directly, the results of such eventually update the ABC indicators in SAP system. The next step is to assign MRP type to each ABC group of products, which is discussed in the following section.

5.5 Selection of Inventory Control System

As discussed in chapter 3.3, inventory control system (ICS) determines how inventory of a material is reviewed and replenished. The equivalent term of ICS in SAP is interpreted as MRP type, “MRP type determines how the material will be planned” (Agrawal 2016: 114). MRP type is configured in material master record MPR1. Different MRP types in SAP are listed in Figure 15.

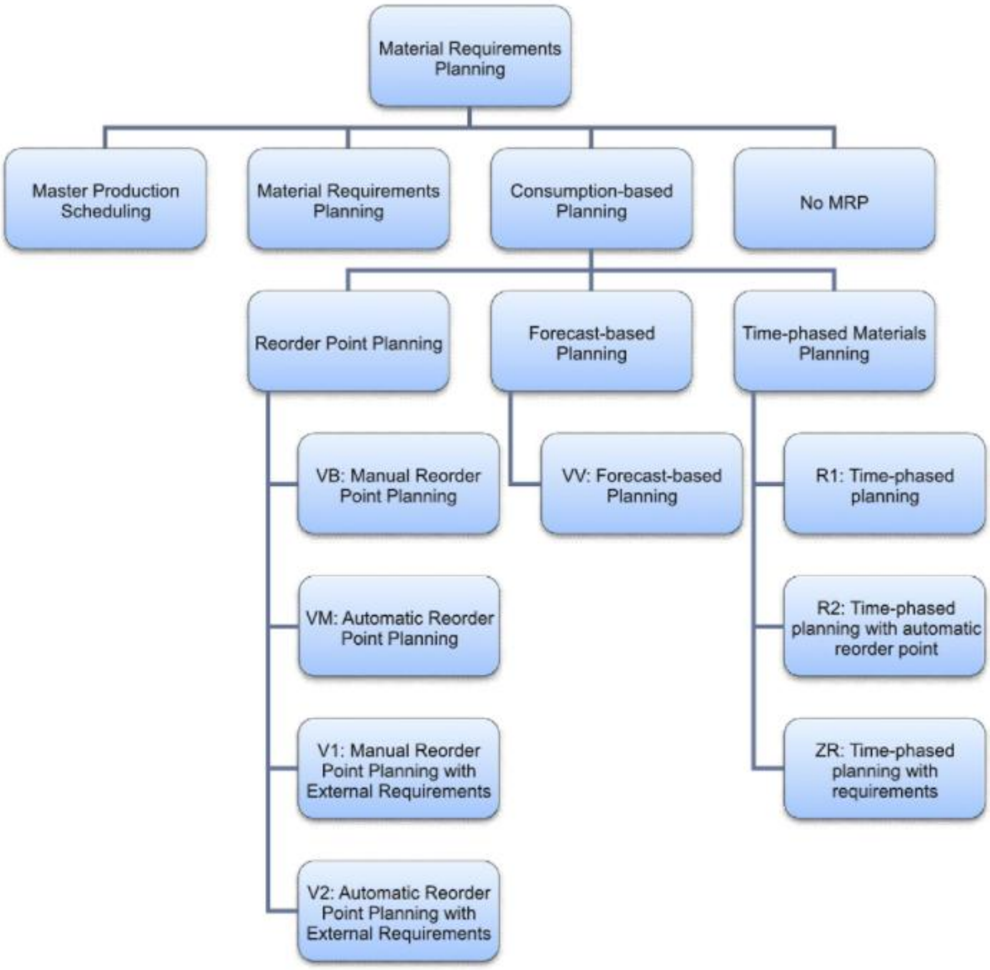
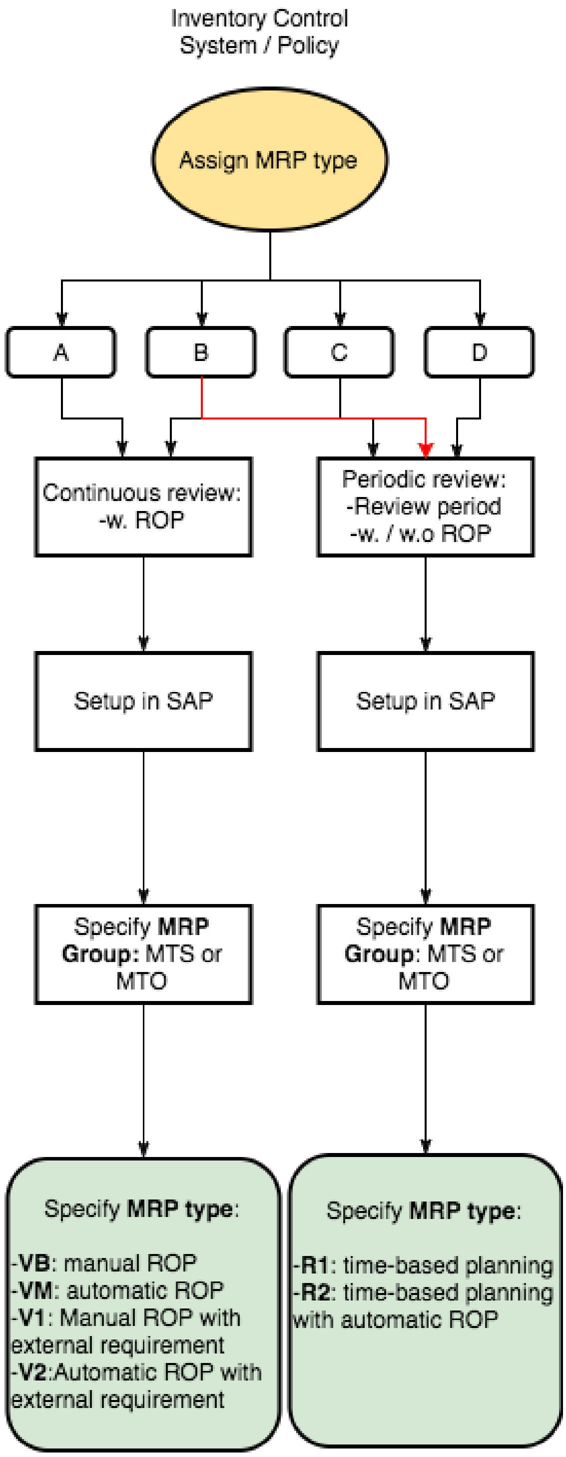


Figure 15. SAP MRP type (Agrawal 2016: 114).

As seen from Figure 15, the three main categories of MPR types for consumption-based planning are reorder point planning, forecast-based planning and time-phased materials planning. *Reorder point planning* corresponds to continuous review inventory control system, and *time-phased material planning* corresponds to periodic review inventory control system. VB, VM, V1 and V2 are MRP types belong to reorder point planning. R1, R2, ZR are MRP types belong to time-phased material planning. Based on this interpretation on SAP MRP types, the step 2 of the draft proposal, selection of inventory control system was designed as follows in Flow Chart 3.

Flow Chart 3. Step 2 - assign MRP type in the draft proposal.



As seen from Flow Chart 3, assigning MRP type starts after inventory being categorized into A, B, C or D. Rushton et al. (2011) suggests expensive products should adopt continuous review while cheap products should adopt periodic review and less frequent replenishment. The result of ABC analysis varies by methods and criteria as seen in Flow Chart 2, however, A products are always the most significant that requires as frequent monitoring and replenishment as possible, therefore A products should adopt continuous review. C or D products are always the least important, which require the least attention, hence, periodic review should be adopted. B products, in between, can be either assigned continuous review or periodic review depending on its level of importance. Referring to chapter 3, continuous review requires a fixed re-order point (ROP), on the other hand, periodic review requires a fixed time interval and optional ROP.

After determining either continuous review or periodic review, the next step is to set it up in SAP. First, MRP group is to be specified. MRP group determines whether a product is make-to-stock(MTS) or make-to-order(MTO). MTS is the MRP group for this study.

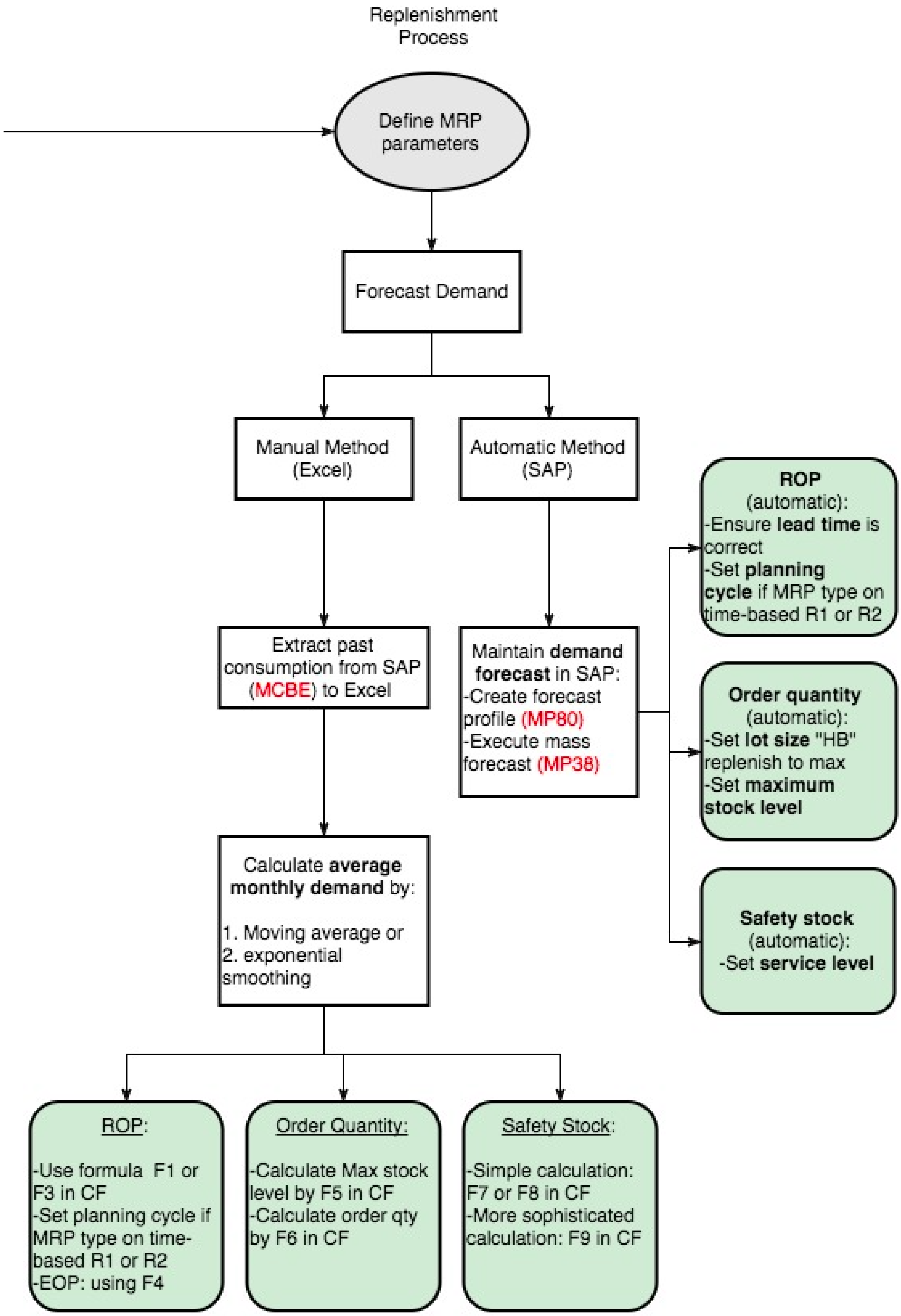
The final step is assigning specific MRP type to each product. VB, VM, V1 and V2 are available options for continuous review. VB: manual ROP, meaning ROP is manually determined without using SAP automatic ROP. VM: automatic ROP, meaning ROP is computed automatically by SAP. V1: manual ROP with external requirement. The external requirement can be a manual reservation (Agrawal 2016, P162). With external requirement means MRP run takes in account reserved quantity, therefore, similar as V1, V2: automatic ROP with external requirement, takes in account reserved quantity. Two MRP types to choose for periodic review are R1: time-based planning and R2: time-based planning with automatic ROP.

After assigning MRP type to each product, the next step is to define MRP parameters. The three MRP parameters are re-order point (ROP), order quantity and safety stock, the settings of such are discussed in the following section.

5.6 Specification of Replenishment Parameters

In the previous section, MRP type for specific ABC group was discussed. This section continues to discuss the setting of MRP parameters. The three key parameters are re-order point (ROP), order quantity and safety stock, the calculation of such can be done either manually or through SAP automatically. The suggested approach is listed in Flow Chart 4 below.

Flow Chart 4. Step 3 - define MRP Parameters in the draft proposal.



As seen in Flow Chart 4, the starting point of defining MRP parameters is demand forecast, this refers to the replenishment process in conceptual framework. In this draft proposal, demand forecast can be done either by excel as the manual method or by SAP as the automatic method. The automatic method is explained first, followed by the manual method.

The *automatic method using SAP* in this proposal is yet confirmed by SAP technician, it is based on the researcher’s own discovery from SAP online help documentation on help.sap.com. To utilize automatic computation of ROP, order quantity and safety stock, demand forecast is to be enabled first (Help.sap.com 2017). Demand forecast is typically done with mass processing in the background (Help.sap.com 2017). If automatic forecast model is selected, SAP analyzes the demand patterns from past consumption data and automatically select the demand model from 1. constant model, 2. trend model, 3. seasonal model and 4. seasonal and trend model (Help.sap.com, 2017: forecasting). As shown in Figure 16, transaction code M38 or MPBT seems able to execute total forecast on multiple products.

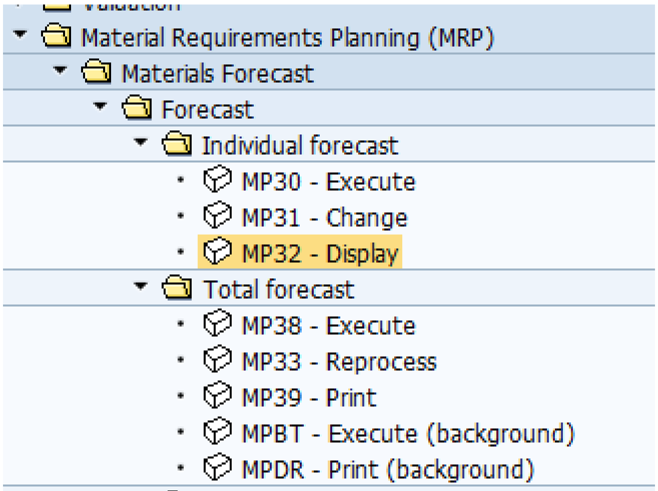
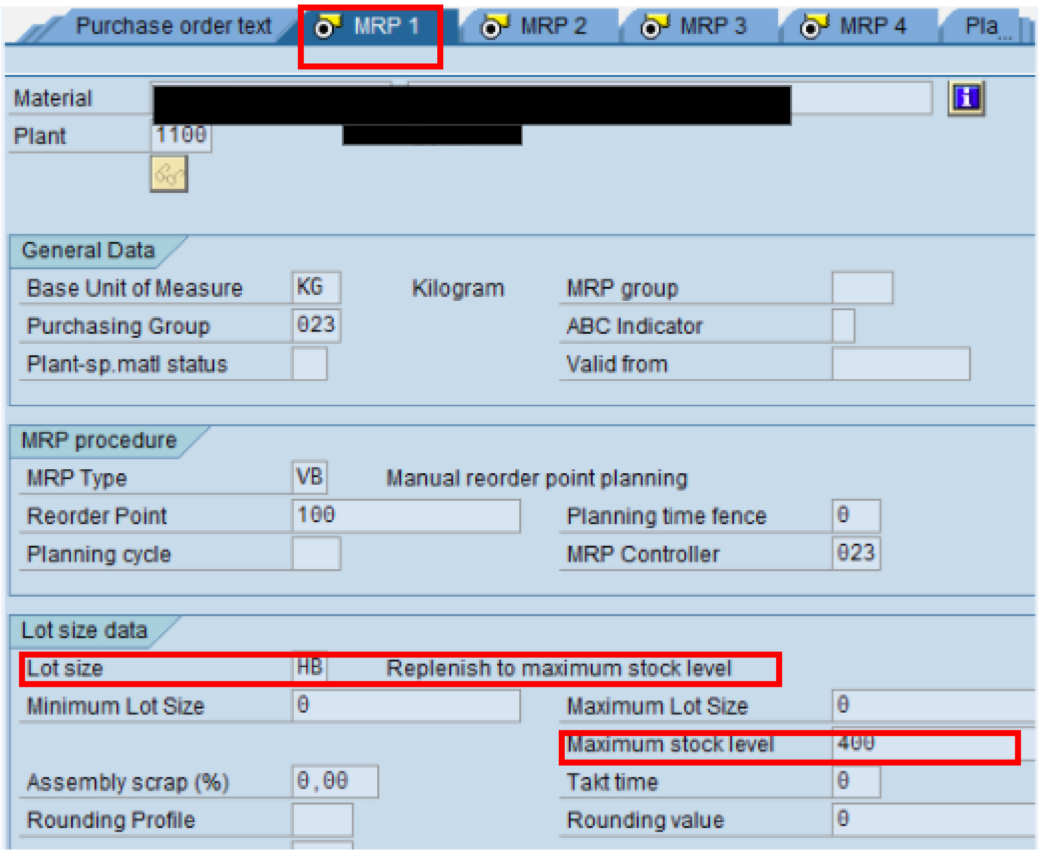


Figure 16. SAP material forecast total forecast MP38

After running demand forecast using the transaction code in Figure 16, the system then “use these forecast values to calculate the reorder level and the safety stock level, taking the *service level*, which is specified by the MRP controller, and the material’s replenishment *lead time* into account, and transfers them to the material master. Since the forecast is carried out at regular intervals, the reorder level and the safety stock level are continually adapted to the current consumption and delivery situation. This means that a contribution is made towards keeping stock levels low” (Help.sap.com

2017: reorder point planning). Therefore, to ensure the quality of ROP and Safety stock, replenishment lead time and service level need to be up-to-date in material master MRP review. As for the order quantity, if the stock is to be replenished to the maximum level, by giving the maximum order level, the order quantity is computed to bring stock back to that level, in this case, lot size is “HB”. These relevant settings are highlighted in Figure 17 below.



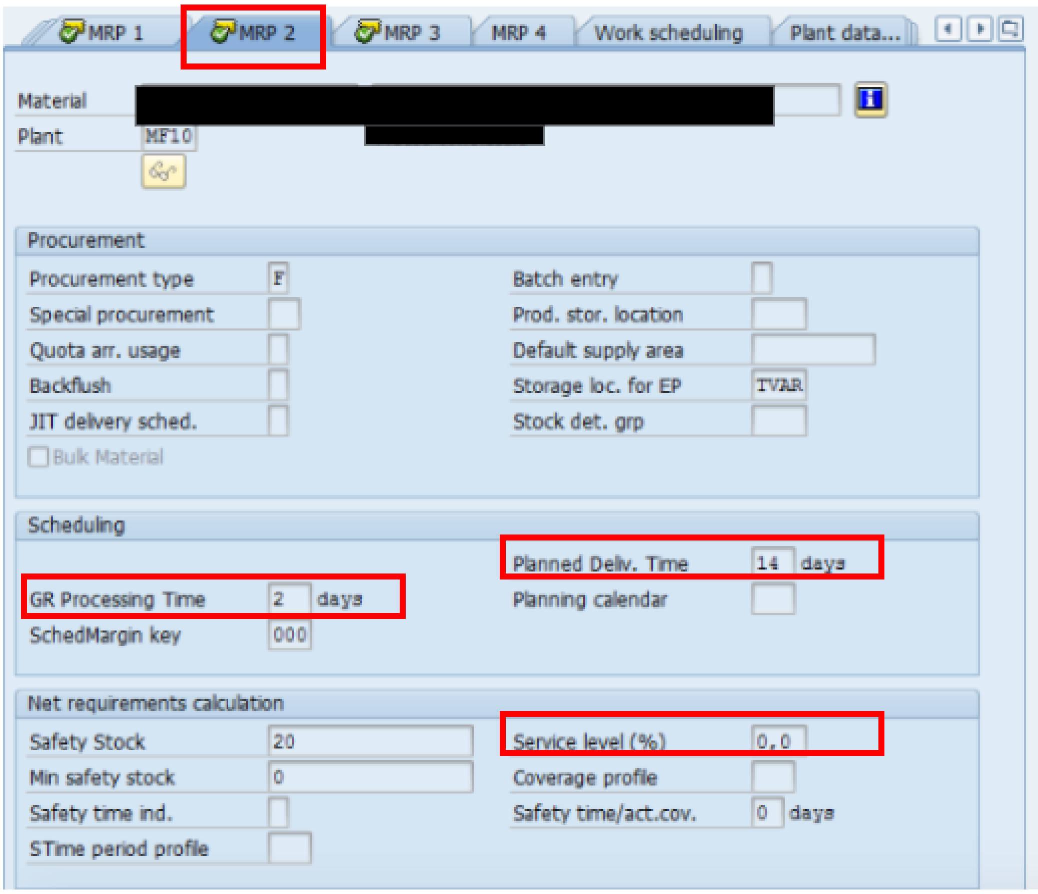


Figure 17. MPR settings in MRP1 and MRP2.

In Figure 17, MPR1 and MRP2 are views in material master. In MRP1 view, lot size setting and maximum stock level is under lot size data, these two settings affect how order quantity is calculated. In MRP2 view, planning delivery time and GR processing time are under scheduling. Planning delivery time is the total lead time from the issue of an order to the arrival of the goods. GR processing time is the processing time of goods receipt. Service level in percentage is found under net requirement calculation.

The manual method using excel starts from exacting past consumption data from SAP. One of the transaction codes for this execution is MCBE, where *valuated stock issued quantity* can be computed based on specific time period, plant, storage location and materials (Edv-buchversand.de. 2017). Then, average monthly demand is calculated by two methods, moving average or exponential smoothing. Moving average is more commonly used due to its simplicity, therefore it is recommended for this study.

After calculating *average monthly demand* from past consumption data, the next critical step is to calculate re-order point (ROP), order quantity and safety stock. As seen in the green bubbles, ROP is calculated using formula F1 or F3 from conceptual framework. If ROP is accompanied by planning time cycle such as in periodic review, a planning cycle is to be specified. According to existing knowledge in chapter 3.4.2, an emerging order point (EOP) is also important when inventory review is not conducted continuously. The general guideline for setting EOP is formula F4. As for order quantity, this requires max stock level, which can be calculated by formula F5, order quantity then equals to max stock level subtracted by existing stock and ordered quantity based on formula F6. The formula for safety stock is either F7 or F8 in simple manner or F9. King's formula F9 is recommended as it takes in account service level and demand variation.

5.7 Summary of the Draft Proposal

This draft proposal was driven by the aim to improve the weaknesses identified in the current state analysis. The remedies for treating the weaknesses were identified from existing knowledge and then extended with the stakeholder input (from data 2). Table 10 shows how the weaknesses identified from the CSA were addressed and how they are transformed by the proposal.

Table 10. Comparison of the current state and the proposal.

	Current Inventory Managment for MTS Product	Proposed Invent Management for MTS products
Inventory Category Management	-All A products are treated equally regarldess consumption or cost, not further classified	-The current A products (the actual make-to-stock products) are categorized into A, B, C, or D through the analysis of their value and demand. A is the primary, B is secondary, C and D are less important.
Inventory control System	-Continuous review applied for all products -Periodic review is not adopted.	-Continuous review (closest monitoring) ONLY applied to the primary products such as A -Periodic review (less frequent monitoring) applied to secondary, lower valued products such as C and D
Replenishment process	-ERP demand forecasting is not explored and utilized. -New purchase order is not fully automated -No standard process nor guideline for safety stock setting or management	-Demand forecast feature found in the ERP system. -Based the proposal, by setting up MRP parameters properly in ERP system, new purchase order creation can be fully automated. -Both simple and sophisticated safety stock formulas are proposed. The latter takes into account service level.

As seen from the Table 10, the draft proposal targeted the main weaknesses from the same three main subjects addressed in conceptual framework, specifically, inventory category management, inventory control system and replenishment process. Improvements are seen from each subject. For instance, the proposal turns the current "A" products (MTS products) into new ABC groups by given criteria, shrinking the amount of A products and shifting focus to the real A products, which facilitates decision making on inventory value reduction. Furthermore, with many SAP features related to inventory control being currently ignored, this proposal provides a practical guideline on how to explore and utilize these features, for example, the *MRP types* for configuring the type of inventory control system, and the demand forecasting feature that can compute re-order point (ROP) and safety stock level automatically. All in all, the proposal introduces the best practices about inventory management from theories to the real-life context, which can be applied to MTS products in general, not limited to one business unit or one product type. In the next section, this draft proposal is tested and validated.

6 Validation of the Proposal

This section validates the draft proposal developed in section 5. A testing was done by following the flow chart 1, the testing result was presented to the top management for final evaluation. Firstly, *overview of validation phase* discusses the steps used for the testing. Secondly, *testing the proposal* shares the results of the testing. Lastly, *summary of the validation* including feedback from the stakeholder is discussed.

6.1 Overview of Validation Phase

Due to the time constraint, only the manual method in draft proposal was tested in Excel. The purpose is to validate the proposal, unleash the potential benefits and discover challenges. The validation was conducted by the steps in Figure 18.

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Extract Data from SAP to Excel	Clean Up Material List	Do ABC analysis	Assign MRP Type	Forecast Demand	MRP paramters	Summary of Report
-Masterial list (SQ1) -Consumption in past 12 months (MCBE)	-Filter ZM01, A products -Removing testing products -Remove obsolete products -Exclude products created after 2017	-A: 80% cost 80% demand (12m) -B: 80% cost 20% demand -C: 20% cost 80% demand -D: 20% cost 20% demand or -A: 70% cost * past 12m consumption -B: 20% cost * past 12m consumption -C: 10% cost * past 12 m consumption	-A: VB (manual ROP) -B: VB (manual ROP) -C: R1 (time based planning) -D: R1 (time based planning)	-Calculate average consumption of past 12m using moving average	Safety stock: -Use formula F9 ROP: -Use formula F3 Max stock level: -Use formula F5 Planning cycle: only for R1 -365/(Annual consumption/MOQ) -or manually define Lot size: -Lot size "HB", replenish to max	-Number of materials by new A, B, C -'Saving from SS

Figure 18. Validation phases of the draft proposal.

As seen from Figure 18, validation phase consisted of 7 steps corresponding to the flow chart in draft proposal. *Step 1*, the necessary data were first extracted at once from Excel, this includes a list of full inventory SKUs (tcode: SQ01) and a list of the past 12-months consumption at individual SKU level (tcode: MCBE). *Step 2*, referring to Flow Chart 2 in section 5, the raw data was cleaned up to leave only current make-to-stock product, this step involved filtering only MRP Group:ZM01 and ABC indicator: A, removing testing products with “-Z” suffix, removing obsolete products and excluding products created after 2017, the concern is over insufficient consumption data for products created after 2017, which may affect the quality of the testing results. *Step 3*, two ABC analysis methods suggested in Flow Chart 2, they were both tested in Excel. *Step 4*, each SKU was assigned to a MRP type as listed in Flow Chart 3, this was done by creating an excel column titled MRP type, MRP type VB is for A, VB or R1 for B, R 1 for C and D. *Step 5*, the past 12-months consumption was averaged to get the fore-casted average monthly demand for the future. *Step 6*, MRP parameters were calcu-lated using relevant formula suggested in Flow Chart 4, the columns were added to store parameters of safety stock, re-order point (ROP), Max stock level, planning cycle and lot size respectively. *Step 7*, pivot table report was used in Excel to summarize the results of ABC categorization and saving from safety stock. Figure 19 shows the main columns of results visible in Excel testing run.

ABC Categorization		Assign MRP Type		Define MPR Parameters									
Current ABC	New ABC	Current MRP Type	New MRP Type	Forecasted average monthly demand	Current Safety Stock	New Safety Stock	Current ROP	New ROP	Current Planning Cycle	New planning cycle	Current Max stock	New Max Stock

Figure 19. Columns of the results for testing.

As shown in Figure 19, the first row indicates the three subjects in the draft proposal, to which the second row belongs. In the second row, the white columns show the current values, the green columns represent the new values. In other words, the green col-umns contain the results of the testing run in comparison with the current values in white columns. The whole testing results are presented in the following three sections.

6.2 Testing of Inventory ABC Categorization

As described in step 3 in validation phase, ABC analysis or categorization were tested by two criteria, the results differ as shown in Figure 20.

Category	Total No.	Percentage	Previous	Criteria
A	1	0,1 %	1078	80% cost / 80% demand
B	182	16,9 %	0	80% cost / 20% demand
C	182	16,9 %	0	20% cost / 80% demand
D	713	66,1 %	0	20% cost / 20% demand

Category	Total No.	Percentage	Previous	Criteria
A	110	10,2 %	1078	70% usage value
B	158	14,7 %	0	20% usage value
C	810	75,1 %	0	10% usage value

Figure 20. Two ABC analysis for testing.

As seen from Figure 20, the blue and green tables represent the different results of ABC analysis by giving different criteria. The base data contains total 1078 SKUs under current A category. In the blue table, only one SKU is classified as A. On contrary, in the green table, there are 110 A products, that is equivalent to 10,2% of total SKUs. B products and C products are 14,7% and 75,1% respectively in numbers of SKUs. The green table appeared to produce relatively more reasonable result. Therefore, the further testing was following the classification in the green table.

6.3 Testing of Assigning MRP Type

Following the results of ABC categorization, the respective MPR types were assigned to individual SKUs in Excel in Figure 21.

Material	Decription	Current ABC	New ABC	Current MRP Type	New MRP Type
SKU1	description 1	A	A	PD	VB
SKU2	description 2	A	B	PD	R1
SKU3	description 3	A	C	PD	R1

Figure 21. Assigning MRP type for testing.

As seen from Figure 21, MRP type of new A products moved from PD to VB (manual ROP), that of B product moved from PD to R1 (time-based planning), same to C products.

6.4 Testing of Defining MRP Parameters

Testing of setting MRP parameters involved computing new safety stock, new planning cycle, new ROP and new maximum stock level for counting order quantity. Below Figure 22 shows only 3 SKUs of each ABC category for demonstration purpose. Total 1078 SKUs were analyzed.

						F9		F2		F3		F5
Material	Current ABC	New ABC	Current Service Level	Service Level	Current Safety Stock	New Safety stock	Current Planning Cycle	New Planning Cycle	Current ROP	New ROP	Current Max Level	New Max Stock Level >=
SKU 1	A	A	0,00	97 %	7	7,3	0	1	0	13	0	13
SKU 2	A	A	0,00	97 %	7	8	0	1	0	13	0	14
SKU 3	A	A	0,00	97 %	5	5	0	1	0	9	0	10
SKU 111	A	B	0,00	95 %	27	12	0	14	0	26	0	29
SKU 112	A	B	0,00	95 %	3	3	0	14	0	6	0	8
SKU 113	A	B	0,00	95 %	20	16	0	14	0	34	0	37
SKU 269	A	C	0,00	90 %	2	1	0	28	0	3	0	4
SKU 270	A	C	0,00	90 %	3	3	0	28	0	6	0	9
SKU 271	A	C	0,00	90 %	270	51	0	28	0	227	0	289

Figure 22. Setting of MRP parameters for testing.

As seen from Figure 22, the green columns highlight the new value of MRP parameters. On top of each green cell is the formula used to calculate the value. The formulas are mentioned in conceptual framework. For example, the *new safety stock* level was calculated by King 2011's formula F9 when variability in demand exists.

$$Safety\ stock = Z\ x\ \sqrt{\frac{LT}{DP}}\ x\ \sigma_D \text{ (King 2011, P34)}$$

During this testing, the service level was set at highest 97% for A products, 95% for B products and 90% for C products, the equivalent Z scores are 1,88 / 1,65 / 1,28. LT is the total lead time in days, and DP is demand cycle in days which is 30-days in this case. σ_D is the standard deviation of consumption in the past 12 months.

Figure 22 shows current planning cycle is not in place. In principle, new planning cycle should be defined according to formula F2 in conceptual framework: review intervals=total yearly purchase / discount quantity. However, this formula was not used during the testing. There are two reasons, the first reason is not all products are offered discount by vendors based on certain order quantity, the second reason is the discount quantity data is not properly maintained in the current ERP system where only single base price is stored for a product. Thus, the new planning cycle was set as 1 day for A, 14 days for B and 28 days for C. Planning cycle of 1 day makes inventory review system literally a continuous review system and it is needed to calculate re-order point (ROP) and other parameters.

Current ROP, as seen from Figure 22, is not in use either. The new ROP is calculated using Formula F3 in conceptual framework:

ROP or MIN= (Demand x lead time) + Safety stock + review period stock level.

The demand is average daily demand. The review period is equivalent to the new planning cycle.

In Min-Max system, max stock level is required to calculate the order quantity. Figure 22 shows current max stock level is not in use. To calculate the new max stock level, Formula F5 was used:

MAX stock level ≥ ROP or MIN stock level + review period stock level

For testing purpose, Max stock level was set equal to ROP+ period stock level. The problem of this formula is, MAX stock level should be no lower than ROP plus review period stock level, it is not clear what exact level the max stock level should be. Furthermore, if the review period is short as 1 day and demand is lower than 1 piece per day, there is no significant difference between Max and Min as seen from SKU1, where the roundup of Max is equal to Min, which made calculating order quantity almost impossible. As suggested by Wrye, M. (2011), a simple formula perhaps can be used, although further testing and reasoning is needed.

$$Max = Min + (Min/2)$$

After the testing, the max stock level appears to be one of the challenges to tackle during future implementation.

6.5 Summary of Validation

The objective of this study is to minimize inventory value while maintain the service level. Therefore, the validation needs to reflect the saving of some kind. Figure 23 shows the summary of the testing results.

Category	Count of New ABC	Percentage of New ABC	Sum of Total annual usage value past 12m /a	Sum of Total annual usage value past 12m %	Sum of Saving on Safety Stock	Sum of Total current Safety Stock
A	110	10 %		70 %		
B	158	15 %		20 %		
C	810	75 %		10 %		
Grand Total	1078	1		100 %		
				Percentage Saving from Safety Stock	26 %	

Figure 23.The summary of testing results.

Figure 23 summarizes the results of new inventory ABC categorization, among the total 1078 inventory products, there are 110 A products, 158 B products and 810 C products, which account for 10%, 15% and 75% respectively. A products represent the largest 70% of total annual usage value, B products account for 20% and C products make up the least 10%. A saving of 26% was seen from saving stock alone, which is equivalent to the sum of saving on safety stock divided by sum of total current safety stock in value.

During the one-to-one discussion, this summary of testing results along with the draft proposal was shared with the key decision maker of the business unit. The discussion is recorded in Appendix 10. The purpose was to seek final validation and approval on the proposal. The feedback has been positive. According to the top management, the safety stock formula is interesting, different safety stock level can be adjusted by service level, the saving on safety stock is satisfactory and indicates that the framework serves its purpose of reducing inventory value. Although selling is important, reducing capital tied up to inventory is one of the key performance indicator in headquarter, it is the top management's goal. In terms of the overall of the proposal, the feedback from the top management has been positive:

> *"I like the idea very much. We know this is the right way we are supposed to do, and you make it with your own method. Good work. You should definitely go ahead with your proposal, finish the thesis and graduate. Please send me your thesis, I am interested to read it and check it. What shall we do next? Perhaps we can start from testing it in SAP testing environment." (Appendix 10, Director of Business Unit).*

As seen from the above feedback, the proposal was validated and given the greenlight to go ahead. An implementation plan was expected from the management. Therefore, an implementation plan is suggested in the following section along with the summary of the entire study.

7 Conclusions

This section summarizes this thesis study, addresses the practical implication of the proposed inventory management framework, and suggests the next steps towards implementation. The last section discusses the overall evaluation of the thesis.

7.1 Executive Summary

The objective of the thesis is to suggest an inventory management framework for make-to-stock (MTS) products that balances minimizing inventory value and maintaining service level, as there is excess amount of inventory yet a framework for properly managing inventory does not exist. The outcome is the inventory management framework. To reach the desired outcome, the study was conducted in the following steps.

The study starts with the search for *existing knowledge* that focuses on three main subjects: inventory category management, inventory control system and replenishment process. As a key component of supply chain management, inventory management is co-related with other functions. Refining inventory management is a process that balance inventory and inventory related functions to avoid sub-optimization and achieve a cost-effective total solution. Inventory category management suggests inventory should be segmented and therefore treated differently, as “one size fits all” inventory planning may result in high cost or low stock availability. Then the type of inventory control system determines how inventory in each category should be reviewed, whether continuously or periodically. Inventory replenishment process starts with demand forecasting and followed by supply planning, supply planning involves three replenishment parameters: when to order, how much to order and how much safety stock to maintain. The formulas that calculate these parameters were studied and reviewed. The outcome of the existing knowledge is the conceptual framework.

Next, based on the best practices from existing knowledge, the *current state analysis* was conducted on the same three areas: inventory categorization, inventory control system and replenishment process. Interviews were arranged with purchasers, logistics manager and senior management. In all the three areas, both strengths and weaknesses were identified and listed. Over thousand make-to-order products are simply categorized in only one category regardless the value and demand. A “one size fit all” inventory control system is applied to all these products. Demand forecasting is not being used to configure replenishment parameters in the ERP system, re-order point

(ROP) is also not in use, while safety stock is mistakenly used as ROP and calculated without a standard formula. The outcome of the current state analysis is the summary of strengths and weaknesses of the current inventory management.

The *draft proposal* focused on the weaknesses of the current state and adopted the methodology from the conceptual framework to tackle these weaknesses. The proposed framework starts with inventory categorization, followed by selection of inventory review policy, and finished with defining replenishment parameters. The framework aims for overall saving from inventory by defining the right time to replenish, the right amount to replenish and the right safety stock. Particularly, the amount of safety stock takes service level into calculation, thus, specific service level can be maintained.

In addition, the relevant configurations in SAP were also studied. Without the configuration in SAP, changes do not happen. As a result, the draft proposal is a flow chart that contains three steps, from inventory categorization to assigning inventory control system (MRP type in SAP) to defining replenishment parameters, each step point to the settings in SAP. Moreover, the draft proposal was presented to purchasers, logistics managers and senior management for feedbacks and improvements.

The proposal was *validated* through testing. The testing results along with the proposal were presented to the top management for validation of the case company. The feedback was positive. Serious interest was aroused during the one-to-one discussion. The proposal received support from the top management, who wished to know the next steps how to put the plan into practice.

Moreover, the summary of benefits and challenges of the framework listed in Table 11 were shared with the top management who acknowledged the same.

Table 11. Benefits and challenges of the proposed inventory management framework.

Benefits of the Framework:
-Holistic solution that avoids sub-optimation -Saving on safety stock (testing result 19% -26% saving) -Potential saving on logistics cost by less frequent ordering on low value products -Potentially fully automate purchase -Increase efficiency by leveraging SAP forecasting -Increase customer satisfaction by focusing on important products
Challenges to Note:
-Implementation complexity in SAP -ABC category, ROP, Max, Safety Stock are not static but dynamic, monitoring and adjustment required -New product ABC categorization and demand forecasting

As seen in Table 11, the framework brings numerous benefits to the company, not only in terms of cost saving, but also for productivity and efficiency improvement.

7.2 Next Steps and Recommendations towards Implementation of the Proposal

Following the endorsement from top management on the proposal, the following immediate steps are suggested in Table 12 as a guideline for implementation.

Table 12. Next steps for implementation.

Steps	Owner	Participants
Step 1: select 1st group of products for piloting (approx. 10% of all) -Keep current ABC indicator unchanged. -Reconfigure only MRP type, re-order point, planning cycle, lot size, safety stock -Set timeline and KPI for piloting (eg. 1 month as timeline, stock level, availability, no. of PO as KPI) -Carefully monitor events in SAP daily -Final reporting on the 1st pilot project	To be confirmed	1.Purchasers 2. SAP team
Step 2: select 2nd group of products for piloting (approx. 50% of all) -Keep current ABC indicator unchanged. -Reconfigure only MRP type, re-order point, planning cycle, lot size, safety stock. Take in the observation from Step 1 and adjust configurations or formulas if needed. -Set timeline and adjust KPI if necessary. -Carefully monitor events in SAP daily -Final reporting on the 2nd pilot project	To be confirmed	1.Purchasers 2. SAP team
Step 3: fully implement to 100% products -Run ABC analysis on 100% products and assign new ABC indicators. -Configure MRP type for all products -Configure re-order point, plannint cycle, lot size, safety stock for all products.	To be confirmed	1. Top management 2. SAP team 3. Purchasers 4. Product managers 5. Sales & Marketing 6. Others

The above Table 12 contains the concrete actions, ownership and participants of each step. As suggested by the senior management, the implementation can be started with a small group of products first before rolling out to all products especially in SAP (Appendix 9, Aftersales director). Step 1 starts with approximately 10% of all products. Following the success of Step 1, Step 2 expands the testing to approximately 50%-70% of all products. Step 3 implements to 100% of all products.

In addition to the immediate next steps in Table 12, the following Table 13 suggests the full implementation plan particularly for Step 3 – fully implement to 100% products. The customized plan adopts the concept of PDCA (plan-do-check-adjust) cycle, as PDCA is a management method for continuous improvement, and inventory management is a continuous improvement project.

Table 13. Full implementation plan.

1. Plan: build concrete implementation plan
-Plan targets/objectives, planned budget, resources, duration, KPI, roles and responsibilities, risk prediction.
-Obtain approval from Top Management

2. Do: implement the plan
-Sequence actions and document processes
-Allociate resources, roles and responsiblities to individual level, delegate authorities.
-Arrange training
-Start actions

3. Check:
-Report weekly and monthly
-Collect feedback from operational staff
-Check KPIs
-Review training needs

4. Adjust:
-Adjust the plan

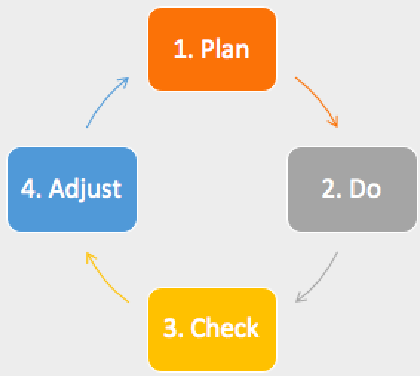


Table 13 shows that the full implementation plan consists of four steps in a PDCA cycle. The practical actions of each step are also listed and can be refined. This circular plan provides a standardized method for continuous improvement and fosters teamwork. The successfully implementation, however, requires top management's support and enforcement.

7.3 Thesis Evaluation

Combination of reliability and validity, as well as possible other criteria such as relevance, rigor, logic etc, provide scientific proof to the quality of research. Reliability and validity are the most typical requirements for any acceptable, relevant research. To evaluate how reliable and valid the research process was in this study, both reliability and validity need to be tested.

Reliability in qualitative research relates to key points of trustworthiness and authenticity of research. Reliability measures if a finding or data is free from error and consistent results can be achieved following the same procedure or using the same methodology. Concept of reliability consists of two dimensions, repeatability and consistency (Zikmund 2003: 300). Repeatability requires research procedure to be elucidated and well documented, in this way, any other investigators can repeat the research. Consistency means ensuring that any external investigator following the documented procedure, should receive the same results or reach the same conclusions. The objective of reliability is to eliminate biases and ensure accuracy in the research process and results. One way to increase reliability of a case study is to maintain logical chain of evidence (Benbasat et al.1987; Yin 1994).

To evaluate the reliability of this study, the processes and methods of data collection and data analysis were discussed and approved by stakeholders in the early stage, each process was documented, so that other researchers can replicate the research in the exact same way. Additionally, the proposal was built against the theoretical background and best practice, and proved relevant to the context of the case company in discussions and interviews with different participants.

Validity is defined as "the extent to which [a test] measures what it claims to measure" (Gregory 1992: 117). In other words, validity provides a proof whether a study measures what it claims. In qualitative research, validity ensures that the tools used, as well as findings and data are accurate. As such, validity of a study requires multiple sources of evidence. Moreover, validity needs to be performed continuously, not in one single instance. Many researcher stress that reliability is essential but not sufficient condition for validity, a reliable study does not mean valid, but a valid study must be reliable at the same time.

To evaluate the validity of this study, stakeholders of the case company not only endorsed the research design and the authenticity of the collected data, and reviewed data analysis methods, but also tested the relevance and logic of the proposal building to ensure it is in accordance with the objective.

In addition, some researchers also stress the need for relevance and logic as part of ensuring a rigorous study.

Logic means "cause-and-effect explanation of an action, decision, event, phenomenon or solution" (BusinessDictionary.com 2017). In this study, the logic was ensured by the steps illustrated in research design diagram and logical chain of evidence.

Finally, relevance means the study is connected to issues or problems in real-world. (Concepts L 2013). In this study, the relevance was treated as part of the reliability and concentrated on ensuring the fit between the objective and the outcome.

References

Agrawal, P. (2016). SAP MM Consumption-based MRP. 1st ed. PHI Learning Pvt. Ltd., 2016.

Benbasat, I., Goldstein, D. and Mead, M. (1987). The Case Research Strategy in Studies of Information Systems. MIS Quarterly, 11(3), p.369.

Brink H.I.L. (1993). Validity and Reliability in Qualitative Research. Curiatonis, 16 ed. (2), 1

BusinessDictionary.com. (2017). What is logic? definition and meaning. [online] Available at: http://www.businessdictionary.com/definition/logic.html [Accessed 23 Apr. 2017].

Concepts, L. (2013). Relevance Definition. [online] The Glossary of Education Reform. Available at: http://edglossary.org/relevance/ [Accessed 23 Apr. 2017].

Crocker, L., and Algina, J. (1986) Introduction to Classical and Modern Test Theory, Harcourt Brace Jovanovich College Publishers: Philadelphia

Douissa, M. and Jabeur, K. (2016). A New Model for Multi-criteria ABC Inventory Classification: PROAFTN Method. Procedia Computer Science, 96, pp.550-559.

Dubé, L. & Paré, G., 2003. Rigor in Information Systems Positivist Case Research: Current Practices, Trends, and Recommendations. MIS Quarterly, 27(4), pp.597–635. Available at: http://www.jstor.org/stable/30036550.

Edv-buchversand.de. (2017). [online] Available at: http://www.edv-buchversand.de/chapter.php?cnt=getchapter&id=gp-108.pdf [Accessed 17 Apr. 2017].

Gregory, R. J. (1992). Psychological testing: history, principles, and applications. Boston, Allyn and Bacon.

Help.sap.com. (2017). Reorder Point Planning - SAP Documentation. [online] Available at: https://help.sap.com/saphelp_erp60_sp/helpdata/en/56/97b6535fe6b74ce10000000a174cb4/content.htm [Accessed 15 Apr. 2017].

Help.sap.com. (2017). SAP Library - Creation of the Demand Forecast. [online] Available at: https://help.sap.com/saphelp_scm700_ehp03/helpdata/en/ef/3bc95360267614e10000000a174cb4/frameset.htm [Accessed 15 Apr. 2017].

Help.sap.com. (2017). SAP Library - Forecasting (LO-PR). [online] Available at: https://help.sap.com/erp2005_ehp_05/helpdata/EN/43/6db6531de6b64ce10000000a174cb4/frameset.htm [Accessed 15 Apr. 2017].

King, P. (2011). Crack the code: understanding safety stock and mastering its equations. APICS - The Performance Advantage. 21(4) 33-36.

Miles, MB. & Huberman, AM. (1994). Qualitative Data Analysis (2nd edition). Thousand Oaks, CA: Sage Publications

Muller, M. (2011). Essentials of Inventory Management Second Edi., AMACOM.

Murphy, P. and Wood, D. (2014). Contemporary logistics. 1st ed. Harlow: Pearson, pp.137-156.

O'Brien, J. (2009). Category management in purchasing : a strategic approach to maximize business profitability, Kogan Page.

Ravinder, H. & Misra, R.B. (2014). ABC Analysis For Inventory Management: Bridging The Gap Between Research And Classroom. American Journal Of Business Education – Third Quarter, 7(3), pp.257–264.

Rushton, A., Croucher, P. & Baker, P. (2011). The Handbook of Logistics & Distribution Management. Kogan Page.

Russell, R. and Taylor, B. (2011). Operations management creating value along the supply chain. 1st ed. Hoboken, New Jersey: John Wiley & Sons.

Sezen, B. (2006). Changes in performance under various lengths of review periods in a periodic review inventory control system with lost sales: A simulation study. International Journal of Physical Distribution & Logistics Management, 36, pp.360–373.

Thomopoulos, N. (2015). Demand forecasting for inventory control. 1st ed. Springer International Publishing.

USAID (2011). The Logistics Handbook: A Practical Guide for the Supply Chain Management of Health Commodities. Published by The U.S. Agency for International Development. Available from: http://apps.who.int/medicinedocs/documents/s20211en/s20211en.pdf

Woodside, A. and Wilson, E. (2003). Case study research methods for theory building. Journal of Business & Industrial Marketing. Vol. 18 (6/7), 493-508.

Wrye, M. (2011). Don't Over Complicate the Formula. [online] Beyond Lean. Available at: https://beyondlean.wordpress.com/2011/10/12/dont-over-complicate-the-formula/ [Accessed 20 Apr. 2017].

Yin, R. K. (1994). Case study research: Design and methods (2nd ed.). Newbury Park, CA: Sage Publications.

Zikmund, W. (2010). Business research methods. 1st ed. Mason, OH: South-Western Cengage Learning.

Data 1: Field note 1 for interview with logistics manager.

Date	11/10/2016
Name (code) of the informant	MTSJS
Position	LOGISTICS MANAGER
Duration	NA

Subject	**Questions**	**Answers**
Current inventory categorization	What are inventory products? Can I have a list of all inventory products?	You may get the list from helpdesk. If you receive it from helpdesk, that's good, please also show it to me.
Current inventory categorization	What are current types of inventories?	Inventory product is only ZM01 A products and safety stock should be always in place. ZM01 B are those products we keep in stock for reasons such as bulk purchase, delivery time constraint etc, but they are not inventory product in that sense, we don't promise our customers that they are available in our warehouse. Thus, inventory product is only ZM01 A
Current Replenishment process	What is current purchasing process?	Purchasing process is in our logistics memo.

Data 1: Field note 2 for interview with aftersales director

Date	18/01/2017
Name (code) of the informant	MTSAM
Position	Director
Duration	NA

Subject	**Questions**	**Answers**
Current inventory category	How is a product classified as make-to-order or make-to-stock product? what are the considera-tions	When considering the ABC classification, it is always a promise to the end user. If the class is A it means that the product is stocked and should be always available. This decision is done by product managers together with sales people. The other option of selecting something to be used as stocked product is for reasons of transportation costs. If the product is of small size and low cost, it is normally economically smart to buy it always in batches even if the need is just for one at a time.
Current replen-ishment process: safety stock	How is safety stock level determined and by whom?	Safety stock determination and manage-ment should be done by purchase people (see attached slide where the situation is explained. It is in Finnish but I think you understand it any-way, right?).
Current replen-ishment process: safety stock	How is safety stock managed or updated later on and by whom?	By purchaser.
Current Inventory control system	How is MRP type determined in SAP?	I do not know the other MRP-types, they are not in use in the company, but in some other Group companies. This is one part of the 'complicated process' I men-tioned in previous email. I think that there would be plenty of options for doing automated or semi-automated material procurement in MRP but the problem was that none of the consultants ever showed us how they are working so we are using the one we chose in the start, which means PD that is work-ing related to Safety stock, Minimum order lot and Planned Delivery Time.

Replenishment process	As far as you know, what are existing practices used to reduce inventory? pros and cons?	We have done some rounds of mass optimization when I was i charge, meaning that I used excel for calculation of average consumption and then reset the safety stock levels accordingly. There is no repeating procedure to do this.
Replenishment process	Have you tried or considered automating purchase order for MTS products by configuring re-order-point and economic order quantity in SAP? If yes, what is your opinion?	re-order-point and economic order quantity in SAP? If yes, what is your opinion? This is in use for own production (Manufacturing unit). It has been used for some time and it is mainly working ok, but it is still creating some extra manual work because the delivery times of our sales orders are constantly changing and the automatic setup is quite 'strict'. For example if the original order is for 15.5. for 5 pieces, the automated purchase order is created ok. But if after the order is made the original shipping date is moved to 10.5. the automatic purchase program creates a new purchase order, because the original is arriving too late.

Data 1: Doc. wholesale inventory product control

Wholesale inventory product control (English translation)

Logistics / Purchasers control	AMG / Product Managers Control
MPR Group -ZM01=make-to-stock product -ZM02=make-to-order product **Safety Stock** -Desired available quantity in warehouse for inventory product **Minimum lot size** -Order requisition amount -ZM01 = make to stock -ZM02 = make to order **Planned delivery time** -Total delivery time from order issue to goods receipt Goods receipt time = GR time -Warehouse reserved unloading time	**A-product=make-to-stock product or inventory product** -Always ZM01 -Safety stock always >0 -A product availability to be monitored -AMG meeting or product managers decide on A products **B-product=optional product** -Usually ZM02, can be also ZM01 -Safety stock by default is 0, minimum lot size can de due to logistics reasons. -AMG decides on B selection **C product=project product** -Wholesale purchase make-to-order products from group suppliers. -Can be inventory product exceptionally (for exam-ple, big chain customer's orders)

Updated on 06.03.2017

Original document in Finnish

Logistiikka / Ostaja ohjaa

- MRP Group
  - ZM01 = Varasto-ohjautuva
  - ZM02 = Tilausohjautuva
- Safety Stock
  - Saatavilla olevan saldon tavoitemäärä varastoitaville tuotteille
- Minimum lot size
  - Tilauseräehdotus
  - ZM01 = Varasto-ohjautuva
  - ZM02 = Tilausohjautuva
- Planned delivery time = PDT
  - Oletettu toimitusaika ostotilauksesta meidän varastoon
- Goods Receipt time = GR-time
  - Varaston vastaanotolle varattu puskuri

AMG / Tuotepäällikkö ohjaa

- A-tuote = varastoitava tuote
  - Lähtökohtaisesti aina ZM01
  - Lähtökohtaisesti aina safety stock >0
  - Seurataan A-saatavuus listalla
  - AMG / tuotepäällikkö määrittää A-tuotteet
- B-tuote = valikoima tuote
  - Normaalisti ZM02, voi olla myös ZM01
  - Safety stock oletusarvoisesti 0, minimum lot size voi olla logistisista syistä.
  - AMG päättää B-tuotevalikoiman
- C-tuote = projektituote
  - Tukkumyynnin oston ostama tilattava koodattu tuote, ryhmätoimittajalta.
  - Voi olla varastoitava poikkeussyin (esim. ison ketjuasiakkaan menekkituote)

Tuoteluokituksen nimiä ei vielä hyväksytty
(käsitellään MMT/AMG 2015)

Data 1: Field note 3 for interview with purchasers

Date	30/01/2017
Name (code) of the informant	MTSPUR
Position	Purchasers
Duration	NA

Subject	**Questions**	**Answers**
Replenishment process	What is the strength of the current replenish-ment process of A products? (what is good?)	Answer 1: 1. It is semi-automatic. SAP automatically generate purchase request when safety stock falls short. Purchaser can simply drag and drop PR to turn it to a new pur-chase order. 2. It does take into account future out-bound orders. 3. Supplier has been pre-set. Answer 2: Sap creates automatically purchase requi-sitions for stock items (the earlier system did not). The requisitions take into account the delivery time and the safety stock. It is a simple and easy system.
Replenishment process	What is the weakness of the current replen-ishment process of A products? (what should be improved?)	Answer 1: 1. Purchase needs to manually decide when to order, how much to order to save logistics cost or get discount from supplier 2. Purchase request date does not take into consideration realistic lead time 3. Containerized shipment reduce logistics cost, but bring in unnecessary stock, es-pecially when demand quantity is lower than container loading quantity. Container-ized shipment is mainly ordered manually. 4. A new purchase request is generated whenever safety stock falls short, which leads to multiple separate purchase re-quests, purchaser needs to manually con-solidate these purchase requests. Answer 2: - The current system does not automati-cally calculate the average demand of items based on the history data when cre-ating the purchase requisitions. This is why sometimes the pur. reqs may come too late, so you have to check the A prod-uct situation also manually for popular products. - There is a lack of a simple list of all cur-rent A products per vendor, which would

		be useful when checking the quantities manually for PO's of A products.
Replenishment process	What strategy have you used to reduce A products inventory? Pros and Cons?	Answer 1: 1. Monitor MB52 inventory value. Sort by descending to identify highest contribu-tors, order less for future if necessary. Answer 2: -minimizing lot size Answe 3: -Reduced the amount of safety stock. The inventory diminish, but there might be something out of stock more often. Answer 4: - Regular follow-up of stock quantities by function MB52 and reduction of safety stocks of some items if needed.
Replenishment process	What do you update regularly? (multiple selection)	Answer 1: Safety stock, Planned delivery time Answer 2: Safety stock Answer 3: Safety stock Answer 4: Safety stock, Planned delivery time

Replenishment process	How often do you adjust safety stock?	Answer 1: Sometimes Answer 2: Sometimes Answer 3: Sometimes Answer 4: Sometimes
Replenishment process	How do you calculate the amount of safety stock?	Answer 1: 1-2 x consumption Answer 2: (Max consumption-average consumption)* lead time Answer 3: Generally average monthly consumption multiplied 1- 1,5 with some exception, subject to delivery time or some other special agreement. Answer 4: In general, the average demand for a period of approximately one month. There are also exceptions (for example for expensive units or units with a very short lead time).

Data 1: Field note 4 for interview with aftersales director.

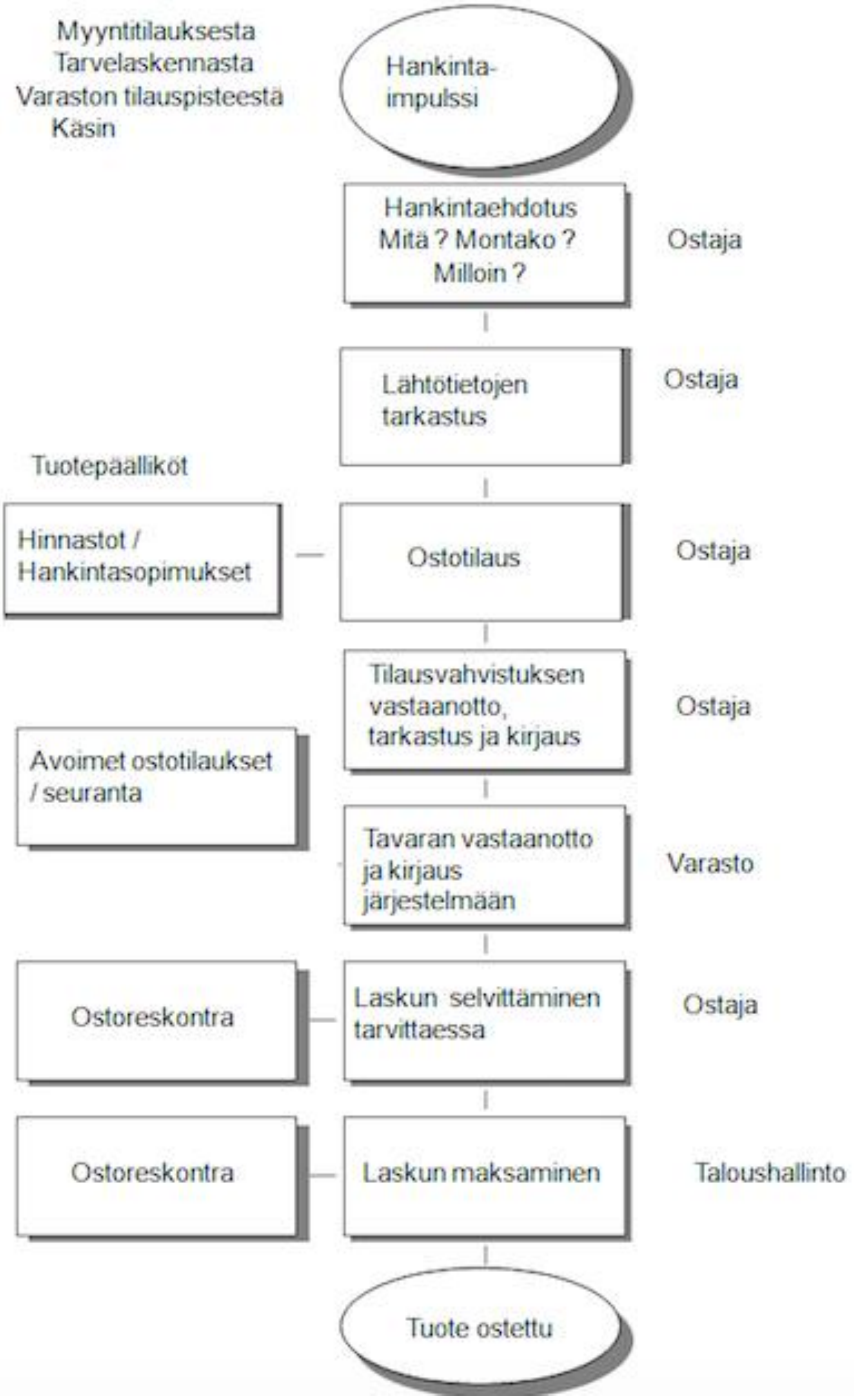
Date	22/03/2017
Name (code) of the inform-ant	MTSAM
Position	Director
Duration	NA

Subject	**Questions**	**Answers**
Demand Forecasting	Do we have demand fore-casting process in place? If yes, can you describe it briefly? If not, why not?	No, we do not have any external or au-tomated demand forecasting process. The process is fully related to purchase person being active and following the trends and open orders in SAP. For many of our products the demand is so unstable and fluxuating that it might not even work with an automate - but then again I guess there could well be a hun-dred or even more articles that have a quite constant flow and could be fore-casted better than today.
Demand Forecasting	For all equipments(not spareparts) in Wholesale, are demands of such inde-pendent or dependent? (I assume they are independ-ent, typically finished goods' demand is independent)	Relating to the table below, our demand is almost fully independent. Only things that could be considered dependent are the Chinese equipment (dependancy coming from the limit in purchase quanti-ty related to a container) and maybe something with our own production in Kerava where things are more economi-cal to be produced in batches.
Demand Forecasting	When a new product is added to our assortment, is there any initial demand forecast or anticipation? how is it done? eg. by ex-perience, hunch?	Your proposal is quite correct. If the product is something we do not previous-ly have, then the forecast is based on hunch/experience, normally that of the product manager. Of course if the situa-tion is so that we replace an existing product with a new similar featured prod-uct, then the demand can be forecasted related to the consumed quantities of the previous model.
Demand Forecasting	Do we do past consumption analysis on existing or old products?	Yes we have done it several times in bigger 'runs' with excel (I did it when I was responsible of purchase). But ac-cording to our instructions, this is also a process that should be done by purchase persons as part of their normal work. The consumption levels should be checked regularly and safety stocks / minimum order quantities adjusted accordingly.

Data 1: Doc. current purchasing process

Hankintaprosessi

Hankintaprosessin tarkoitus on hankkia asiakkaan tilaamat tuotteet oikea-aikaisesti, sekä huolehtia, että A-tuotteiden saatavuus on tavoitteiden mukainen. Prosessin omistaa logistiikkapäällikkö.

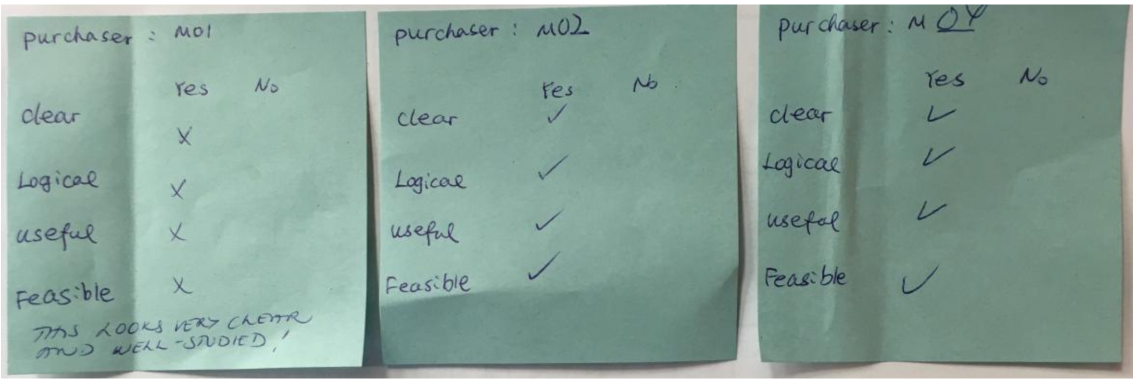


Data 2: Field note 5 for group discussion with purchasers.

Date	10/04/2017
Type of Data Collection	Group Discussion
Name (code) of the informant	M01, M02, M04
Position	Purchasers
Duration	13:00-13:30, 30mins

Subject	**Content**
Feedback on draft Proposal	Do you think the proposl clear, logical, useful and feasible? -M01: It is clear, logical, useful and feasible. This looks very clear and well studied. -M02: ABC analysis in this proposal is not new, we tried it before, but not sure why it didn't turn out, perhaps it is good to find out what happened before. Overall the proposal is clear, logical, userful and feasible. -M04: It is a ready proposal. Overall it is clear, logical, useful and feasible. Can you give one improvement suggestion? -M01: It would be good to giving one example using one product code in thesis. -M02: No, but I have some old materials regarding ABC analysis and inventory management if you are interested to read. -M04: No.

Original sticky notes:



Data 2. Field note 6 for 1-1 discussion with logistics manager.

Date	11/04/2017
Type of Data Collection	1-1 Discussion
Name (code) of the informant	MTSJS
Position	Logistics Manager
Duration	13:00-13:30, 30mins

Subject	**Content**
Feedback on draft Proposal	<u>So the ABC categorization you proposed is to categorize only the current A products right? How about other B,C products?</u> -Yes, so the current A products will be categorized into A, B, C by their value or importance. Because the A products are the "real" make-to-stock products. The current B, C under make-to-stock product group are actually not stock products, they are in the warehouse for reasons, for example, supplier's MOQ or reservation for certain big project. <u>How does ABC categorization affet our current operation?</u> -The idea of the new ABC categorization will affect the current purchasing process. The current replenishment or purchase process are the same for all stock products, but the new method suggests that different replenishment process with different parameters will be applied to different group of products. If the SAP method is fully adopted, purchasing process for stock products can be fully automated in the future. <u>What do you think about the proposal? do you think it is possible to bring it forward?</u> -It involves a lot of SAP knowledge, I cannot make comment on that, I need to talk to the manager who is familiar with SAP. I will arrange a meeting for that.

Data 2. Field note 7 for group discussion with director and manager.

Date	18/04/2017
Type of Data Collection	Group Discussion
Name (code) of the informant	MTSJS & MTSAM
Position	Logistics Manager and Director
Duration	10:00-11:00, 60mins

Subject	**Content**
Feedback on draft Proposal	-Your proposed ABC analysis is basically categorizing current A products into new ABC. The problem with this is, our definition of A is different from the theory, our A product means a commitment to our customers that they can take from our stock. It might be quite hard to change the mindset for many people in the company. Our A means make-to-stock from sales point of view, but we use the same ABC indictor for MRP field in SAP. -The critieria that define the importance of ABC require thorough consideration, value might not be the only or appropriate criterion. -You can definitely start with the excel manual method first. or You can start testing some products in SAP, configure them in the new way, and observe the changes. -Testing the whole idea in SAP might be challenging, testing environment is useful but limited. In real world, things are happening all the times, but it is not the case in testing environment, the data in the testing environment is static. Therefore testing environment cannot fully simulate the real world scenario. -I don't get the ROP idea though, we have safety stock, shouldn't it be the ROP? Why should ROP equal safety stock + lead time demand? Will it then increase our average stock value? -This proposal seems useful for spareparts unit since the demand is relatively stable and in large quantities, interesting to see how this idea work for spareparts unit. -Your propsal looks 100% feasible. I am positive about it. You should go ahead with this proposal

Data 3. Field note 8 for 1-1 discussion with business unit director.

Date	13/04/2017	
Type of Data Collection	1-1 Discussion	
Name (code) of the informant	MTSSK	
Position	Business Unit Director	
Duration	15:30-16:15, 45mins	
Subject	**Content**	
Feedback on draft Proposal & Final Validation	MTSSK: tell me about the safety stock calculation? Where did you get the formula? Show me how to calculate? What is the Z score? can you send me the link where you get the safety stock formula? -Here is the article that explains the safety stock formula, where you can see Z score is relevant to service level. I got it from MIT website. I will send you the link. MTSSK: The safety stock formula looks very interesting. We can set different service level for different products. For example, the service level of expensive products can be slightly lower while that of cheap products can be higher because we can afford to keep more of them in the stock. MTSSK: Explain the numbers on the testing report. MTSSK: The 26% saving on the testing results imply potential saving on overall stock value. Lowering the capital tied up to inventory is one of the very important performance indicator in our headquarter. MTSSK: The idea of this proposal is at strategic level. I like the idea very much. We know this is the right way we are supposed to do, and you make it with your own method. Good work. MTSSK: It seems there are many SAP features that are not in use. Have you tried those SAP transactions yourself? -I went to check whether I can access to those transactions and how they look like, but I haven't tested all the transactions in SAP yet. MTSSK: What shall we do next? Perhaps we can start from testing it in SAP testing environment. -Or we can start with computing the parameters in excel first and update the parameters in SAP and configure SAP properly. MTSSK: You should definitely go ahead with your proposal, finish the thesis and graduate. Please send me your thesis, I am interested to read and check it.	