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DEVELOPMENT OF PRODUCT DATA MANAGEMENT AND MATERIAL CONTROL

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Abstract

Product data management and especially its relation to material control is becoming ever more important. Enterprise resource planning systems, which coordinate processes between different departments, are almost a necessity for effective materials management in today's production industry. Material control problems at Nokka Companies were recognised, and the need for developing the current situation was essential in order to survive in a fiercely competitive market environment.

A project called Modular Control was launched in the beginning of 2011 to shift the production style from make-to-order to assembly-to-order and diminish the numerous material shortages that caused the production to halt. To succeed in the project, product data, material management and the usage of enterprise resource planning system had to be revised and reengineered.

The project is expected to finish in late 2011 and if successful, the project will shorten Nokka's lead times, improve delivery reliability, secure work places, enable global expansion and therefore bigger market shares. Better results in material control have already been achieved by reengineering the purchase order process from manual methods to automatically generated orders and in the process of creating engineering change orders. The visual appearance of the raw and work in progress inventory has changed radically, since approximately 30 % of warehouse space was freed by removing obsolete items, which were in the way of efficient material control. The usage and general awareness of the capabilities of Nokka's enterprise resource planning system has also improved drastically, which has resulted in more effective and analytical usage of the system.

Keywords
Product data management, material control, materials management, enterprise resource planning system, ERP

Miscellaneous

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Tiivistelmä

Tuotetiedon hallinta ja erityisesti sen yhteys materiaalin hallintaan on yhä tärkeämpää yritysten toiminnassa. Toiminnanohjausjärjestelmät, jotka koordinoivat yrityksen prosesseja eri osastojen välillä, ovat lähes välttämättömiä tehokkaan materiaalivirran hallinnassa nykypäivän teollisuudessa. Materiaalin hallinnan ongelmat tunnistettiin Nokka Yhtiöissä, ja tarve tilanteen kehittämiseksi oli elintärkeää Nokan kilpailukyvyn säilyttämiseksi kiristyneillä markkinoilla.

Opinnäytetyö oli osa projektia, jonka tavoitteena oli siirtää lopputuotteen valmistus kohti kokoonpanotyötä ja eliminoida lukuisat materiaalipuutteet, jotka aiheuttavat tuotantokatkoksia. Projektin onnistumisen kannalta oli keskeistä, että tuotetiedon, materiaalien hallinnan sekä tuotannonohjausjärjestelmän käyttöä muutettiin ja kehitettiin.

Hyviä tuloksia on saavutettu muuttamalla manuaalinen ostotilausprosessi automaattiseksi sekä selkeyttämällä muutosilmoitusprosessia. Varastoista poistettiin epäkurantti tavara, joka hankaloitti tehokasta materiaalien hallintaa. Näin ollen tuotantotilojen visuaalinen ilme parantui ja varastohyllytilaa vapautui noin 30 %. Nokan tuotannonohjausjärjestelmän käyttö ja yleinen ymmärrys sen mahdollisuuksista on kasvanut merkittävästi. Tuotannonohjausjärjestelmän käytöstä on tullut analyyttisempaa ja huomattavasti tehokkaampaa. Projektin odotetaan lyhentävän Nokan pitkiä toimitusaikoja sekä parantavan toimitusvarmuutta. Projekti luo myös perusteet entistä paremmalle kansainväliselle kasvulle sekä turvaa työpaikkoja.

Avainsanat (asiasanat)
Tuotetiedon hallinta, materiaalin ohjaus, tuotannonohjausjärjestelmä, ERP

Muut tiedot

CONTENTS

TERMINOLOGY

ATO	Assemble to Order
BOM	Bill of Material
CAD	Computer Aided Design
CRM	Customer Relationship Management
ECO	Engineering Change Order
EDM	Engineering Data Management
ERP	Enterprise Resource Planning
ETO	Engineer to Order
GDP	Gross Domestic Product
ID	Identification
MPS	Master Production Schedule
MRP	Material Requirement Planning
MRP II	Material Resource Planning
MTO	Make to Order
MTS	Make to Stock
OCC	Operating Cash Cycle
PDM	Product Data Management
PIM	Product Information Management
PLM	Product Lifecycle Management
SaaS	Software as a Service
ROI	Return on Investment
TIM	Technical Information Management
WIP	Work in Progress

1 INTRODUCTION

Nowadays the competition of the market shares in the manufacturing industry is starting to become very cut-throat. It is not enough that a company is able to launch new innovations, since they are usually copied or modified by the competitors. A strong brand is a necessity and a far-reaching support for a company, but if it is not able to meet the needs of the customer the brand will not sustain the company for long. Therefore listening to the customer needs and providing variety combined with a short lead time and great quality is the key issue for winning a greater share of the market. (Kotler 1999, 3-9.)

In order to meet the needs of the markets, internal processes often need to be revised and modified. These modifications are usually started when the company is hanging by a thread trying to secure the future operations. This phenomenon has been identified at Nokka Companies and a project, discussed in this thesis, has been launched to modify the processes.

Since the thesis is a case study that is based on project work, both quantitative and qualitative methods were needed to complete it. As quantitative methods, ABC-analysis was conducted and extended with XYZ-analysis. Interviews and team meetings were used as qualitative research methods. The data for the quantitative analyses was derived from the database of Nokka’s enterprise resource planning (ERP) system. The data was processed and converted to information. The quantitative information and the knowledge gained from the qualitative methods were combined in order to develop Nokka’s current situation. In Table 1 the actions done and the results achieved are summed. These actions are listed in the order of appearance in the thesis and are explained more thoroughly in the later chapters.

TABLE 1. Actions and results summed.

Actions	Results achieved
Organising the item register	Better search functions for items, up-to-date item descriptions, savings can increase up to 100 000 Euros annually.
New engineering change order model	Better traceability of changes, minimising the risk of leaving materials obsolete.
3D configurator	Great potential to increase sales, utilising modular structures, more accurate sales orders.
ABC-XYZ analysis	Foundation for defining material control strategies.
Defined material control strategies	Securing the availability of materials with proper supplier selection and safety stock levels.
Adding warehouse locations, removing obsolete material	Potential to save 200 000 € annually by cutting search time, improving inventory turnover and visual appearance.
Familiarising Nokka’s ERP system	ERP training increased general awareness of its abilities, eased the change process, will enhance material controllability.
Automating purchase orders	Decreased manual labour and hassle, focusing resources better, securing material availability.
Capacity management	More accurate situation reports on manufacturing’s state.

1.1 Objectives of the thesis

One of the main objectives for the project was to develop materials management by implementing new material control procedures in order to avoid material shortages. To develop material control, product data management and enterprise resource planning systems were studied and leveraged for the purposes of the main objective. With the help of new material control procedures, the aim was to shorten lead times and create foundations for more global operations in the future. By improving lead times and delivery reliability globally, the work places of the employees at Nokka are secured for the future.

1.2 Nokka Companies – globally local

Nokka Companies is a family owned consolidated corporation which consists of two independent subsidiary companies, Nokka Oy and Pematic Oy. Nokka Oy was founded in 1967 in Viitasaari by Mr. Jorma Nokkala, who at the moment is the chairman of the board. Later in 1970 Nokka moved to Muurame, where it is still operating. Nokka started its production with snow blowers and manure spreaders. Snow blowers have continuously been in production since the beginning. Nowadays the main products, besides snow blowers, are forest trailers and hydraulic grapple loaders with a trailer or tractor mounting. In the mid 1980’s Nokka made two acquisitions, joining Wärtsilä’s agricultural branch and Tume Oy to itself. Later these companies were sold forward and Nokka’s focus was concentrated on their main products.

Cylinder manufacturing was a part of Nokka’s production till 1999 when Pematic Oy was incorporated from Nokka. Pematic is one of the biggest business to business cylinder manufacturers in Finland and they produced over 80 000 cylinders in 2008.

Nokka Companies employ around 130 people and its turnover in 2008 was 19 million euros. The turnover is generally divided around 60/40 % between Nokka and Pematic. As the share of export in Nokka is over 60 % and they export to over 25 different countries, it is fair to denote that Nokka is an export driven company and the share of export is expected to increase in the future. Nokka and Pematic share the manufacturing site that has an area of 10000 m^2 and Pematic has an additional area of 2000 m^2 for surface treatment, assembly and outbound logistics. (Nokka Companies 2011).

2 PRODUCT DATA MANAGEMENT

2.1 PDM philosophy

Managing various files, spreadsheets, pdf-documents, technical drawings etc. in a personal computer's folder structure has its own difficulties. When extending this same style of file management to a corporation where dozens of workers handle and edit the same documents every day – a hassle is guaranteed. Over time, file management has had different abbreviations and forms, such as engineering data management (EDM), product information management (PIM), technical information management (TIM) etc. (Philpotts 1996, 11). Nowadays these various management philosophies have been compressed together into what is now known as product data management (PDM) (see Figure 1).

FIGURE 1. Product data management.

PDM is a tool that helps engineers and managers to integrate information flow processes and manage them better. Product data management systems are information systems that are able to keep track of a vast amount of information that is essential for a product throughout its lifecycle, from design to disposal. (Philpotts 1996, 11). Allowing a PDM system to handle the information flow, ensures the delivery of right information to the right people at the right time and in the right form. This way the communication between personnel and departments enhances when the time spent on searching or even working the wrong document is minimised. (Liu & Xu 2001, 252.) Figure 2 illustrates a PDM system in action.

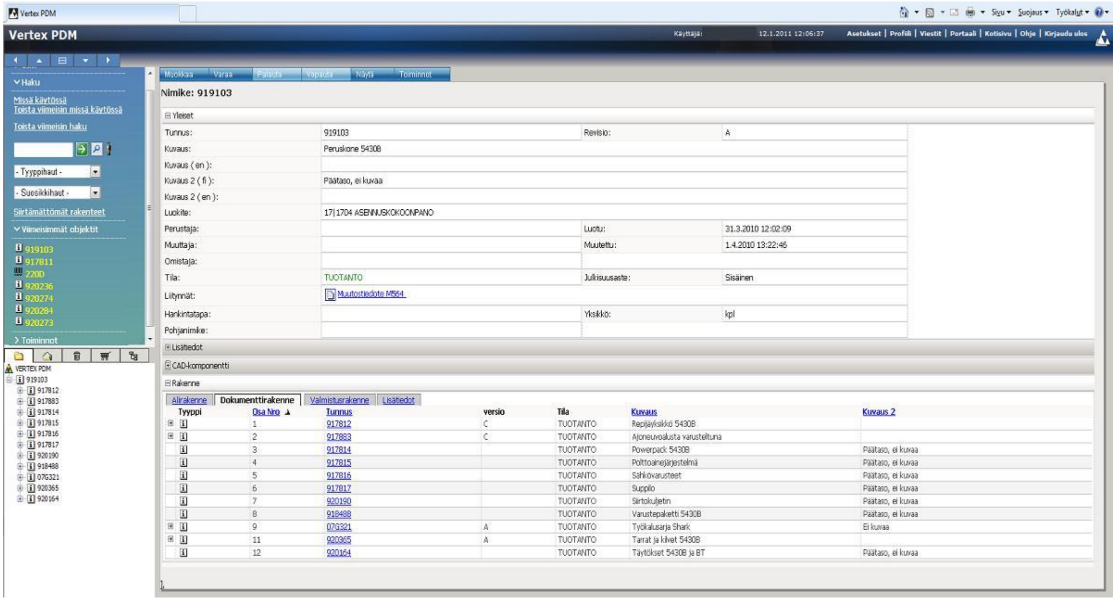


FIGURE 2. PDM system in use (Vertex PDM 2011).

Sometimes PDM systems are confused with enterprise resource planning systems due the similarities in their descriptions. PDM, in contrast of ERP, strongly focuses on the design and the documents that are created during the design phase. The product's relationship to these documents is then managed throughout the whole lifecycle of the product, whereas ERP systems are more concentrated on manufacturing and the phases that the product spends in the manufacturing company. (Liu & Xu 2001, 252.)

2.2 From product data to innovation

Often the terms data and information are mixed. Data alone is raw unprocessed figures that do not have any meaning. Information, on the other hand, is derived from data by processing, has a meaning and it can be interpreted. For example a figure 1950 by itself is meaningless. The figure can mean a year, price, distance, nearly anything. If the figure is attached to a sentence, for example, '1950 people answered the survey' it is now processed and transfered to information. (Bellinger 2004.)

When information is gathered and memorised, it becomes knowledge or, to be exact, amassed knowledge. For example, a child learning multiplication tables is amassing knowledge. The child can tell you that 5 times 5 equals 25 but he/she is not capable of calculating 52 times 630. For the child to be able to perform such a difficult calculation he/she needs to understand the patterns and apply them. (Bellinger 2004.) An educational environment is a perfect example of this kind of behaviour since there are students who memorise things for an exam and yet forget them later, and students who truly understand issues and can apply them later.

Wisdom already starts to approach the twilight zone of philosophy. According to Rowley (2006, 1248-1249), wisdom is the use of understood knowledge combined with right and wrong judgement decisions. Bellinger (2004) states that computers are not capable of achieving wisdom because of the humanity needed in the decision making. At this rate of development in information technology, everything seems to be possible.

According to Matthews' (1997, 208) observations, a connection between wisdom and creativity exists. Creativity, on the other hand, arouses innovations which lead to new products and product data. Figure 3 illustrates the knowledge cycle.

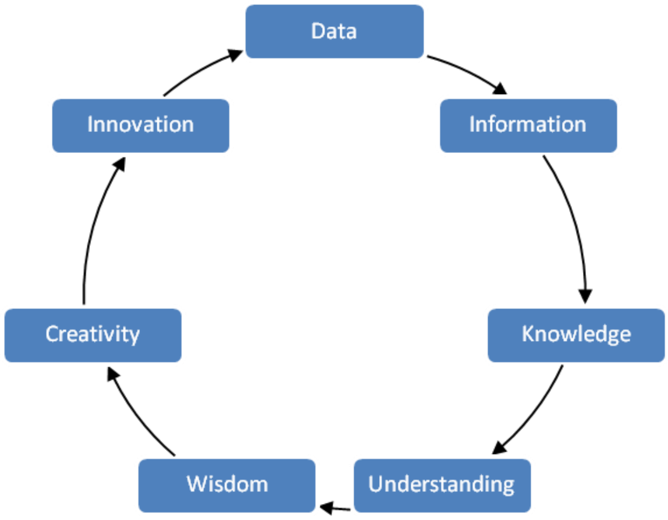


FIGURE 3. Knowledge cycle.

In the context of PDM, the inputs to the system are mere data and partly information. The bill of materials (BOM) consists of data, but technical drawings and maintenance manuals are already information for the system. The system needs patterns and frames on which it performs the activities told. Modern computer systems are capable of learning patterns and utilising them in various activities e.g. in work flows.

2.2.1 Item register

In PDM systems everything begins from a single item. An item can be, for example, a rivet, an axle or a tyre. All the parts that relate to the final product are called items. Development of PDM and the functions of various IT systems have their roots in a functional item register. It is essential that the item register is uniform according to a company's or more general standards. (Sääksvuori & Immonen 2002, 19.) A single item can contain tens of different data attributes. Below are a few most common ones listed:

- Item identification code
- Description 1 & 2
- Item group
- Procurement type (manufactured/purchased)
- Procurement duration (lead time)
- Warehousing and purchasing units
- Warehouse location
- Safety stock level
- Bill of material code.

Normally the items are sorted into categories and sub-categories. A top category can be, for example, hydraulic equipment, and its sub-categories can include hydraulic tubes, cylinders and valves. Logical and not too detailed categorization of items eases the search of a single item and the managing of the register. Too detailed categorisation increases the work needed to maintain the register and the probability for errors. (Sääksvuori & Immonen 2009, 19.) As reporting usually is important for companies, proper categorisation also helps to fetch reports based on different categories. For example, a report on the number of different hydraulic or pneumatic cylinders or the purchases of them in a given time frame, is now easily accessible due to proper categorisation.

2.2.2 Bill of material

Once the items are properly identified and categorised, they can be gathered to a bill of material (BOM). In its simplest form the BOM is a list of parts that are required to build a product. It contains the item's identification (ID) code and the quantity needed. A more complex BOM can hold a multi-level structure from the product's sub-assemblies, and it may include several different technical drawings and other documents from the sub-assembly manufacturer. (NEMI 2002.)

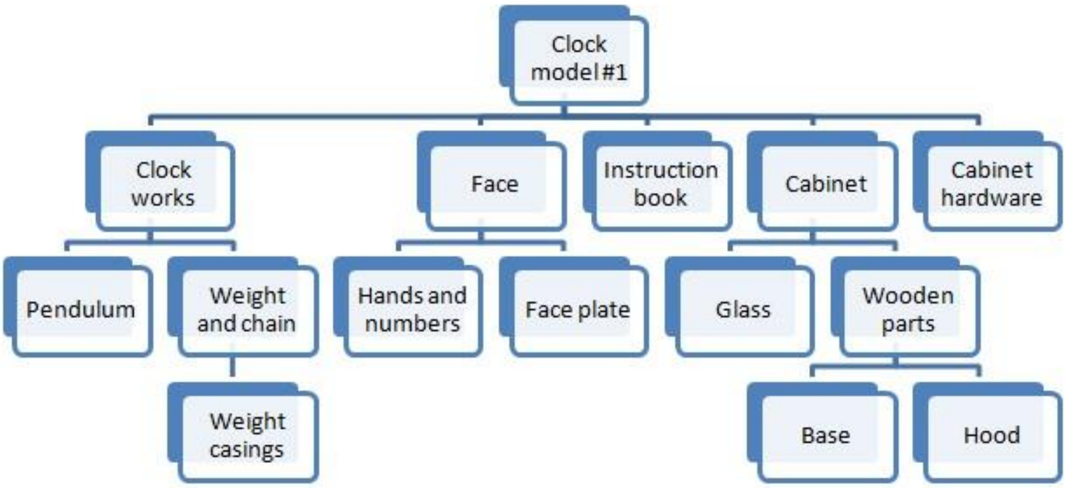


FIGURE 4. Traditional BOM (Stonebraker 1996, 253).

Basically there are two ways of expressing BOMs; A traditional fixed single or multi-level BOM and a modular BOM. The traditional BOM is fixed to the product's model and each model will have a unique BOM whereas a modular BOM can be customised. (Stonebraker 1996, 252.)

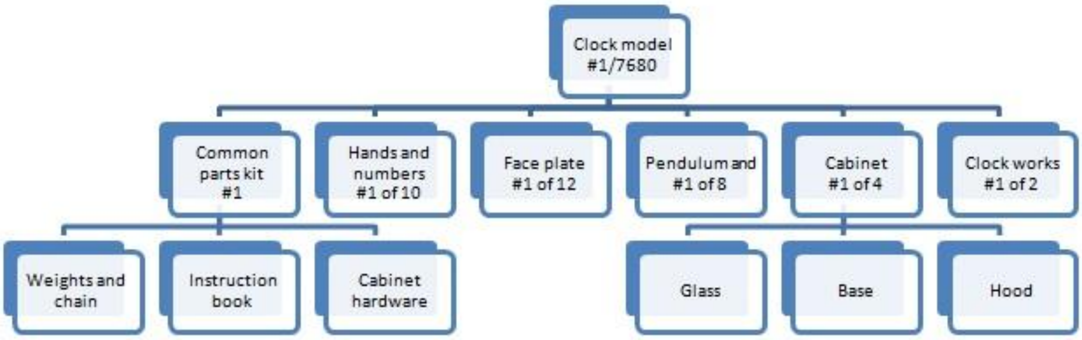


FIGURE 5. Modular BOM (Stonebraker 1996, 253).

As it can be seen in Figures 4 and 5, the modular design reduces the number or material levels to three instead of four. With the modular design, you can assemble 7680 different clock models (1*10*12*8*4*2=7680), assuming that every model is compatible with different modules, and manage 37 modules instead of having 7680 individual bills of material. (Stonebraker 1996, 253.) The modular design will reduce the number of errors and save time, since someone should input the data to the system. It is better to do one properly than bungle 7680 different BOMs.

In modern PDM systems the BOM can be generated automatically when the final product has been designed. This data can be then transferred, for example, to an ERP system to serve the manufacturing purposes. (Philpotts 1996, 14.) PDM systems reduce the amount of manual labour needed, but in order for the PDM system to automatically form BOMs it needs a viable item register to support it.

2.2.3 Work flows

In PDM systems' work flow management section the work processes are described and modelled in a flow chart. The modelled work flow is then executed and the PDM system manages the actual work flow, so that the right work is done at the right time with the right information by the right person (Choi, Lee & Shin 2010, 650). The PDM system gives notifications to control the activities. For example, a designed part that has not been approved yet by the management will not be manufactured.

There are two types of work flows: static and dynamic. Static work flows are fixed and once they are modelled and started they have to be finished according to the model. Dynamic models can be modified easily since usually there is a visual flow chart that can be used in a drag-and-drop style. Once a dynamic model has been started, it can be changed if the process needs to be changed while the work flow is in progress. (Qiu & Wong 2007, 453.) Older PDM systems usually apply the schematic static work flow, whereas the newer systems use graphical work flow modelling as can be seen in Figure 6 below. After modelling the work flow, permissions are assigned to different users allowing them to approve, release or modify the documents.

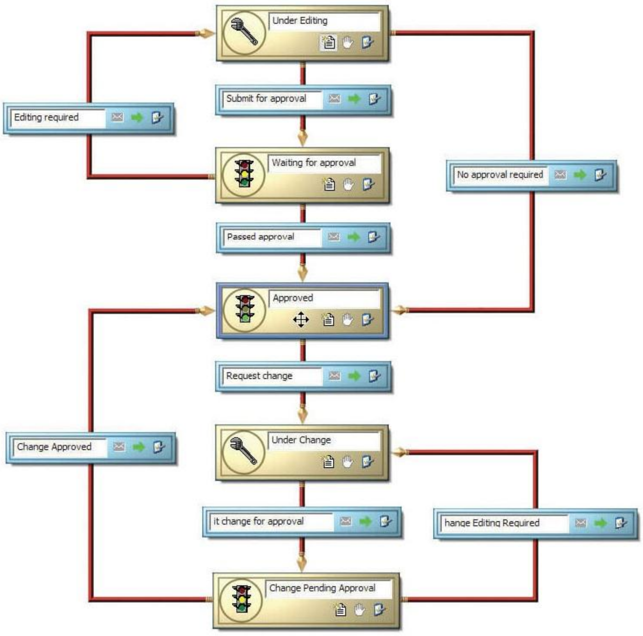


FIGURE 6. SolidWorks Enterprise PDM work flow (Javelin 2011).

2.2.4 System architecture

All PDM systems basically have three same main functional components in their architecture that the PDM system is built on: the data vault, meta-database and the application.

The data vault is a file server that stores any format of files (Sääksvuori & Immonen 2002, 24). To edit a document or a technical drawing whilst a PDM system is in use, the document needs to be checked out from the vault and then checked back in. This process secures the document's integrity in order for it not to be duplicated. (Manninen 2010.)

Metadata, in a digital context, is the data used for describing the file or the content of a document. The need aroused from libraries due to their massive amount of descriptive data. (Lehikoinen et al. 2007, 81.) For example, in an item the description fields are metadata and its values can be "Sprocket" and "Ø100mm". The meta-database in a PDM system controls the document's relation to other documents and the rules for how the system links information (Sääksvuori & Immonen 2007, 24).

The application combined with the rules in a meta-database form the PDM software. For the user, the functions of a PDM system are shown as various user interfaces. The metadata is inserted into the user interface since the application is not able to detect the content of a document. The trend in the future, however, is that the applications will be capable of detecting some amount of the content and insert the metadata automatically, thus minimising human errors. (Sääksvuori & Immonen 2007, 24). Figure 7 illustrates an example of a PDM system's architecture.

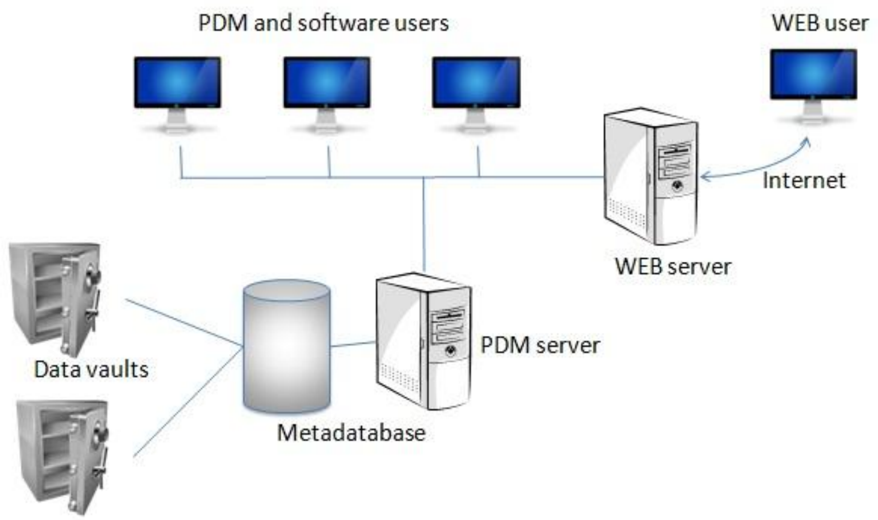


FIGURE 7. Example of PDM system architecture (Sääksvuori & Immonen 2002, 26).

2.3 Integration with other systems

When the PDM systems started to boom they were used alongside separate systems, like ERP, customer relationship management (CRM), computer-aided design (CAD) and word processing software. Some companies may have had to insert the same data several times to different systems before the real benefits of PDM were achieved. PDM systems are especially designed for managing product data, whereas CAD and ERP are not. On the other hand, PDM is not designed for creating drawings or controlling material flow, so rather than ruling out one another, they complement each other. Listed below are the most common systems in which a PDM system is usually integrated:

- Enterprise resource planning (ERP) system
- Computer-aided design (CAD) system
- Image processing software
- Cost accounting system
- Sales and customer relationship management (CRM) system
- Viewers.

When the systems have been integrated, the same data is now updateable from different systems. It is important to lay rules for users, where the data is updated and who owns the information. If the data is updated from a single system, the other systems can easily replicate the data according to their needs. (Sääksvuori & Immonen 2007, 24).

2.4 Business benefits

Implementing a PDM system takes time and is usually a fairly long project. The benefits do not appear immediately and sometimes they might be hard to notice. In spite of the work needed in the beginning to successfully implement a PDM system, if the time spent on searching the data is taken into account the investment pays back quite quickly – both financially and operationally.

Keeping the product data in separate hard drives and folders does not promote visibility inside a company. Nowadays geographical distance and time difference creates new problems. Everyone is not within a shouting distance from each other.

This causes the data to outdate in personal drives and the correct version of a document will not be available for everyone. When introducing a PDM system, the data is stored to a single location and the process enables quick search functions. (Kropsu-Vehkaperä, Haapasalo, Harkonen & Silvola 2009, 764; SolidWorks PDM 2009.)

Due to the effective search functions, the right data is available for everyone without wasting time to look for the data. Saving time and minimising errors create valuable financial savings which result as better operating efficiency. Designers, for example, can reuse already designed parts instead of drawing new parts to the system that might overlap with the already existing ones. (SolidWorks PDM 2009.)

According to Philpotts (1996, 15), Kropsu-Vehkaperä et al. (2009, 764), processes for designing products, making change orders and sharing information are usually inadequately defined. People are lacking information, which causes communication problems and might lead to financial losses. Modelling and defining these processes to a PDM system causes the work methods to be systematic, allowing everyone to stay informed on the most up-to-date information.

2.5 The future trend

PDM nowadays consists of data related to the final product. In the future PDM systems will gain more content and features. There are already product lifecycle management (PLM) systems available that contain a wider scope of functions related to a product’s whole lifecycle. In addition to PDM systems, PLM systems focus on reengineering product development and manufacturing processes and their relation to product lifecycles. PLM is a strategic decision that leverages PDM and other technologies. PLM systems improve productivity in the supply chain rather than in a single production unit. PDM sets the foundation for PLM and usually is a natural path to continue if a business keeps growing (see Figure 8). Implementing PLM straight away is a very long process whereas, PDM delivers results quicker and is usually more reasonable for small and medium sized companies. (SolidWorks 2008, 2; PLM Technology Guide 2008.)

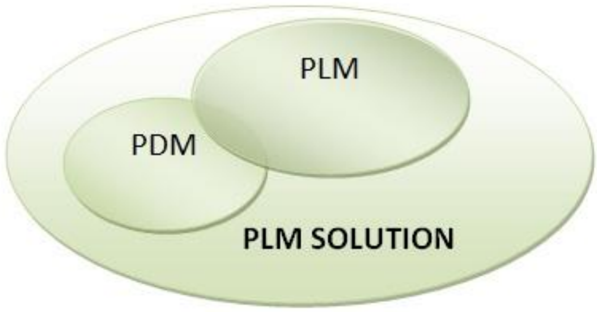


FIGURE 8. PLM solution (SolidWorks 2008, 3).

3 PRODUCTION AND MATERIAL CONTROL

3.1 Production flows

In a factory the physical arrangement and capabilities of machines determine how production control should operate. A job shop type production is very flexible in manufacturing a range of different products. The machines are not specified only for one task and different tools/configurations need to be set up every time the work changes. The challenges of a job shop lie in its unpredictability of process and setup times. (McKay & Wiers 2004, 20.)

Flow shops, on the other hand, are much more specialised in a single product or to a few models of it. Machines are arranged according to the production sequence and the production flows through it. Compared to a job shop, a flow shop is much easier to plan and control, but it becomes economical only when a certain volume of production can be reached. (McKay & Wiers 2004, 20.) Figure 9 illustrates the differences between a flow shop and a job shop.

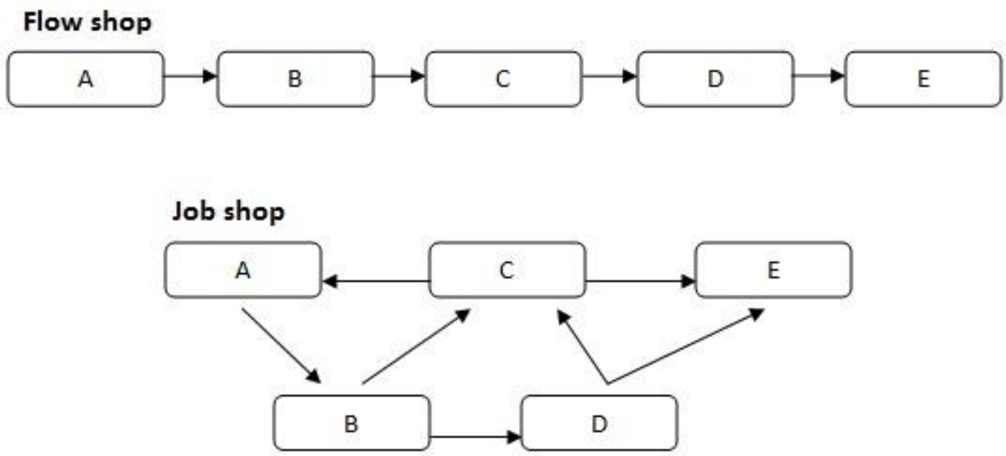


FIGURE 9. Job shops and flow shops (McKay & Wiers 2004, 20).

Combinations of these two styles can be arranged, which results in variation in production volumes and product variety. As Figure 10 illustrates, increasing the volume of production decreases the product variety and vice versa. When job and flow shop production styles are combined, products are usually produced in batches. Batch production can be seen as a compromise with product volume and variety, but has its own problems. The production facilities tend to be larger than in the far end production styles due to the lack of specialisation and bigger variety. Capacity and material management are a challenge, since the whole batch is moved from one work post to another. Changing products also increases the risk of leaving a certain amount of material obsolete if material management is sloppy. (Miltenburg 2005, 339-340.)

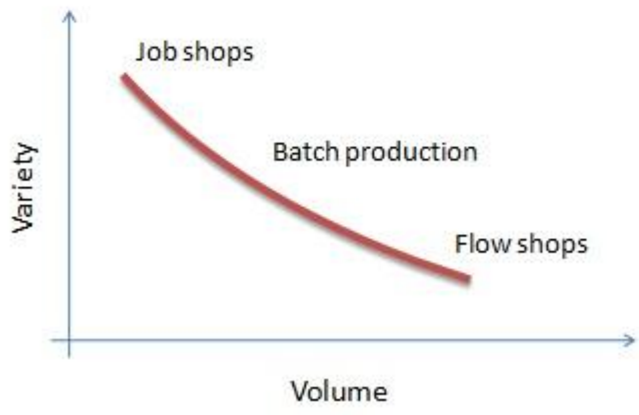


FIGURE 10. Production volume versus variety.

3.2 Order penetration point

The order penetration point (OPP) is defined as the point where a customer order is linked to a product. In other words, a company begins to add value to the product designated for the customer at the point of OPP, except in the case of make-to-stock (MTS), where the product is already fully processed. According to Arnold, Chapman and Clive (2008, 4-5) there are four main manufacturing strategies (see Figure 11) that are defined in the following paragraphs.

3.2.1 Engineer-to-order

In engineer-to-order (ETO) manufacturing, the customer sets all the specifications and is involved in the product design. If there are plenty of orders, a backlog will arise. The final product is fully customised according to the customer needs. The delivery lead time is long because everything is started from scratch. Usually inventories do not exist in ETO manufacturing, because the final product is unknown. For example, big cruise ships are ETO products.

3.2.2 Make-to-order

Make-to-order (MTO) means that the manufacturing begins or is put to a backlog when then customer order has been received. Inventory is kept as raw material and standardised parts allowing partial customisation of the final product. Sub-assemblies are not usually held in the inventory due to the high costs. Delivery lead time is reduced due to the lower amount of design needed. Aircraft are a good example of MTO products.

3.2.3 Assemble-to-order

In assemble-to-order (ATO) manufacturing, the final product is assembled or put to a backlog when the customer places an order. The product is usually made of standardised components or modules that can be attached together. The customer can customise the final product on the terms of the modules. Delivery lead time is shorter since the components/modules are kept in the inventory. On the other hand, the inventory value increases. Nowadays cars use the ATO ideology and people can select their own modules through the internet. Another example of an extremely late ATO order penetration are paints, which are mixed (assembled) just a few seconds before the transaction.

3.2.4 Make-to-stock

Make-to-stock (MTS) means that the finished goods are produced to an inventory and sold from there onwards. The delivery lead time is the shortest and the customer usually has limited or no chances of customising the product. Usually the inventory value is quite high if the demand is unpredictable. This is the most common and usually the easiest strategy to follow. MTS usually utilises flow shop production systems to mass produce products such as crockery and casual clothes.

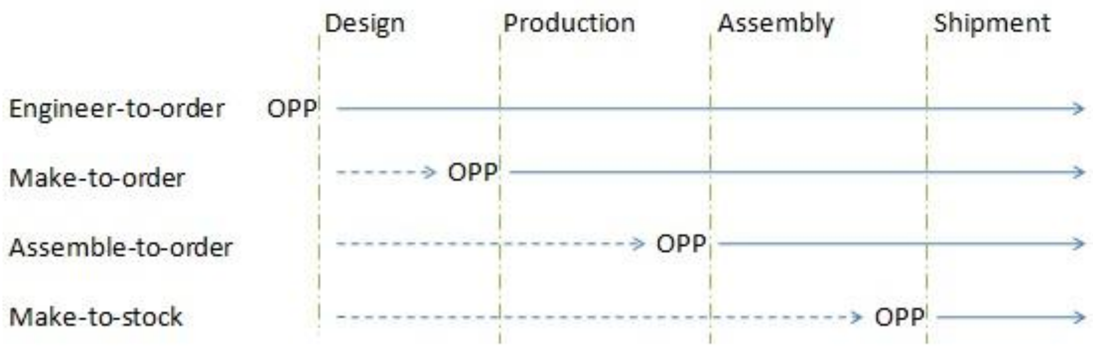


FIGURE 11. Order penetration points (Olhager 2003, 320).

3.2.5 Order penetration point constraints

By shifting the OPP in the manufacturing value chain, a company may gain some strategic advantage, but the market also adds its constraints (see Figure 12). Requirements for the lead time restrict how far backwards the OPP can be positioned. If the product is expected to be available from the shelf, a customer will get it from somewhere else if needed. (Olhager 2003, 321.)

Seasonality, customer order size and frequency are related to forecasting and consumer behaviour, which create the constraints for the OPP shift. During a low season, a company might shift their OPP forward and produce finished goods to stock. Later during a high season, they would sell their stocks and replenish the inventory on the MTO basis. (Op. cit. p. 321.)

The demand for a larger product range or customisable products prevents a forward shift of the OPP (Op. cit. pp. 321-322). The automobile industry is a good example, since the degree of customisation is high. Manufacturing highly customized cars based on a forecast would leave vast amounts of finished cars obsolete later. Therefore a forward shift is nearly impossible.

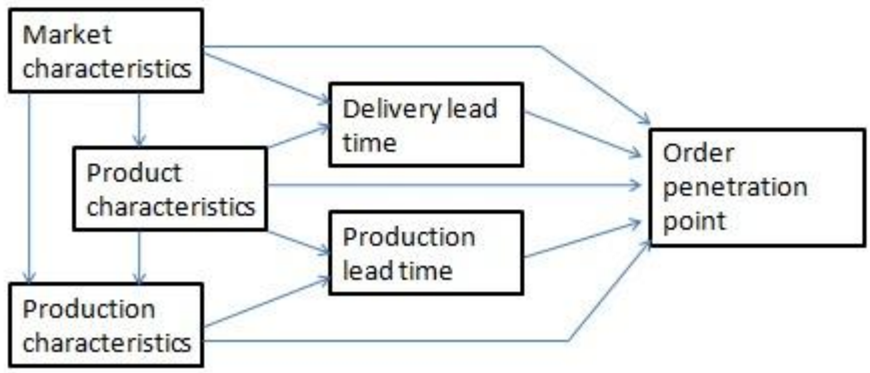


FIGURE 12. Factors impacting the positioning of OPP (Olhager 2003, 323).

3.3 Capacity management and production planning

As the MTS strategy holds finished goods in the inventory to meet the customer needs, the other strategies have to be able to meet the demand in available capacity and material. Since unused capacity represents lost revenue and unavailable capacity can cause lost sales, the capacity planning should be as accurate as possible. (Chen, Mestry, Damodaran & Wang 2009, 1461.)

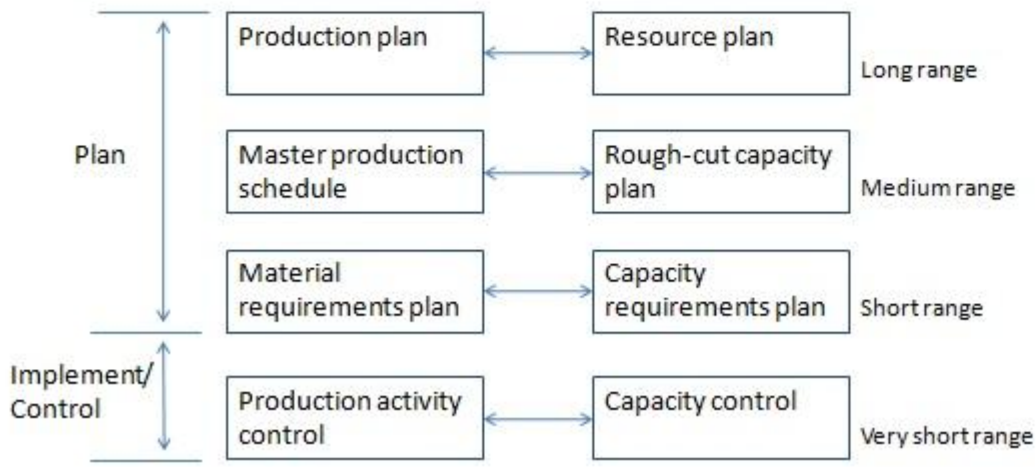


FIGURE 13. Planning levels (Arnold et al. 2008, 128).

Figure 13 illustrates how capacity management and production planning are usually divided into four stages: long-, medium- and short term planning and implementation control. (Olhager, Rudberg & Wikner 2001, 215; Arnold, Chapman & Clive 2008, 127-128.) The long term capacity planning horizon is from one to five years, whereas implementation control focuses on the current moment. Managing the capacity can be compared to adjusting a valve (see Figure 14). There is a certain load which needs to go through the valve; if the valve is almost closed it will trickle little outputs. By adjusting the valve, capacity can be increased or decreased.

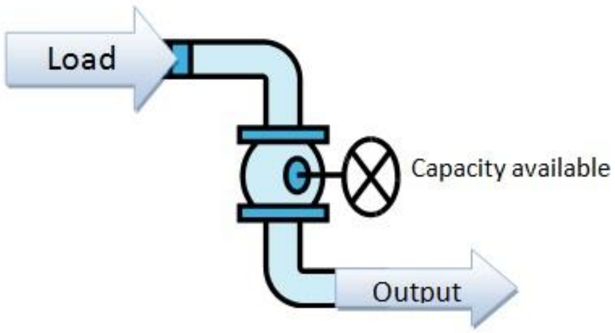


FIGURE 14. Adjusting capacity.

3.3.1 Master production schedule

The master production schedule (MPS) is a framework for planning production, inventory and staffing. The MPS gives a timetable of the planned output for each product usually within a week’s time span. For example, the manufacturer might have an aggregate production plan to produce 1000 computer keyboards within a month. The MPS defines that in the first week 100 Scandinavian and 150 American keyboards will be produced. Since forecasts are just estimates of the future, they are usually adjusted in the MPS to meet short term variations and capacity constraints. (Waters 1999, 102.) The planning horizon is usually from 3 to 18 months, but it is mostly determined by the purchasing and manufacturing lead times (Arnold et al. 2008, 24-25).

3.3.2 Materials requirement planning

The material requirements planning (MRP) is a detailed list of parts to be purchased and manufactured, which is used to plan the needed materials for production. It is based on the scheduled manufacturing and forecasts from MPS. The basis of MRP are the BOMs and the lead times. It matches the inventory levels and scheduled receipts, and based on this information, the system calculates the required quantities for each sub-assembly and component. (Segersted 1996, 127.) An MRP flow chart is illustrated in mathematical and text form in the Appendices 1 and 2 respectively.

3.4 Managing inventories

Nearly every manufacturing company carries some kind of an inventory. Mostly, according to Arnold et al. (2008, 254), inventory represents 20 % to 60 % of the total assets of a manufacturing company. As the inventories are used, their value is converted to cash eventually, which improves the cash flow and return on investment (ROI). Inventories result from production, as final products, or then inventory supports production in the form of raw material or work-in-process (WIP). Since inventories exist practically everywhere, though sometimes they are referred to as reserves or stores, inventory management has become an important field due to the fact that the amount of money tied up in the inventory could be used somewhere else (Waters 2003, 4).

3.4.1 Balancing supply and demand

Usually keeping an item in the inventory does not create extra value for the product; on the contrary, it is losing its value over time. There are exceptions however, such as classy wines, unique pieces of art or historical items. For manufacturing companies inventories are essential for balancing out the supply and demand. The demand can be internal or external, meaning a demand from the next work phase or then from the end customer. (Waters 2003, 8.) As it can be seen in Figure 15, on day 7 the inventory level decreases below 0. In practice, a work process should be done on that day but there is no material available. Considering a car assembly, this would stop the entire assembly line at the cost of tens of thousands of Euros per hour.

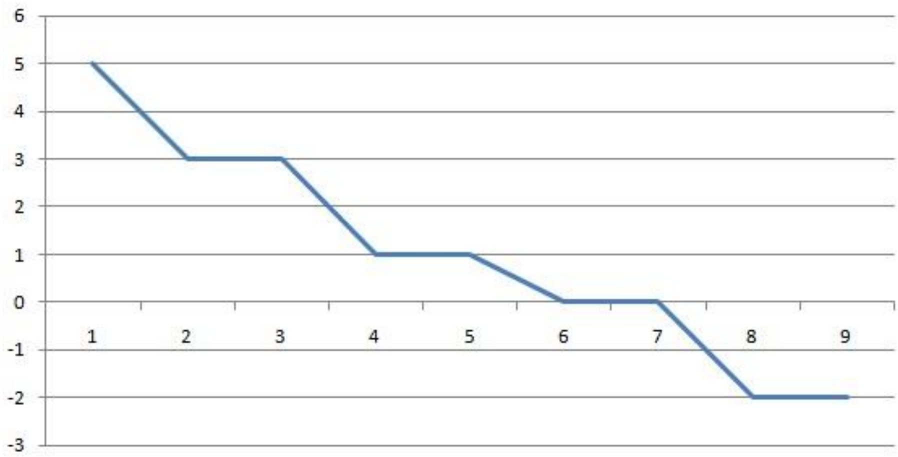


FIGURE 15. Daily inventory level in computer systems.

Carrying massive inventories to secure the availability of all items will be inefficient, since the amount of money involved to the inventory would be too great. Therefore, forecasts are made and shared with the suppliers to ease the production and inventory planning. In forecast driven industries, a small change in customer behaviour can cause a big distortion in forecasts to the beginning of the supply chain. This is known as the Bullwhip or Forrester effect. A 5 % fluctuation in the end customer's behaviour can cause over 40 % fluctuations upstream in the supply chain. (Disney & Towill 2006, 160-162.) Over-ordering from the supplier builds up great inventories, which are then consumed later on. The supplier relays the information to its suppliers, who predict that they will sell over the usual amount, where the effect of over-ordering is amplified (see Figure 16). As the excess inventories are consumed downstream of the supply chain, the supplier's supplier is now preparing to manufacture over the actual demand. (McCullen & Towill 2002, 165-166.)

Reducing bullwhip is essential, as otherwise, from time to time, some supply chain parties are carrying excess inventories and others are having material shortages. Everybody will be in lose-lose situation since the costs will be carried onwards in the supply chain. Comprehensive information sharing in the whole supply chain, smoothing the forecasts and reducing panic-ordering are key issues in avoiding the bullwhip effect. (Disney & Towill 2006, 162).

FIGURE 16: The bullwhip effect (Disney & Towill 2006, 163).

Giannoccaro, Pontrandolfo and Scozzi (2001, 186), state that the growing innovation rates and shorter lifecycles make forecasting much more difficult. This will increase the risk of material shortages, or instead excess inventory, which will be obsolete later. It will also amplify the bullwhip effect ever more.

3.4.2 Prioritizing inventories - ABC-XYZ analysis

According to Gopalakrishnan and Sundaresan (2006, 32) the ABC analysis is an analytical management tool used to determine where to place efforts in order to maximise the results. The ABC analysis is based on the Pareto principle, also known as the 80/20 rule, which states that 20 % of the items create 80 % of the costs. This class is known as the A-class. In the B and C-classes the following 30 % and 50 % create the final 15 % and 5 % of the costs respectively. The percentages are not absolute and usually vary. (Arnold et al 2008, 271.)

Even though an ABC analysis seems like an easy choice to categorise items, it has its pitfalls. The data used for making the analysis has to be consistent. However, if the data is not consistent, the results might be very confusing. (Hoppe 2006, 55.) One has to keep in mind that the data used is always historical data. Planned changes in final products do not appear in the analysis. Therefore, interpreting the analysis needs knowledge about the company and its operations.

The ABC analysis is a primary analysis and it can be used for secondary analyses such as the XYZ analysis. In the XYZ analysis, the items are classified according to the usage fluctuations. Each category derived from the ABC analysis is divided into three more sub-classes, resulting as classes $A_{X,}$ $A_{Y,}$ A_Z etc. The fluctuation of X class items is minimal and the consumption is steady over time. Y class items can be categorised as items that have seasonal behaviour, meaning that the consumption is not steady all the time. Z class items are not used regularly and their fluctuation is stochastic. (Hoppe, 2006, 60.)

When combining the ABC and XYZ analyses, strategic actions for each class can be determined. It should be kept in mind that the A class is still considered the most important class even though there are now $A_{X,}$ A_Y and A_Z sub-classes. A_z might seem insignificant, but it is still an A class item, it just fluctuates stochastically.

3.4.3 Working capital

According to Nordea (2011), working capital is a measure of a company’s efficiency. It shows how much a company’s capital is invested in operating processes. If the amount of working capital is great, a company needs lots of money to run day to day operations and vice versa. When analysing working capital, there are four major elements that require special attention (Atrill & McLaney 2007, 385-417).

- Inventory
- Trade receivables
- Cash
- Trade payables.

Working capital can be calculated by adding up inventories, receivables and cash, and then deducting payables and bank overdrafts from them. It is the difference between current assets and current liabilities. Working capital investments cannot be avoided in practice, since all companies need cash to operate. Traditionally, working capital has been seen as a positive component of the balance sheet. However, it actually does not contribute to a company's profits or losses since it sits and waits for disposition on the balance sheet. Obsolete and not saleable inventory might be even hidden in the working capital figures. (Sagner 2010, 13-14.)

As mentioned earlier, inventory does not increase the value of the product. The costs of holding inventories include lost interest, warehouse costs, insurance and the risk of obsolescence. However, if inventories are not held, it may cause lost sales and production interruption that creates more costs when ordering material immediately. (Atrill & McLaney 2007, 388-389.)

Trade receivables mean the sales made on credit, allowing the customer to pay later. This results in lost interest, lost purchasing power, administrative costs and bad debts. If the credit is denied, it might result in lost sales. (Op. cit. p. 398-399.)

Cash is essential for day-to-day activities; wages, overheads expenses and purchased goods must be paid. If the future cash flow seems uncertain, the cash on hand acts as a buffer to meet the required payments. If the company is able to borrow cash quickly, the cash on hand can be reduced. Holding cash results in lost interest, but not holding it enough can cause a decrease in solvency, loss of opportunities, the inability to claim cash discounts and the cost of borrowing. (Op. cit. p. 406-408.)

Trade payables in this context mean the money that a company owes to its suppliers from whom it purchases on credit. The cost of purchasing on credit includes a higher purchase price than immediate cash payment and administrative costs. If not purchasing on credit, the payment might have to be paid at the time when it is inconvenient. (Op. cit. p. 413-415.)

Inventory holding period is the time from the receipt of the physical goods till they are sold forward. Operating cash cycle is similar, but applied to the company's cash. OCC is the time between paying the goods from debit and receiving the money from the customer. (Op. cit. p. 409-410.) Figure 17 illustrates the operating cash cycle (OCC) and the inventory holding period. By extending the terms of payment to suppliers and reducing the terms of payment for customers, the OCC and the amount of working capital can be reduced.

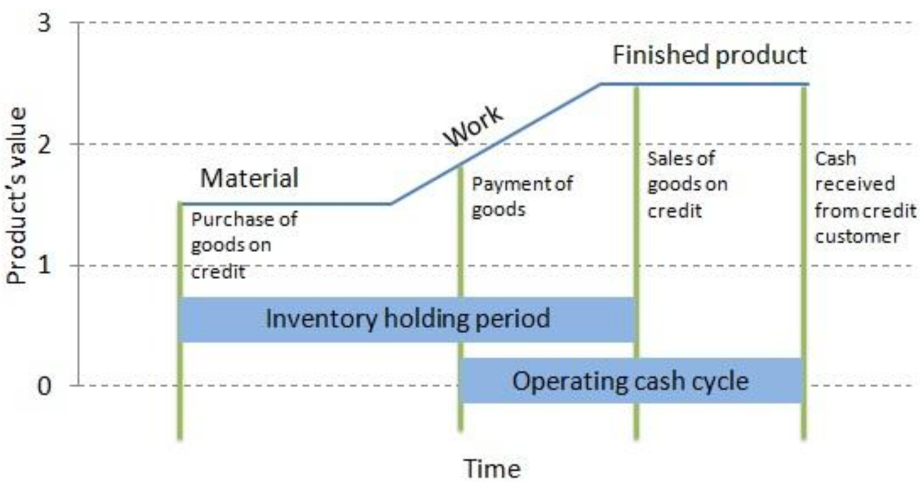


FIGURE 17. Working capital (Modified from Atrill & McLaney 2007, 410).

4 ERP SYSTEMS SUPPORTING BUSINESS PROCESSES

4.1 Background of ERP systems

An enterprise resource planning (ERP) system, as it is known nowadays, started its evolution in the 1960s from the concept of inventory control. The methods that customised software and procedures utilised were based on basic inventory control concepts, such as reorder points. In the 1970s the focus shifted from inventory management to material requirement planning (MRP) systems to plan and control manufacturing. Early MRP systems phased the required raw materials, components and assemblies according to the available capacity, so that the final product would be finished on the due date. In the 1980s MRP evolved to material resource planning (MRP II) that was capable of aggregating planning and demand information for procurement and in-house production. MRP II was an extension of the first version with more functional tools. (Gupta & Kohli 2006, 689.) Usually these two abbreviations are cross referred, and only MRP is used.

Besides MRP development, other systems were also developed for the purposes of human resource management, sales and marketing, and finance (see Figure 18). In the mid 1990s these other perspectives were integrated to a single computer system that is nowadays known as ERP. These systems had graphical user interfaces and advanced system architecture compared to older MRP systems. In this decade ERP systems are developing to be more automated and functional in the internet. Therefore location or user platforms do not create any restrictions. (Gupta & Kohli 2006, 689.) The licensing and one-time purchase of an ERP system is also moving on towards a software-as-a-service (SaaS) based model. In SaaS the user pays, for example, a monthly subscription to have the system available. Thus the vendor receives a continuous flow of money and the user does not have to invest large amounts of money at once. (Madapusi & Miles 2011, 90-91.)

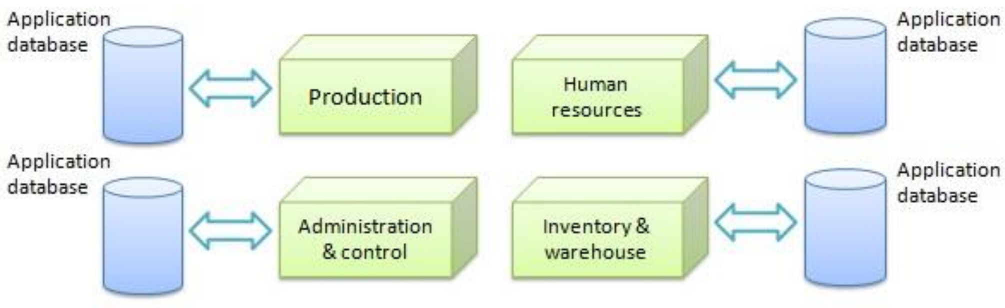


FIGURE 18. Stand alone applications' architecture (Loh & Koh 2004, 3434).

4.2 Structure of an ERP system

Before the ERP revolution, within a company each department typically had their own computer systems that were optimised for a particular way of working. Communicating and relaying data and information was laborious and inefficient. Nowadays ERP systems consist of modules that communicate between each other by uploading the data to an ERP database from which it is then shared forward to other modules (see Figure 19). This enables data or information to be fetched from other departments automatically. When purchasing an ERP system or buying it as a service the company decides which modules it wishes to function. (Loh & Koh 2004, 3434-3435.)

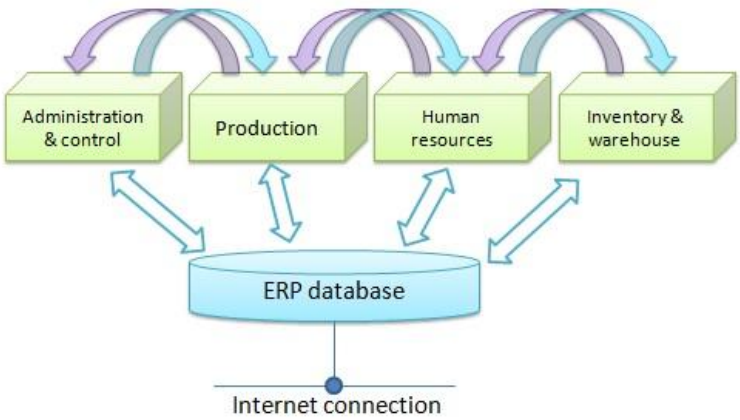


FIGURE 19. ERP integrated architecture (Loh & Koh 2004, 3435).

Nowadays ERP systems use client-server computing where the clients and servers are linked together in order to be able to share the data in real time. The term ‘client’ refers to an ERP user who can use the system over the internet or in a local network. A server provides the computing resources, software and the data to the client. (O’Leary 2000, 13-14).

4.3 ERP systems in small and medium sized enterprises

According to European Commission (2005) an enterprise is categorised as a small and medium sized enterprise (SME) if its number of employees is less than 250 and its turnover is less than or equal to 50 million Euros or the balance sheet total is less than or equal than 43 million Euros. Table 2 clarifies the definition of a SME.

TABLE 2. Definition of a small and medium sized enterprise (European Commission 2005).

Enterprise category	**Headcount**	**Turnover**	**or**	**Balance sheet total**
medium-sized	< 250	≤ € 50 million		≤ € 43 million
small	< 50	≤ € 10 million		≤ € 10 million
micro	< 10	≤ € 2 million		≤ € 2 million

Due to the fact that the ERP market for large companies has saturated, the interest of ERP vendors is now focused on small and medium-sized enterprises (Laukkanen, Sarpola & Hallikainen 2007, 321). In China alone, there are 42 million SMEs that count as 99 % of the total number of companies creating approximately 60 % of the gross domestic product (GDP) (People’s Daily Online 2007). When SMEs started to adopt ERP systems, they were usually designed for large organisations and therefore required considerable investments in terms of time, money and manpower. ERP systems designed for large organisations did not serve the purposes of SMEs, which were looking for quick actions to implement more efficient and automated processes while minimising costs. (Laukkanen et al. 2007, 320).

4.4 ERP – a competitive advantage

From the vendor's point of view ERP systems are off-the-shelf solutions to a company's problems. Initially, the main problem that they were designed to solve was the fragmentation of information in large organisations. Managing pieces of information spread around hundreds of laptops and office computers is pure chaos. Successfully implemented ERP systems can provide marvellous benefits, such as the time taken for IBM's Storage Systems Division to re-price all products decreasing from 5 days to 5 minutes, and Fujitsu Microelectronics order filling cycle decreasing from 18 days to 1½ days. Naturally these developments sound tempting to every company. (Davenport 1998.) According to Mulcahy (n.d.), the unfortunate truth, however, is that only 34 % of projects succeed.

For example, FoxMeyer Drug claims that implementing an ERP system helped to drive it into bankruptcy. If the ERP system is poorly customisable, most companies have to rework their processes to meet the requirements of the system. Sometimes the change can result in significant improvement – sometimes in a bankruptcy. (Davenport 1998.)

By analysing and specifying the needs before implementing an ERP system, the probability of succeeding will be higher. By rushing through the implementation phase and installing an ERP without thinking the business processes through, the project is doomed to fail. Because the ERP system is a corporate-wide process and way of doing business, everyone from end-users to top management should be involved in planning and implementation. (Davenport 1998.) By gaining enough understanding about ERP systems and defining the true need for an ERP system, it is capable of contributing a competitive advantage for the company.

5 CURRENT SITUATION AT NOKKA

The years 2009 and 2010 were rather difficult for Nokka Companies due to the late 2000s global recession. As the market began to recover in early 2010 Nokka launched a project called Nokka on the Rise (*Nokka Nousuun*). The main objectives of this project were to raise the current business back to being profitable, achieve long term growth in global markets and gain 18 million Euros of revenue till mid 2011, after which it would pursue a 10 % annual growth in revenue.

The importance of global markets in logging is constantly increasing. Finland's logging market possibilities for Nokka are estimated to be 15 € million, in Europe approximately 300 million and globally close to a billion Euros. It is logical that Nokka aims to achieve 80 % of its revenue from global markets by the end of 2012. (Nokka Companies 2011.)

Nokka's current situation is quite challenging but its potential to grow financially and internationally is remarkable. The brand is well taken care of and viable, therefore able to grow. Sales and marketing channels are secured in Finland and quite well in Europe. The next logical step is to expand them more in Europe and to other continents. Developing materials management and productivity with reliable suppliers has been an issue at Nokka for a long time. Keeping the strategic decisions and implementing them with a good focus in mind is the key to succeeding in the future.

5.1 Product data management

Analysing the current situation of product data management by interviewing and following processes, it became clear that the lack of clear procedures and exact responsibilities of people has caused the product data to wander around endlessly in hard drives and servers. The data is duplicated, modified and shared, which results in outdated versions of documents and excess costs, both in the personnel and production. The constantly increasing amount of data and information decreases the efficiency of working. More time is spent on searching and handling the wrong documents. As the number of items continues to increase, employees have learned ways to control the document chaos without further decreasing the efficiency.

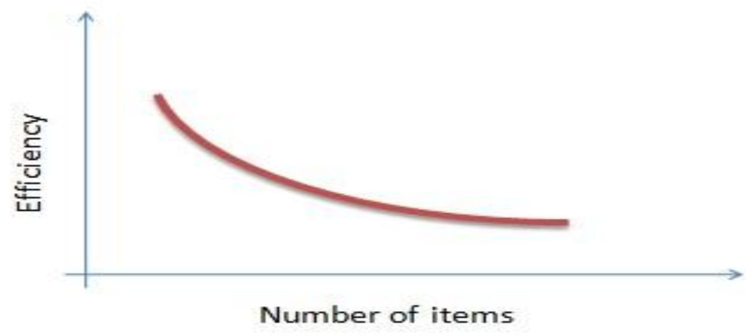


FIGURE 20. The size of item register versus working efficiency.

5.1.1 Item register

At the moment there are nearly 40000 items (39906 to be exact) in Nokka's item register. As Figure 21 illustrates, the number of items has been increasing steadily, approximately at the rate of 1630 new items per year, over the last 16 years. Only 5000 of these items have been used during the past two years. Finding items from the register can be frustrating and there are also items that overlap. Processing so many items also takes capacity from the computer's point of view but is not a restrictive factor. Searching for data would be extremely faster if the item register only had a quarter of the current data.

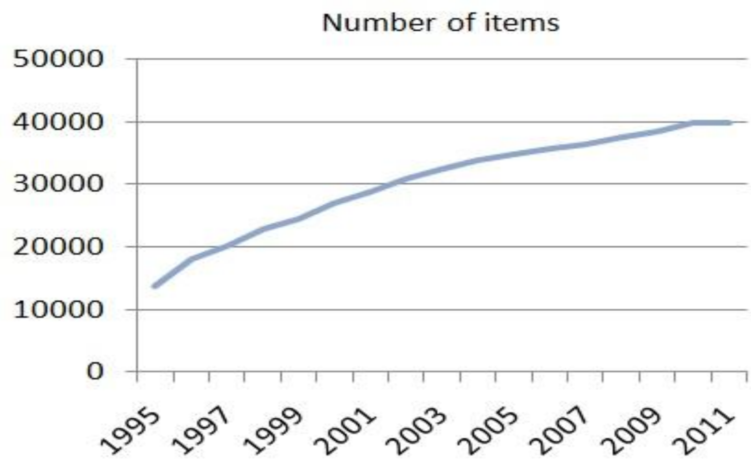


FIGURE 21. The amount of items at Nokka.

The attributes behind an item are often invalid due to copying the items. When an item is copied from an existing one, the attributes will be copied automatically to the new item. For this reason, some of the parts that are purchased are classified as manufactured in-house and vice versa. Also the order quantities, safety stock levels, lead times and description fields are therefore wrong.

The description fields have been lacking information, which has caused the designers to redraw the already existing items. From Figure 22 it can be seen how troublesome it can be to find a suitable pivot (*tappi*) among the existing ones. To find out the dimensions of the item, the technical drawing needs to be opened. Sometimes it is faster to design a new item instead of searching for the existing one. Also, if a change to the technical drawing has been made the description has not been updated in the description field of the item. There are also items that belong to wrong groups, as it can be seen in Figure 22 in the group (*ryhmä*) column.

According to the analysis conducted, searching items takes a tremendously long time and is nearly impractical. Nokka has ended up in this situation because of poor training, slack rules and nonexistent discipline in creating new items and maintaining the existing ones.

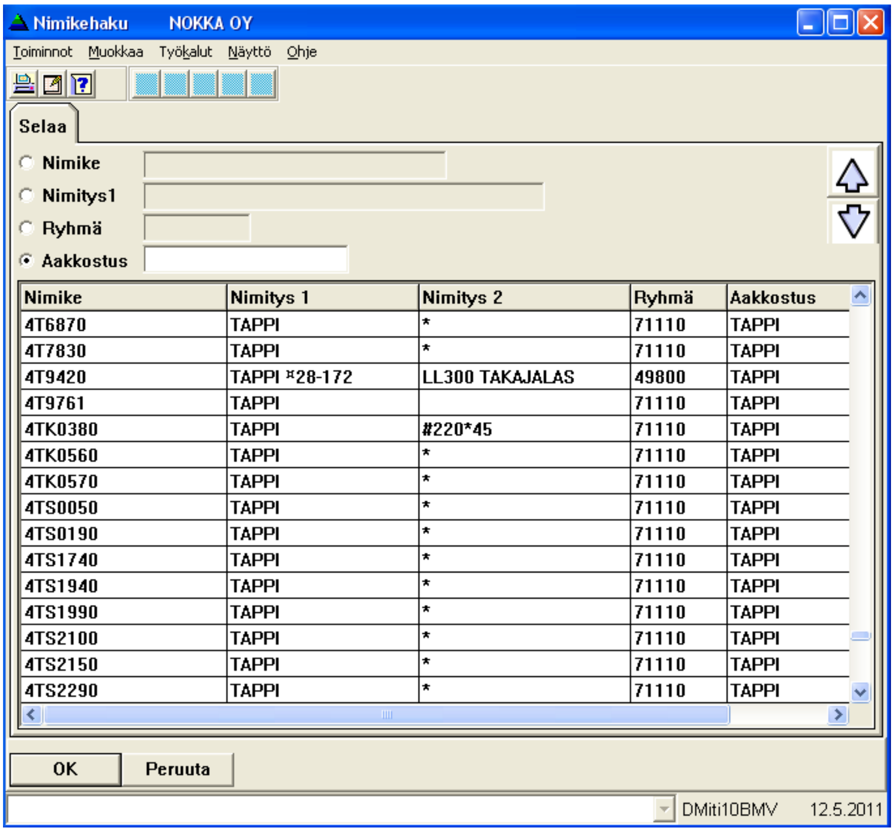


FIGURE 22. Item search without descriptions.

5.1.2 Engineering change orders

As in many industries, engineering change orders (ECOs) have been difficult to follow through. The impulse for changing something in the design might come from the end user, retailer, manufacturing or from the designer. Since there are many departments and suppliers involved in the change process, following it through is heavy. The process for making a change order has not been properly described or modelled, and thereby changes tend to take months, sometimes they are even forgotten before they are finished.

5.1.3 Missing and scattered data

The product data is not merely items. It consists of spare part catalogues, photographs, various revisions of technical drawings, tenders and many more. Instead of a comprehensive and integrated data management system, files and folders are managed by different departments. At the moment technical drawings are stored in a single network drive, where only a few people are allowed to make changes. Designers access and use these documents, but they also create spare part catalogues, maintenance manuals and define the technical specifications which are then handled by marketing, sales and after sales. Plenty of Excel sheets are also created to indicate the document number and the path but people have been copying these documents and making their own changes to them which results in confusing and out-of-date information. Scattered data is hard to find and share. There is also plenty of information which has not been documented anywhere. This type of information is dangerous since people are not able to find what they are looking for if they do not happen to ask it from the right person. Missing and scattered data is one of the most critical problems that cause frustration and financial losses due to the time spent searching and handling the wrong documents.

5.1.4 Formulating bill of materials

As soon as the designer has drawn the assembly, a prototype has been built and the assembly is ready for production, the bill of material is made. The purchasing department inserts the BOM data manually to the ERP system according to the technical drawings. In the manual insertion there are four critical fields with a lot of room for error:

- Item code
- Amount
- Type
- Sub BOMs.

If the item code has a typing error, a wrong part is consumed from the inventory, and if the amount is too small or too big, it affects the quantities in the MRP calculation. The type means the procurement type; raw material, purchased part, manufactured in-house, semi-assembly or a fake part. An item might be a sub-assembly of the main product, and therefore it has a BOM of its own. This BOM code needs to be inserted correctly, otherwise the same problems, as mentioned earlier, will occur.

Inserting BOMs manually to the ERP system increases the number of flaws in the BOMs, is troublesome and time consuming. Time spent for locating and correcting the errors in BOMs might take even hours.

5.2 Material control

Because of the vast number of items and the fact that Nokka manufactures parts in house from raw steel materials, and there are various manufacturing steps, buffers and semi-assemblies in the inventory, the controlling has been a challenge. The current method for material control, both for manufactured and purchased items, is a mixture of various models. Over time the control methods have been ranging between manual and automated control.

Nokka’s production system is flexible semi-job shop production styled and it is capable of producing a wide variety of metal products. Constraints in controlling a job shop production are the cross-referring parts that can be used in many places and the lack of streamlining. The final products have not changed dramatically during the last years and therefore some habits have been rooted in the production.

5.2.1 Manual control and pull system

At the moment some items are controlled purely manually, so that when the item is finished or looks like it is going to finish, an order is placed. A pull system has also been in use where the employee delivers a material control card to the previous work phase or to the purchaser. In Figure 23 a material control card is illustrated. The problem in manual control is that the items usually finish before the order is placed, and when they are needed, only then does the signal come to order more material. The pull system needs to give clear signals to the employees in order to function properly. For example, a kanban/two-box method signals the employee well. In Nokka, if considering pivots, they are usually stored in a bin. For the employee to be able to identify the order point he/she needs to calculate or otherwise keep track of how many items there are in the bin.

According to the employees, the material control cards kept disappearing and the pull system's purpose was to shift management's responsibilities of the material control to the employees. This caused the material control to shift towards manual control and has created mistrust inside the company.

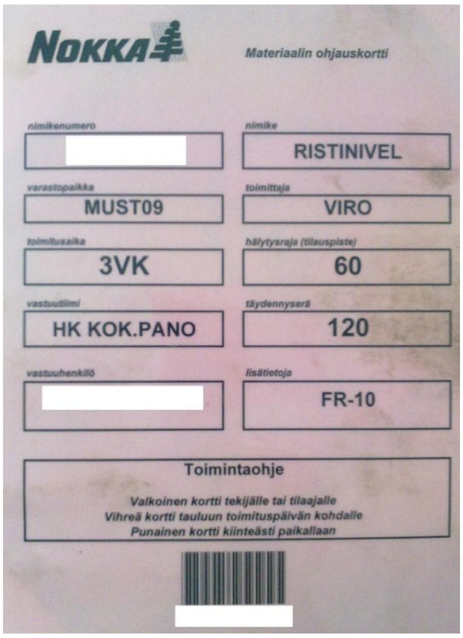


FIGURE 23. Nokka's material control card.

5.2.2 Automated control

The automated control uses the ERP system's material requirements planning function to calculate the needed materials. As shown in Figure 24, the MRP calculation first checks the quantities on hand, then the requirements that include the sales and prognoses of a final product and the status of semi-assemblies and materials. It adds the materials and products that have been ordered or scheduled for manufacturing to the quantity balance. After checking the quantity balance for each item the MRP compares the control method of the item and, as a result, it gives purchase and manufacturing proposals, purchase orders, expedite notes or nothing if the control method is defined as manual.

At the moment this method is used with caution since the outputs are considered as untrustworthy. However, some items are occasionally controlled with the information derived from the MRP calculation.

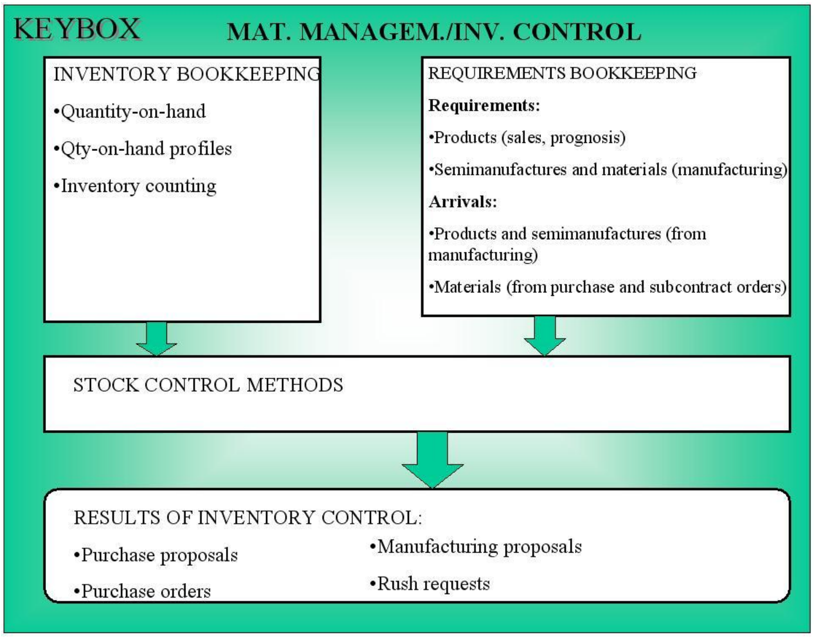


FIGURE 24. Keybox's MRP run (Visma n.d.).

The input for the MRP calculation can be a sales order, manufacturing order or basically anything that decreases the amount in the inventory below a specified level. Based on the product's or item's BOM the system calculates the amount of needed materials. The mistakes in BOM and the invalid item data reflects immediately to the purchase and manufacturing proposals made by the system.

5.2.3 Problems in material control

The biggest problem in Nokka's material control is the imbalance between the quantities in the ERP system and the actual inventory quantities. The imbalance of the quantities can be caused in various different ways. If the BOM is lacking an item or it has too many quantities defined, the balance will be unequal. Also if the item is specified accidently to a wrong warehouse the balance will be consumed from the other warehouse causing the balance to mix. Figure 25 illustrates the contrast of the imbalanced quantities. The quantity in the ERP system shows -198 pieces and the image on the right is the actual level of inventory which was 40 pieces.

FIGURE 25. Item's inventory situation in Keybox compared to actual inventory.

The mistake that imbalances the quantities can also be caused in the factory, not just by the ERP system. If a certain item is finished and it is replaced with another similar item, the balance of two items will be wrong. Each work phase has a work card that states the BOM. When the barcode on the work card is read, the semi-finished item will be added to the inventory and the items in its BOM will be consumed from the inventory. The importance of scanning the work cards when finishing the work has not been understood properly in the factory and therefore it has been sometimes neglected which has caused massive inaccuracy in the balances.

When the work card is handed to the employee it also states a quantity of how many items should be produced. Occasionally when the work card states that 10 items should be produced, 100 will be made due to the settings of the machine or, for example, for the reason that the entire steel rod is easy to cut at the same time. If the employee scans and marks that 100 of that item is done, it does not cause the balances to distort. Nevertheless, it causes material shortages because the material might have been planned to use somewhere else and it is now consumed. This is due to lack of discipline and lenient rules in the factory.

Material shortage due to inaccurate data hinders the planning, frustrates the employees and causes them to give notifications to the management on the finished items that interrupts the employees' work. Lost material also creates troubles and creates excess costs. The trust of the factory employees that the ERP system could be capable of taking care of the materials they need to complete their work is very low. Some of the work posts are hoarding material by giving notifications to management to order more material in order for the material not to run out. This causes the amount of working capital to increase because a bigger portion of it will be tied to the inventory.

With the current salary expenditures a material shortage that halts half of the production for two days costs approximately 10000 € plus the additional the distress ordering costs and possible lost sales in the future. Solving the uneven balances also wastes valuable working hours.

5.3 Keybox enterprise resource planning system

Nokka acquired Keybox ERP system in 1995 from Liinos that later on merged with Visma. It was updated in 2002 and it is a rather old system. Licences for Keybox are no longer sold. Nevertheless, Visma has a vision that in 2015 there will still be customers who need Keybox support and they are willing to provide it. Figure 26 illustrates the processes in manufacturing and Keybox's relation to them.

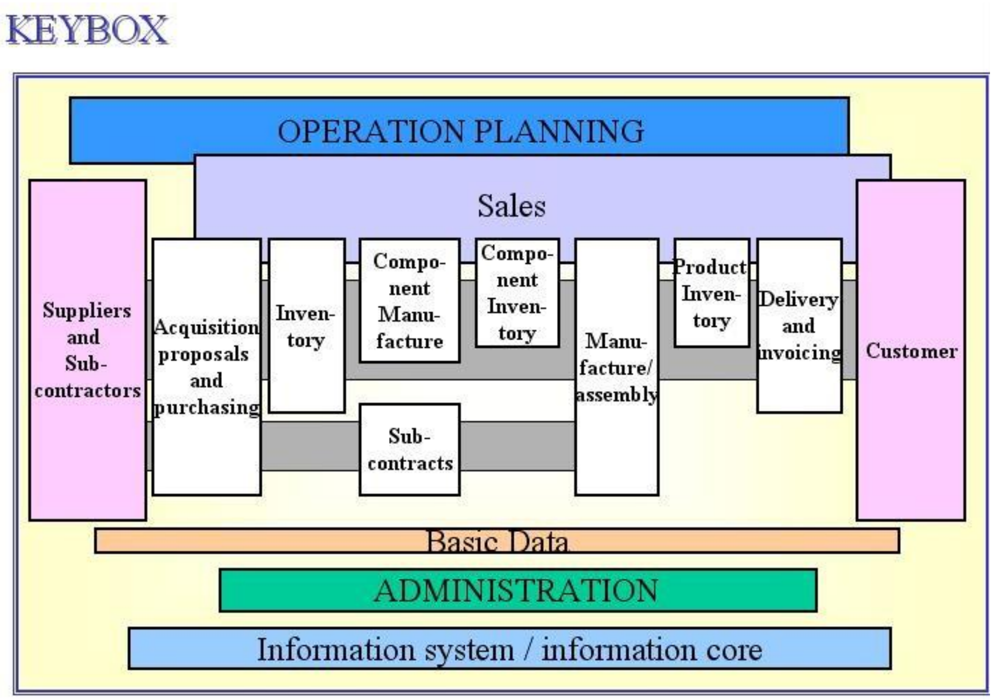


FIGURE 26. Keybox processes (Visma n.d.).

5.3.1 Overview of Keybox ERP system

Keybox is a real time enterprise resource planning system that coordinates all the core functions of a company. It can be used to control and plan all the activities in a company. Keybox consists of operative and administrative modules that include:

- Sales
- Material control
- Production control
- Costing
- Financial management.

The system uses the same database, technical and visual appearance in all functions. It is capable of supporting different organisations and companies within the same system allowing the organisations to access each other's data with permission. Also, usage rights and language preferences can be de defined for each user, customer and supplier separately. The operative functions are capable of supporting any production type from ETO to MTS and a combination of these in parallel.

It is a vast system that can support a wide range of companies, from small business to global organisations. Currently there are still about 20 companies in Finland that use Keybox as their ERP system.

5.3.2 Keybox at Nokka

Despite the system's age, the functions are the same as in newer ERP systems. The usability of the system is sometimes a bit clumsy but it does not affect working much when users gets used to it. Keybox has faced a lot of critique inside the company from its usability to its outputs. As mention earlier only 34 % of projects succeed and this critique is an imminent result from the lack of Keybox training. The employees have been changing and the work content of the staying employees has changed. Training has not been sufficient and the employees have had to work their ways around the system. Many of the employees have lost their trust in the system due to its so called inability to process inputs and form correct purchase and manufacturing proposals. This has caused employees to bypass the system and fetch the required data from the database with their own queries. After the query the data is filtered in Excel in order to rule out the unwanted proposals.

This has caused several employees to process the same data outside of Keybox and once the first person has input the data to Keybox, for the rest it seems that the system is processing the data wrong. Working outside of the ERP system with the same data as in the ERP is very hazardous since the designed process is broken and some necessary steps from the process might be skipped.

The operative data and information is available in Keybox but the usage of it is very light. The functions that Keybox possesses are not utilised well either. The most functional module is the financial management which is used daily, is up-to-date and serves the purposes of Nokka Companies well. The general knowledge of Keybox and the abilities to use it are generally at a rather low level due to a lack of training and changing processes. Most of the employees know their tasks in Keybox very well but cannot necessarily link the task to a bigger content due to the lack of training.

6 RE-ENGINEERING BUSINESS PROCESSES

After finding and visualising the root causes for Nokka’s production problems, the need for establishing a project to change the current situation was acknowledged, and a project called Modular Control was launched. Its purpose was to change the production process from make-to-order towards assemble-to-order as much as possible, and reduce the number of material shortages to a minimum. The project was planned carefully, trying to identify all the necessary actions to be done in order to be able to control modules and develop the current situation. The Modular Control project is expected to be finished in late 2011. By succeeding, the results of the project will give Nokka a competitive cost/quality advantage, reduce lead times and support more global operations in the future.

Modularity in the product design creates a great opportunity to shift the production process. By creating modular warehouse locations and maintaining the modular levels, the work needed to complete a customer order is only assembly. When the module inventory level decreases, it is replenished in order to secure the readiness for quick deliveries.

6.1 Project planning

The functions of the project mostly focus on the changes in production and purchasing, but also other departments are connected to the change. A rough estimate of the work packages and timing was scheduled first, and all the needed functions and resources to complete the functions were planned afterwards. The project was piloted (tested the procedures) with a new model that Nokka launched in early 2011. The piloting of the project revealed several new tasks and detailed problems that were updated to the project plan. In the beginning of the project it was agreed that communication along the project is essential. Keeping everyone in the company informed of the project's progress maintains the project's awareness among all the employees. Also, situational awareness is kept high by arranging meetings every 2nd to 4th week and by updating an information board in common premises. Figure 27 illustrates a snapshot of the project plan with actual functions and their relations. Project groups were assigned to tasks and once the tasks were completed, the groups were reorganised and assigned to new tasks. The rough plan of work packages can be found from Appendix 3.

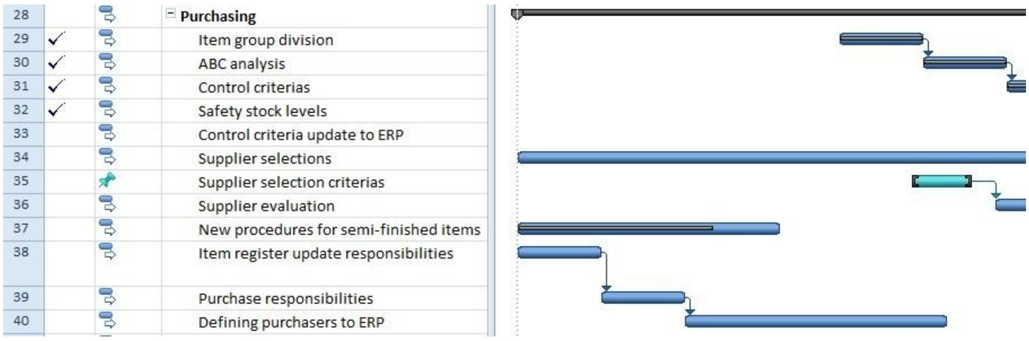


FIGURE 27. Modular control project plan.

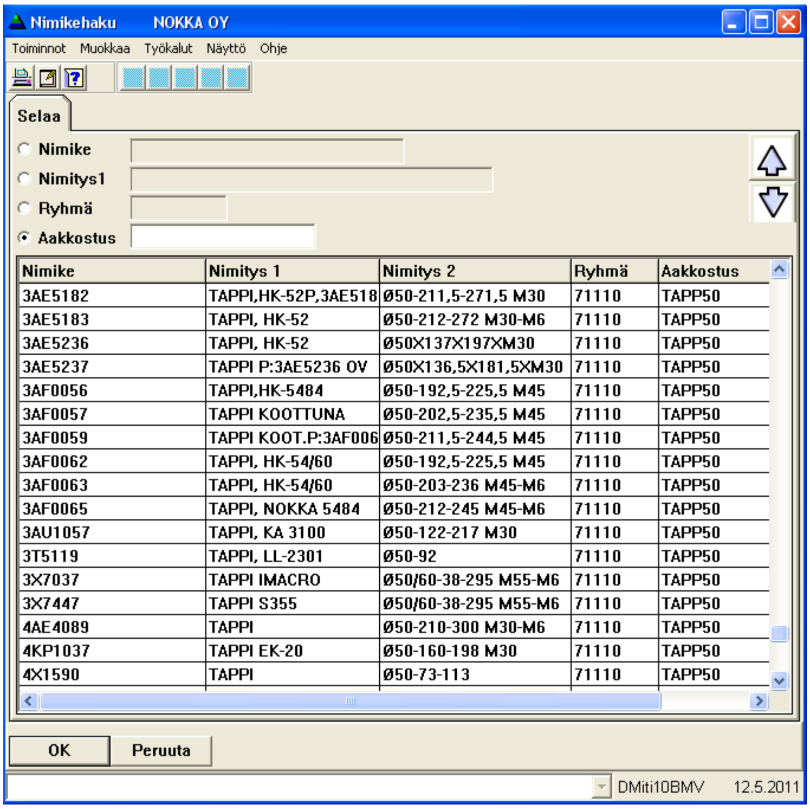
6.2 The necessities of product data management

Up-to-date and accurate product data is the base for building assemblies and final products. Based on the product data and its attributes, ERP and PDM systems are created. If the product data is corrupted or misleading, the functions in ERP and PDM systems will not work, since their roots are in functional product data. Fixing and maintaining product data properly is essential for Nokka, since otherwise the efforts made for better controllability are useless.

6.2.1 Organised item register

In Nokka, pivots, bushings and hydraulic components are the item groups that include a lot of items that can be used in new designs. The descriptions were extremely poor in the items that belong to these groups, and the need for getting information on these items, in order to avoid overlapping ones, was high.

The data from each group was exported from the database to Excel, where it was edited. The pivot group by itself already contains over 1500 items. The only way to add the descriptions for these items was to open the technical drawing of the item and fill the description manually. After finishing the description fields, a search field, which had not been utilised before, was filled with correct data. For the pivots, the search field enables to seek pivots based on the diameter. After finishing the changes, the edited data was imported back to the database. Compared to Figure 22 on page 38, Figure 28 below illustrates the updated information, which can be browsed via the user interface of Keybox.



Nimike	Nimitys 1	Nimitys 2	Ryhmä	Aakkostus
3AE5182	TAPPI,HK-52P,3AE518	Ø50-211,5-271,5 M30	71110	TAPP50
3AE5183	TAPPI, HK-52	Ø50-212-272 M30-M6	71110	TAPP50
3AE5236	TAPPI, HK-52	Ø50X137X197XM30	71110	TAPP50
3AE5237	TAPPI P:3AE5236 OV	Ø50X136,5X181,5XM30	71110	TAPP50
3AF0056	TAPPI,HK-5484	Ø50-192,5-225,5 M45	71110	TAPP50
3AF0057	TAPPI KOOTTUNA	Ø50-202,5-235,5 M45	71110	TAPP50
3AF0059	TAPPI KOOT.P:3AF006	Ø50-211,5-244,5 M45	71110	TAPP50
3AF0062	TAPPI, HK-54/60	Ø50-192,5-225,5 M45	71110	TAPP50
3AF0063	TAPPI, HK-54/60	Ø50-203-236 M45-M6	71110	TAPP50
3AF0065	TAPPI, NOKKA 5484	Ø50-212-245 M45-M6	71110	TAPP50
3AU1057	TAPPI, KA 3100	Ø50-122-217 M30	71110	TAPP50
3T5119	TAPPI, LL-2301	Ø50-92	71110	TAPP50
3X7037	TAPPI IMACRO	Ø50/60-38-295 M55-M6	71110	TAPP50
3X7447	TAPPI S355	Ø50/60-38-295 M55-M6	71110	TAPP50
4AE4089	TAPPI	Ø50-210-300 M30-M6	71110	TAPP50
4KP1037	TAPPI EK-20	Ø50-160-198 M30	71110	TAPP50
4X1590	TAPPI	Ø50-73-113	71110	TAPP50

FIGURE 28. Item search with descriptions.

For each group a model item was created in order to avoid the mistakes that result from copying an existing item and making changes to that. Along with these model items, a guide for establishing new items was made. The description data is now available whenever an item is handled in the system. It is also available in the work cards, which help the employee if he/she is ever hesitating whether or not the item is the right one. Previously the employee should have got the technical drawing of the item and measured it, which could have taken even 30 minutes.

In the inventory there were quite many pivots and bushings that had been received in a hurry and delivered without any markings. They had been in the inventory for at least a year and nobody knew where they belonged. Now that the description fields had been filled, 80 % of those items were identified by measuring them with a calliper and searching from the item register. The remaining 20 %, which were not identified, are items that do not have technical drawings in the computer. Considering the savings that are achieved annually, by decreasing the amount of new design work, cutting down searching time, locating and removing obsolete items from the warehouse, the indirect savings can be up to 100 000 € annually if the cost per man hour is approximately 30 €.

6.2.2 Model for engineering change orders

In order to fully understand how the change order process flows, the process was mapped. Instead of starting the process mapping with a computer, post-it notes and a wall were used to have a good overall awareness of the situation. Employees participated by sharing their ideas on the post-it notes. Functions of different departments were written on the notes, then organised and improved. Changes to the flow chart were made in co-operation with the department managers, and they were revised several times. In the end, the flow charts were drawn with a computer, which are illustrated in Appendix 4. Figure 29 is a sample of the change order process flow of the Research and Development department.

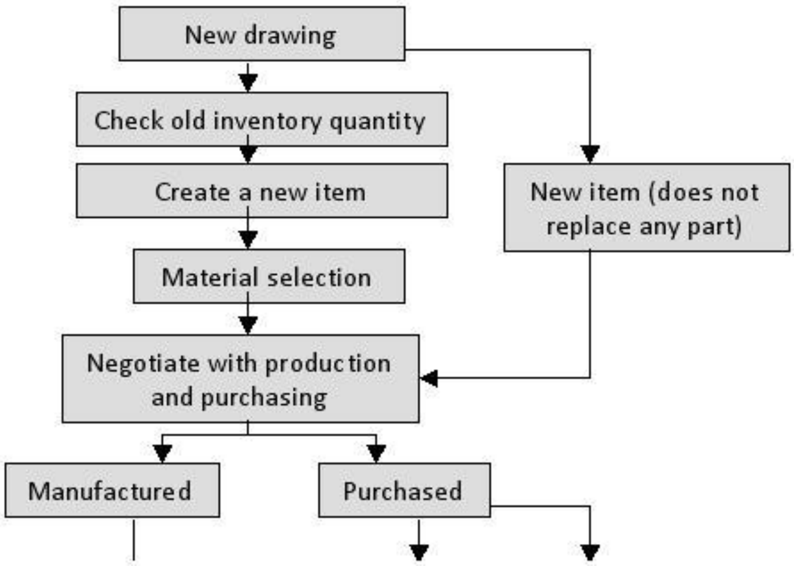


FIGURE 29. Engineering change order flow of the Reasearch and Development department.

Based on the flow charts, a change order form, which is linked to the technical drawing, was created. The change order form connects the technical drawing and the departments that relate to the change order process to a single file. The form has macros embedded that enable notifications to other departments about the status and processing of the change order. The code of the macro can be found from Appendix 5. It also contains a check list of the tasks that need to be completed before forwarding the change order to another department. The person who begins to handle the change order is responsible for completing the tasks. This increases the commitment to the task.

The new change order form was tested several times with real and imaginary changes to ensure that it is foolproof for all kinds of changes. The form is in use at Nokka and enables better visibility and traceability of the changes. A change which had been stuck and forgotten in the old process for a few months was repeated, and the whole change process was completed in 3 weeks. Due to the lack of engineering change orders lately, not much other user experience of the form has been available. Continuous improvement of the form and the ECO process is essential. A sample of the change order form of the Production department can be found from the Appendix 5.

6.2.3 SolidWorks Enterprise PDM

The discussion on acquiring a PDM system for Nokka started in 2010 and in the late 2010, a SolidWorks sales representative introduced the SolidWorks Enterprise PDM software. The EPDM runs on the SolidWorks design software, whereas other PDM systems are usually separate systems that are linked together from a certain interface. Enabling EPDM to run on SolidWorks allows SolidWorks and EPDM to function seamlessly together.

Managing the several revisions and other related documents in the long run starts to be impractical. Especially the revision control is difficult, since a copy of an older version of the drawing might be stored somewhere else. EPDM automatically revision controls all the documents and allows a return to older versions if needed. Since the same item can be used in several assemblies, making changes becomes very much easier. The EPDM shows where the item is used and makes the change to the selected assemblies. Every time an item is handled, it has to be checked out from the data vault that prevents simultaneous editing of the same item.

The EPDM is capable of generating BOMs automatically and synchronises them with the ERP system. This would prevent the mistakes and lapses that are possible while inserting the BOM manually. Each item that is inserted to the EPDM has a data card that contains information of the file, which can be seen without opening the file. There is also a 2D and 3D preview with dimensioning and basic functions available immediately.

To handle the product data better, ease the engineering change order process, improve communication between different departments and automatically create bills of material are the main advantages of the EPDM that it could provide for Nokka. These improvements are essential in the future. After finishing modular control, project implementation of a PDM software starts to be current. If the costs of recreating lost data, searching for missing documents, correcting BOM lapses and the costs of inventory burden or shortage caused by the incorrect BOMs are considered, the time for return on investment for the Enterprise PDM is fairly short.

6.2.4 3D configurator

Since Nokka's production is built on modules and there is a table of modules, the idea for creating a 3D configurator arouse from the basis of first creating a dynamic module selector. The dynamic module selector asks for a product's model, and based on the selection, it only allows the user to select the suitable modules for the chosen model.

In Appendix 6, a snapshot of Nokka's table of modules is presented. The unnecessary fields were removed from the table of modules and then reorganised. The dynamic module selector was created in Excel by using Excel functions and macros. A model, functions and the framework for the dynamic module selector can be found from Appendix 7. A few problems were faced in the insertion of the functions to limit the number of modules that can be chosen for the module. With the help of various forums in the internet, assistance for the problems was received from all over the world practically in minutes after posting the problem to the forums. The problems were described and the module and file names were changed in order to remain anonymous.

After finishing the first functional version of the dynamic module selector, cost information of the modules was added. The cost of the modules is fetched from the ERP database which allows the cost information to be up-to-date every time the selector is opened. When selecting the modules, it also creates a code of the product that will be manufactured. In addition, the selector was also used for giving forecasts to production.

The idea of expanding the dynamic module selector to include 3D images of the final product and allowing end users customise their own products arouse. The creation of the 3D configurator was assigned to a group of media engineering students, who began to add texture to the 3D models and create the code.

When the 3D configurator is finished, the customer will be able to customize their own product easily, see the technical specifications and a 3D model of the finished product immediately. Once the customer has chosen the specifications, they can contact the closest retailer and order the product. This will prevent the problem of a customer not being sure of the module they have chosen for the product, and a wrong product is manufactured. It is also expected to boost sales, and in the future deliveries straight from the manufacturing directly to the customer could be possible.

6.3 An end to material shortages

Shifting the order penetration point upstream towards ASO decreases the amount of items to control when the modules are considered as final products. By automating the control process for purchasable items as much as possible and concentrating the controlling on modular levels, the purchase and manufacturing orders are generated automatically based on the consumption of modules. The automation process would easily save 80 000 to 120 000 € annually in labour costs, but more important is to focus these resources for future development work. In order to implement an assemble-to-order strategy and put an end to material shortages, various activities have to be completed before it can function properly. These activities are discussed in this chapter.

6.3.1 ABC-XYZ

Based on the item's usage of 2010, the ABC analysis was first conducted from Keybox for two item groups; pivots and bushings. Keybox was enabled to update the ABC class for each item automatically which can be seen when handling the item data. The data received from the ABC analysis was exported to Excel and rearranged. Since there are over 1500 items in the pivot item group only the ones that were actually used in 2010 were considered. Figure 30 illustrates the 228 items and their distribution. Nokka's end products changed quite much in 2009 and therefore, data from a longer time period would be irrelevant for the analysis. Results of the ABC analysis can be seen in table 3 on page 59.

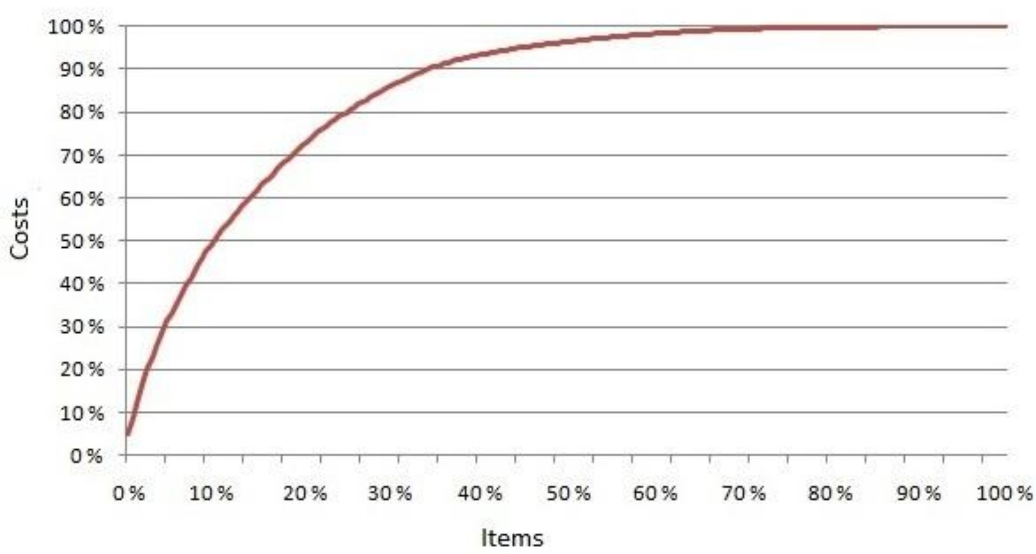


FIGURE 30. ABC distribution.

To expand the ABC analysis to ABC-XYZ analysis, the monthly consumption of items was fetched from the database by modifying and utilising a query. Data fields in the ABC analysis were edited for each month to a form of item number, year and month. For example 1XX201001 and 1XX201002, 1XX representing the item code and the rest 2010 January and February respectively. The same editing was done for the monthly consumption data in order to be able to use the vertical look up function in Excel to match the data fields.

After having the consumption of each month for each item, the coefficient of variance was used as a measure of dispersion (see Figure 31). The advantage of using the coefficient of variation is that the dispersion is a proportion of the mean and makes the figures comparable to each other. Coefficient of variance is equal to standard deviation divided by the mean.

$$C_v = \frac{\sigma}{|\mu|} = \frac{\sqrt{\frac{\sum x^2 - n\mu^2}{n-1}}}{\frac{\sum \mathrm{x}}{n}} = \frac{\sqrt{\frac{\sum x^2 - n\left(\frac{\sum \mathrm{x}}{n}\right)^2}{n-1}}}{\frac{\sum \mathrm{x}}{n}}$$

FIGURE 31. Coefficient of variance.

The levels for X, Y and Z classes were set to X ≤ 80 % < Y ≤ 200 % < Z. After defining the classes for each item, the data can be filtered in Excel to show only the desired ones. Safety stock levels were also calculated using two different methods, which allows a good comparison of the methods. The calculated safety stock values are taken into use and have not run out. This analytical tool enables an easy browsing and a good comparability of items. In Figure 32 the unfiltered analysis data can be seen. A larger sample of the analysis can be found from Appendix 8.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total usage	Unit price	Total	% of total	Cumulat.		St.Dev	Mean	Coef. of var.	
	30	40	26	40	24	30	8	28	44	42	54	10	376	21,2179	7977,9304	5,06 %	5,06 %	A	13,60036	31,33333	43 %	X
	14	20	13	19	12	14	2	4	4	4	6	9	121	46,9766	5684,1686	3,60 %	8,66 %	A	6,141636	10,08333	61 %	X
	21	18	42	30	27	39	6	63	42	39	36	54	417	12,168	5074,056	3,22 %	11,88 %	A	15,63868	34,75	45 %	X
	0	0	0	0	0	0	0	22	39	1	24	13	99	48,9925	4850,2575	3,08 %	14,96 %	A	13,2605	8,25	161 %	Y
Item	25	17	25	30	18	21	1	15	19	31	23	21	246	17,35	4268,1	2,71 %	17,66 %	A	7,856671	20,5	38 %	X
codes	0	40	0	109	81	0	0	0	49	0	111	0	390	10,293	4014,27	2,55 %	20,21 %	A	44,81173	32,5	138 %	Y
	0	0	0	0	0	0	9	11	0	4	13	24	61	64,467	3932,487	2,49 %	22,70 %	A	7,704288	5,083333	152 %	Y
	0	0	64	0	28	15	0	47	0	53	0	31	238	16,3735	3896,893	2,47 %	25,17 %	A	24,05234	19,83333	121 %	Y
	72	117	94	125	100	66	10	98	104	94	75	64	1019	3,5379	3605,1201	2,29 %	27,46 %	A	30,50621	84,91667	36 %	X
	19	7	15	22	11	12	0	8	11	16	17	11	149	21,4526	3196,4374	2,03 %	29,48 %	A	5,915439	12,41667	48 %	X
	0	2	0	2	0	1	4	10	19	18	20	1	77	39,4165	3035,0705	1,92 %	31,41 %	A	8,073057	6,416667	126 %	Y
	22	8	17	24	11	13	0	8	12	17	19	13	164	17,0024	2788,3936	1,77 %	33,18 %	A	6,665151	13,66667	49 %	X
	0	29	16	0	0	62	0	62	0	0	0	61	230	11,9286	2743,578	1,74 %	34,92 %	A	27,13211	19,16667	142 %	Y
	110	0	0	0	77	0	0	102	27	30	87	0	433	6,2474	2705,1242	1,72 %	36,63 %	A	44,72839	36,08333	124 %	Y
	39	30	47	47	36	36	2	34	37	46	36	35	425	6,2512	2656,76	1,68 %	38,32 %	A	11,85103	35,41667	33 %	X
	20	23	0	0	0	24	0	23	0	0	75	0	165	15,6956	2589,774	1,64 %	39,96 %	A	22,13646	13,75	161 %	Y
	14	0	0	0	8	0	0	60	0	0	0	0	82	31,0487	2545,9934	1,61 %	41,57 %	A	17,31963	6,833333	253 %	Z
	0	0	0	0	0	0	0	0	80	100	96	0	276	8,7	2401,2	1,52 %	43,10 %	A	41,85256	23	182 %	Y
	22	44	0	0	0	44	0	0	0	0	50	41	201	11,7757	2366,9157	1,50 %	44,60 %	A	21,68001	16,75	129 %	Y
	21	7	17	22	11	13	0	8	11	17	19	11	157	14,4843	2274,0351	1,44 %	46,04 %	A	6,430868	13,08333	49 %	X
	30	0	0	148	0	0	0	0	0	0	0	0	178	12,5148	2227,6344	1,41 %	47,45 %	A	42,81426	14,83333	289 %	Z
	21	28	28	32	34	25	3	30	36	36	40	32	345	6,1793	2131,8585	1,35 %	48,80 %	A	9,63068	28,75	33 %	X
	25	17	25	30	17	21	1	15	19	31	23	21	245	8,0823	1980,1635	1,26 %	50,06 %	A	7,890827	20,41667	39 %	X

FIGURE 32. ABC-XYZ analysis data.

6.3.2 Defining control strategies

Based on the ABC-XYZ analysis, control strategies for A, B and C items, and actions for how to deal with the fluctuation, were defined. Also safety stock levels were calculated based on the analysis and the dispersion information was handed to the suppliers of the A class items in order to ease their production planning.

The suppliers for A-class items were selected based on the price and their delivery reliability. They also agreed to keep their own safety stock of the items that they deliver to Nokka. A small amount of B- and C-class items will be kept in the inventory, but the most important thing at this phase is to ensure the certainty of the suppliers. Presumably in the future, as the models are quite new, a larger share of money is tied up in A-items, so chasing the lowest price for B and C items is not prudent. Even though the A-class is usually considered as the class with the most importance, which it is statistically, when considering the production halts caused by material shortages, the class of the item does not matter. A shortage of a C-class item causes the production to stop as well as an A-class item; statistically it just does not happen as often. Securing the availability of B and C items is crucial, and focusing Nokka's own controlling efforts on A items reduces the amount of working capital.

Table 3 shows the dispersion of the ABC-XYZ items. In the table, the data on pivots and bushings is combined. The X items have a great potential for automated controlling procedures since the demand is fairly stable. The A_Z class in this case is the troublemaker. These items have a high unit price and they are consumed with high volumes stochastically. These items will tie up money in the inventory and their turnover time will be long. The supplier has agreed to keep these in his inventory and, if necessary, produce more with a shorter lead time. The C_Z items at Nokka are usually spare parts that are sold to end users. The demand is usually a few items in a year and the after sales department has their own inventory for these items.

TABLE 3. ABC-XYZ distribution.

	X	Y	Z	Total
A	19 %	7 %	2 %	**28 %**
B	8 %	13 %	2 %	**23 %**
C	3 %	15 %	31 %	**49 %**
Total	**31 %**	**35 %**	**34 %**	100 %

6.3.3 Warehouse locations

Since there are approximately 70 warehouse shelves at Nokka, the employees estimated that 10-20 % of their time is spent on searching the materials that they need. Annually, this costs approximately 200 000 € for Nokka. To tackle this problem, the warehouse shelves were named. Each shelf has a unique number and the level is denoted by a letter, for example, 145C. The accuracy of the warehouse locations was left to the level grade, allowing relocating material on the same shelf level without involving Keybox processes in it.

The next inventory count is planned to take place in the spring/summer of 2011. While conducting the inventory count, the material locations are updated at the same time to Keybox. Responsibilities to maintain the warehouse locations in Keybox were given to the storemen. They are also the employees who possess the rights to receive material and to deliver them to right locations.

As soon as the locations are input to Keybox, a PC for searching an item's location will be installed in the factory. The locations of the items also appear on the work cards, which are printed for the employees. By cutting the time spent on searching the items, important savings for the company are achieved. Instead of searching, the time can be used to produce products, which cuts the lead time for finished products, or for development work in the factory.

6.3.4 Removing obsolete items

A part of the modular control project was to remove the obsolete items from the warehouse. Based on the inventory reports and discussions with the employees, it was obvious that there are items in the inventory that have not been used in many years. After the removal of obsolete items, approximately 30 % of the warehouse space was freed, leaving some warehouse shelves nearly empty. In addition, the items that were blocking walking and forklift paths were removed. The operation had an important impact on the visual appearance, safety and the controlling of the inventory. The inventory turnover is also expected to improve when the removed materials are depreciated from the bookkeeping.

To maintain the overall appearance and improve it even more, the monitoring needs to be continuous and critical. The storemen have an extremely important role in keeping up the appearance. Previously the workers in the initial production were delivering the manufactured materials to locations they thought were right. A waiting area for manufactured parts was created, and now only the storemen have the permission to move material to right locations. They also maintain the item descriptions on the side of the pallets, making it quick and easy to see what there is on the pallet.

6.4 Leveraging the power of Keybox

Real product data, accurate BOMs and fully defined control strategies form a base for the proper usage of ERP and especially the MRP function. So far the operative work has taken place in Keybox without fully understanding the capabilities of the system. Vast amounts of data have been created over the years, and the procedures in creating operative data have been good. It gives a good background for linking the operations corporate wide and leveraging Keybox back to life. The activities done at Nokka can also be implemented at Pematic. The process for understanding and the key-elements utilised from Keybox are discussed in the following chapters.

6.4.1 Benchmarking

The usage of the Keybox ERP system was benchmarked in a company that manufactures industrial electronics. The company has management organisations, manufacturing and assembly all over the world. They use Keybox in two languages, Finnish and English. Only a few modifications are done to their system which made the comparing easier, as Nokka has not made special modifications to Keybox either. The representative was an MRP & ERP specialist for the company and agreed with the top management's statement that the company has no need for changing their ERP system in the near future, since it does not have a negative effect on their growth.

Most of the processes, such as purchasing, were fully automated. Keybox formed purchase orders and sent them to the suppliers automatically. It also expedited the sent orders if needed and split the orders to different suppliers according to the set parameters. Their warehouse operations were divided into two steps. The first one was when an item was taken from the inventory: it was scanned immediately. The second step added the finished product to the inventory. This allowed them to get accurate reports on the work in progress (WIP) inventory's value. Benchmarking the company really revealed the potential of Keybox despite its age.

The education of the employees at Nokka has been initiated. The goal is to increase the general awareness of Keybox's functions by going through the main tasks that are done in Keybox in person. Some amounts of scepticism arouse from the new functions, but after understanding the system's logic and how Keybox could ease the processes, many employees committed themselves to improving its usage. The changes do not usually happen overnight. Change management and motivating people has to be long-span and continuous, otherwise the changes tend to be forgotten.

6.4.2 Keybox outputs and reporting

Once Keybox has a master schedule, accurate BOMs and up-to-date inventory record input, it is capable of producing reliable and realistic outputs from the MRP run. The primary outputs that Keybox's MRP produces are purchase proposals, manufacturing proposals and automated purchase orders. These are the most important outputs that control the available materials according to the set parameters. Each time the MRP run is complete, it replaces the old data with the newest available and therefore always shows the current situation.

The secondary outputs that are created based on the MRP runs include various reports of the inventory's value, ABC-analysis, work-in-progress etc. Keybox has many built in reports that can be used just by entering the time range and, for example, the item group. Due to the age of Keybox, to have the reports in an electronic form require some amount of manual organising. If the specific report is not available from Keybox, a report can be customised and fetched from the database using a query. There are numerous queries available but still quite a lot of customisation is needed.

Accessing the database by using Microsoft Access for the queries is risky, since the data is available for editing, unless it is not exported to Excel. If changes are made to the database, the changes affect the operation of the system immediately and they are usually irreversible. To prevent unnecessary mishaps with the database, a reporting program, for example Crystal Reports, could be used. A set of readymade reports can be made for the program, and these reports are updated automatically. The reports can also be published to a secured internet site, where they would be available on the go.

Accurate and quick reporting is essential in today's business. Having the right reports available allows the employees and management to follow the development trends and influence them. Creating standard reports eases the communication between people since the same standard applies for everyone. Of course the situation where customised reports are needed may arise, but they need to be implemented in a way that does not cause possible harm to the database. Only a few people shall have the rights to create customised reports.

6.4.3 Automated purchase orders

Since material shortages is one of the main problems and Keybox is capable of automatically forming purchase orders, the function was tested first, and step by step taken into operational use. For Keybox to be able to form accurate purchase orders, there are three major issues that need to be taken into account.

The item data needs to be up-to-date. Procurement type, lead time and safety stock levels need to be reviewed. If the procurement type is set to 'manufactured', Keybox will give a proposal to manufacture it. Too short lead time will cause the items to be delayed and the inaccurate safety stock level causes material shortages or excess inventory. In Keybox, the item also needs a check mark to allow it to form automatic purchase orders of the item.

The quantities in the inventory and in the system need to match. If the quantity in the system is greater than the actual inventory, material shortages will occur and this causes the production to halt. Vice versa, excess inventory will be carried, which causes the amount of working capital to increase.

Keybox needs a contract with the supplier, which is entered to the system. In the contract, the agreed items, purchase prices and possible batch sizes are defined. This contract is needed in order for Keybox to link the items that need to be ordered to the right supplier.

The automatic purchase order is formed in the MRP run, after which it needs an approval. The approval is made manually, but a possibility for automated approval exists. If the order is dismissed, Keybox will form the same purchase order in the next MRP run, since according to the system, the materials are still needed. To prevent Keybox from ordering the unwanted items, the check mark from the item data must be removed or another parameter, such as safety stock level or details of the contract, need to be changed. In the future the suppliers could be linked to the purchase orders with the help of electronic data interchange over the internet. The approval of the purchase orders would be unnecessary and the supplier would get the order immediately.

The automated ordering has been launched for the A-class pivots and bushings based on the ABC analysis. The A-class items have between divided between two suppliers in order to secure their ability to deliver material. Since no constraints or barriers for the automated ordering have arisen, the method is being expanded to laser and flame cut metal plates. A short term goal is to order 50 % of the items automatically, and in the long run nearly all. Eventually the manual work needed in ordering is cut to minimum and the resources can be focused more on sourcing instead of purchasing.

6.4.4 Managing capacities

Keybox has good capacity management tools. Over the years, Nokka has input lots of accurate data of the capacities and durations of work phases. The utilisation of the data has not been as efficient as possible. Keybox processes capacity planning in two stages: rough-cut capacity planning and capacity requirements planning.

The rough-cut capacity planning is a tool for sales and production and used for a make-to-order type of production. In rough-cut capacity planning the production is divided into areas and groups. The groups can be, for example, a whole factory or a production line, where the capacity available and unit prices are determined for each group. This feature does not suit Nokka's production very well since it would require a much wider organisation. Dividing the production into areas allows large global organisations to handle their production better when it is not centralised. This is one of the features which show that Keybox can be used in nearly all organizations, no matter what their size is.

The capacity requirements planning feature in Keybox serves Nokka's purposes extremely well. With this feature, the overall capacity can be controlled and each manufacturing stage can be taken into a closer examination. It is linked to the material requirements plan and the status of each work can be observed. It allows the management to check the needed materials if they are available for the scheduled work, and the status of the required capacities at the time of manufacturing.

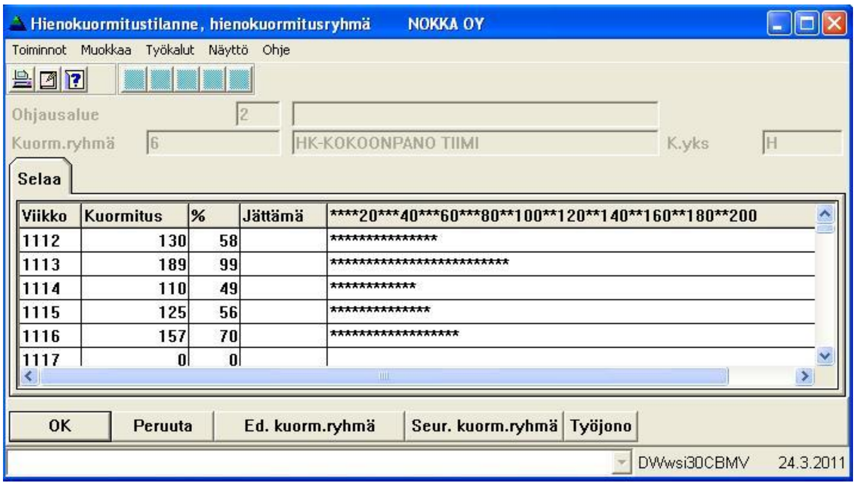


FIGURE 33. Capacity management in Keybox.

As soon as the quantity imbalances are fixed in the system, cross checking the available materials for new work tasks gives accurate information. The capacity observation has been taken into use, and based on the information from it, the production can announce much more accurate lead times for the final products. In the future a possible production planner and scheduler could work for Nokka and act as a link between the production and sales. Figure 33 illustrates the planned load for the grapple loading assembly team.

7 CONCLUSION

Product data management is the future area of development for many companies. Without a viable product data, material control and document handling is troublesome and hectic. Problems in material control usually result in control methods that deviate from the modelled processes in the ERP system and cause a vicious circle that is difficult to stop. The modular control project has affected this problem by setting new standards for production.

Nokka’s modular control project planning started in late 2010 and the implementation began in early 2011. The project concentrated on diminishing the material shortages and changing the production style from make-to-order towards assemble-to-order. The project's reporting focused on linking product data management, material control and the utilisation of Nokka's Keybox enterprise resource planning system together.

Considering the impact of the project, it has a significant value for Nokka and other small and medium sized companies that are struggling with similar problems. The project's success determines whether Nokka will continue the struggle in Finland's markets or expand and profit globally. As the project is still in progress and hard evidence on the results of the project are still forming, the actions done so far have been successful, and new ways of working have already been rooted at Nokka. These results are on the way to creating foundations for shorter lead times, secured work places and global expansion.

Implementing a PDM system for Nokka in the future is realistic and reasonable. More research on PDM implementations needs to be conducted in order to guarantee a smooth transition. At the moment, replacing Keybox with a new system is not relevant. Renewing ERP systems is very time consuming and expensive. Therefore, once Keybox's core functions have been fully utilised in the processes of Nokka, replacing Keybox can be considered. A new ERP with a reporting system would enhance the usability as well as internal and external reporting.

The start up and the first implementations of the project can be seen as successful. Theories were reflected into practice successfully, and the results have proven to be useful at Nokka. Viable product data management and a proper usage of ERP system in order to diminish material shortages are the essentials of surviving in the modern cut-throat markets. The project also gives a framework that can be implemented in other similar manufacturing companies. Constant training of the personnel, and maintaining and developing the processes are essential for keeping up-to-date in the future as well. Based on the results of this project a follow-up project mapping global expansion possibilities could be initiated.

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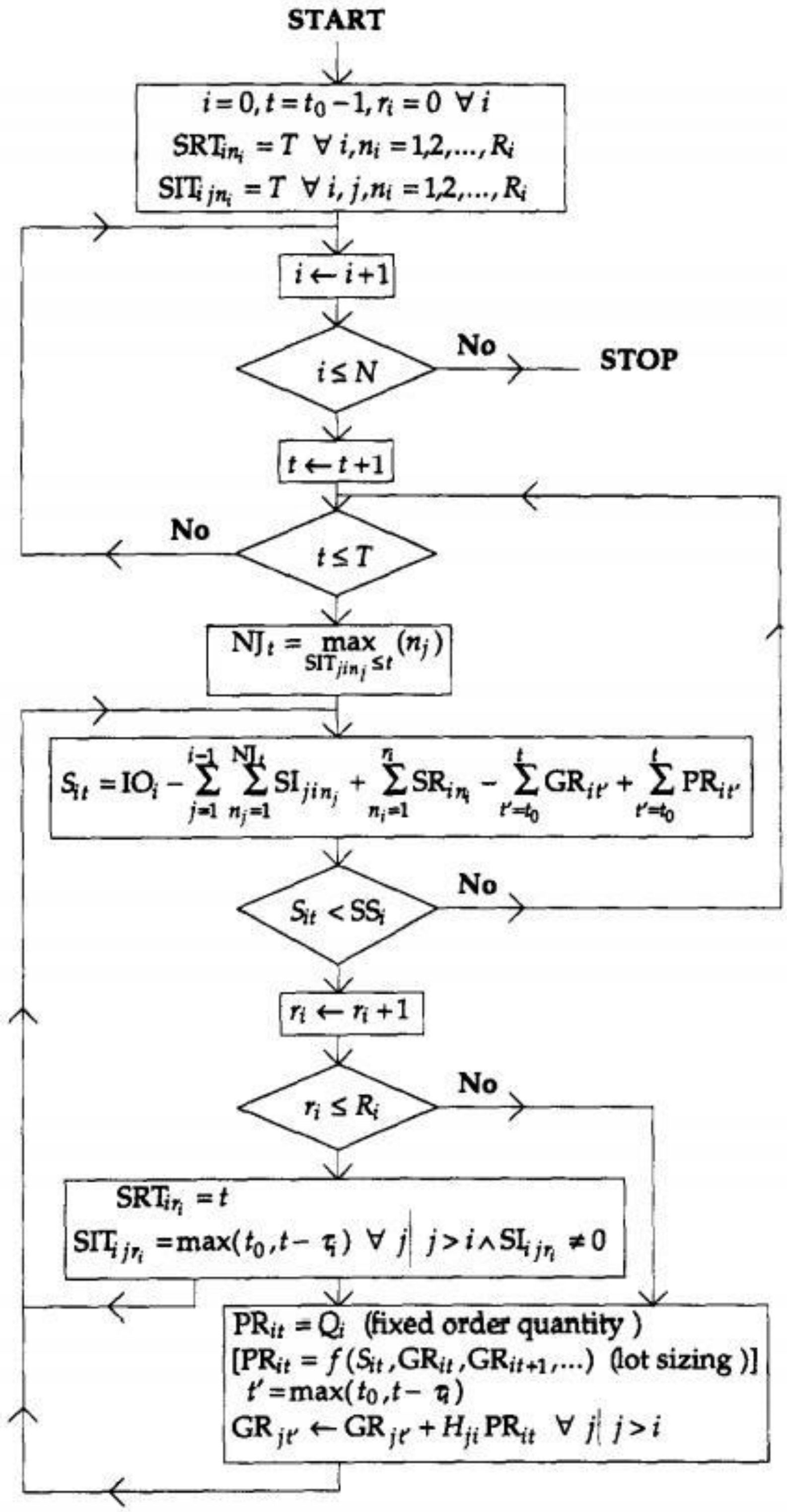
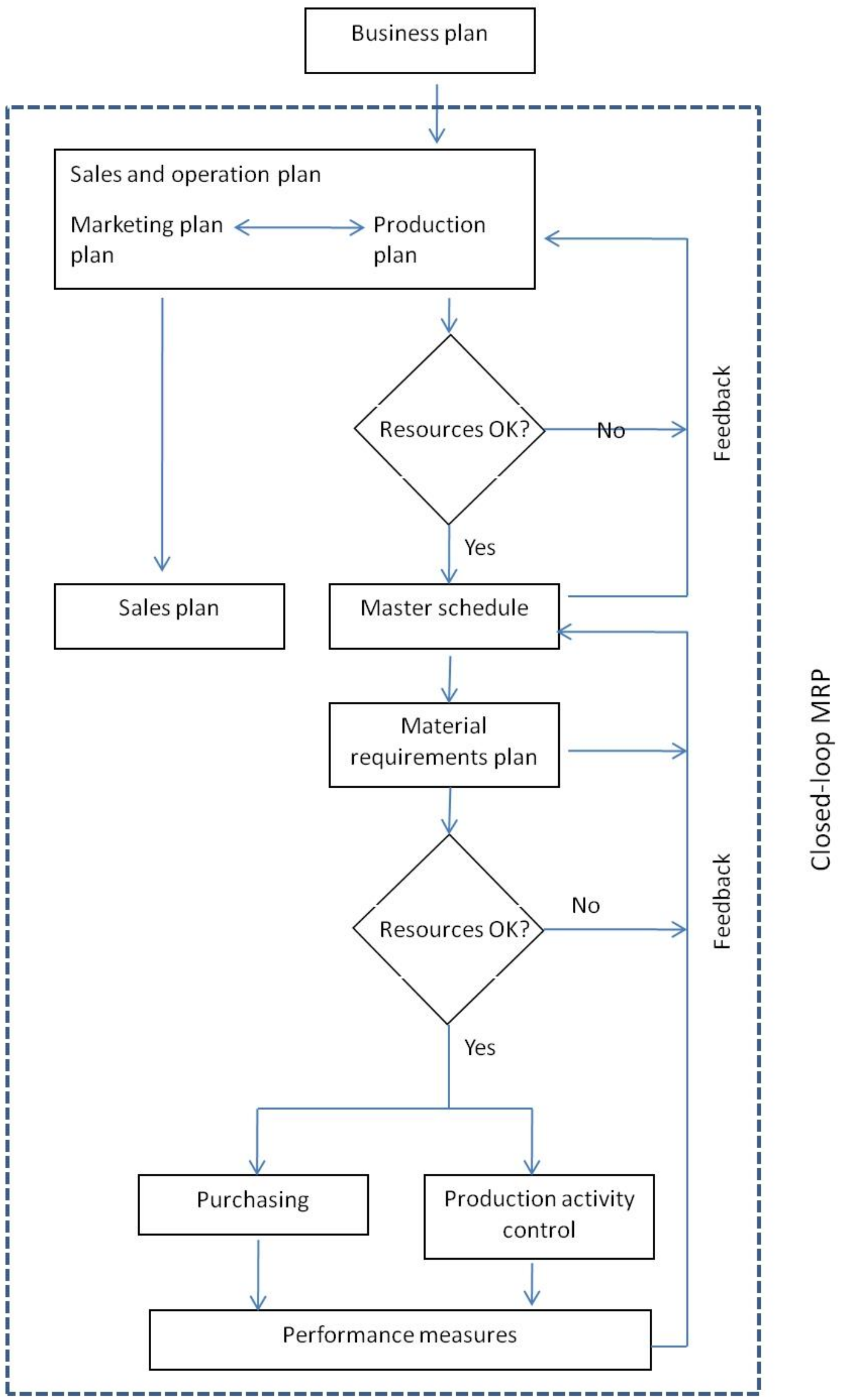
APPENDICES

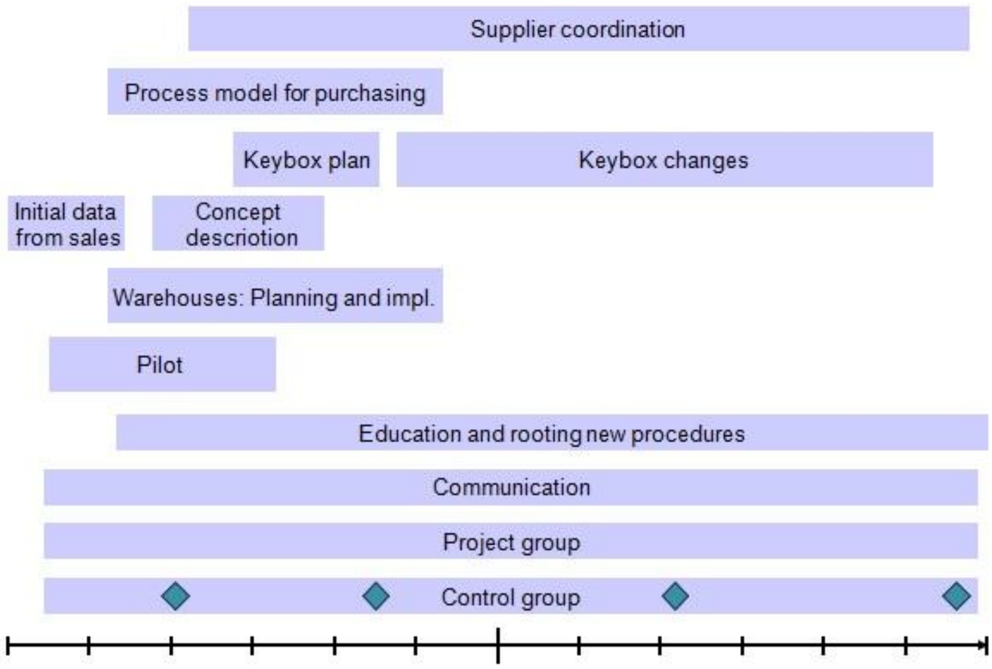
Appendix 1. MRP mathematical flow chart (Segersted 1996, 130).



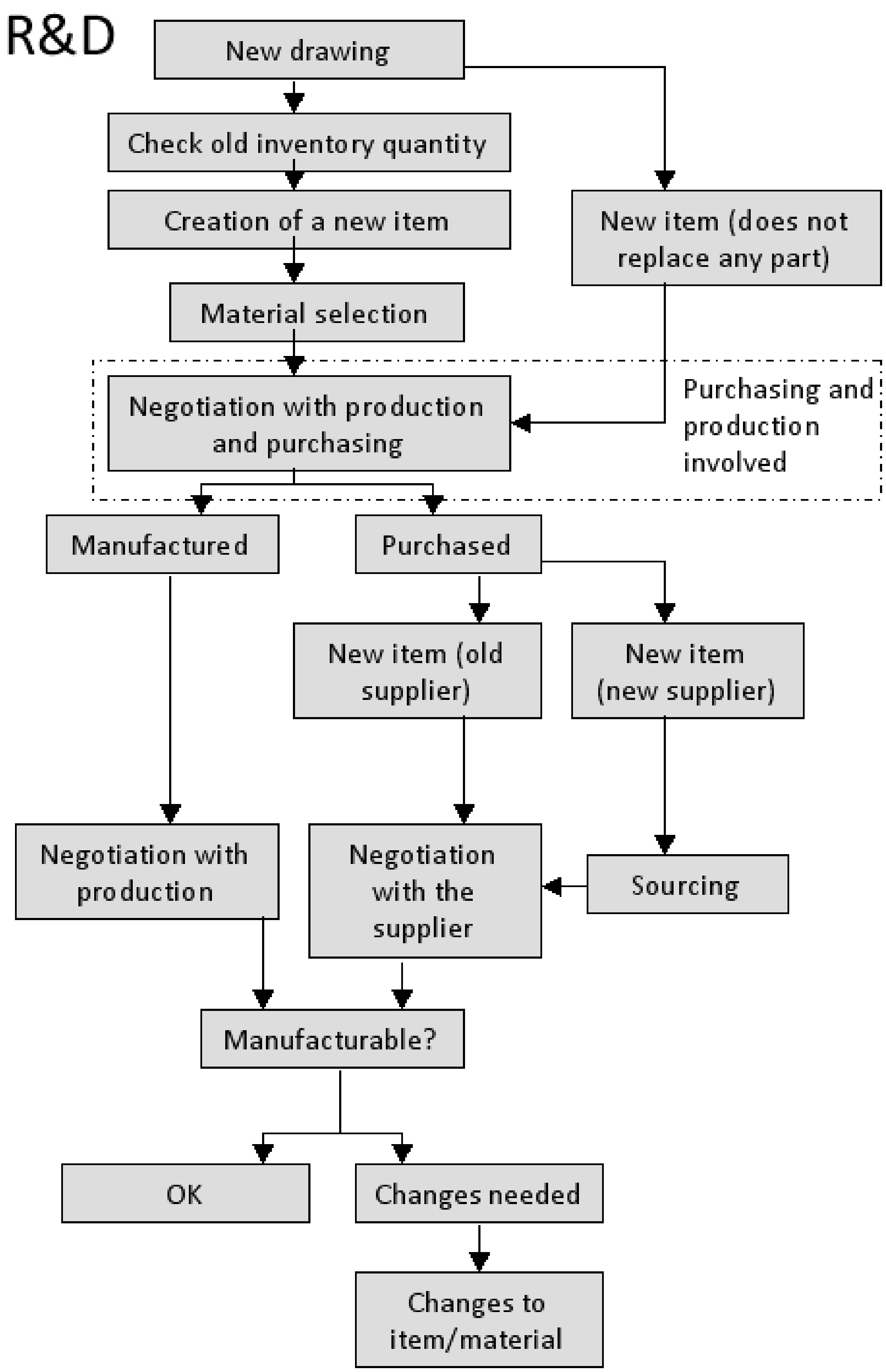
Appendix 2. MRP flow chart (Arnold et al. 2008, 29).

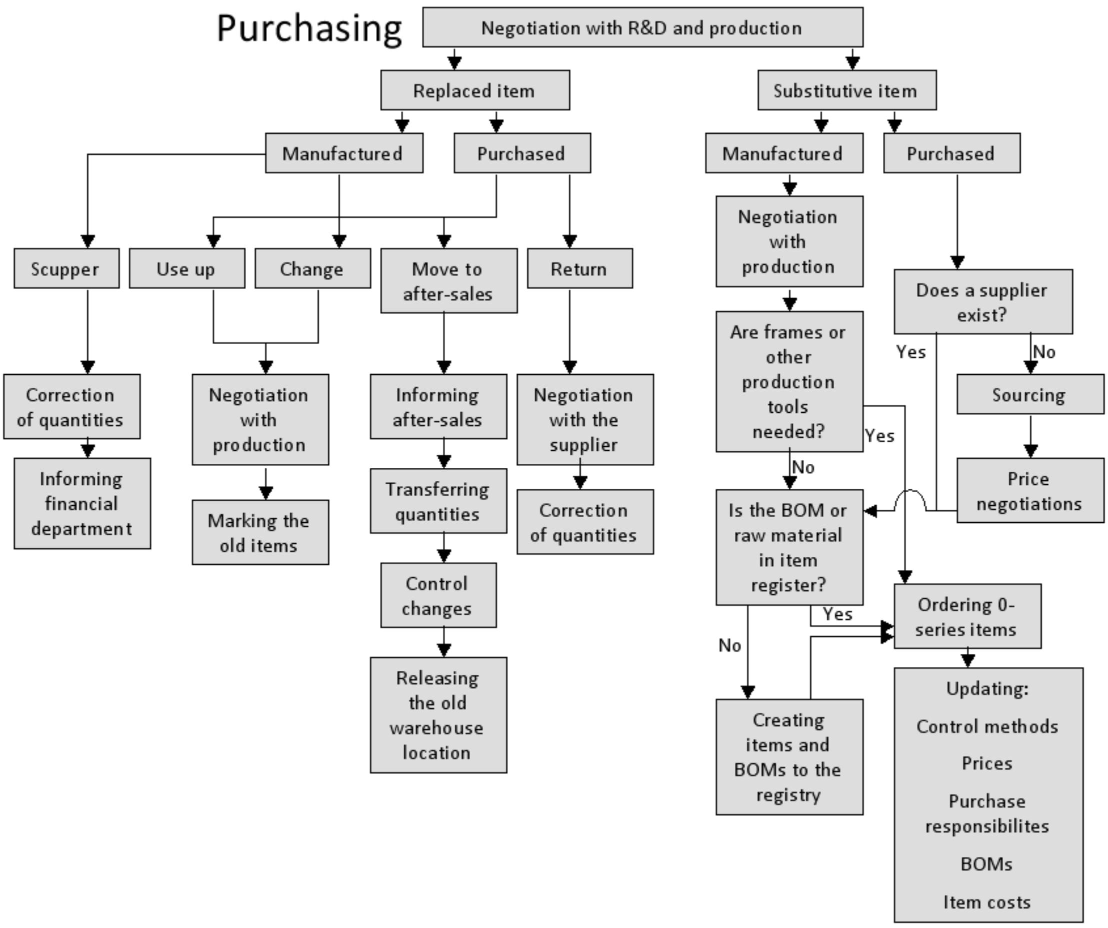


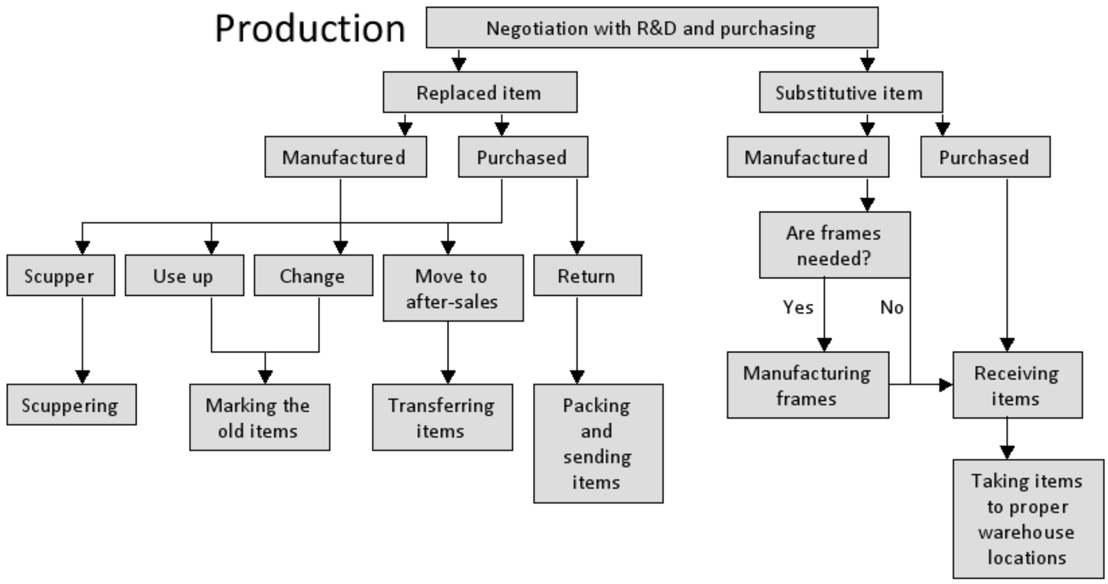
Appendix 3. Rough plan of Modular Control project's work packages



Appendix 4. Engineering change order flow charts




Purchasing
Negotiation with R&D and production
Replaced item
Substitutive item
Manufactured
Purchased
Manufactured
Purchased
Negotiation with production
Scupper
Use up
Change
Move to after-sales
Return
Are frames or other production tools needed?
Does a supplier exist?
Yes
No
Correction of quantities
Negotiation with production
Informing after-sales
Negotiation with the supplier
Sourcing
Yes
No
Informing financial department
Marking the old items
Transferring quantities
Correction of quantities
Price negotiations
Is the BOM or raw material in item register?
Control changes
Yes
Ordering 0-series items
No
Releasing the old warehouse location
Creating items and BOMs to the registry
Updating:
Control methods
Prices
Purchase responsibilites
BOMs
Item costs


Production
Negotiation with R&D and purchasing
Replaced item
Substitutive item
Manufactured
Purchased
Manufactured
Purchased
Are frames needed?
Scupper
Use up
Change
Move to after-sales
Return
Yes
No
Scuppering
Marking the old items
Transferring items
Packing and sending items
Manufacturing frames
Receiving items
Taking items to proper warehouse locations

Appendix 5. Sample of production's change order form and the macro

Tuotanto, korvaavan nimikkeen toiminnot

Muutoksen kriittisyysaste (myynti luokittaa)
KORKEA - Muutos läpi 2 viikossa!

Uusi/Korvaava nimike: ABCDEF
Korvattava nimike: GHIJKLM
Mahd. poistet. nimike 0

1. Materiaalin vastaanotto ☐
2. Varastopaikan selvitys ja päivitys ☐
3. Vienti oikeaan varastopaikkaan ☐
4. Tarvitaanko jigejä?
   - ☐ Kyllä — Valmista jigit
   - ☐ Ei — OK

Hankinta tilannut uudet osat?
TOSI
Osat saapuvat: 21. toukokuuta 2011

Tuotanto, korvattavan nimikkeen toiminnot

Korvattava nimike: GHIJKLM

1. Valitse tapahtuma
   - Romutus ☐ Siirry kohtaan 1.2.
   - Loppuun käyttäminen ☑ Siirry kohtaan 1.3.
   - Muutos/korjaus ☐ Siirry kohtaan 1.3.
   - Siirto varaosille ☐ Siirry kohtaan 1.4.
   - Palautus ☐ Siirry kohtaan 1.5.
   - Jää käyttöön muissa rakenteissa ☐ Siirry kohtaan 1.6

1.2. Toteuta romutus ☐

1.3. Laputa korvattava tavara tiedoilla:
- Korvaava nimike tai muutos/korjaustiedot ☑
- Aikataulu suunniteltu ☑

1.4. Toteuta siirto ☐

1.5. Pakkaus ja lähetys ☐

1.6. Tarkasta muutokset
Laputa vanha tavara ☐

2. Ilmoitus muutoksen voimaantulosta
   - Suunnittelulle ☐
   - Hankinnalle ☐
   - Myynnille ☐

Muutos vaikuttaa myös näihin osiin:

1234
5678

Pvm. lopetettu: 1.6.2011
Toteuttaja: X

Lähetä valmistumissähköposti tästä

```
Sub Painike51_Napsautettaessa()
        Dim OutApp As Object
        Dim OutMail As Object
        Dim strbody As String

        If ActiveWorkbook.Path <> "" Then
                Set OutApp = CreateObject("Outlook.Application")
                Set OutMail = OutApp.CreateItem(0)

        strbody = "<font size=""3"" face=""Calibri"">" & _
                "Dear colleaques,<br><br>" & _
                "Muutosilmoitus:<br><B>" & _
                ActiveWorkbook.Name & "</B> has been
                processed.<br>" & _
                "Link to the change order: <br><br>" & _
                "<A HREF=""file:\\" & ActiveWorkbook.FullName & _
                """>Linkki<br><br></A>" & _
                "" & ActiveWorkbook.FullName

        On Error Resume Next
        With OutMail
                .To = XXXXX@nokka.fi; XXXXX@nokka.fi
                .CC = ""
                .BCC = ""
                .Subject = "Change order " & ActiveWorkbook.Name & "
                has been processed"
                .HTMLBody = strbody
                .Display   'or use .Send
        End With
        On Error GoTo 0

        Set OutMail = Nothing
        Set OutApp = Nothing

        Else

        MsgBox "The ActiveWorkbook does not have a path, Save the file first."

        End If

End Sub
```

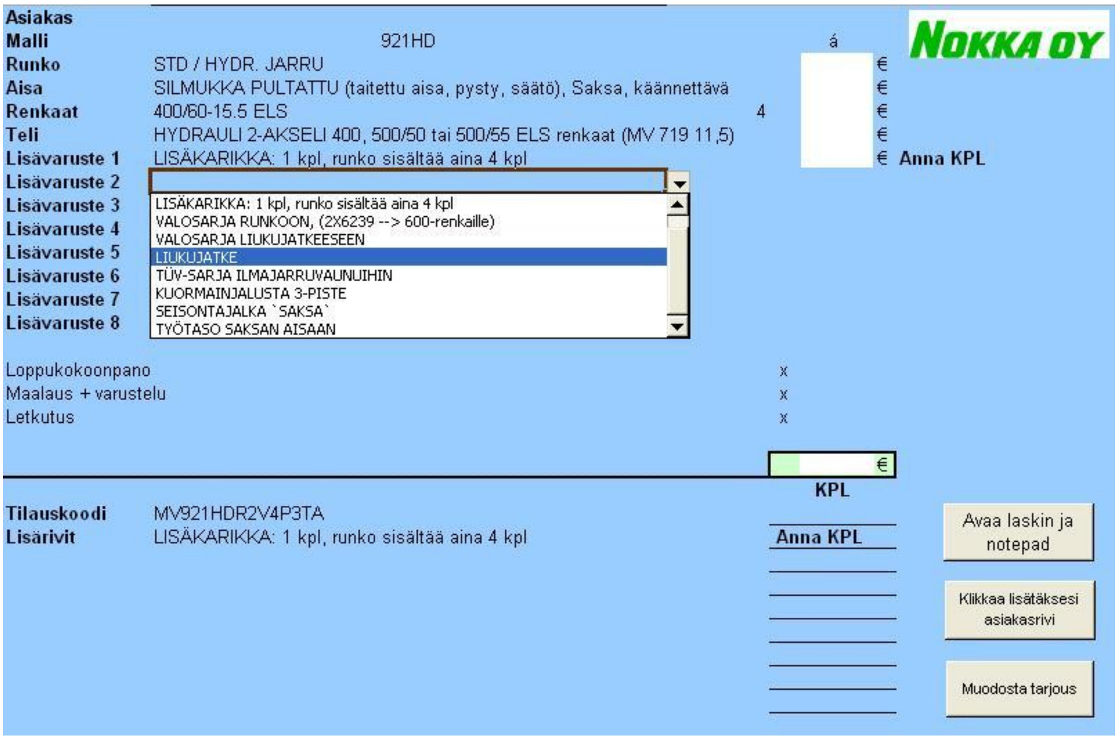
Appendix 6. Snapshot of Nokka’s table of modules

NOKKA OY

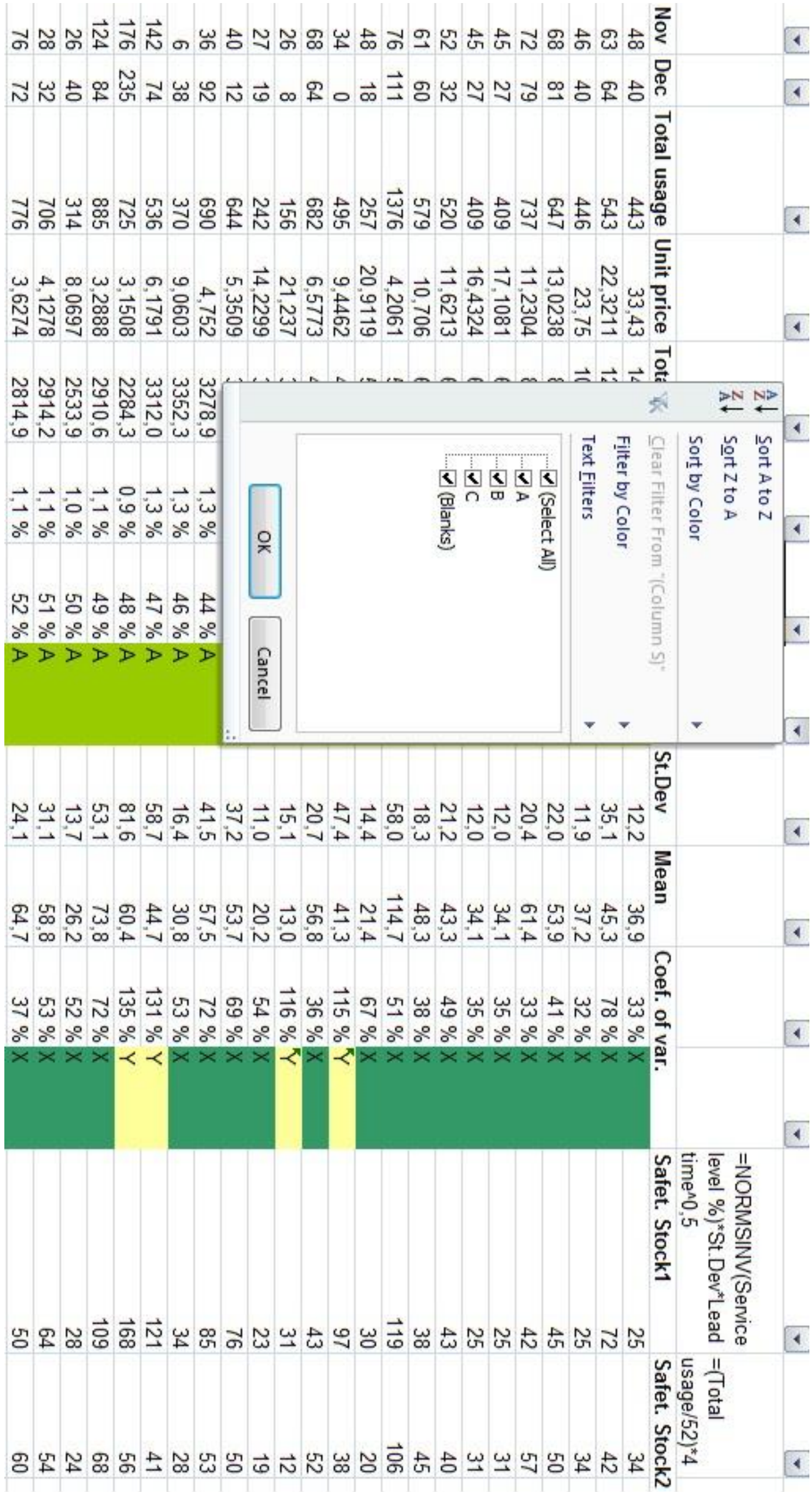
TUOTENUMEROT JA TEKNISET TUNNUKSET NOKKA METSÄPERÄVAUNUILLE

		1-palkki			2-palkki
VARUSTELU		MASTER			leveä runko
KOODI	MALLI	719	819	951SE	1102SX
	Suositeltavat kuormaimet	2752	2752	4572SE	4469SX - 4572SE
	RUNKO:				
R1	STD	X	X	- - - -	- - - -
R2	STD / HYDR. JARRU	* * *	* * *	X	X
R3	HYDRAULI NORJA	- - - -	- - - -	- - - -	- - - -
R4	BELGIA, 6 paria karikkaholkkeja	- - - -	- - - -	- - - -	X
R5	ILMA	- - - -	- - - -	- - - -	- - - -
R9	STD / HYDR. JARRU hydraulinen serminsiirto	- - - -	- - - -	- - - -	- - - -
	VETOAISA: Hydr. aisanohjaus				
V1	SCAND. PYÖRIVÄ SILMUKKA	X	X	X	X
V2	SILMUKKA PULTATTU (pysty, ei säätöä), Saksa	X	X	- - - -	- - - -
V9	SILMUKKA PULTATTU (taitettu aisa, pysty, ei säätöä), Saksa, käännettävä	X	X	- - - -	- - - -
V3	SILMUKKA PULTATTU (pysty, säätö), Saksa	X	X	- - - -	- - - -
V4	SILMUKKA PULTATTU (taitettu aisa, pysty, säätö), Saksa, käännettävä	- - - -	- - - -	x	- - - -
V5	KUULA PULTATTU (taitettu aisa, pysty, säätö), Saksa, käännettävä	- - - -	- - - -	- - - -	- - - -
V6	SILMUKKA AGGREG. PULTATTU (vaaka), Saksa, käännettävä	- - - -	- - - -	- - - -	- - - -
V7	KUULA AGGREG. PULTATTU (vaaka), Saksa, käännettävä	- - - -	- - - -	- - - -	- - - -
V8	SILMUKKA AGGREG. PULTATTU (vaaka), Saksa	X	x	- - - -	- - - -
	MALLI	**719**	**819**	**951SE**	**1102SX**
	RENKAAT: Valitse 2 + 2 kpl				
P1	RENKAAT oik.	X	- - - -	- - - -	- - - -
	11.5/80-15.3 vas.	X 11.5/80-15.3 [illegible]	- - - -	- - - -	- - - -
P2	RENKAAT oik	- - - -	X	X	X
	400/60-15.5 vas.	- - - -	X 400/60-15.5 14PR	X 400/60-15.5 14PR	X 400/60-15.5 14PR TT
P3	RENKAAT RV+VS+T2" Nokia oik	- - - -	- - - -		- - - -
	400/60-15.5 ELS vas.	- - - -	- - - -		- - - -
P4	RENKAAT RV+VS+T2" oik.	- - - -	- - - -	X	X
	500/50-17 vas.	- - - -	- - - -	X 500/50-17	X 500/50-17
P5	RENKAAT RV+VS+T2" Nokia oik	- - - -	- - - -	- - - -	- - - -
	500/55-17 ELS vas.	- - - -	- - - -	- - - -	- - - -

Appendix 7. The module selector



Appendix 8. ABC-XYZ tool



												=NORMSINV(Service level %)*St.Dev*Lead time^0,5	=(Total usage/52)*4
Nov	Dec	Total usage	Unit price	Tota				St.Dev	Mean	Coef. of var.		Safet. Stock1	Safet. Stock2
48	40	443	33,43	[illegible]	[illegible]	[illegible]	[illegible]	12,2	36,9	33 %	X	25	34
63	64	543	22,3211	[illegible]	[illegible]	[illegible]	[illegible]	35,1	45,3	78 %	X	72	42
46	40	446	23,75	[illegible]	[illegible]	[illegible]	[illegible]	11,9	37,2	32 %	X	25	34
68	81	647	13,0238	[illegible]	[illegible]	[illegible]	[illegible]	22,0	53,9	41 %	X	45	50
72	79	737	11,2304	[illegible]	[illegible]	[illegible]	[illegible]	20,4	61,4	33 %	X	42	57
45	27	409	17,1081	[illegible]	[illegible]	[illegible]	[illegible]	12,0	34,1	35 %	X	25	31
45	27	409	16,4324	[illegible]	[illegible]	[illegible]	[illegible]	12,0	34,1	35 %	X	25	31
52	32	520	11,6213	[illegible]	[illegible]	[illegible]	[illegible]	21,2	43,3	49 %	X	43	40
61	60	579	10,706	[illegible]	[illegible]	[illegible]	[illegible]	18,3	48,3	38 %	X	38	45
76	111	1376	4,2061	[illegible]	[illegible]	[illegible]	[illegible]	58,0	114,7	51 %	X	119	106
48	18	257	20,9119	[illegible]	[illegible]	[illegible]	[illegible]	14,4	21,4	67 %	X	30	20
34	0	495	9,4462	[illegible]	[illegible]	[illegible]	[illegible]	47,4	41,3	115 %	Y	97	38
68	64	682	6,5773	[illegible]	[illegible]	[illegible]	[illegible]	20,7	56,8	36 %	X	43	52
26	8	156	21,237	[illegible]	[illegible]	[illegible]	[illegible]	15,1	13,0	116 %	Y	31	12
27	19	242	14,2299	[illegible]	[illegible]	[illegible]	[illegible]	11,0	20,2	54 %	X	23	19
40	12	644	5,3509	[illegible]	[illegible]	[illegible]	[illegible]	37,2	53,7	69 %	X	76	50
36	92	690	4,752	3278,9	1,3 %	44 %	A	41,5	57,5	72 %	X	85	53
6	38	370	9,0603	3352,3	1,3 %	46 %	A	16,4	30,8	53 %	X	34	28
142	74	536	6,1791	3312,0	1,3 %	47 %	A	58,7	44,7	131 %	Y	121	41
176	235	725	3,1508	2284,3	0,9 %	48 %	A	81,6	60,4	135 %	Y	168	56
124	84	885	3,2888	2910,6	1,1 %	49 %	A	53,1	73,8	72 %	X	109	68
26	40	314	8,0697	2533,9	1,0 %	50 %	A	13,7	26,2	52 %	X	28	24
28	32	706	4,1278	2914,2	1,1 %	51 %	A	31,1	58,8	53 %	X	64	54
76	72	776	3,6274	2814,9	1,1 %	52 %	A	24,1	64,7	37 %	X	50	60