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Implementing an MRP System in a Procurement Department

Case study: Cargotec Finland Oy

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Tässä opinnäytetyössä käsiteltiin SAP MRP -järjestelmän käyttöönottoa Cargotec Finland Oy:n hankintaosastolla nykyisen hankintajärjestelmän joustamattomuuden vuoksi. Työssä tutkittiin MRP-järjestelmän hyötyjä ja haittoja käytännön esimerkkien kautta sekä luotiin hankintaosastolle tarkistuslista järjestelmän parametrien muuttamiseen.

Järjestelmän käyttöönottoa varten valittiin testierä testattavia materiaaleja, jotka jaettiin kiinteissä erissä ja tarpeen mukaan ostettaviin. Kiinteissä erissä ostettaville materiaaleille määritettiin laskennalliset parametrit. Määritykseen käytettiin teoriatiedon perusteella soveltuvaa laskentakaavaa. Sekä kiinteissä erissä että tarpeen mukaan ostettaville materiaaleille määritettiin hälytysraja, jonka alituttua uusi ostopyyntö muodostuu automaattisesti. Tämän lisäksi osalle materiaaleista määritettiin laskennallinen varmuusvarasto, jotta vältytään varaston ehtymiseltä. Määritetyt materiaalien parametrit syötettiin MRP-järjestelmään laaditun ohjeistuksen mukaisesti. Materiaalien parametrien perusteella laskettiin teoreettiset säästöt uusien ostotilauksien määrien ja materiaalien ostoeräalennettujen hintojen pohjalta. Varastonarvon muutos laskettiin tyhjälle ja täydelle varastolle.

Tuloksena saatiin valituille materiaaleille parametrit ja ne syötettiin järjestelmään. Parametrien perusteella ostotilausten kustannukset vähenivät noin 72 prosenttia ja materiaalien ostokulut noin 12 prosenttia. Varaston arvon laskettiin kasvavan noin 3,5-11,3 % verrattuna nykyiseen. Tulosten lisäksi hankintaosastolle saatiin laadittua yksinkertainen tarkistuslista materiaalien parametrien muokkaamista varten.

Laskennalliset tulokset MRP-järjestelmän parametreista ovat yhtenäisiä teoriatiedon mukaisiin olettamiin. Tuloksia tulee kuitenkin tulkita vain suuntaa antavina, sillä osa laskelmien arvoista oli vain arvioitu. Lisäksi parametrejä muokataan operatiivisessa toiminnassa jatkuvasti, jolloin myös laskennalliset tulokset muuttuvat. MRP-järjestelmää voisi jatkojalostaa muun muassa muodostamaan ostopyyntöjen sijaan automaattisesti ostotilaukset, joka poistaisi manuaalisen työvaiheen kokonaan.

Asiasanat: materiaalinhallinta, mrp, hankinta

ABSTRACT

Tampereen ammattikorkeakoulu
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Implementing an MRP System in a Procurement Department
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The purpose of this thesis was to examine and to execute the implementation process of an MRP system in the procurement department at Cargotec Finland Oy due to the inflexibility of the current system. The aim was to explore the advantages and disadvantages of the MRP system through practical examples and to create a checklist for changing the system parameters. For this implementation, only a small batch of materials was chosen.

As a result, material parameters were defined and inserted into the MRP system. Based on the material parameters, the cost of purchasing orders for chosen materials decreased by 72 percent and the cost of purchased materials fell by 12 percent. The total stock value was calculated to increase a maximum of 11.3 percent compared to the current one. In addition, a simple checklist for modifying the material parameters was created for the procurement department.

The results should only be used as a guideline, as some of the values of the calculations were only estimates. In the future, the MRP system could be developed further into a more automated system.

Key words: material planning, mrp, procurement

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ABBREVIATIONS AND SYMBOLS

BOM	Bill of Materials
DOQ	Discrete Order Quantity
EOQ	Efficient Order Quantity
ERP	Enterprise Research Planning
FOQ	Fixed Order Quantity
FPO	Fixed Period Ordering
JIT	Just-In-Time
LFL	Lot-For-Lot
MOQ	Minimum Order Quantity
MPS	Master Production Schedule
MRP	Material Requirement Planning
PDM	Product Data Management
PO	Purchase Order
PR	Purchase Requisition
PRP	Production Requirement Planning
VMI	Vendor Managed Inventory

1 INTRODUCTION

The purpose of this thesis was to examine and execute the implementation process of Material Requirements Planning system into the current SAP Enterprise Recourse Planning system for project procurement at Cargotec Finland Oy. The target was to examine an MRP system presenting the advantages and disadvantages of it with practical examples and to create a simple check-list for using SAP MRP in procurement. The MRP system was decided to introduce in the company due to the inconvenience of the current PRP (Production Requirements Planning) system regarding the purchasing of the materials used in own production. Introduction of MRP was intended to reduce workload in procurement and material planning department and to generate purchasing savings in general.

This thesis contains examination of developing procurement activities and examination of MRP system in general. Material parameters in MRP are more closely examined based on the universal methods with their theoretical and estimated impacts to the procurement. Moreover, this thesis includes introduction to the company, current state in procurement department and the desired target. The implementation of the MRP is covered from selecting the first batch of materials into the MRP to defining required material parameters and integrating them in to the system.

In this first phase of the implementation process, which this thesis examines, only a small portion of the materials in production was decided to add into the MRP system. This way integrating the system could be done in a controlled manner. Installing, customizing and testing the MRP module was left out as they were out of the scope of this thesis. In addition, all activities required from material planning and other departments were not examined because the focus of this thesis was decided to be limited particularly in Procurement department. In addition theory and formulas of simple mathematical calculations including percentage calculations are not examined in this thesis. In this thesis, all names of the materials and suppliers, quantities, prices and all other data has been changed due to the classified content.

2 THEORETICAL BACKGROUND AND MRP

Procurement department is responsible for purchasing and obtaining all materials, supplies and services required either in an inventory or in a project. Among the purchasing activities, are identifying the sources of supplies, managing and negotiating with suppliers and obtaining everything with cost-efficiency in required delivery time. (Stevenson 2014, 660.)

The main goal of a procurement is to create value to the company and to the customer. In Industrial companies, it is estimated that between 60 – 70 % of the revenue comes from purchased materials and parts. Savings as little as couple of percent in procurement will significantly improve profitability. On the other hand, the same result in sales would require a significant sales increase. (Ritvanen 2011, 35.)

2.1 Developing procurement

It is obvious that developing strategies and activities and reducing purchasing costs increases the profitability of a company. There are several ways of developing procurement which leads to increased value of a company and cost savings directly or indirectly. For example, increasing employee capability with training and development leads to more confident, effective and productive working. Maintaining and developing a good and close relationship with suppliers leads to more trustful and efficient cooperation. Learning to negotiate with different kinds of vendors gives a possibility to price discounts and faster lead times. One of the most appreciated qualities still is reducing costs while procuring the materials needed. (Mark Wins. 2016.)

“The key is to think carefully before making a purchase. It sounds easy but any procurement professional will understand this point since they might get tempted to create purchase orders for every request that comes at their desk. This is where the trap lies, leading to unnecessary expenses”. This is the basic reason why developing supply chain and material planning of procurement is highly important. (Mark Wins. 2016.)

2.2 Material planning methods and supply chain in procurement

In ordering, delivering and stocking materials, there are always risks for example in material obsolescence, cost of capital and fragment in delivery. There are vast amount of different types of material planning and procurement models, which affects the purchasing and material liabilities in different ways.

2.2.1 Liabilities of ordering, delivering and stocking

When ordering, manufacturing and delivering items, there needs to be clear rules on when the liabilities between seller and buyer shifts. Especially with long lead items, which has been ordered based on early forecasts, knowing the boundaries of liabilities is essential. Both, seller and buyer wants to secure their businesses by limiting their own liabilities to as low as possible. For agreeing the terms and liabilities of the delivery easily, universal incoterms have been introduced to help different parties of business. (Transportation issues. 2011.)

Usually when ordering items, the liability and ownership transfers to the customer when items are delivered or ready to be delivered, depending on the terms. (Transfer of ownership. 2011). These kinds of rules have to be agreed on mutually between the buyer and the seller before ordering.

2.2.2 Material planning models

JIT (Just-In-Time) is a methodology where purchased materials are always ordered in exact quantities that production needs with delivery date just in time (Miettinen 1993, 51). It was developed in Japan at Toyota car factory to shorten the time between purchase order and payment, reduce inventory costs and space required. In addition, the other key elements are the improvement of quality, increase in productivity and reduction of planning complexity. (Just in Time (JIT) Production. 2019.) Still, JIT is reliant to close located suppliers with quick response times in case of stock outs in order to keep the production running (Patricia Barlow. 2015).

Two-bin Kanban system is part of a lean methodology. The basic principle is to store two separate boxes filled with the same material in the inventory. When the first box empties, it will be refilled and the second box should cover the material need during the replenish time of the first box. This minimizes the risk of material deficiency, but increases the stock value with excess materials. This is usually a visually controlled method, which relies on communication between the inventory staff and procurement and therefore is exposed to human errors. (Aaron Lyles. 2014.)

VMI (Vendor Managed Inventory) is a business model where vendor takes responsibility of the certain materials in the inventory. They replenish the buyers stock for example when asked or periodically. This minimizes the liabilities of procurement concerning purchase orders and lead times and warehouse concerning visually controlled systems. This can also decrease stock value and possible safety stocks may be removed caused by continuous stock replenishing. In addition, the ownership of the materials can be arranged to be the seller's until materials are used by customer. This removes the risk of material obsolescence and minimizes the stock value. However, VMI might come more expensive as buyer is reliant on only one supplier with its prices. In addition, the supplier or their logistics partner has to have an access to the inventory so there has to have a full trust between both parties. (Martin Murray. 2018.)

In addition, there is a possibility for the supplier to keep its own inventory in its own premises for the materials and delivers them when needed and or ordered. This leaves the liability of the materials to the customer until they are ordered, delivered or ready to be delivered depending on the terms. Especially concerning custom manufactured items, using this method, the liability of the material obsolescence stays with the supplier until they are ordered. This model however, is always separately agreed with.

Along with these examples of material planning and procurement methods, there is Material Requirement Planning with its own advantages.

2.3 Material Requirements Planning

Material requirements planning (MRP) is a way to calculate and plan material needs in order to obtaining them in required quantities and time (Slack 2010, 422). This is a step towards automation in production of assembled products (Stevenson 2014, 495). MRP system became popular in the 1970's as it was able to help companies by calculating material volume and timing. (Slack 2010, 408). After the original and separate MRP system, MRP II (Manufacturing Resource Planning) was introduced in the 1980's. This system allowed information to be shared in local-area networks. MRP II was also able to model "what-if" scenarios and issue instructions in changing demand. This also is the principle of ERP, but in a much wider basis throughout the whole organization and every function of it. (Slack 2010, 409.) Nowadays MRP systems are usually integrated into full ERP systems as modules, in order to communicate with other departments and activities throughout the business. To work with full potential and flexibly, MRP needs changeable and updatable input information. Below is a figure (1) to simplify the inputs and outputs of MRP.

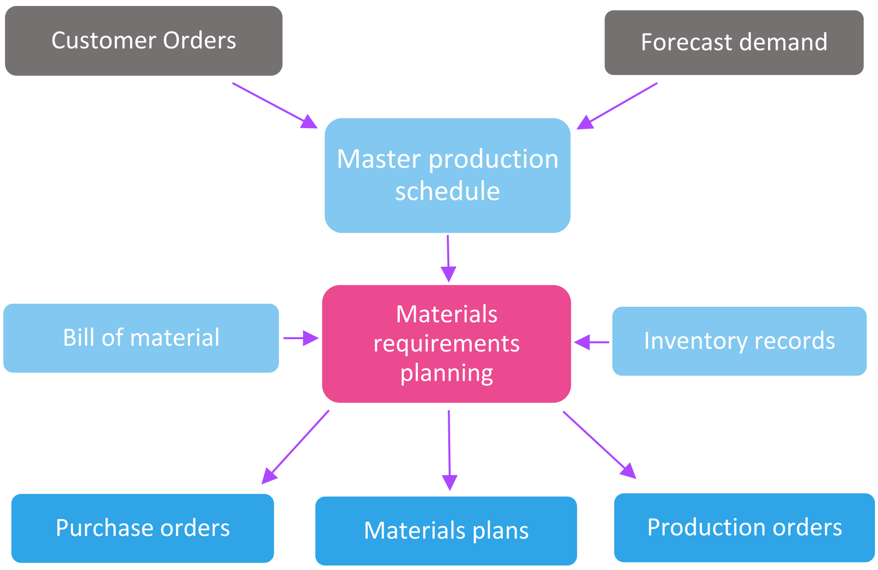

Figure 1. MRP schematic (Slack 2010, 422. modified)

Two important and also first inputs are customer orders and forecast demand, which together forms MPS (Master Production Schedule). (Slack 2010, 422). MPS is one of the three major inputs for MRP along bill of material and inventory records (Stevenson 2014, 496).

Master production schedule states which items, in what quantities and when they are going to be produced or assembled. MPS separates the planned horizon into specific time-periods, which usually is shown in weeks. Besides customer orders, item quantities of MPS may also come from forecasts and warehouse orders. (Stevenson 2014, 497)

From master schedule, the MRP calculates quantities of each part and its sup-parts needed in a finished product. This information comes from Bill of Materials (BOM). (Slack 2010, 424). BOM is a listing of all parts, sub-parts and assemblies needed to produce one unit of a product. Every finished product has its own BOM. The listing is hierarchical and usually shown as a structure tree where quantities of each parts and materials are visible. (Stevenson 2014, 499)

MRP needs to recognize that some required parts or materials are already in stock or reserved from stock for production. This is what inventory records refers to. (Slack 2010, 425.) In addition, inventory records includes the preferred supplier, lead-time, pricing and lot size policy. As well as BOM, inventory records needs to be accurate in order MRP to function correctly. (Stevenson 2014, 500.)

When it comes to using MRP system, aside from the three main inputs needed, there are also other considerations. To determine the ordering quantities, known as lot sizes, there are several models. In order to minimize the risk of material deficiency caused by material lead times, a reorder point and a safety stock is recommended. (Stevenson 2014, 508)

2.4 Lot Sizing in MRP

Defining a quantity in witch to order is highly important aspect in inventory management and procurement. First thing in defining a lot sizing method is to know the demand of the certain item. Independent demand is a demand for a finished product, whereas dependent demand is for the subparts, sub-assemblies and raw materials of it. The goal for both demand items is to order them in such quantities, which minimizes the ordering and holding costs. The more uneven the usage of a material is, a Lot-for-Lot ordering is preferred. Also for minimizing the holding cost, this is also recommended for items with high price. For materials with more even usage, a Fixed Order Quantity is recommended. Fixed Period Ordering comes useful if materials are preferably ordered in a certain periods. (Stevenson 2014, 509.) In addition, there are also other different methods to determining ordering quantities, which are out of the scope of this thesis.

2.4.1 Lot-for-Lot Ordering

The simplest ordering method is Lot-for-Lot ordering, also known as Discrete Order Quantity (DOQ). The order quantity always matches the demand for single need. Along with ordering size being equal to the need, this method minimizes the holding costs for inventory when each item is ordered by demand. However, when required quantity varies per period and orders are in different sizes, the advantage of Fixed Order Quantity is lost. This includes the use of standard packages and other procedures, which could lead to cost savings. (Stevenson 2014, 509)

For example, if a sales order is placed for 8 pieces of certain material, MRP generates a purchase requisition for 8 pieces. Then a new sales order of 3 pieces of the material is placed. This time MRP generates a completely new purchase requisition for these 3 pieces (Figure 2).

	Period (month)					
	1	2	3	4	5	6
Demand	8	3	1	40	9	11
Purchase requisition	8	3	1	40	9	11

Figure 2. Lot-for-Lot ordering (Stevenson 2014, 509. modified)

As seen in the figure (2), MRP does not combine these material needs but generates separate requisitions for all separate demands.

2.4.2 Fixed Order Quantity

If usage of a material is uniform, Fixed Order Quantity (FOQ), also known as Economic Order Quantity model (EOQ), is often used. There are also modified versions of this formula and separate software, which are sometimes preferred. As the name of EOQ refers, ordering quantities are always constant. This model usually minimizes the overall costs as order quantities are calculated to be the most economical related to the quantity of orders and the holding cost of the inventory. This is normally used with lower-level items with dependent demand, steady usage and delivery times. (Stevenson 2014, 509.)

For example, the demand in the first period is 8 pieces (Figure 3), and EOQ is defined as 40 pieces.

	Period (month), EOQ 40					
	1	2	3	4	5	6
Demand	8	3	12	20	9	11
Purchase requisition	40	0	0	40	0	0

Figure 3. Fixed Order Quantity (Stevenson 2014, 509. modified)

When no items are already in stock, the purchase requisition is created for 40 pieces. The demand in the second and third periods are 3 and 12, which does not drop stock level under 0, so no requisitions are created. In the fourth period the demand rises to 20 pieces, which drops the stock level under zero, so a new purchase requisition is created for 40 pieces.

Fixed Order Quantity for ordered items can be defined with empirical value. However, it might be more profitable to calculate the Economic Order Quantity. Most common way is to use the Wilson formula (1).

$$Q = \sqrt{\frac{2 \cdot D \cdot S}{H}} \tag{1}$$

In the equation *Q* refers to the order quantity, *D* refers to the material demand of a certain period, *S* to the ordering cost per order and *H* to the inventory holding cost of a certain period. Inventory holding cost is a sum of all costs related to the inventory including, for example:

- Workers' salaries and wages.
- Rent of the Inventory and energy needed.
- Equipment used in inventory.
- Risk of material obsolescence and loss.
- Cost of capital.

Cost of Capital refers to the capital needed to run the inventory while waiting for the payment of sales. For example, the rent, energy, and all annual costs for inventory are 100 000 euros. Stock value is 500 000 euros which risk of obsolescence and loss is 10 %. There are 1 000 slots for pallets, which each contains 30 pieces of material. This way holding cost *H* for one piece of material can be calculated as follows:

$$H = \frac{100\ 000\ \frac{€}{\mathrm{a}} + (500\ 000\frac{€}{\mathrm{a}} \cdot 0{,}1)}{1\ 000 \cdot 30} = \frac{150\ 000\frac{€}{\mathrm{a}}}{30000} = 5{,}0\ \frac{€}{\mathrm{a}} \tag{2}$$

This results to annual holding cost of 5 euros per material. Ordering costs *S* for EOQ formula (1) is the time spent for the single order, transformed into money. Examples of ordering costs are:

- Cost to create a purchase requisition.
- Cost to create a purchase order.
- Cost to inspecting the received items.
- Cost to storing the received items.
- Cost to handling the supplier invoice.

With knowing the figures for these costs, ordering cost can be calculated. (Steven Bragg. 2019.) For example, all above listed actions takes 12 minutes each. The salaries transformed into hourly wage is 50 euros. This way every action for single order takes 60 minutes, which costs 50 euros to the company.

When knowing these costs and the demand for the material, EOQ can be calculated. For example, certain material demand is 2000 pieces per year, costs 50 euros to place one order and 5 euros to hold in an inventory per year. Using Wilson formula, *Q* can be calculated as follows:

$$Q = \sqrt{\frac{2 \cdot D \cdot S}{H}} = \sqrt{\frac{2 \cdot 2000\,\frac{\text{pcs}}{\text{a}} \cdot 50\,\frac{€}{1}}{5\,\frac{€}{\text{a}}}} = 200\ \text{pcs} \tag{3}$$

This calculation gives ordering quantity of 200 pieces, which is the most economical in the inventory holding and ordering cost point of view.

However, Wilson formula relies on assumptions that ordering cost is constant, demand is uniform, lead time is fixed and does not take possible ordering quantity discounts into account. Nonetheless, this formula is preferred for manufacturers with own production and not necessarily for retail or wholesale for which there are other, more complex options. (Joannes Vermorel. 2012.)

2.4.3 Fixed Period Ordering

If materials are wanted to be ordered in specific periods, FPO (Fixed Period Ordering) is used. This model gives the change to create Purchase Orders for example once a week or once a month. Basically MRP creates purchase requisition quantities based on the consumption of the predetermined periods, usually two or three. (Stevenson 2014, 510.)

For example, a demand for a certain part is 70 pieces in the first week and second week demand is 50 pieces (Figure 4).

	Period (2 weeks)					
	1	2	3	4	5	6
Demand	70	50	1	80	4	51
Purchase requisition	120	0	81	0	55	0

Figure 4. Fixed Period Ordering. (Stevenson 2014, 509. modified)

Using two period ordering method, first order batch would be 120 pieces as seen in the cumulative demand row in the figure 4.

This method comes convenient for materials with seasonal variations and with large fluctuations in the demand. In addition, longer lead time can be more manageable and inventory management can be more efficient with constant checking to the re-order point, which in other hand requires more work. (Fixed Period Ordering. 2018.)

2.5 Reorder Point and Safety Stock

When purchase order for a material is placed, it triggers the supply chain of it, called lead-time. To avoiding the stoppage in a continuous production or sales due to this lead time, a reorder point is used. Reordering point is a defined stock level for a material, which triggers a new purchase requisition. The remaining items under reorder point should cover the need in production until the new material batch arrives. (Stevenson 2014, 508.)

In a theoretical dependent demand production system, every purchased item arrives exactly when needed. This way there is no need to have any excess parts in stock for back up, called a safety stock. However, for independent demand system, where parts are needed in different time intervals and which delivery times may differ, a Safety Stock comes useful. In order to avoiding any stoppage in production caused by missing parts, determining a safety stock for materials with high risk of deficiency is reasonable. However, for lower-level items and for items with flexible delivery times it may not be necessary. Besides, holding a safety stock for all lower-level items loses the advantage of MRP, which is to plan material requirements cost-efficiently and avoiding a high stock value. (Stevenson 2014, 508.)

Calculating the reorder point *ROP* starts with defining the demand rate and lead-time, which are shown in the Reorder point –formula:

$$ROP = d \cdot LT \tag{4}$$

Where *d* refers to the demand rate of the material in days or weeks, and *LT* refers to the lead-time in days or weeks. Result is then rounded upwards in order to avoid too small reorderpoint. (Stevenson 2014, 569.)

If safety stock is needed, there are several models of calculating it. Common factor for safety stock calculations is the service factor. Below (table 1) is shown the normal distribution chart of service factors. Service level is a risk for the possibility of material loss caused by too small safety stock. Bigger percent represents greater service level and thus smaller risk of material loss. This factor should be determined by production management. (Stevenson 2014, 570.)

Table 1. Normal distribution for service factors (Skuvault. 2019)

Service Level	Service Factor	Service Level	Service Factor
50.00%	00.00	90.00%	01.28
55.00%	00.13	91.00%	01.34
60.00%	00.25	92.00%	01.41
65.00%	00.39	93.00%	01.48
70.00%	00.52	94.00%	01.55
75.00%	00.67	95.00%	01.64
80.00%	00.84	96.00%	01.75
81.00%	00.88	97.00%	01.88
82.00%	00.92	98.00%	02.05
83.00%	00.95	99.00%	02.33
84.00%	00.99	99.50%	02.58
85.00%	01.04	99.60%	02.65
86.00%	01.08	99.70%	02.75
87.00%	01.13	99.80%	02.88
88.00%	01.17	99.90%	03.09
89.00%	01.23	99.99%	03.72

Service factor (table 1) multiplies the amount of safety stock with desired service level, which lowers the risk of stock-out. The higher service level is wanted, the bigger the multiplier is, causing higher safety stock. (Stevenson 2014, 570.)

When calculating a ROP with a safety stock, the service factor can be added to the reorder point -formula with the safety stock factor as:

$$ROP = d \cdot LT + z \cdot \sigma_{dLT}, \quad (5)$$

where z is the number of standard deviations and σ_{dLT} is the standard deviation of lead-time demand. This formula assumes that every variety in demand can be described as a normal distribution. (Stevenson 2014, 571.)

Among this simple formula, there are three other common ways of calculating safety stock. First method assumes that demand is only variable function and can be presented as:

$$ROP = \bar{d} \cdot LT + z \cdot \sigma_d \cdot \sqrt{LT}, \quad (6)$$

where $\bar{d}$ is average daily or weekly demand, σ_d is standard deviation of demand in days or weeks, and LT is the lead-time in days or weeks. (Stevenson 2014, 572.)

If then lead-time is variable and demand is stable, then reorder point with safety stock can be calculated:

$$ROP = d \cdot \overline{LT} + z \cdot \sigma_{dLT}, \quad (7)$$

where d is daily or weekly demand, $\overline{LT}$ is average lead-time in days or weeks and σ_{dLT} is standard deviation of lead time in days or weeks. (Stevenson 2014, 572.)

However, if both lead-time and demand during it are variable, then reorder point with safety stock is now:

$$ROP = \bar{d} \cdot \overline{LT} + z \cdot \sqrt{\overline{LT} \cdot {\sigma_d}^2 + \bar{d}^2 \cdot {\sigma_{LT}}^2}. \quad (8)$$

(Stevenson, W. 2014. 572.) For example, average daily need $\bar{d}$ is 4 pieces with deviation σ_d of 1 piece and average lead time $\overline{LT}$ is 14 days with deviation σ_{LT} of 2 days. Service level z is set to 1,64. Therefore reorder point with safety stock *ROP* can be calculated

$$ROP = \bar{d} \cdot \overline{LT} + z \cdot \sqrt{\overline{LT} \cdot {\sigma_d}^2 + \bar{d}^2 \cdot {\sigma_{LT}}^2} \quad (9)$$

$$= 4 \cdot \frac{\mathrm{pcs}}{d} \cdot 14 \cdot \mathrm{d} + 1{,}64 \cdot \sqrt{14 \cdot \mathrm{d} \cdot \left(1 \cdot \frac{\mathrm{pcs}}{d}\right)^2 + \left(4 \cdot \frac{\mathrm{pcs}}{d}\right)^2 \cdot (2 \cdot \mathrm{d})^2}$$

$$= 65{,}56 \ldots \mathrm{pcs} \approx 66 \text{ pcs}.$$

With this formula (9), the final reorder point with safety stock is 66 pieces when rounded up.

3 COMPANY AND THE CASE

Cargotec Finland Oy is Cargotec Corporation’s Kalmar department located in Tampere, Finland. Kalmar provides on-ports cargo-handling solutions globally. This contains different types of terminal tractors, container carriers and whole infrastructure. Kalmar also provides retrofitting and automation solutions for older or off-brand equipment.

Before 2012, Kalmar’s facilities located in different section in Tampere with its own container carrier production. After the whole production was relocated, Kalmar moved to new premises to focusing in prototype manufacturing, testing and for managing the procurement of whole machines that would be built elsewhere. At the same time, the old Baan ERP system was changed into SAP ERP and MRP system was dropped off. Nonetheless, a power unit production for these machines still did continue in the new premises and has been growing since.

Procurement department at Kalmar is responsible for sourcing and purchasing parts, materials and services both, for global local projects in Tampere. Most of these orders are placed according to Purchase Requisitions made by Material Planning department. This department is responsible for planning requisitions according to actual customer need in order for projects to obtain right items and equipment. Still some of the orders are placed directly for stock to be used in own production.

3.1 Baseline in Production and Procurement

Global projects are always customized for the customer so almost every equipment and infrastructure is in some way different from another. This causes a high variance in materials needed. This also applies to prototypes, as they are always unique before reaching production. The highly variable material requirement needs flexible system for production and procurement. The current Production Requirements Planning in SAP ERP used is somewhat equivalent to JIT system, which was explained in the chapter 2.2.1. However unlike JIT system, the costs of the materials purchased with current PRP system are allocated straight to the projects. This way there is no stock value for these materials even though they are located in the inventory before reaching production. Also when purchasing just the quantities each project needs, there is no excess inventory needed or the risk for the material obsolescence.

However, the power units manufactured in Tampere has fairly low variance in materials. Currently every item used in a specific project is purchased separately excluding the lower-level materials, which are ordered directly to stock in bigger quantities. Separate orders forces into buying material in smaller quantities, which is less cost-efficient and increases workload in procurement, material planning and warehouse. In addition, total amount of purchase orders to be placed increases, which costs more to the company. Still, even if same parts are being ordered at the same time for different projects, they need to be separated into individual order lines by the project they are ordered for. This is necessary for dividing the cost of the products to right project when invoices are handled, but at the same time increases the risk of carelessness in order handling. Below is a simplified flowchart (figure 5), which shows the current state of Procurement process.

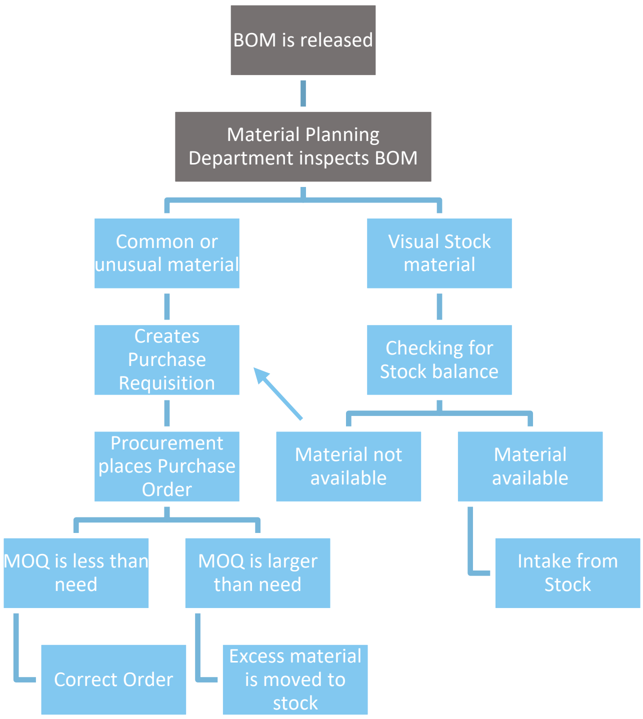

Figure 5. Simplified flowchart of current process in procurement

As seen in the figure 5, right after the BOM (Bill of Materials) of the new project is released, it goes through Material Planning department. That department either places Purchase Requisitions (PR) for Procurement or manually checks if materials needed can be found in stock. If stock balance is found empty, purchase requisitions for new materials are placed.

Supervising the stock levels and manually generating all Purchase Requisitions requires an excess amount of work. Current system does not support automatic stock balance supervising which would alarm if stock level were too low. The amount of materials having MOQ (Minimum Order Quantity) that exceeds the need of one project is relatively high. Because of the customer-need based production, every material needs to be purchased to one project at a time. This leads to several similar purchase order (PO) in a short time. Many of these orders has MOQ-materials and every exceeding material needs to be placed to the stock. This requires manual work done both, by the procurement and the production-planning department. Overall, growing amount of production requires increasing amount of work, which needs a more agile system to function.

3.2 Target

In order to reduce workload and costs, a SAP MRP module was introduced. Common materials used in production could be integrated into MRP, which would automatically generate Purchase Requisitions if needed as shown in the below figure (6).

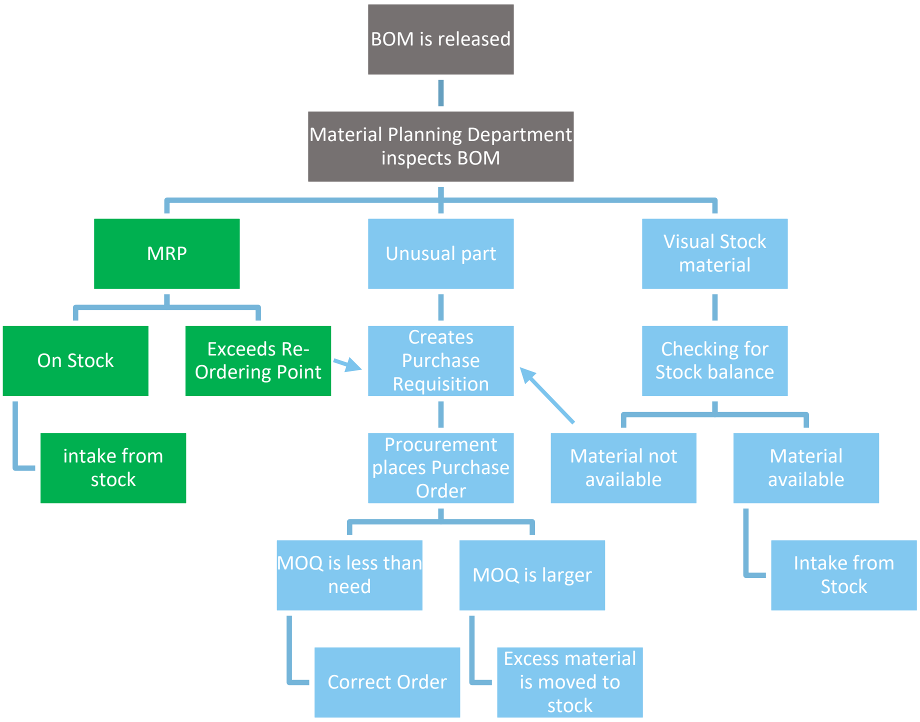

Figure 6. Simplified flowchart of target process in procurement

Even though a completely new process is added to the system (Figure 6), the new automatic supervising of the stock levels and generation of purchase requisitions decreases work needed from the material planning department. Fixing the order quantities decreases the amount of work in procurement and even in suppliers.

Although every existing material could be integrated into MRP, only a portion of them were integrated. Managing certain materials in MRP and others in normal ERP purchasing environment requires some manual work. This is needed when filtering materials for purchase requisition from product BOM. Still the total amount of work is just a fraction of the manual work required in running all the materials in the ERP purchasing environment.

3.3 SAP MRP in procurement

SAP is an ERP system invented in German in 1972 and is widely used by large corporations and smaller businesses (SAP History. 2019). SAP MRP itself is a module inside SAP ERP, which allows material planning fully integrated with the other procedures inside SAP (Material Requirements Planning in the Logistics

Chain. 2019). The reasons for implementing particularly SAP MRP in Kalmar was the easy access to it, same interface as current ERP system and its current and future use in other departments inside Cargotec.

SAP MRP works like any other MRP system, calculating material requirements in quantities and delivery dates. To work with full potential and to calculate all individual material needs for production, it needs access to the MPS and to the BOM as described in the chapter 2.2. Although SAP ERP has capability for creating and managing MPS and BOM in its own environment, at Kalmar these are managed through separate software because of the more convenient use. The company's target, as described in the earlier chapter 3.2, does not however need to have MPS or the whole BOM integrated into the MRP as material planning is executed only for certain materials inside BOM. Instead of the MPS integration, BOM is released inside SAP when needed and the materials of it are separated to project purchasing, stock intakes including visual stocks, and to the MRP.

In order to add single materials into MRP run, a transaction code MM02 is used in SAP for changing MRP material master data (Figure 7). If only viewing the material master data is desired, the transaction code MM03 would be used. And if creating completely new material master data, MM01 would be used. The logic for these numbers is sufficient also for other transactions inside SAP.

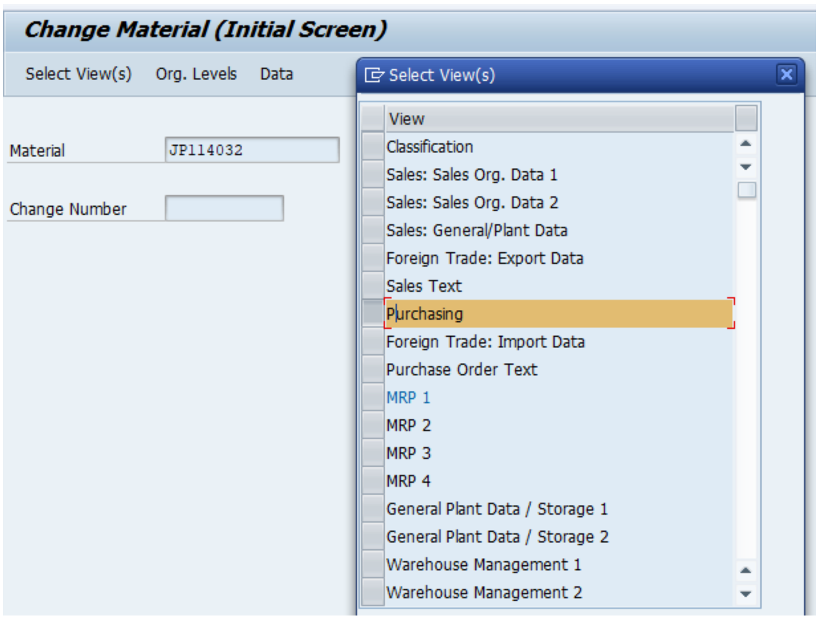

Figure 7. MRP Material master behind SAP transaction MM02

The individual material code is then placed to the requested field and a preferred view is selected. Views needed in procurement are Purchasing and MRP 1 and MRP 2. After selecting the view, in this case first the Purchasing, the plant is typed in a pop-up window for which the material change is desired. SAP uses plants as determining the specific company plant for managing the material data, purchasing and other activities. It only changes the material data for the selected plant, so if the material is used in other plant, it will not affect them.

In the purchasing view (Figure 8), some of the general material data can be seen. This information comes from the PDM system and material info records inside SAP and does not need to be changed when integrating it into the MRP. Also in this view, the automated Purchase Order generation can be activated in the "Autom. PO" tick box if needed.

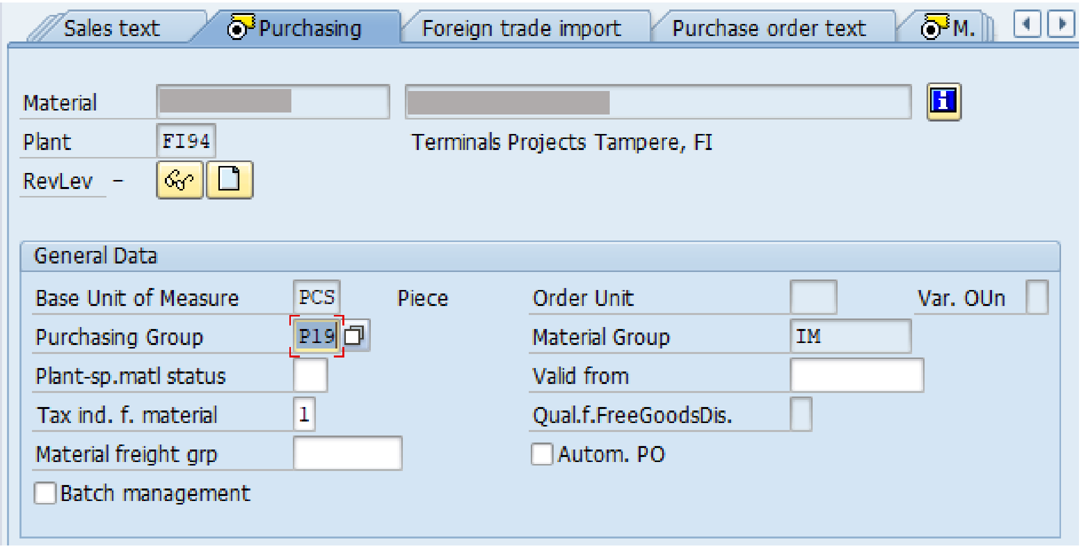

Figure 8. Purchasing view behind SAP transaction MM02

The most essential setting in this view (Figure 8) is the Purchasing Group. This determines the purchaser to which the purchase requisitions for each materials are generated. Next view, the MRP 1 (Figure 9), includes the settings for the MRP type and order quantities. These features are the key elements on determining how the purchase requisitions are generated regarding the order quantity and timing.

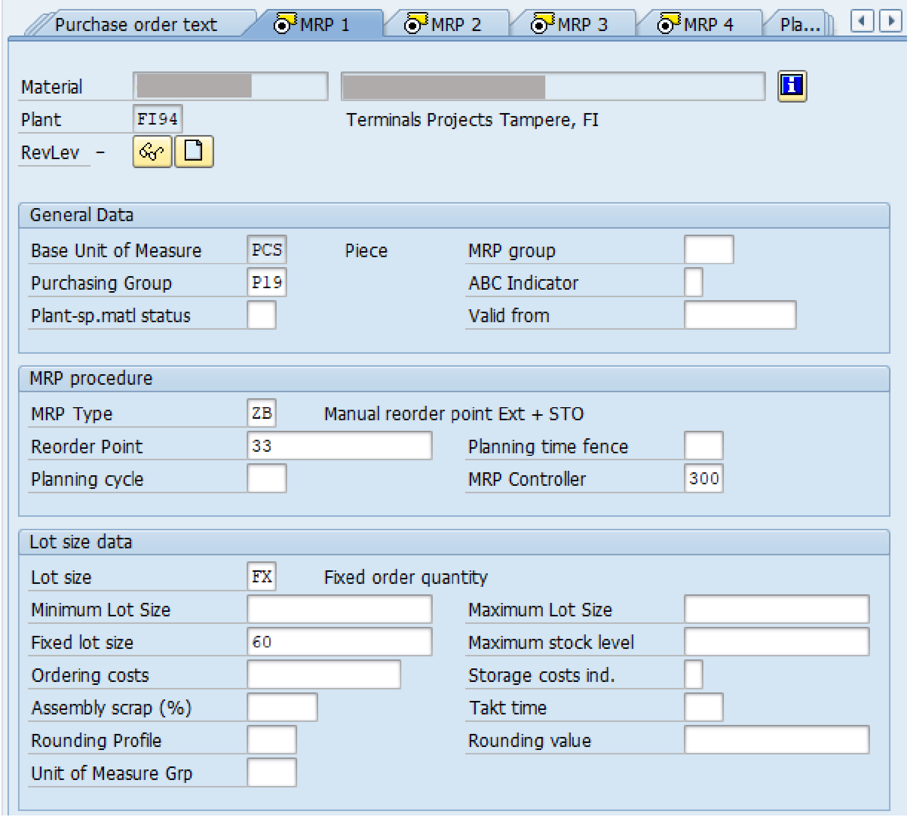

Figure 9. MRP 1 parameter fields behind SAP transaction MM02

In the MRP Procedure field in figure 9, the MRP Type determines whether the material is included in the MRP run or not. Basic options for this are “ND” and “PD”. “ND” excludes the material from the MRP run, and “PD” adds it into it. However, option “PD” cannot understand reordering points. If a reordering point is desired to the selected material, option “ZB” is selected, as shown in the figure 9. There are other options too for this setting, for example time-phased, forecast based, and MPS based planning, but they are out of the scope of this thesis. Planning cycle is only used with time-phased planning when a certain delivery cycle is desired. MRP controller 300 is also a default value and has been specified for the plant used by project procurement at Kalmar.

Material lot sizes are determined in the Lot size data (Figure 9). There are several different lot sizing procedures to use, but most common and the ones that this thesis examines are “EX” (Exact lot size) for lot-for-lot ordering and “FX” (Fixed lot size) for fixed order quantity. With “EX”, a minimum and maximum lot sizes comes useful if there is a minimum or maximum desired ordering quantity for a certain material. If however lot sizing method “FX” is used, the ordering quantity is added to the fixed lot size data field as shown in the figure X. The other empty boxes are for different lot sizing methods and determining lot size with ordering and storage costs, which are not examined.

In the MRP 2 view (Figure 10), procurement type and planned delivery date can be modified. Procurement type defines how the material is obtained. There are three options for this. “E” refers to in-house production, “F” to external procurement and “X” refers to both of them. Therefore all externally procured materials need to have either “F” or “X” selected. In the figure 10, the “F” is chosen, which creates a purchase order for procurement if needed.

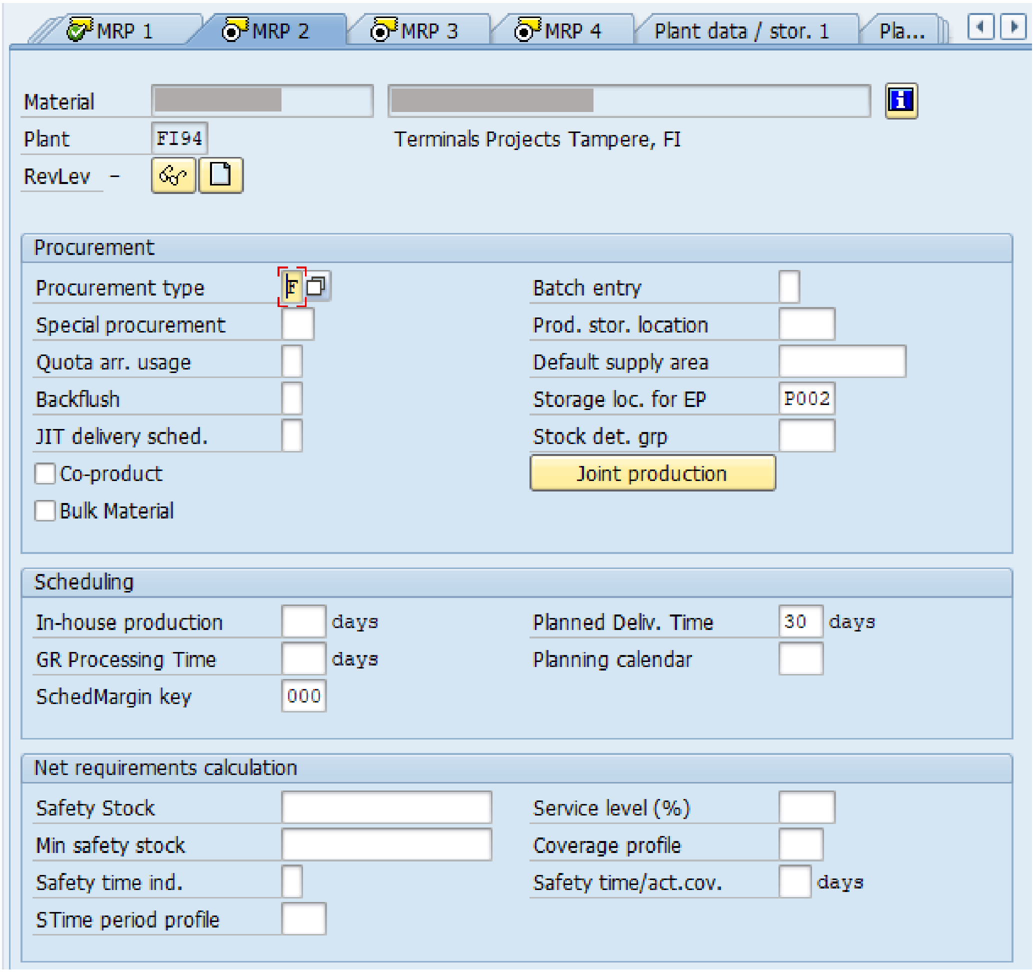

Figure 10. MRP 2 parameter fields behind SAP transaction MM02

The system also needs a storage location for procured materials. Storage location for in-house production is defined in the “Prod. stor. location” box and storage location for external procurement is defined in the “Storage loc. for EP” box. Other boxes in the procurement field are not required or examined further.

In the scheduling field (Figure 10) can be defined the timing for each materials. in external procurement, the GR (Goods Receipt) processing time can be left empty if receiving the materials in the inventory can be done during the day of delivery. The same applies to the in-house production time. If for example the GR processing time is set to 1, MRP adds 1 day to the requested delivery date. Planned delivery time is the most important data for the materials with a defined reorder point (MRP type is “ZB”). The MRP calculates the requested delivery date to the purchase requisition with the planned delivery time determined in the MRP 2 view. If there is no reorder point determined (MRP type is “PD”), the requested delivery date will be determined by the demand delivery date.

There are also other parameters available in these described and in other views. They however are not relevant for using in procurement in this phase of MRP implementation and therefore are not examined.

4 RESEARCH METHODS

Several research methods were used and combined during this project. Basic knowledge of the system in general was gathered from vast amount of literature and websites, but also from the procurement and material planning team that has used MRP system before. This subject has been researched widely before and aspects and structures of them were also utilized during this thesis. Vast amount of information about SAP MRP was also acquired from internal SAP controllers and personal use with which also check list for procurement (Appendix 1) was gathered. In addition knowledge and data was also acquired from Finance department, warehouse workers and management in order to get a broad vision in consideration. Several meetings were organized to discuss about the requirements and the features of the SAP MRP. Also separate meetings were organized regarding the decision of the materials and parameters. Calculations were based on formulas found from literature, which were then cross-checked with updated information found from websites and articles. All calculations were done in an Excel sheet in order to duplicate formulas efficiently for all materials.

4.1 Material selection

Material selection started by viewing a BOM of a common power unit. The BOM was selected by the similarity to the past and the future products. This way a maximum amount of common materials with other power units was integrated to the MRP. From this BOM, all project-variable and visually controlled lower-level items were filtered out. All the other materials were marked to be integrated into MRP. From these materials, a smaller batch of materials was selected for the first phase of the implementation in collaboration with procurement and material planning department and warehouse staff. The suitability for the first phase was defined with the following features:

- Parts manufactured according to Kalmar drawings.
- Parts with a MOQ.
- Parts that already have a safety stock in system.

Parts being manufactured only for Kalmar by drawings, have a high possibility for quantity discounts and therefore suitable for being purchased in larger quantities. Parts with minimum order quantities were added in order to avoid ordering them in too large quantities for single projects.

Materials were divided into FOQ (Fixed Order Quantity) and LFL (Lot-for-lot) materials. FOQ materials were chosen by their lower value, minimum order quantities. LFL materials were chosen by their high price or large dimensions.

4.2 Defining material parameters

Definition of material parameters started by defining the lot sizing methods for the selected materials. These were determined in collaboration with procurement and material planning departments, also reflecting to the literature point of view. Order quantities for the materials with the FOQ model were determined manually with the traditional EOQ formula. Although there are other ways of determining the quantity, as mentioned in the earlier chapters, but in this first implementation phase the sufficiency of the traditional way was examined. To determine the ordering quantities with EOQ model, the holding cost of the inventory and ordering costs were determined.

For the holding cost calculation, the layout of the inventory was acquired from the material planning department, which was used to calculate the total inventory area. The amount of the pallet slots and boxes was calculated by hand. Holding cost for one unit of material was calculated by calculating the holding cost both, for one pallet slot and a box, and then diving the cost by the quantity of the material fitting either one.

Financial figures for inventory were acquired from Finance department. Every cost were calculated with figures from the year of 2018 in order to get estimate results for a full year incoming. Some costs, for example cost of capital and risk of obsolescence were only estimated as defining exact numbers was not possible with the available data. Moreover, the impacts of these figures were determined to be minor to the final results. As assembling is managed in the same premises as the inventory, the area and the costs were divided just for the inventory. Figures for the ordering costs were empirically estimated in collaboration with the procurement team and warehouse staff.

For calculating reorder points and safety stocks, information about vendor lead times were obtained from the material purchasing data of the full year of 2018. This way more accurate average lead-times with variations could be determined. In order to determine demand of materials for the following year, the master production schedule with yearly forecasts of units was acquired from the production management. Safety stock for each material was calculated with the formula (8), where both, lead time and demand is a variable as every item had some variation in the lead times analyzed in the purchasing history data. For lead time variation, a value of 5 days was used for every material, as it was a common for all. For the service factor presented in the chapter 2.4, a value of 1,64 was used with all materials as it was defined to be enough. The average variation in daily demand was estimated to be the same value as the average daily usage of each material.

4.3 Effects of MRP

Cost savings comparing the purchasing done with PRP model and MRP system were calculated with the average unit prices from 2018. Limiting the data to just one year minimized the amount of normal price increase during earlier years. Still, using the data from the whole year gave a sufficient amount of data for more accurate results. The average price in 2018 was multiplied with the forecasted quantity of the year 2019 which gave the estimated total value for the specific material, which could have been paid with the forecasted quantity of 2019. This value was compared to the annual total value calculated with the correct ordering quantity discount price. Most materials had a scaled ordering quantity discount determined in the SAP material master and some were inquired separately from the vendors. This way their opinion was taken into account concerning the most reasonable manufacturing and packing quantities.

Moreover the cost for decreasing quantity of purchase orders was included in the total cost savings. This was calculated by the difference of the total ordering cost per material in 2018 and the total ordering cost with the order quantities using EOQ model and forecasted power unit quantity. Total order quantity per material in 2018 was compensated with the forecasted quantity in order to get more accurate results.

5 IMPLEMENTATION

The implementation process required the batch of materials to be chosen and their individual parameters. With the materials and parameters they could be integrated into the MRP system. First the use of the universal EOQ formula for the materials with fixed order quantity required the holding and ordering costs to be calculated. Calculations for these figures are not shown in a form of formulas caused by their simplicity.

5.1 Costs of inventory and placing a purchase order

Area used for the inventory was calculated to be 36 % of the whole area of the premises. The amount of pallet slots in the inventory with the current layout was calculated to be 998 pieces, whereas quantity of small boxes was 2440 pieces. It was calculated that one pallet fits 36 boxes. This way the total amount of fixed pallet slots was calculated to be roughly 1065,77 pieces. The whole cost for the inventory was calculated with current stock value of 1 424 407,26 euros the below figures:

- Annual costs for the inventory (36 % of the total): 255 324,91 €.
- Annual cost of capital (5 % of the costs of the inventory): 12 766,25 €.
- Annual risk for loss (5 % of the current stock value): 71 220,36 €.

From the annual cost report provided by the finance team, only salaries and pensions were omitted, as cost for labor was included in the costs of placing a purchase order. These figures added to the holding cost formula (2), an annual cost for holding *H* one pallet slot was calculated:

$$H = \frac{255\ 324{,}91\ € + 12\ 766{,}25\ € + 71\ 220{,}36\ €}{1\ 065{,}77 \ldots \mathrm{pcs}} = 318{,}37\ \frac{€}{\mathrm{pcs}}. \qquad (10)$$

Dividing the total annual cost of 339 311,52 euros with the fixed pallet slot quantity of roughly 1066 pieces, the annual holding cost for one pallet was calculated to be 318,37 euros. This transformed for smaller boxes and therefore divided by 36, the annual holding cost for one box in the inventory was calculated to be 8,84 euros.

One pallet was estimated to fit 18 pieces of material SF25048x in the material list (Appendix 2). This way annual holding cost for one piece of unit was calculated by dividing 318,37 euros by 18 pieces, resulting to annual unit cost of 17,68 euros. Calculating the holding cost for material located in a box could be done the same way using the annual holding cost of one box.

Ordering costs were calculated with an estimated average hourly gross salary of 37,2 euros for the company. Handling one order position was empirically estimated to averagely take 2 minutes from the material planning department, 3,5 minutes for purchasing department and 6 minutes from warehouse including inspection, making goods receipt, shelving and un-shelving. In addition it was estimated to take 5 minutes for issuing the invoice. This totaling to 16,5 minutes, the total cost for one order position would be 10,2 euros when calculating the time spent with the hourly salary. The average amount of order positions in one order was calculated to be 3,9 pieces. The total average cost of one purchasing order would then be averagely 37,2 euros when multiplying the cost of one order row with the average amount of order rows in one purchase order.

5.2 Material selection

Material selection for this first implementation phase started with running the BOM of the Power Unit used in Project M. Materials in the BOM were filtered using Excel sheets into non-MRP and MRP materials. Selected MRP materials were then processed with procurement, material planning departments and warehouse staff and a batch of 50 materials was selected (Appendix 2). Section of the listed materials can be seen in the below table (2).

Table 2. Part of the MRP material listing (Appendix 2)

Material	Material description	Vendor	Avg LT	BOM Qty	Annual Qty	MOQ	Lot size type
SF55087x	Electromechanical part	Vendor 1	56	1	100	2	**LFL**
JG55276x	Electromechanical part	Vendor 2	21	2	200	20	FOQ
LP52288x	Mechanical part	Vendor 3	14	1	100	30	FOQ
SF25048x	Mechanical part	Vendor 4	28	1	100	1	FOQ
SF32345x	Mechanical part	Vendor 5	14	10	1000	1	FOQ
SF12493x	Mechanical part	Vendor 5	14	10	1000	1	FOQ
SF45203x	Mechanical part	Vendor 6	60	2	200	2	FOQ
SF19595x	Electical part	Vendor 6	56	4	400	3	FOQ
H659458x	Mechanical part	Vendor 7	56	1	100	1	**LFL**
SF94148x	Electromechanical part	Vendor 8	7	2	200	1	FOQ
O406322x	Mechanical part	Vendor 9	21	10	1000	1	FOQ

In the table 2, internal material ID, material description, the main vendor, lead time in days, and quantity required in the BOM and vendor-based MOQ are shown. In addition, the selected lot size types are visible as LFL implying lot-for-lot model and FOQ implying Fixed Order Quantity. All of these materials were selected by their diverse properties regarding net value, vendors, material category and minimum order quantities. There are for example electric components, machined parts, washers and lugs and several other material types in the list.

5.3 Defining material parameters

This chapter includes EOQ calculations for lot size method FOQ and calculations for reorder points and safety stocks. In addition, theoretical estimations for economic effects are undergone compared to PRP system.

5.3.1 Lot size

Using the calculated holding and ordering costs, the economic order quantity was calculated with the EOQ formula (1) for the materials with FOQ model. For example, material SF25048x in the material list (Table 2) has annual demand with the forecasted total quantity of 100 pieces and 18 pieces fits in one pallet. Therefore the economic order quantity could be calculated:

$$Q = \sqrt{\frac{2 \cdot D \cdot S}{H}} = \sqrt{\frac{2 \cdot 100 \text{ pcs} \cdot 37{,}2 \text{ eur}}{318{,}37 \text{ eur} \cdot \frac{1}{18}}} = 20{,}5.. \text{pcs.} \tag{11}$$

This calculation stated the economic order quantity to be roughly 21 pieces. This was then downgraded to be 10 pieces with procurement team. Materials located in the box, instead of the pallet, the holding cost in the formula (2) was changed to the holding cost of one box. This model was applied to all materials with a same formula generated in excel, which results can be found in the appendix 3 in the column “EOQ”.

All results were then analyzed with procurement team, and based on the EOQ model, most of the material quantities were modified to be more convenient and suitable for procurement. These results can be found in the “Fixed EOQ” –column in the appendix 3. Calculations for the materials with “LFL” were not done as they are ordered in the same quantity as their demand. These can be found in the material listing with pricing data (Appendix 2) with the mark “LFL” in the last column.

5.3.2 Reorder point and safety stock

In order to determine the reordering point for materials, an average usage of material and lead time had to be defined. The average usage was calculated by dividing the forecasted annual quantity to a daily need. In this case, where forecast was 100 pieces, the daily average was calculated by dividing the forecast by 12 months and again with 30 days, resulting in 0,28 pieces per day. For every material, this value was then multiplied with their BOM quantity in order to get the daily demand for each material. The lead time of the material SF25048x is 28 days. It’s quantity in a single BOM is one piece. Therefore the reordering point could be calculated:

$$ROP = d \cdot LT = 28 \text{ d} \cdot 0{,}28 \frac{\text{pcs}}{d} = 7{,}84 \text{ pcs.} \tag{12}$$

This calculation stated the reordering point to 7,84 pieces, which then was rounded upwards to 8 pieces as instructed in chapter 2.5. This calculation was then applied to each FOQ material with their individual lead times and BOM quantities. They are shown in the appendix 1 in columns “Avg LT” referring to the lead time and “BOM qty” referring to the required quantity. All results can be shown in the appendix 3 in the column “ROP”.

The formula (8) for reorder point with safety stock was modified just for calculating the safety stock. The basic reorder point formula was removed from it, and the factor for safety stock was defined as *SS*.

Safety stock *SS* for the material SF55087x, with the lead time of 56 days with the common variation of 5 days can be calculated:

$$SS = z \cdot \sqrt{\overline{LT} \cdot {\sigma_d}^2 + \bar{d}^2 \cdot {\sigma_{LT}}^2} = \tag{13}$$

$$1{,}64 \cdot \sqrt{\overline{56} \cdot \mathrm{d} \cdot (0{,}28 \cdot \frac{\mathrm{pcs}}{\mathrm{d}})^2 + \overline{(0{,}28 \cdot \frac{\mathrm{pcs}}{\mathrm{d}}})^2 \cdot (5 \cdot \mathrm{d})^2} = 4{,}13 \ldots \mathrm{d}.$$

Rounding the value upwards, for this material a safety stock was calculated to be 5. Safety stock were not calculated for each material, as safety stocks were decided to leave out. Only for the LFL materials safety stocks were determined. These can be found in the appendix 3 in the column “Safety stock”. Also these were discussed with procurement team, and the safety stocks were modified, which can be found in the same appendix in the column “Fixed safety stock”.

5.3.3 Economic effects of the material parameters

Theoretical estimations for cost savings were combined, with the cost saving due to the changing amount of purchase orders and the cost savings due to the material quantity discounts. The total ordered unit quantity in 2018 of the material KS12601x was 1460 pieces with the total value of 3 220,0 euros (Appendix 4). Therefore average unit price was 2,20 euros. The total quantity of purchase orders in 2018 was 10 pieces, so calculating the total ordering costs with the ordering costs of 37,2 euros calculated in the chapter 5.2, the total annual ordering costs would be 372 euros. The total ordering costs with MRP can be calculated with the updated unit price with quantity discount totaling 1,78 euros (Appendix 4.). When fixed EOQ is 500 pieces (Appendix 3), and annual total demand is 2000 pieces (Appendix 2), the annual quantity of purchase orders is 4. Calculating with the same ordering costs results in total annual ordering costs of 148,8 euros. For this material ordering costs develops ordering savings of 223,2 euros annually. Estimated annual ordering cost saving was calculated for each material and results can be found in the appendix 4 in column "Savings / a, PO Qty". Combining ordering savings for each material, annual cost savings are 16 242,77 euros. With PRP system, ordering costs were 22 598,2 euros and with MRP system 6 355,4 euros, which is 71,87 % less. Comparison between costs for each purchasing method can be found in the below figure (11).

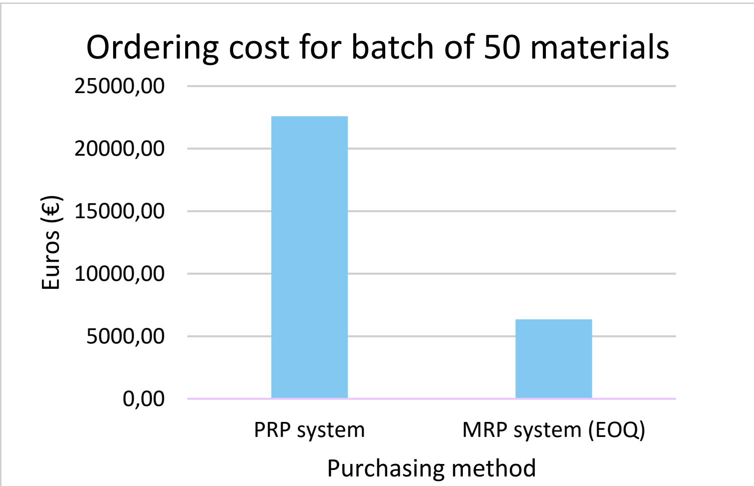

Figure 11. Ordering cost for batch of 50 materials

Material cost saving for material KS12601x was calculated to be 851 euros (Appendix 4) when comparing the annual costs of old unit price to the discounted unit price. Therefore the total annual saving for this material with MRP totals to 999,8 euros. Results for cost saving per price difference for all materials can be found in the Appendix 4 in the column "Savings / a, price diff.". Combining material cost savings for each material, annual cost savings are 58 821,3 euros. With old prices, annual total material value would have been 492 951,30 euros. With new prices, annual material value was calculated to be 434 130,00 euros, which is 11,93 % lower. Comparison between annual material costs with both purchasing method can be found in the below figure (12).

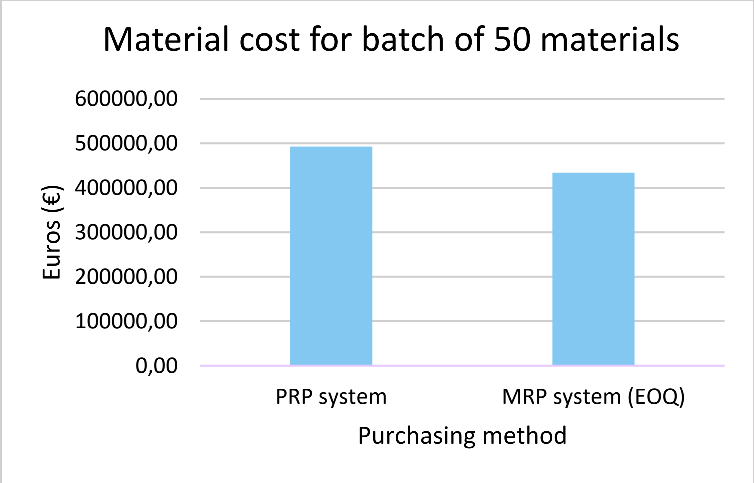

Figure 12. Material cost for batch of 50 materials

The stock value for this same material is between the reordering point and maximum stock balance depending when it is defined. Minimum stock value is just at the reordering point, which for this material is 100 pieces. Therefore the stock value is 178 euros. At the maximum stock balance with EOQ of 500 pieces and one unit under reorder point, the stock balance is 599 pieces. With this value, the maximum stock value is 1 066,22 euros.

Minimum and maximum stock levels for each material can be found in the appendix 4 in the two last columns. When combining stock value changes with each material, the minimum stock value is 49 625,7 euros and maximum is 161 572,6 euros. With the current stock value of 1 424 407,26 euros, these increases it minimum of 3,48 % and maximum of 11,34 %.

5.4 Integrating material parameters into the MRP

Adding the materials into the MRP run were done using the SAP transaction code MM02 according to the instructions (Appendix 1), which was introduced in the chapter 3.3. Material master data change for KS12601x (Appendix 2) started with checking the purchasing group and automated PO to be off in purchasing view (Figure 13).

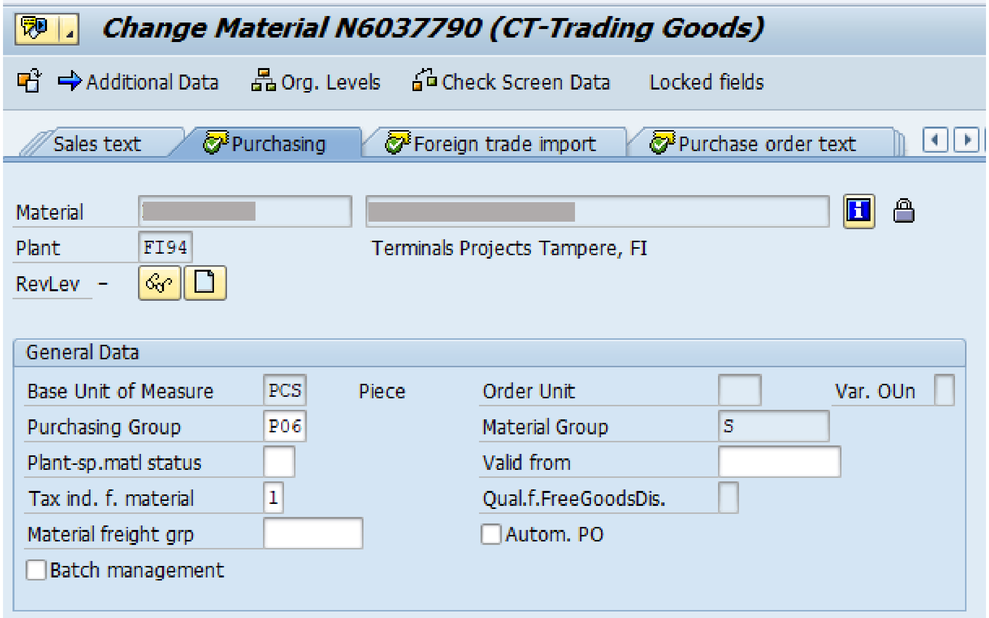

Figure 13. KS12601x purchasing data behind Purchasing view

Other data was not needed to be changed. In the MRP 1 view (Figure 14), the MRP type was defined as “ZB” as the reordering point was calculated to be 100 pieces (Appendix 2). MRP controller data “300” is a default value which was not required to be changed.

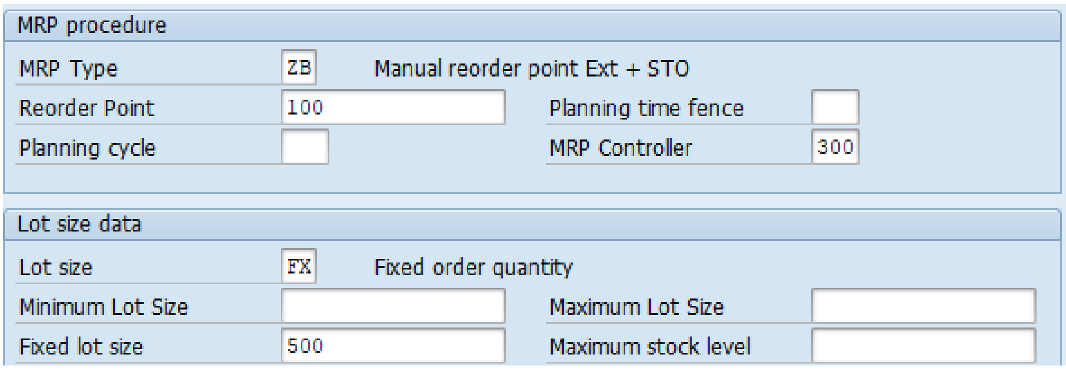

Figure 14. KS12601x MRP procedure and lot sizing behind MRP 1 view

This material was defined to be procured in fixed quantities and therefore a default value of “EX” was changed to “FX”. In addition, the defined fixed lot size of 500 pieces (Appendix 2) was added to the lot size box. Next step was to determine the procurement type and the scheduling of this material (Figure 15).

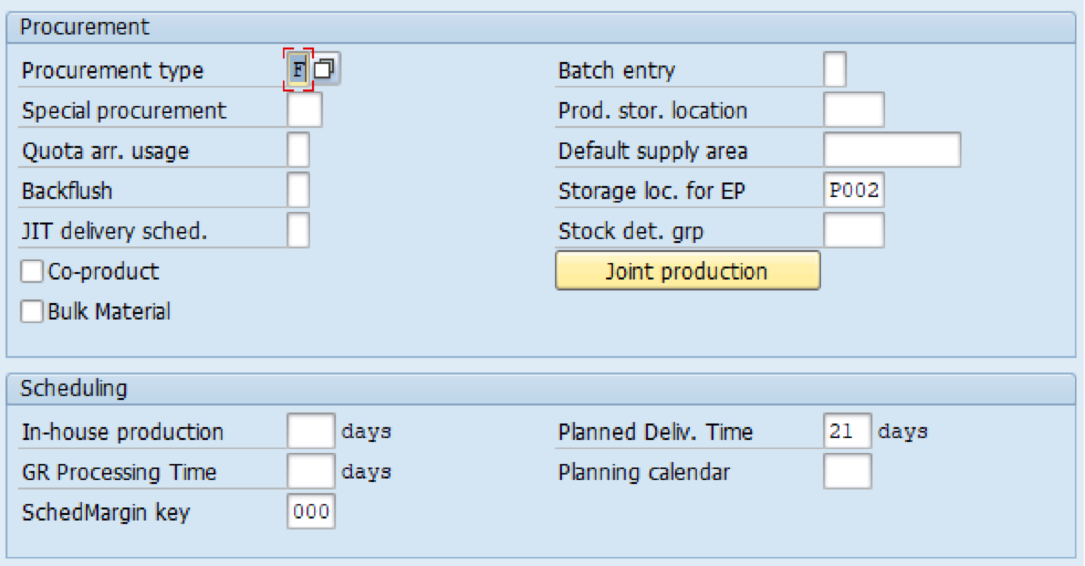

Figure 15. KS12601x procurement and scheduling data behind MRP 2 view

With a default value of “F”, the procurement type is external using the storage P002. Planned delivery time was filled with the average lead time of this material (Appendix 2). With these settings for this material, MRP creates a purchase requisition to external procurement for a batch of 500 pieces every time the stock level drops under 100 pieces. Planned delivery time is 21 days from the creation of the purchase requisition because the GR processing time is set to be 0. These modifications were done to each material with their individual values found from the appendices 2 and 3.

6 RESULTS

This chapter examines the results for material parameters and their economic effects. In addition, the created check-list is presented. Economic effects for each material can be found from the appendix 4, whereas check-list for procurement can be found from the appendix 1.

6.1 Material parameters and economic effects

The material parameters, which were determined in chapters 5.3.1 and 5.3.2 based on calculations were modified quite a lot with the procurement team. This can be shown for example with the lot size of the material SF25048x. Calculation gave a lot size of 21 pieces, whereas it was downgraded to 10 pieces which was defined as more convenient. Also lot sizes for other materials (Appendix 3) were either upgraded or downgraded a lot. This shows the inconvenience of the general EOQ model for Cargotec Finland Oy. Reorder points were not modified that much, but safety stocks were eliminated for almost every material.

Annual cost savings with EOQ model in MRP system just for the quantity of purchase orders was calculated to be 16 242,77 euros, which is roughly 71,9 % lower than with the PRP system. This is a logical result and agrees with theoretical view, but does not necessarily lead to equal cost savings in practical use as values used in calculations were only estimated. Therefore this should only be used as a referential result. However, this percentage also shows the figure for the amount of decreasing workload on procurement and other associated departments, which is somewhere accurate result with achieved material parameters.

Cost savings for the material price difference was calculated to be 58 821,3 euros, which is roughly 11,9 % lower. However, most of the price decrease comes from a single material, with annual cost savings of nearly 53 500,00 euros (Appendix 4). Still, as mentioned in the chapter 2.4.2, with EOQ, overall costs are minimized. Both, ordering cost and material prices was successfully lowered, however only in a theoretical aspect.

On the other hand, the current total stock value was calculated to increase from roughly 3,5 % to roughly 11,3 % depending on the seasonal stock levels. This is a major increase just with the 50 materials selected. But of course the current stock level does not include the project parts, which are located in the inventory, which costs are already divided for different projects. Therefore a major increase in stock value is logical.

Overall, decrease in costs was expected and also something taken for granted as also theory of MRP stated. Increase in stock value was also recognized before this project started.

6.2 Check-list for procurement

A simple check-list (Appendix 1) consists of the procedures that a procurement need for changing the MRP material parameters. It was kept simple and short and simple for backup use when needed. Order of the changes was kept logical with the view orders in SAP MRP. Also excess features, which are not currently planned to be used were not included.

7 CONCLUSIONS AND FUTURE TARGETS

This thesis aimed for examining an MRP system in general and its advantages and disadvantages in practice at Cargotec Finland Oy. These effects were examined reflected with a chosen batch of 50 materials. In addition, a check-list was gathered for procurement department in order to change material parameters in SAP MRP.

During this thesis, decent and factual results were achieved, which helps procurement department in understanding SAP MRP system more. During this thesis, knowledge in MRP systems and its parameters increased enormously. Right at the beginning of this thesis, EOQ model could have been replaced for some more convenient as calculating all required figures for it required a massive amount of work. But on the other hand, it provided a vast amount of information about it, its advantages and disadvantages.

The following chapters evaluates the achieved results in a deeper standpoint. Also possible future research, which could be done to develop the system is presented.

7.1 Evaluating research results

Even though, economic results shows cost decrease in purchase orders as nearly 72 %, it can only be used as a referential result as the figures for the calculations were mainly estimated and direct monitoring for these costs are not used. The exact result is impossible to calculate as times used for creating and dealing with purchase orders vary enormously. The fact is, when order batches are bigger, the amount of purchase orders decreases. The saved time still goes for other activities in procurement.

The cost savings from price decrease is more accurate as factual data was used determining the costs. These results for materials are somewhere accurate until the parameters are changed, which is going to be a part of operational work in procurement department. The increase in the stock level also is somewhere accurate, but will live from seasonal varieties and from the changing parameters of materials.

Some cost saving might also occur from changing logistics when delivering materials into the inventory. Bigger batches from a same supplier requires less logistics as smaller. These aspects were not examined in this thesis as they would have been nearly impossible to determine and required excessive amount of work. True economic effects can be acquired only after long period monitoring.

Still, by summarizing these results, there is very high potential for MRP to decrease overall costs. Only with the batch of 50 materials, nearly 60 000 euros was estimated to be saved just with the material prices. Expanding this model for every material in production, the cost savings could potentially follow linearly resulting in enormous savings.

7.2 Future research

Even though MRP was implemented successfully into the procurement department, it will require more studying. The basic EOQ model should be replaced to something more convenient when determining parameters for the next batch of materials. The inappropriateness of the formula can be seen when comparing the EOQ results to fixed EOQ results in the appendix 3. Nearly all results had to be either increased or decreased quite a lot based on empiric experience of the procurement team. Finding a proper way of determining order batches could be a topic for a next thesis.

SAP MRP is able to place automatic purchase orders as currently it generates only purchase requisitions. Placing orders would further decrease the amount of work required from the procurement. Also exploiting BOM, history data and forecasts more could get more out of the whole system leading to more efficient purchase orders and delivery times.

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APPENDICES

Appendix 1. Check list for MRP material run

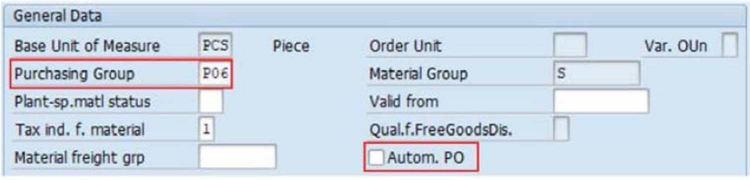
1 (2)

CHANGING MATERIAL MASTER FOR MRP

MM01 – Create | MM02 – Change | MM03 - View

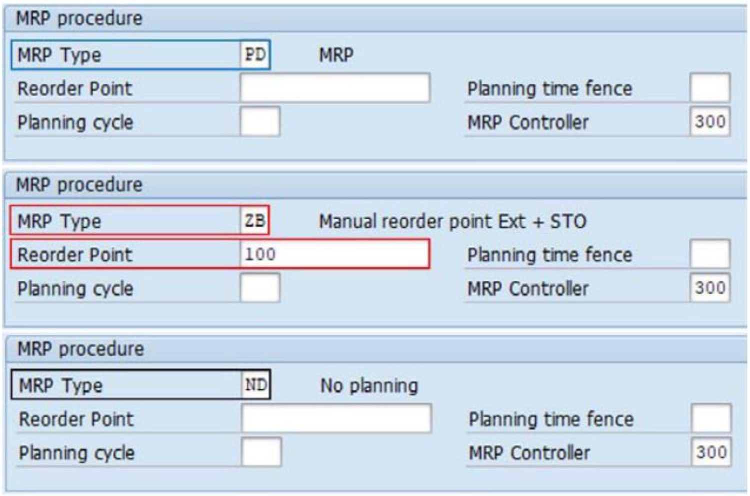
Purchasing view in MM02

1. Check the Purchase Group
2. Automated PO should be unticked



MRP 1 view in MM02

3. Change MRP Type
   a. PD = MRP run without reorder point
   b. ZB = MRP run with manual reorder point
   c. ND = Not in MRP run

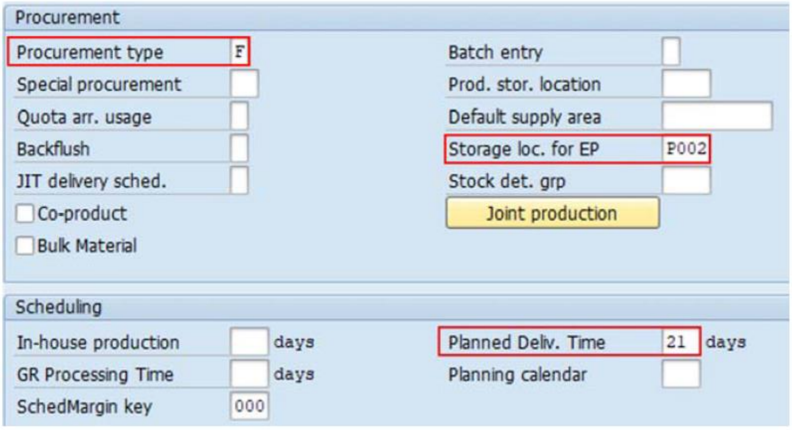


4. Change Lot size
   a. FX = Fixed Order Quantity (PR qty is constant)
      i. Fixed lot size is mandatory
   b. EX = Lot-for-lot (PR qty = demand qty)
      i. Optional use of minimum and maximum lot sizes

2 (2)

MRP 2 view in MM02

5. Procurement type
    a. F = External procurement
    b. E = In-house production
    c. X = Both
6. Storage loc. for EP = Storage location for external procurement
7. Planned Deliv. Time = Average delivery time
    a. If several vendors, vendor average delivery time is used
    b. If Reorder point is defined, <u>planned delivery time</u> is used in PR
    c. If Reorder point is not defined, <u>demand date</u> is used in PR



Appendix 2. Material listing with demand data

Material	Material description	Vendor	Avg LT	BOM Qty	Annual Qty	MOQ	Lot size type
SF55087x	Electromechanical part	Vendor 1	56	1	100	2	**LFL**
JG55276x	Electromechanical part	Vendor 2	21	2	200	20	FOQ
LP52288x	Mechanical part	Vendor 3	14	1	100	30	FOQ
SF25048x	Mechanical part	Vendor 4	28	1	100	1	FOQ
SF32345x	Mechanical part	Vendor 5	14	10	1000	1	FOQ
SF12493x	Mechanical part	Vendor 5	14	10	1000	1	FOQ
SF45203x	Mechanical part	Vendor 6	60	2	200	2	FOQ
SF19595x	Electical part	Vendor 6	56	4	400	3	FOQ
H659458x	Mechanical part	Vendor 7	56	1	100	1	**LFL**
SF94148x	Electromechanical part	Vendor 8	7	2	200	1	FOQ
O406322x	Mechanical part	Vendor 9	21	10	1000	1	FOQ
O603245x	Mechanical part	Vendor 9	21	1	100	1	FOQ
OP78746x	Mechanical part	Vendor 9	21	1	100	1	FOQ
KS12601x	Mechanical part	Vendor 9	21	20	2000	1	FOQ
O606307x	Mechanical part	Vendor 9	21	1	100	1	FOQ
P606692x	Mechanical part	Vendor 9	21	5	500	1	FOQ
Q615269x	Mechanical part	Vendor 9	21	1	100	1	FOQ
R616241x	Mechanical part	Vendor 9	21	1	100	1	FOQ
R618791x	Mechanical part	Vendor 9	21	1	100	1	FOQ
R602595x	Mechanical part	Vendor 10	42	1	100	1	FOQ
P602396x	Mechanical part	Vendor 10	42	1	100	1	FOQ
P604548x	Mechanical part	Vendor 10	42	1	100	1	FOQ
P609785x	Mechanical part	Vendor 10	42	1	100	1	FOQ
P609454x	Mechanical part	Vendor 10	42	2	200	1	FOQ
KK09236x	Mechanical part	Vendor 10	42	1	100	1	FOQ
RT06669x	Mechanical part	Vendor 10	42	1	100	1	FOQ
H610662x	Mechanical part	Vendor 10	42	1	100	1	FOQ
A610523x	Mechanical part	Vendor 10	42	1	100	1	FOQ
A612324x	Mechanical part	Vendor 10	42	1	100	1	FOQ
N615541x	Electical part	Vendor 10	42	1	100	1	FOQ
N632574x	Mechanical part	Vendor 10	42	1	100	1	FOQ
N645709x	Mechanical part	Vendor 10	42	1	100	1	FOQ
N616668x	Mechanical part	Vendor 10	42	1	100	1	FOQ
N611662x	Mechanical part	Vendor 10	42	1	100	1	FOQ
N612627x	Mechanical part	Vendor 10	42	1	100	1	FOQ
SF10165x	Electical part	Vendor 11	14	5	500	1	FOQ
SF45466x	Electical part	Vendor 12	21	1	100	1	FOQ
H70260xx	Mechanical part	Vendor 13	14	4	400	1	FOQ
SF30307x	Mechanical part	Vendor 13	14	1	100	1	FOQ
SF13088x	Mechanical part	Vendor 13	14	1	100	1	FOQ
SL12587x	Mechanical part	Vendor 13	14	2	200	1	FOQ
SL12036x	Mechanical part	Vendor 13	14	4	400	1	FOQ
SJ12125x	Mechanical part	Vendor 13	14	1	100	1	FOQ
GF12486x	Electical part	Vendor 13	14	4	400	250	FOQ
GF56142x	Mechanical part	Vendor 14	21	10	1000	100	FOQ
GF18675x	Mechanical part	Vendor 15	7	2	200	1	FOQ
FF19061x	Mechanical part	Vendor 15	7	1	100	1	FOQ
AF22542x	Electical part	Vendor 15	7	2	200	1	FOQ
TF13418x	Mechanical part	Vendor 16	14	1	100	1	FOQ
N600056x	Mechanical part	Vendor 16	14	1	100	1	FOQ

Appendix 3. Material listing with lot sizing data

Material	Avg usage	Lot size type	Pallet (0) Box (1)	Qty in pallet / box	EOQ	Fixed EOQ	ROP	Fixed ROP	Safety-stock	Fixed safety stock
SF55087x	0,28	**LFL**		3					5	6
JG55276x	0,56	FOQ		750	194	100	12	12	6	0
LP52288x	0,28	FOQ		30	27	30	4	20	3	0
SF25048x	0,28	FOQ		18	21	10	8	6	3	0
SF32345x	2,78	FOQ	1	100	949	500	39	100	28	0
SF12493x	2,78	FOQ	1	10	300	500	39	100	28	0
SF45203x	0,56	FOQ		10	22	60	33	33	8	0
SF19595x	1,11	FOQ		450	212	90	62	62	16	0
H659458x	0,28	**LFL**		0,5					5	6
SF94148x	0,56	FOQ	1	40	268	80	4	4	5	0
O406322x	2,78	FOQ	1	40	600	500	58	100	31	0
O603245x	0,28	FOQ	1	15	116	50	6	10	3	0
OP78746x	0,28	FOQ	1	15	116	50	6	10	3	0
KS12601x	5,56	FOQ	1	100	1342	500	117	100	62	0
O606307x	0,28	FOQ		400	100	30	6	6	3	0
P606692x	1,39	FOQ		3600	671	100	29	29	15	0
Q615269x	0,28	FOQ		150	61	30	6	6	3	0
R616241x	0,28	FOQ		150	61	30	6	6	3	0
R618791x	0,28	FOQ		400	100	30	6	6	3	0
R602595x	0,28	FOQ		4	10	10	12	12	4	0
P602396x	0,28	FOQ		12	17	20	12	12	4	0
P604548x	0,28	FOQ		24	25	20	12	12	4	0
P609785x	0,28	FOQ		8	14	20	12	12	4	0
P609454x	0,56	FOQ		500	158	100	23	23	7	0
KK09236x	0,28	FOQ		160	63	50	12	12	4	0
RT06669x	0,28	FOQ		300	87	20	12	12	4	0
H610662x	0,28	FOQ		10	16	20	12	12	4	0
A610523x	0,28	FOQ		40	32	20	12	12	4	0
A612324x	0,28	FOQ		100	50	20	12	12	4	0
N615541x	0,28	FOQ		8	14	20	12	12	4	0
N632574x	0,28	FOQ		2000	224	50	12	12	4	0
N645709x	0,28	FOQ		6	12	20	12	12	4	0
N616668x	0,28	FOQ		20	22	20	12	12	4	0
N611662x	0,28	FOQ		2000	224	100	12	12	4	0
N612627x	0,28	FOQ		250	79	20	12	12	4	0
SF10165x	1,39	FOQ		240	173	100	19	19	14	0
SF45466x	0,28	FOQ		1000	158	100	6	6	3	0
H70260xx	1,11	FOQ		500	224	100	16	16	11	0
SF30307x	0,28	FOQ	1	50	212	100	4	4	3	0
SF13088x	0,28	FOQ	1	40	190	100	4	4	3	0
SL12587x	0,56	FOQ	1	40	268	200	8	8	6	0
SL12036x	1,11	FOQ		400	200	100	16	16	11	0
SJ12125x	0,28	FOQ	1	20	134	100	4	4	3	0
GF12486x	1,11	FOQ	1	20	268	250	16	16	11	0
GF56142x	2,78	FOQ	1	100	949	1000	58	58	31	0
GF18675x	0,56	FOQ	1	500	949	300	4	4	5	0
FF19061x	0,28	FOQ	1	250	475	80	2	2	3	0
AF22542x	0,56	FOQ	1	1000	1342	500	4	4	5	0
TF13418x	0,28	FOQ		100	50	30	4	4	3	0
N600056x	0,28	FOQ		100	50	30	4	4	3	0

Appendix 4. Material listing with price data

Material	Updated Price / unit	PO Qty - 18	PO Qty MRP	Ann. unit qty -18	Total annual price of units 2018	Avg price / unit 2018	Costs of PRP	Savings / PO Qty	Saving /a Price diff.	Min Stock value	Max stock value
SF55087x	6 930,00 €	6		74	512 820,00 €	6 930,00 €					
JG55276x	48,35 €	12	2	204	9 863,40 €	48,35 €	10 138,69 €	389,01 €	0,0 €	580,2 €	5 366,9 €
LP52288x	13,65 €	3	3,33	90	1 228,50 €	13,65 €	1 497,80 €	0,00 €	0,0 €	273,0 €	668,9 €
SF25048x	481,00 €	9	10	89	42 809,00 €	481,00 €	48 502,86 €	4,48 €	0,0 €	2 886,0 €	7 215,0 €
SF32345x	0,28 €	11	2	794	222,32 €	0,28 €	831,92 €	472,24 €	0,0 €	28,0 €	167,7 €
SF12493x	2,90 €	11	2	794	2 302,60 €	2,90 €	3 451,92 €	472,24 €	0,0 €	290,0 €	1 737,1 €
SF45203x	1 054,00 €	10	3,3	165	218 014,00 €	1 321,30 €	264 742,29 €	350,10 €	53 459,4 €	34 782,0 €	96 968,0 €
SF19595x	24,00 €	12	4,44	333	8 058,60 €	24,20 €	10 254,25 €	397,19 €	80,0 €	1 488,0 €	3 624,0 €
H659458x	1 120,00 €	12		94	120 905,00 €	1 286,22 €					
SF94148x	5,16 €	13	2,5	174	895,76 €	5,15 €	1 624,90 €	495,69 €	-2,4 €	20,6 €	428,3 €
O406322x	0,85 €	10	2	725	676,75 €	0,93 €	1 482,95 €	469,82 €	83,4 €	85,0 €	509,2 €
O603245x	7,40 €	9	2	80	892,60 €	11,16 €	1 563,94 €	368,51 €	375,8 €	74,0 €	436,6 €
OP78746x	7,40 €	9	2	80	892,60 €	11,16 €	1 563,94 €	368,51 €	375,8 €	74,0 €	436,6 €
KS12601x	1,78 €	10	4	1460	3 220,00 €	2,21 €	4 956,69 €	386,38 €	851,0 €	178,0 €	1 066,2 €
O606307x	13,45 €	9	3,33	80	1 469,40 €	18,37 €	2 284,94 €	315,39 €	491,8 €	80,7 €	470,8 €
P606692x	7,32 €	9	5	400	3 148,00 €	7,87 €	4 383,19 €	248,99 €	275,0 €	212,3 €	937,0 €
Q615269x	11,85 €	9	3,33	79	1 390,30 €	17,60 €	2 213,73 €	321,06 €	574,9 €	71,1 €	414,8 €
R616241x	10,20 €	9	3,33	79	1 278,30 €	16,18 €	2 071,96 €	321,06 €	598,1 €	61,2 €	357,0 €
R618791x	9,65 €	9	3,33	80	1 266,00 €	15,83 €	2 030,69 €	315,39 €	617,5 €	57,9 €	337,8 €
R602595x	103,00 €	10	10	81	8 681,76 €	107,18 €	11 210,06 €	93,45 €	418,2 €	1 236,0 €	2 163,0 €
P602396x	12,36 €	10	5	81	1 169,50 €	14,44 €	1 935,66 €	292,64 €	207,8 €	148,3 €	383,2 €
P604548x	12,00 €	9	5	81	1 072,09 €	13,24 €	1 766,22 €	243,46 €	123,6 €	144,0 €	372,0 €
P609785x	39,14 €	8	5	80	3 204,16 €	40,05 €	4 403,59 €	199,19 €	91,2 €	469,7 €	1 213,3 €
P609454x	4,00 €	8	2	160	674,56 €	4,22 €	1 241,59 €	318,71 €	43,2 €	92,0 €	488,0 €
KK09236x	4,00 €	8	2	80	337,28 €	4,22 €	819,99 €	318,71 €	21,6 €	48,0 €	244,0 €
RT06669x	10,00 €	9	5	80	858,85 €	10,74 €	1 521,75 €	248,99 €	73,6 €	120,0 €	310,0 €
H610662x	36,05 €	9	5	80	2 320,30 €	29,00 €	3 348,56 €	248,99 €	-704,6 €	432,6 €	1 117,6 €
A610523x	35,00 €	8	5	79	2 914,10 €	36,89 €	4 092,16 €	204,24 €	188,7 €	420,0 €	1 085,0 €
A612324x	30,00 €	8	5	79	2 497,80 €	31,62 €	3 565,20 €	204,24 €	161,8 €	360,0 €	930,0 €
N615541x	15,45 €	8	5	79	1 248,90 €	15,81 €	1 984,32 €	204,24 €	35,9 €	185,4 €	479,0 €
N632574x	4,00 €	8	2	79	333,04 €	4,22 €	825,00 €	323,75 €	21,6 €	48,0 €	244,0 €
N645709x	30,90 €	8	5	79	2 497,80 €	31,62 €	3 565,20 €	204,24 €	71,8 €	370,8 €	957,9 €
N616668x	25,00 €	9	5	79	2 081,50 €	26,35 €	3 088,67 €	254,67 €	134,8 €	300,0 €	775,0 €
N611662x	3,00 €	8	1	80	227,54 €	2,84 €	682,81 €	358,55 €	-15,6 €	36,0 €	333,0 €
N612627x	10,00 €	9	5	80	868,00 €	10,85 €	1 533,19 €	248,99 €	85,0 €	120,0 €	310,0 €
SF10165x	164,00 €	10	5	363	59 592,00 €	164,17 €	82 631,39 €	349,55 €	82,6 €	3 116,0 €	19 352,0 €
SF45466x	23,00 €	9	1	80	1 840,00 €	23,00 €	2 748,19 €	408,35 €	0,0 €	138,0 €	2 415,0 €
H70260xx	10,00 €	9	4	79	790,00 €	10,00 €	5 815,44 €	1 656,08 €	0,0 €	160,0 €	1 150,0 €
SF30307x	0,77 €	10	1	82	63,14 €	0,77 €	562,84 €	446,00 €	0,0 €	3,1 €	79,3 €
SF13088x	1,60 €	10	1	82	131,20 €	1,60 €	645,84 €	446,00 €	0,0 €	6,4 €	164,8 €
SL12587x	3,25 €	11	1	165	536,25 €	3,25 €	1 181,18 €	491,34 €	0,0 €	26,0 €	672,8 €
SL12036x	6,20 €	5	4	242	1 500,40 €	6,20 €	2 809,25 €	169,89 €	0,0 €	99,2 €	713,0 €
SJ12125x	4,80 €	11	1	86	412,80 €	4,80 €	989,57 €	469,73 €	0,0 €	19,2 €	494,4 €
GF12486x	3,80 €	2	1,6	36	136,80 €	3,80 €	2 405,31 €	821,56 €	0,0 €	60,8 €	1 007,0 €
GF56142x	1,75 €	10	1	1280	2 240,00 €	1,75 €	2 061,24 €	271,40 €	0,0 €	101,5 €	1 849,8 €
GF18675x	0,04 €	11	0,67	966	38,64 €	0,04 €	98,73 €	64,17 €	0,0 €	0,2 €	12,1 €
FF19061x	0,46 €	8	1,25	67	30,82 €	0,46 €	521,69 €	425,89 €	0,0 €	0,9 €	37,3 €
AF22542x	0,16 €	11	0,4	966	154,56 €	0,16 €	122,73 €	74,79 €	0,0 €	0,6 €	80,5 €
TF13418x	22,43 €	11	3,33	122	426,17 €	22,43 €	2 602,20 €	226,41 €	0,0 €	89,7 €	740,2 €
N600056x	7,82 €	11	3,33	112	132,94 €	7,82 €	1 173,27 €	258,48 €	0,0 €	31,3 €	258,1 €