UNIVERSITY OF VAASA
FACULTY OF TECHNOLOGY
DEPARTMENT OF PRODUCTION

Mika Mäkelä

IMPLEMENTING SAP - MATERIALS MANAGEMENT MODULE
Case ABB Transformers, Vaasa, Finland

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EQUATIONS

SYMBOLS AND ABBREVIATIONS

ASCC	Advanced Supply Chain Collaboration. Software for managing supply chains
Baan	ERP Software created by Baan Inc
BOM	Bill Of Material. Parts list of components needed in the end product
ConWIP	CONstant Work In Process
CT	A production line in the case company
ERP	Enterprise Resources Planning system
ES	Enterprise System software
ETO	Engineer-to-order manufacturing principle
FISAP	Tailored version of SAP used currently in ABB
GTH	Warehouse in case company used for non valuated items
GTW	Warehouse in case company used for valuated items
Kanban	A visual card for signaling the need for an item
KTI	A production line in the case company
KTN	A production line in the case company
LUC	Least Unit Cost
Master Data	Data which is the key to the operations for ERP
MM	Materials Management module in SAP
MPS	Master Production Schedule
MRP	Materials Resources Planning calculates the need and timing inside ERP
MTO	Make-to-order manufacturing principle
Of-the-box	Commonly used non tailored software
OsA	A project for harmonizing processes inside ABB
OTD	On Time Delivery calculations
PDM	Software for managing Product Data
PP	Production Planning module in SAP
RFID	Radio Frequency Identification for automated identification
SAP	ERP Software created by SAP AG
SAP R/2	Mainframe version of SAP
SAP R/3	Client/server version of SAP
SOX	The Sarbanes-Oxley Act is used in all public companies listed in U.S

TOC	Theory of Constraints
WIP	Work In Process
VMI	Vendor managed inventory

UNIVERSITY OF VAASA
Faculty of technology
Author: Mika Mäkelä
Topic of the Master's Thesis: Implementing SAP – Materials Management module. Case ABB Transformers, Vaasa, Finland
Instructor: Professor Petri Helo
Degree: Master of Science in Economics and Business Administration
Department: Department of production
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ABSTRACT
ERP implementation projects are wide and challenging projects that need lots of resources. The companies want to make sure that these projects succeed and the investment carries positive results. This research is made as a case study to an organization that is in predefinition phase of SAP implementation project. The research is constrained to the processes inside Materials Management module in SAP. Its first objective was to describe the current processes of the case company. The second objective was to compare the current processes of the upcoming ERP and give solution proposals for the conflicting parts. The third objective was to research why the case company has material shortages which affect the functioning quality of the current ERP. Through these three steps the overall objective could be achieved: Successful predefinition for the Materials Management module in the case organization.

The research consists of both qualitative and quantitative analysis. The quantitative part is based on data collected from the current ERP. The qualitative part of the research was based on interviews and informal discussions in multiprofessional project teams. Background material consisted of blueprint documents, process flowcharts, instructions as well as other internal material of the case company. The research can be considered as success because all of the processes were examined comparing the processes used in SAP and the conflicting processes were reported. Also solutions were found for occurred conflicts and the material shortages.

KEYWORDS: ERP, SAP, materials management, MRP, lot sizing

VAASAN YLIOPISTO
Teknillinen tiedekunta

Tekijä:	Mika Mäkelä
Tutkielman nimi:	SAP materiaalihallintamoduulin implementoiminen. Case ABB Transformers, Vaasa, Finland
Ohjaajan nimi:	Professori Petri Helo
Tutkinto:	Kauppatieteiden maisteri
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TIIVISTELMÄ

ERP implementaatiot ovat laajoja projekteja, jotka vaativat huomattavia resursseja. Yritykset haluavat varmistaa että nämä projektit onnistuvat ja investoinnit tuottavat positiivisia tuloksia. Tämä tutkimus tehtiin tapaustutkimuksena yritykselle, joka oli SAP implementoinnin määrittelyvaiheessa. Tutkimus rajattiin tarkastelemaan Materials Management moduulin sisällä tapahtuvia prosesseja. Tutkimuksen ensimmäinen tavoite oli kuvata nykyiset. Toisena tavoitteena oli verrata nykyisten prosessien soveltuvuutta tulevaan ERP järjestelmään, sekä antaa ratkaisuehdotuksia ongelmakohtiin. Kolmas tavoite oli tutkia syitä miksi case organisaatiossa on materiaalipuutteita, jotka vaikuttavat nykyisen ERP:n toiminnan laatuun. Näiden kolmen tavoitteen kautta voidaan saavuttaa kokonaistavoite, joka on: Menestyksekäs materiaalihallinnan moduulin määrittely case organisaatiossa.

Tutkimus sisältää sekä kvalitatiivista että kvantitatiivista analyysiä. Kvantitatiivinen osa perustuu nykyisestä ERP:stä kerättyyn dataan. Kvalitatiivinen osa tutkimuksesta perustuu haastatteluihin ja epävirallisiin keskusteluihin monialaisissa projektiryhmissä. Taustamateriaalina käytettiin blueprint dokumentteja, prosessikaavioita, ohjeistuksia kuten myös case organisaation sisäisiä materiaaleja. Tutkimusta voidaan pitää onnistuneena, sillä kaikki yrityksen materiaalihallintoon vaikuttavat prosessit läpikäytiin vertaillen SAPin standardiprosesseihin. Ristiriitaiset prosessit raportoitiin ja niihin annettiin ratkaisuehdotukset. Syy materiaalipuutteiden ilmenemiseen löydettiin ja niiden poistamiseksi luotiin ratkaisu.

AVAINSANAT: ERP, SAP, materiaalinhallinta, MRP, eräkoon määrittäminen

1. INTRODUCTION

Enterprise resources planning (ERP) system implementations have been in common discussion for several years. There has been a lot of arguing about the benefits and disadvantages with the ERP systems. Many companies have achieved direct cost savings, transparency in processes and efficiency in production and in materials management. On the other hand many implementations have failed or at least they have not been successful and huge losses have been reported. The systems cannot work efficiently themselves; they need to be configured for the processes of the company. The parameters have to be examined and defined so that the system can make right calculations and reporting.

Earlier it was common to build fully tailored systems for companies, nowadays most of the implementations are done with common of-the-self systems. These common systems are designed by the business area’s best practices and many companies want to develop their processes in the way of these best practices. This means re-engineering of current processes. One may ask that if all the companies have similar processes, where does the competitive advantage come from (Ptak 2004: 101.)? The competitive advantage does not come from the system itself anymore, but instead it can be found through the improvements in process handling. An efficiently functioning ERP can be of big help on that.

ERP projects are usually big and challenging projects that last for several years and require lots of resources. Once the implementation is made there is usually no turning back, so the companies want to make sure that the projects will be successful. Many studies can be found where the pitfalls are described but there are far less studies which tell how successful implementations are made.

This research is made as a case study for a specific case company, the ABB Transformers. However, the questions asked are common so it can be used as studying material in other similar cases too. This thesis can be used in companies that have made the decision to implement an ERP system. It does not give thought whether to implement ERP or not. It also does not compare ERP packages that can be found. Decision on which package is the most suitable for the company has to be based on comparison between the processes the company uses and the processes that can be found in the ERP system. The right solution is the system that is the most suitable for the most of the company's processes. The rest of the internal processes have to be re-engineered to suit the system selected or the system has to be tailored to the case company.

1.1. Research problem, objectives and constraints

ABB is a multinational corporation headquartered in Zurich, Switzerland. ABB has decided to harmonize its processes. As part of this project they have chosen SAP as the new common ERP system. This thesis is made for one of the local business units of ABB, the ABB Transformers, and its function is to help on the decision process when the new ERP is implemented. The author of the thesis participates on the ABB SAP group of materials management. This research was made during the predefinition phase of the implementation process. The research is targeting on the materials management part of the ERP software. Materials management includes the inner and outer logistics, warehousing and purchasing. Material assets cover large part of the most companies' assets. Materials management has several links to other parts of the business, for example finance and accounting, production, sales and distribution.

The objective of the project given for the author of this thesis was to examine the case company's processes in materials management in order to make sure that the case company would be ready for the ERP change process. The goal given to this research is to accelerate and make easier the ERP change process in the case company. This is done by describing the current processes and by mapping the critical issues in the context of Materials Management. Finally development proposals for solving them are given. The first target is to describe the current processes affecting the materials management. The second target is to map the case company's special issues on materials management and compare them to the processes in standard SAP. The third target is to provide solution proposals for the most critical issue, which was recognized as the MRP calculation. Research of the MRP reaches high importance in this case study because the case company had reported material shortages and means for solving them are needed. Material shortages cause delays in production and in deliveries. Delays are causing direct costs and costs from missed opportunities.

The goal of the MRP research is to increase transparency of the processes and make the materials management clearer and easier to be controlled so that the upcoming ERP could perform as efficiently as it can. This thesis can be of help for the whole project by explaining the implementation process and mapping the issues from the case company's point of view.

This thesis concentrates on the questions inside the materials management (MM) module of SAP. There will be a lot of questions which are related for example to the master data. These questions have to be solved also but they are not in the scope of this thesis. Also finance, asset management, human resources and production are left out of the scope of this thesis.

Transformers local business unit has processes that are not suitable for the standard version of the ERP system. Some of these can be solved with minor changes in the system, some have to be fixed by using work-arounds and some will need changes to the business unit processes. All inessential issues concerning the topic of this thesis are left out of the scope of this thesis and only the most critical ones will be described.

1.2. Research Process

First a big picture Visio of the processes used in the case company was created so that the processes affecting ERP could be recognized (refer appendix 2). Implementation processes were examined by literature review. Through this literature review, comparison against big picture Visio, interviews with the consultants and internal discussions the most crucial processes were recognized. These processes were examined inside the case organization and a risk analysis was done. Through this risk analysis two most critical issues were found. First one is unsettled materials, which needs standardization of the material handling methods. Second is process harmonization for cutting down the conflicting processes. Through this case study these material issues are believed to be caused by the parameters used in MRP. Therefore the research concentrated on MRP calculations, how sorting of material should be made and how the warehouses should be managed. Finally proposal for solving these issues was created.

1.3. Research methods and data

The research was made between January and June in 2008 during the predefinition phase of the ERP implementation project in the case organization. The research was a case study where processes of the case company were examined against common theories. The target of this case study was to provide deep examination to the case company processes prior to provide common knowledge. The research approach is activity based analysis and it tries deeply to understand the subjected problem.

The research methodology is both qualitative and quantitative. Qualitative part consists from interviews and informal discussions with multiprofessional project teams and informal discussions. Background material used consisted of blueprint documents, process flowcharts, instructions as well as other internal material of the case company. Process analysis is based on the literature review and comparison to the current ERP system BAAN. Empirical data was collected from the current ERP system. The analysed data was mainly from 2007. Basic functionalities of the ERP systems are similar so historical data from current ERP was considered as valid. Quantitative data analysis was made to the current parameters and consumption of purchased material. Qualitative analysis based mainly on basic statistic quantities like means, medians and deviations. Analysis was made by using MS Excel and SPSS softwares.

1.4. Structure of the thesis

First chapter leads the reader to the topic by describing the issues behind this project. It also introduces the methods and data used in this case study. Against these issues the objective is introduced how this thesis is supposed to help the overall project. Second chapter is for introducing ERP systems, the alternatives for process management in implementation projects, the risks behind the implementation and a description of what the case company wants from the project. This gives the theoretical background for the empiric examination of the implementation project. Chapter three presents the methods how materials can be managed inside SAP and the fourth chapter introduces the case company. The current processes in the case company that the ERP will control are introduced in chapter five. The sixth chapter describes the analysis done for the material handling and the proposals for developing them. Observations occurred during the case study are described in chapter seven and also future research proposals are given. Finally summary of the process is made in chapter eight and the success of the research is analyzed as whole.

2. ENTERPRISE RESOURCES PLANNING SYSTEMS

Roots of the ERP evolution can be seen from the mid 60´s when the first computer was used for material planning. The process was called Material Requirement Planning (MRP). When the computers became more powerful and could manage more data the production and inventory control professionals further developed this tool and started to use it for capacity management as well. The idea of managing companies' every process inside one system was born. When computers improved further, more connections to business processes were involved and Manufacturing Resources Planning (MRP II) was born. Later on it developed into Enterprise Resources Planning (ERP) since more complex routine tasks could be managed with computers. (Ptak 2004: xxix).

2.1. Tailored ERP systems vs. common systems

A company has two main alternatives when choosing an ERP system. First one is to choose a fully tailored system for company's specific needs. The system will be built to meet the exact needs of the company. The system can be built in house or it can be ordered from a specialised software company. The other alternative is to implement common systems which are also called "of-the-box" systems. However, common ERP systems can very seldom be implemented as standard versions, since they have to almost always be tailored to company's specific use. The degree of tailoring may vary a lot. The case company is moving from common, but highly tailored ERP system to standardized common ERP system with as little tailoring made as possible. This sets challenges for the case organization and therefore the differences between these two alternatives are discussed next.

The first ERP systems were company specified and fully tailored. The shift started over a decade ago when the of-the-box systems began to conquer the market. The development of custom applications is generally very expensive and long lasting – and still the results are not guaranteed to be successful. Businesses develop at enormous speed and making changes to tailored systems requires even more effort than making changes to common systems. The benefit of fully tailored system is that the system can be made so that it will meet all specialities in processes.

Common systems are made for common use and can be tailored to customer specifics. They based on the best practices and the processes have already been in many companies. Implementing a common system will give the organization a chance to examine its processes against the best practices and benchmarking can be done. The disadvantages of common systems are that usually some re-engineering of current processes is needed and this often provokes resistance to change in the organization. Also, the common ERP packages are usually enormous and not easy to configure for business specific use.

2.2. Criticism about enterprise resources planning systems

Davenport (2000: 16-19) recommends to notice four points of Enterprise Systems (ES) that can be considered as disadvantages. They should be thought through in organization at the moment of system selection for understanding the basic truths of ERP systems. He also gave his own opinions, with which one can agree. According to Davenport, these disadvantages are:

Inflexibility

Commonly it is argued that it is too difficult to fit an ERP system to current business. Many companies end up doing business in the way they don't want to just because the system requires it. It is said that enterprise system "is like cement, firstly highly flexible, but rigid later". Large number of people is needed afterwards to make day to day changes. For example Intel needed 12 additional persons for making just the daily changes needed so that the system could run. Davenport asks that these systems are inflexible compared to what? It is possible that a hypothetical object-oriented, highly modular system can someday provide greater flexibility than today's systems. The problem is that the kind of system does not exist now nor is it not seen in near future.

Some systems are also more flexible than others, but according to Davenport there seems to be a trade-off between comprehensiveness and breadth of an ES package and the ease with which it can be configured and modified. It is certainly true that today's systems are more easily configured than those of the past. There are also companies that have argued that implementing an ERP system has made them more flexible than they were before. (Davenport 2000: 16-19) The reason is that now they have only one system to change instead of many.

Long implementation periods

It is commonly criticized that implementing takes too long since a three- to five-year project duration is fairly common in a large company. And even that is overly optimistic for many companies. In a rapidly changing business world a ten years implementation project cannot be accepted. This is noticed by the ERP system developers. For example SAP has published preconfigured "Out of the box" versions that can be implemented quite fast.

One of the first companies to have done a rapid SAP R/3 implementation is Seattle Times newspaper: the duration of the whole implementation process was just 6 months (largely restricted to financial module). Surely one of the quickest SAP implementations was made by the University of Texas Business School, where full SAP education version was implemented over a weekend (Davenport 2000: 19). So it should be pointed out that the actual installation of the system is not what takes time. Defining and making the required business changes is where the time is consumed. Also establishment of common definitions of key information entities and setting up desired reporting and information aggregation structures takes time. Rapid implementation means that the company has to be fit, know exactly their processes and what is the state wanted.

Overly hierarchical organizations

Third commonly expressed criticism is that ERP systems make the companies too hierarchical. They create so called "Command and Control" perspective on the organizations. According to this argument, centralized monitoring and control of information is an outdated perspective in organizations in this era of empowerment. This characterization is true to a greater degree than previous criticism. Enterprise systems do presume that information will be centrally monitored and organizations have a well-defined hierarchical structure.

Davenport (2000: 17) states that most of the companies still have quite hierarchical structure and the business units can be managed under one system. In cases where business units "can do what they will, as long as they make good money" each business unit can have their own ES as some companies have done according to Davenport (2000: 17).

Antiquated technology

The last criticism according to Davenport is that enterprise systems are based on obsolete technique. They are mainly mainframe programs ported into client/server world and they do not have as graphical user interfaces as one could assume comparing to other current software's. These issues are mainly true but can be thought of as quite negligible.

The criticism introduced above can be agreed, but it also describes the way ERP functions. So it is mandatory for a company to understand what implementing ERP means and how will it affect the business and the current processes. When a company is in stage of implementation the issues above should be noticed and thought through because they will affect the way in which the company and its employees will work after the implementation. With proper preparation these issues do not come as surprise.

2.3. ERP implementing strategies

One of the toughest issues any company has to face on the stage of ERP implementation is whether to make changes to ERP software package or to reengineer business processes. Changing business processes to poorly fitting system can be fatal but it can also give a chance for the company to examine its processes. Modifications to fully functional best practice processes can be just a waste of money without gaining anything Ptak (2004: 101). Afterwards company can just have new inventory control system that is not fully functional, but has cost millions. (Ptak 2004: xxxi.)

Ptak (2004: 41) states that a software engineer should not be in charge of an ERP project, but a business executive instead, so that there would be a common language between the management issues and the precise world of software.

New ERP system will and it also should bring changes into current business. If company expects that new system will look and function exactly like the current system there can be only one advice according to Ptak and that is “to stop, save the money and continue with the existing system”. It is essential during the selection phase that the key processes will reflect the system selected.

Determining the implementation strategy is the preceding task to system selection. Smith (1989: 414) lists four strategies for implementation:

The cold turkey approach

The cold turkey approach means that the company switches entirely at one point in time to the new system. This approach is ultimately cost effective and fast, but highly risky because if the new system has a bug, it can stop the entire company for an indefinite period until the bugs are identified and corrected.

The parallel system approach

The old and the new system can be run parentally. This is called the parallel system approach. The old system will be shut down when the new system is proven functional. There is a risk that the results are compared for assuring the functionality of the new system and if there is difference between the results bugs are searched. This is false, because the new system should be more efficient and the results should have different (better and more accurate) results. According to Smith (1989: 414) this system makes sense when converting from manual system to automated system, but not when there is an old ERP system which is being changed to a new version or entire system. Another reason for not using this approach when updating ERP system is that there will not be enough personnel for running both systems.

The pilot approach

One implementing strategy is piloting. The idea of piloting is that the company is divided into process entities which can be examined as whole in ERP system. These entities are called piloting units. A piloting unit (e.g. a production line) will be taken out from the old system and transferred to the new system where it will be tested. When the piloting unit is operating smoothly, it will be extended to other units. The advantage of this approach is that if bugs do arise, the risk is minimized and the damage is confined, as the other units will not be disturbed. The disadvantage of piloting is that more personnel are needed and it may be confusing when two separate systems are used inside one company.

The modular approach

Separate modules of an ERP system can also be implemented at a time. This has the advantage that the personnel involved in implementation can focus sequentially on implementing different parts of the system. The order in which the modules should be implemented differs among companies. It can be said that the modules that are most critical to business critical should be implemented first. However, the upstream modules should be implemented first, because they will provide the data that will be fed to downstream modules. Thus production planning, Master Production Schedule (MPS), MRP, and the capacity planning modules are usually implemented before the execution modules. When the upstream modules are implemented and tested for functionality and reliability, the downstream modules can be implemented with the confidence that difficulties arising are not caused from the upstream problems.

The pilot and the modular approaches are most secure, but on the other hand they are also the most expensive ways of implementing and the process will last the longest. According to Smith (1989: 415) successful implementations are generally combinations of the pilot and modular approaches. A module or a group of modules are implemented as pilot for one product line and, once the operating satisfaction is proven, the module is extended to the remaining product lines or units throughout the company. ABB uses a similar approach. Business units are handled separately and they will go live in waves, so that the first business unit can be fully tested, then another etc. Different modules e.g. HR and finance were in the first phase and the productive modules will be on the second phase.

2.4. Common failures in implementation projects

Smith (1989: 402) and Ptak (2004: 346-349) lists most general pitfalls in ERP projects. These failure strategies can be divided into three main points:

Lack of management commitment and visions

Implementing ERP is an enormous project that requires commitment and personnel. In addition to have success, ERP requires a change in the way management operates the business. Therefore without a strong commitment from management, "there is little hope for success" Smith (1989: 402) states. When implementing ERP system the future aim should be clear so that the system can provide help for reaching these goals. Top management should also actively participate in the process because without their commitment the system can be obstacle for business development. Ptak also encourages companies to challenge the status quo.

Insuffient education

ERP will not be a success itself. It is how well the personnel use the system to manage the business that counts. In order to use the system, people must understand it. Without education and understanding the process will face change resistance from the end users. Ptak (2004: 346-349) lists also doing it alone and letting the consultants do it for you as failure strategies. All parties should be involved and educated so that developing discussions will come up.

Inaccurate data

It does not matter how good the system is if the data used is inaccurate. The calculations will be correct, but when they are based on false data, the result can be fatal when the results are expected to be correct. Unless the company already has an accurate production system database, it will require major effort to improve and maintain the accuracy. Special importance has to be given to bills of material, routings and inventory records.

2.5. Risk management inside ERP projects

Before starting to implement an ERP system, the company has to make the following question to itself: what do we want from the ERP system? This question defines the risk management. A successful project can mean a stabile process that was made quite quickly with minimal or no business disruption. For others this kind of process can mean the best possible opportunity to study their processes and improve them. So there cannot be a common understanding if the project was a success or not. This is why every company answers to the question differently.

According to Ptak (2004: 284) there are just four requirements for ERP system: unique item identification, demand, dependent materials and supply. These are the basic elements of ERP just like oxygen, fuel, and a source of ignition are the basic elements of fire. If one is missing, then functional ERP is not possible. To have an effective integrated system that yields a positive return on investment, each of these items must be very accurate. If the data is not accurate the system will second guess the outputs and develop manual processes instead of using desired automation. This becomes even more challenging when ERP system will be connected to an integrated supply chain. Human intervention will not be possible and the system will guide the company to fully wrong direction. Ptak (2004: 285) states that obtaining these four input elements is a substantial part of the work of the ERP implementation.

As stated before, all the four requirements have to be carefully examined when ERP implementation is made. This thesis concentrates on material management issues on the ERP project so *demand* will be taken under more careful examination. Demand for an item level can be classified as independent or dependent. Demand is independent when no relationship exists between an item and any other item. The demand for independent material is subject to customer preferences and needs like in the case of finished products and spare parts. Demand is dependent when a direct mathematical relationship exists between the demand for an item and another item (Tersine 1988: 327.) Unique item identification is handled in the Master Data. Dependent materials are defined in the bill of material (BOM) structures and those issues are taken care of in the mechanical design and production part. Distribution and supply handles the supply issues. All these have connections to each other but commonly they are divided inside ERP system as described above.

3. MATERIALS MANAGEMENT IN SAP

Materials management consists of management, storing and distributing of raw materials, semi-finished products and finished products. Materials management controls the whole material flow of a company from vendors to end customers. The significance of efficient material control is emphasized in modern companies. Acceleration of operations and need for minimizing of inventories require efficient materials management. Operations management in networks is mainly based on material flows between the companies. Development and management of material flows are issues handled under materials management. Development of information technology supports these challenges (Uusi-Rauva, Haverila, Kouri & Miettinen 2003: 381.)

Materials management has two main objects: support production and minimize inventory. Production has to have the right quantity of the right material at the right time. On the other hand there should be as little invested in inventory as possible. There is a conflict between these two objects, so an optimal balance between them has to be found (Uusi-Rauva et al. 2003: 381-382)

Materials Management module in SAP consist of following sub modules:

- Inventory Management
- Warehouse Management
- Purchasing
- Invoice Verification
- Materials Planning
- Purchasing Information System (Larocca 1999: 181).

The case company uses mostly Engineer to Order (ETO) for production. According to Smith (1989: 7) ETO process means that the customer provides the company detailed information in terms of performance and special needs required from the product. The company designs the product especially for the customer. ETO production is mostly project managed production and only very seldom the product can be repeated in production. This forces lead times to grow longer. Materials must be ordered for the specific project and this is why no long term consumption planning can be made.

3.1. Material handling methods

The core of an ERP system is the calculation that examines what is needed, currently available or coming in. Determining when is the real secret to ERP success through the reduction of inventory and improvement of response time. Ptak says that information replaces inventory (2004: 276).

Crucial for successful materials management is to know the exact demand. This information comes from MRP calculation and the inputs to MRP will come from customer orders. Technological advancements provide opportunity to share almost real-time information between customer, vendor and suppliers. Therefore the customer can get rapid information about delivery time. Vendor can do the production sequence calculations and the suppliers will have information about re-order amounts and timing. Unfortunately the exact demand cannot always be known because the planning has to be made for the future, which means it has to be forecasted. A lean company would function just by the existing information but e.g. long lead times prevent it in the case company.

Lead time means the expected time between the recognition of need and receipts of supply. Lead time has many different sub lead times such as ordering time, processing time, vendor time, inspection time, stocking time, and transportation time. Knowledge of true expected lead time is crucial for a functioning ERP system. There might be a possibility to insert all these individual components or there might be only one field where the total lead time can be inserted in the ERP system. Typically the ordering time, inspection time, and stocking time are fixed values and do not vary by the quantity of parts needed. Vendors processing time typically varies by the amount of products needed and often the transportation time does also vary. A conservative estimate of lead-times is essential for the ERP system to do the calculations and planning (Ptak 2004: 276).

3.2. Material Requirements Planning (MRP)

Material Requirements Planning (MRP) is a computer based system entailing a set of calculations that are used for planning the production or procurement of subassemblies, components, and raw materials required to support a master production schedule. According to Tersine (1988: 328) and Hoppe (2008: 48) MRP was developed to help companies to calculate their dependent material consumption so that it enables maintaining minimum level of dependent demand items in hand, yet assuring that productions schedules for the independent items can be met. Figure 1 describes the functionality of a MRP calculation as a flow chart.

According to Smith (1989: 245) MRP serves three principal purposes:

1. Master production schedule needs to be supported by the planning of production or purchase orders for components and materials. This includes identifying the items to be ordered, specifying the quantities, and scheduling the order release and due dates.
2. Maintaining priorities by updating due dates on orders as conditions change.
3. Providing the principal input to capacity requirements planning in order to project the resources required to achieve the master production schedule.

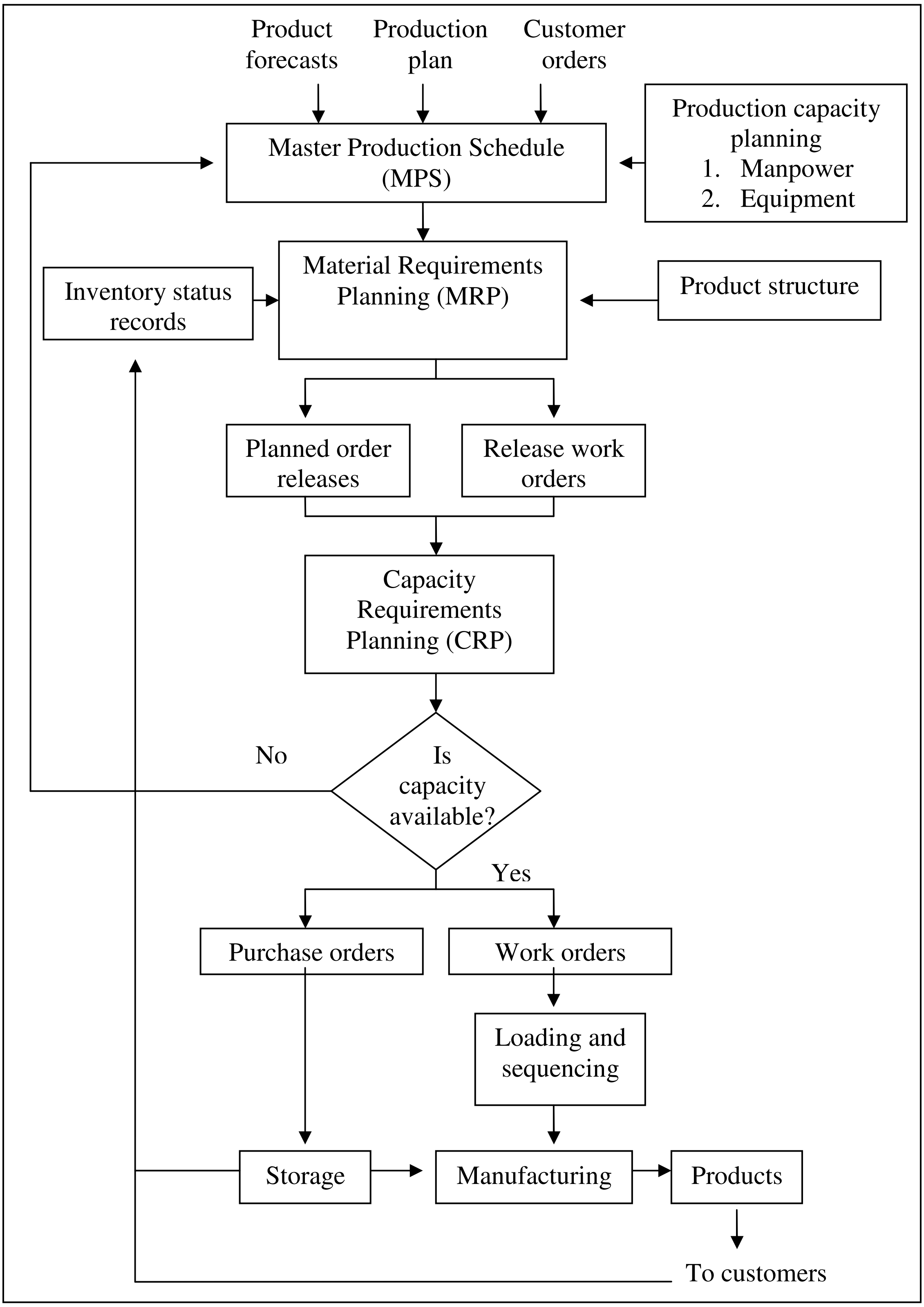

Figure 1. Flow chart of closed-loop MRP system. (Tersine 1988:328).

MRP consist of following information (Smith 1989: 245):

1. The master production schedule;
2. BOM structure for sub material calculation and the sequence in which they are put together;
3. Information from the item data master
    a. Inventory status and scheduled receipts,
    b. Lead time (including buffer lead time),
    c. Safety stock,
    d. Forecast and other external demands,
    e. Order quantity information (including limitations for order quantities),
    f. Shrinkage factor,
    g. Ordering and inventory carrying costs.

Smith (1989: 245) states that the important features of the MRP system are: which items to include; the planning horizon; the length of the time buckets; various categories of orders including planned orders, orders and firm orders; and safety stock and safety lead time. Setting up MRP parameters is always balancing with the results: maintaining high service levels means maintaining larger inventories. On the other hand, larger inventories cause increasing wait times, larger storages and therefore increasing costs (Hoppe 2008: 49). If a company wants to stay as flexible as possible then it must organize its business in such a way that the planned lead times are as short as possible (Hoppe 2008: 49.)

MRP is basically designed to plan and control dependent demand items. Some items that have dependent demand may also have independent demand as service parts. This independent demand in the form of time-phased service forecast can be included in the calculation of gross requirements. In this case safety stock is usually specified in order to protect against forecast errors (Smith 1989: 246). If an item has only independent demand, it can be controlled under inventory system like order point-order quantity (OPOQ). When the inventory reaches inserted order point, a purchase requisition is generated on the ground of order sizing rules which are introduced next.

Order Minimum / Multiple / Maximum

MRP calculation can be limited with lot sizing rules. They can be provided by the vendor or production. Therefore different kind of rules can be added to ERP systems. Order minimum is the limitation used if there is minimum quantity that can be ordered or produced. In case the MRP calculation shows greater value than the minimum, then the order is made for the whole need unless there is some other lot sizing rule defined.

Vendor might have batches in use for customer. Mostly they are used with items that are generally e.g. consumed in pairs, can be produced only in series or are minor value items like screws and bolts. Therefore a multiple rule can be added to ERP system so that the result after MRP calculation is rounded to a greater value. There will be no order for two screws and bolts; it will be 1kg each. The amount exceeding the need will be calculated in inventory (in case of valuated inventory).

The case company can have limitations of their own like space, value, credit limit etc. They may also prefer ordering smaller batches in greater sequence. In that case a maximum rule can be added to ERP and according to this rule purchase orders will be generated to the maximum value entered.

Shrinkage factor

Shrinkage factor, also called scrap allowance, can also be added to MRP. It tells the percentage of pieces expected to be rejected from a lot in production or receiving. The percentage usually comes from experience or from historical data. Once the desired quantity is calculated, the shrinkage factor will be added and the MRP calculation will be made on the original amount. The calculation is as follows:

Equation 1. Shrinkage factor. $ORQ = \frac{DORQ}{1 - SF}$

Where:	ORQ	= Order release quantity
	DORQ	= Desired order receipt quantity
	SF	= Shrinkage factor (decimal fraction)

All the limitations introduced above can be united in an ERP system so that the items are purchased in batches between minimum and maximum quantities. Safety stocks may be used for protecting against larger than expected amounts of scrap. Production and storage limitation as well as the preferences of the vendor have to be taken into consideration for MRP to be effective. Some further analysis and calculations have to be made in order to make sure that the batch (size) ordered is economical.

3.3. ABC Analysis

Smith (1989) argues that for a given level of effort devoted to controlling inventory, results can be improved if the amount of effort allocated to controlling each item is proportional to its importance. This is true for most of the companies because often a small percentage represents a large proportion of the value tied in inventory. H. Ford Dickie developed a method for grouping items according to their importance while working at General Electric. This method is called ABC analysis and the procedure is as follows:

1. Examine all the items and multiply their annual use in units by the cost of one unit. The value of annual use is shown.
2. Rank items in descending order of value of annual use.
3. Divide all items in three groups.
   - A – High value of annual use (80% of total value)
   - B – Medium value of annual use (15% of total value)
   - C – Low value of annual use (5% of total value)

According to Smith (1989) typical result of the analysis is that about 20% of items can be found from category A, 30% from group B and 50% from group C. Therefore materials in group A are the most valuable and have to have precise controlling methods and reporting, whereas materials in group C should be driven in an automated way through the supply chain without manual effort (Hoppe 2008: 58). A typical distribution of materials can be seen in figure 2.

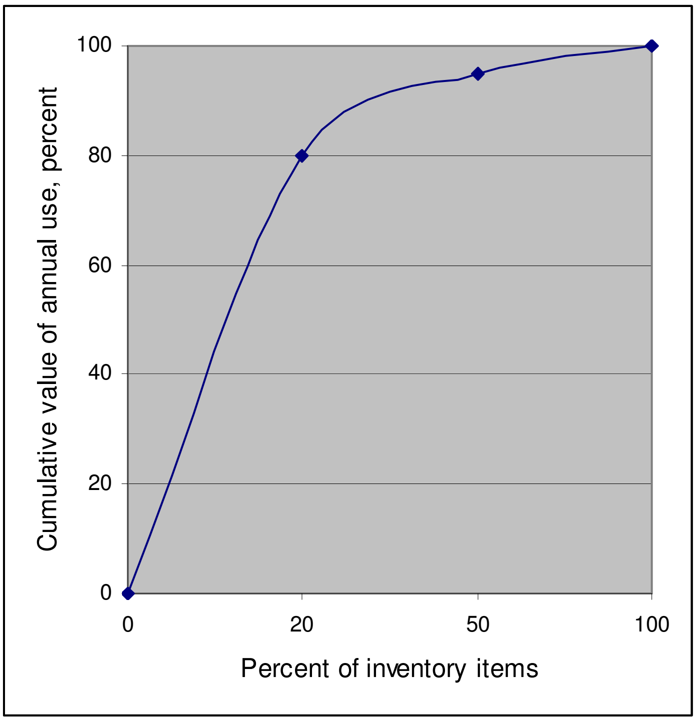

Figure 2. Typical distribution in ABC analysis. (Smith 1989).

Also other factors besides value of annual use may be used as a basis for assigning items to groups. According to Smith (1989: 118) these could include lead time, shelf life, unit cost and whether an item is subject to quality problems or shortages of supply. The number of groups might also be other than three. Each group has to have a controlling method and rules for order sizing. These methods and rules are introduced next.

3.4. Order sizing

Order sizing, also known as lot sizing, calculations are used for determining how much should be ordered. There are several rules that can be used for order sizing; these rules are described in the following paragraphs.

When the material is unique and the lead time is reasonable, it can be ordered directly to the project. Lot for lot principle will be used and there is no need for order sizing calculations. The material is consumed exactly as it is ordered and the storage time is just the time the material has to wait for the production to start. Focus has to be on the calculation of the delivery date and the production start time and on minimizing the gap between these two dates. Unfortunately not all the material can be ordered directly to production with the reference of production number. For example, some material has such a large ordering cost compared to minor value that it is wanted to be kept in stock. Some materials also have such a long lead-time that a buffer has to exist. These materials have to be planned beforehand. The ERP system could do the planning if a systematic logic exists. These logics were examined in the course of the research and compared to the needs of the case company. The ones that were found suitable for the case company are introduced in the following:

- 1. Lot for lot (LFL), which is also known as discrete ordering
- 2. Fixed lot sizing.
    - 2.1. Economic order quantity (EOQ)
- 3. Dynamic lot sizing
    - 3.1. Period of supply
    - 3.2. Period order quantity (POQ)
- 4. Heuristic lot-sizing.

3.4.1. Lot for Lot (LFL)

LFL order quantity is the simplest of lot-sizing rules. This method orders only what is needed for the time period. It is most suitable for companies that want to minimize inventory and do not constantly sell standardized products. The disadvantage of LFL is that it creates the most orders and the delivery costs are therefore the biggest. Each required material is matched with a corresponding order. The benefit of this method is that the inventory is minimized. It is most suitable for very expensive items, items with highly discontinuous demand or high-volume continuous production e.g. assembly lines (Tersine 1988: 163).

Table 1 shows how LFL works. In the figure it can be seen that planned order is released by the planned lead time and exact quantity.

Basic information about this simplified calculation:
- Low level point: 0
- Projected on hand: 0

- Lead-time: 2
- Allocation time: 0
- Storage time: 0

	Time unit (in weeks)							
Item: ABC	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Demand	200	400	200	600	100	300	300	100
Scheduled receipts	200	400						
Projected on hand	0	0	0	0	0	0	0	0
Planned order receipts			200	600	100	300	300	100
Planned order releases	200	600	100	300	300	100		

Table 1. Lot for Lot (LFL) lot sizing example. (Ptak 2004: 277).

3.4.2. Fixed lot sizing

For items that are continuously used in production but the volume is not high LFL is highly uneconomical and more developed calculations are needed. Following methods are very suitable for stable consumption.

Economic Order Quantity (EOQ)
EOQ recognizes the trade-off between the cost of inventory, the cost to process the order and the setup of a machine. The same logic is applied to purchase orders comparing the cost of carrying inventory with the cost of placing the purchase orders. The problem of LFL method is that it generates a purchase order for every item needed and the delivery cost will arise. If one wants to reduce costs of transportation then economic order quantity (EOQ) method should be used (Ptak 2004: 278).

EOQ formula is most suitable when long setup times and comparatively shorter runtimes are expected. Ptak (2004: 278) states that there must be reality injected to the EOQ calculation and all the parts calculated in EOQ must be needed by the business. If a company has only make-to-order production the EOQ will calculate a lot quantity higher than the actual demand. These extra parts should not be made or ordered just for the sake of EOQ. EOQ is an approximation of the order quantity.

EOQ formula, where the result will be in units is:

Equation 2. EOQ. $EOQ = \sqrt{\frac{2US}{IC}}$

Where:

U = annual expected usage (in units)
S = setup cost (in local currency)
I = inventory carrying cost expressed (an annual percentage)
C = cost of the item (in local currency)

An explanation of each variable in the EOQ is as follows:

U - The annual expected usage in units can base on the historic consumption or the forecasted usage based on the master schedule or to another source of demand for the upcoming year.

S - The setup cost includes all the costs associated with changing from one production run to another. Same method can be used for purchase orders. There S stands for cost of placing an order.

I - Inventory carrying cost calculates all the costs that occur from keeping inventory. Most of these costs are overhead costs. This cost is the most difficult to calculate. A rough estimate can be calculated according to Ptak (2004: 279) by adding the cost of borrowing money to the cost of running the warehouse, including all the people, computer systems, and floor space. Other factors to be included in the cost of carrying inventory are the risk of obsolescence, damage, theft or spoilage. The largest part of the inventory carrying cost is the opportunity cost of that money.

C - The cost of the item is the fully loaded cost. These costs include material, labour, overhead, and outside production services. If material is purchased from vendor, then these costs should include all import, transportation and handling costs.

The formula results in frequent order intervals for high unit cost items because the savings in stock holding costs pay for the extra orders. The items with low unit cost are ordered in large quantities because the ordering cost is relatively high comparing the committed capital and the cost of inventory (Tersine 1988: 93).

Ptak (2004: 280), Smith (1989: 120) and Tersine (1988: 94) state that EOQ formula has some underlying assumptions. The first is that the inventory is consumed at a regular and continuous rate. This would mean that the average inventory would be half of the order quantity. In most companies the consumption is inconsistent and non-continuous. Second is that the replenishment is instantaneous and lead time is 0. Third assumption is that the unit cost is independent of order quantity. The formula also assumes that no shortages are allowed and the planning horizon is infinite.

The difficulty of managing inconsistent consumption was the reason why Material Requirements Planning (MRP) was developed. EOQ should be used for determining the scale of optimal order quantity, not the exact quantities. Following methods can be used for varying consumption.

3.4.3. Dynamic lot sizing

Since demand can vary and the material reception has limited capacity, it might not be possible to order material in the most economical batch size. A company might want to determine the time when items are to be received. Order control will be made through the limitation of capacity and the batch sizes will change dynamically. The alternatives for dynamic lot sizing are introduced here.

Period of supply

According to Ptak (2004: 281) period of supply is the most useful order sizing tool. The planner can determine the interval when orders will be made and the lot size will adjust dynamically to the demand. Smith (1989: 139) and Tersine (1988: 224) use fixed interval order system name for Period of supply.

Period of supply can be determined as e.g. 5 working days from next coming Friday and the system will generate a purchase order every coming Friday. The lot size determination will be made through MRP calculation so that it will meet the need until the order interval is met. The advantage of this method is that the inventory can be kept low and it will reach the minimum value e.g. every Friday. Like LFL, without safety stock there will be no leftover inventory. This will not happen with any other method, except LFL which will bring the inventory to zero (+ safety stock) each day.

Smith (1989: 139) states that Period of supply offers advantage of efficient batch operations in data processing, but he also sees two major disadvantages. First one is growing ordering costs if demand is small in a given period. Therefore this system should not be used if demand can have a high variety and the ordering costs are high. The second disadvantage is that quite large safety stocks must exist to secure non interrupted operations because the safety stock must cover lead time plus order cycle.

Period order quantity (POQ)
Another way to determine how often and in what quantities materials should be ordered is to use EOQ with dynamic lot sizing. This is called period order quantity. A yearly expectation of consumption is made and EOQ determines the quantity which is the most economical. According to an example by Ptak (2004: 282), for a material with an annual consumption of 10 000 pcs , the EOQ is 500 pcs. The planner is expected to order 10 000/500 or 20 times per year. On average there are 240 working days per year, so the period of supply would be 12 days. Every time a need for ordering arises, the system would look ahead the next 12 days and group all the requirements to a planned order.

The formula of POQ:

Equation 3. POQ. $$EOI = \frac{EOQ}{\bar{R}} = \sqrt{\frac{2C}{\bar{R}Ph}}$$

Where:

EOI = economic order interval in periods
C = ordering cost per order
h = holding cost fraction per period
P = unit purchase cost
$\bar{R}$ = average demand rate per period

The optional replenishment system

Under the optional replenishment system a review is made after every x units of time. When the inventory reaches order point an order is placed for a quantity that will bring the inventory up to the order level. The advantage of the optional replenishment system is that orders are released only when the inventory has reached the order point, so that uneconomically small orders are avoided. But as with the period of supply, more safety stock must be maintained (Smith 1989: 142-143). According to Smith (1989: 143) it has been proven that this system incurs the lowest cost for a wide range of cost functions e.g. ordering, carrying inventory and shortages. The disadvantage is that it is difficult to determine the best values of the decision variables; mostly they have to be approximated.

If the review period for the optional replenishment system is reduced to zero (continuous review) and customer orders are received one unit at a time, the result will be the same as with the order point-order quantity system. With continuous review when the customer orders will exceed the order point the order quantity plus the amount of the overshoot will be ordered. This system can be easily explained with a figure:

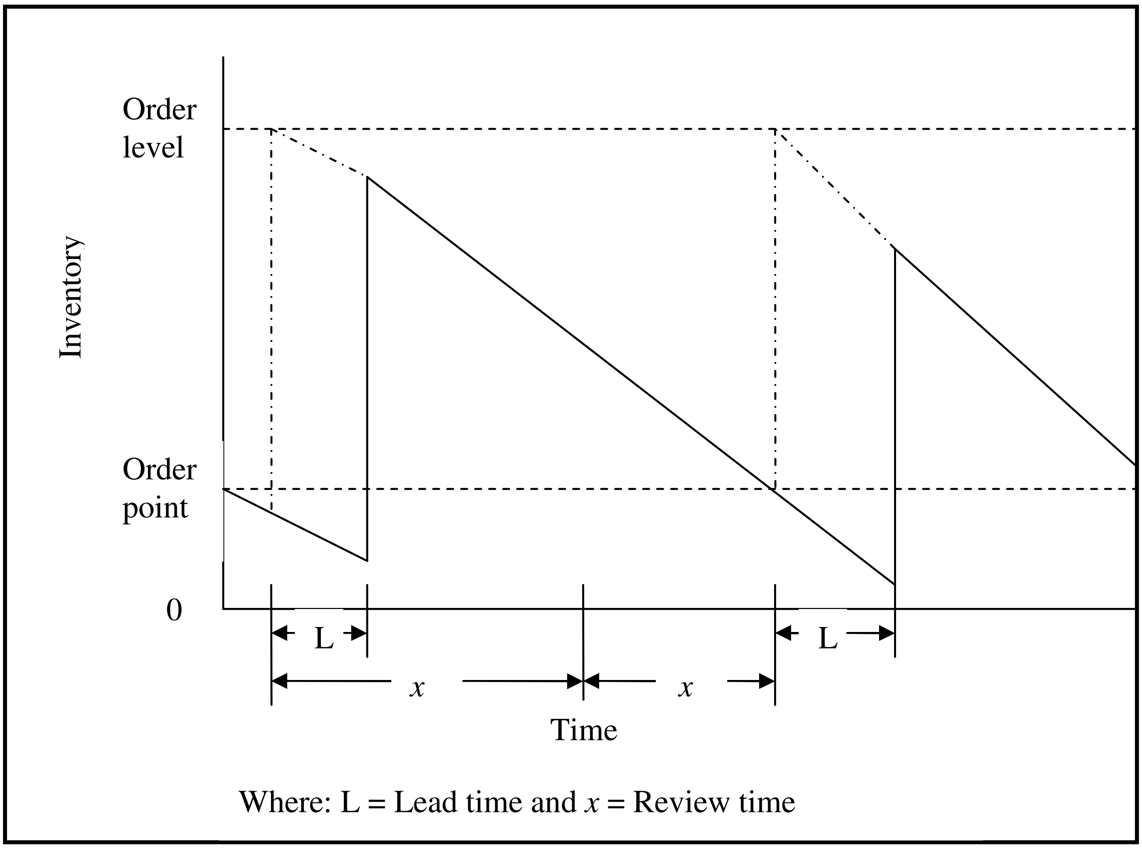

Figure 3. Functionality of the optional replenishment system. (Smith 1989: 142).

3.4.4. Heuristic lot-sizing

The aim of heuristic techniques is to provide a good, although not necessarily optimal, solution with a reasonable amount of computing. All of the following techniques use stopping rules. They start from the first period of time and test prospective orders covering the first period, then the first and second periods, then the first, second and third periods, and so forth, until a stopping period criterion is met. Solution for purchasing will be covering the time periods until the stopping period. The process is repeated starting the next period after last stopping period. (Smith 1989: 260)

Least Unit Cost (LUC)

The first technique is called Least Unit Cost where the smallest unit cost will be searched. The calculation is to divide the sum of ordering and carrying costs by the number of units per order. Stopping period is the fist period, when the unit cost goes up. (Smith 1989: 260)

According to Smith (1989: 260) LUC is widely used in industry, and it seems to be a suitable method for lot-sizing. Mendoza (1968) agrees with Smith and states that LUC algorithm brings near optimal result and it is quite elegant and economical for use. Mendoza (1968: 39-40) and Smith (1989: 260) criticize the algorithm by saying that it leans heavily on the demand of the already established setup period in order to determine the next setup thus assigning decreasing importance to the successive demands occurring in the future periods.

Equation 4. LUC.

$$StorageCost = \frac{\mathrm{Re}\,qmt.*\mathrm{Pr}\,ice*Storage.cst.pct.*TimeInStorage}{100*365}$$

Least Period Cost (LPC) / Silver-Meal

The second heuristic technique was developed by Edward Silver and Harlan Meal and it is commonly known also as Silver-Meal. LPC is a variation of the basic EOQ model and it approaches the optimality of the Wagner-Whitin algorithm for a given time horizon (Tersine 1988: 168). The idea behind LPC is to determine the total costs of ordering and carrying lots covering successively greater numbers of periods into the future and to select the lot with the smallest total costs per period covered (Smith 1989: 262). Tersine (1988: 168) says that LPC guarantees only a local minimum for the current replenishment so it is possible that even lower costs per time unit could be found. However he states that it is unlikely in real cases and compared with the “optimal” solution of Wagner-Whitin algorithm the LPC will provide result which is within 1% from the optimum.

According to Tersine (1988: 169) there are two situations where LPC does not perform well. These are:

1) When the demand rate decreases rapidly with time over several periods or
2) When there is a large number of periods with zero demand.

Least Total Cost (LTC) / Part-period algorithm (PPA)

The developers of LTC, J.J Matteis and A.G. Mendoza based their thought on the fact that in the basic EOQ model the inventory carrying cost is equal to the ordering cost. In the LTC procedure lot sizes cover greater number of successive periods into the future and the largest lot is searched, where the carrying cost is less than or equal to the ordering cost. (Smith 1989: 263). Tersine (1988: 170) says that the exact equality is not usually possible because of the discrete nature of requirements.

Several authors (e.g. Smith 1989: 263 and Tersine 1988: 170-171) have presented this method as determining the lot for which the carrying cost is closest to the ordering cost, which means that sometimes the carrying cost will be greater than the ordering cost. However, it does not perform as optimum because it has a bias towards orders that are too large. (Smith 1989: 263)

3.5. Visual control

Kanban

Kanban is an effective visual tool for controlling production. Kanban is a card or another visual sign, which is sent from the following production task to previous one and it is said on the card which product, how many pieces and in what time they are needed. Following step orders parts needed from the preceding step etc. and production starts when they have received a Kanban card (Regani 2004).

Two-bin system

Two-bin is one of the simplest stock management systems. This system operates without record keeping by using two boxes where the first bin is the consumption bin and the other one is the safety bin. Purchase order is made when the consumption bin gets empty and the former safety bin then replaces the consumption bin. The lot-size is calculated to cover the lead time from vendor. The two bin system suits best for items with low value, fairly consistent use and short lead times. (Tersine 1988: 506)

3.6. Vendor Managed Inventory (VMI)

VMI is an inventory which is fully outsourced to vendor. This means that the vendor follows the consumption of its items by visual control or via data system. Vendor will then restock the bin and invoice the consumption from the customer. Normally VMI is used for material that supports the production and is simple by nature. Examples for VMI material are commonly cleansers, screws, gloves etc. There are companies that are specialized in VMI, e.g. Würth.

3.7. Summary of materials management

Determining which method will be used for material control has to be based on the characteristics of the material and the goals of the organization. All methods above can be used and they will be suitable for right purposes. The methods can be tested in real environment and they can be changed. Examination of the case company was made and it will be introduced next.

4. INTRODUCTION OF THE CASE COMPANY

ABB is a global leader in power and automation technologies. It operates in over 100 countries and employs more than 112 000 people. In 2007 ABB reached record breaking turnover exceeding USD 29 Billion. Group is divided to 5 main business areas which are power products, power systems, automation products, process automation and robotics (ABB 2008 a). Factories in Finland are located in Vaasa and Helsinki.

This case study is made to local business unit Transformers which is located in Vaasa, later called as the case company. Transformers business unit is part of power products in ABB group. Transformers local business unit was formed from incorporation of power transformers and distribution transformers in year 2006 and it concentrates in complex and demanding special transformers, later called as transformers. The product portfolio of the case company can be divided into eight different product groups that are limited to oil insulated transformers with maximum output 170kV and 63 MVA:

- Complex distribution transformers
- Furnace and rectifier transformers
- Marine transformers
- Offshore transformers
- Railway transformers
- Reactors
- Variable speed drives transformers
- Maintenance and after sales.

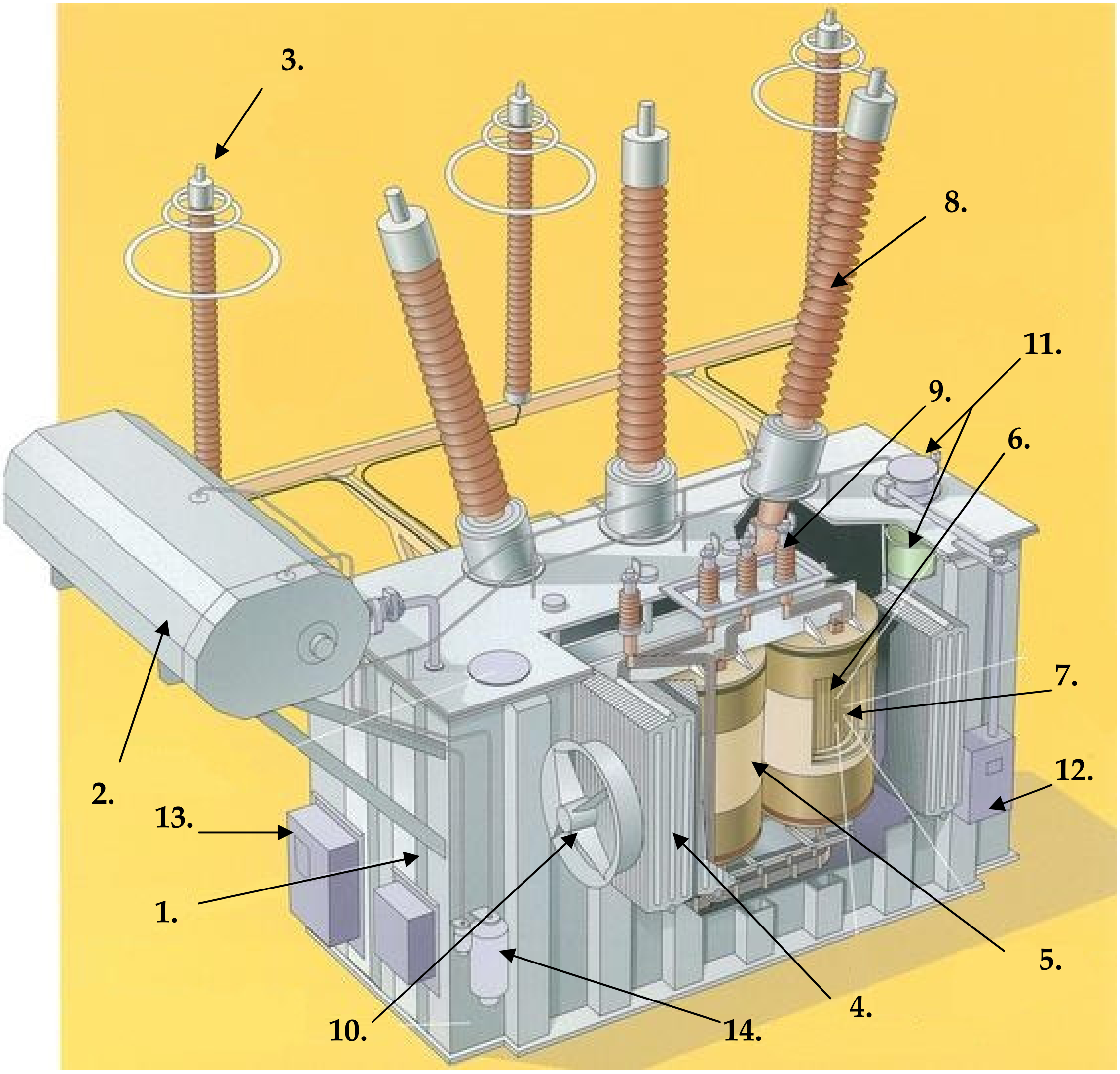

Figure 4. Structure of a Transformer.

1.	Transformer tank	2.	Conservator tank
3.	Surge arrester	4.	Radiator
5.	Oil	6.	Winding
7.	Transformer core	8.	Bushing (high voltage)
9.	Bushing (Low voltage)	10.	Fan
11.	On-load tap charger	12.	Motor drive
13.	Container cabinet	14.	Silicagel breather

One Simple ABB (OsA) is a project that former CEO Fred Kindle started in 2005. The project is expected to last three years and it is going on simultaneously in 24 countries. In the end of the project every attending country will have harmonized financial and personnel processes and services. All processes will be managed with only one ERP system (ABB 2008 d). About 60 different systems will be consolidated into one ERP system per country, significantly reducing the cost structure and complexity. At the end of 2007 ABB had over 200 separate ERP installations. ABB will gradually move from using 50 different ERP brands to implementing common SAP, and in some instances Baan (ABB 2008 d). Michel Demaré, ABB's Chief Financial Officer and current CEO has stated (ABB 2008 d) that the cost effectiveness has been calculated annual sustainable savings of over US $140 million to ABB's bottom line. This will improve ABB's overall competitiveness and enable future growth.

OsA project started in August 2007 in Finland. Six production and project business units are involved with this project. The upcoming system will be based on tailored version of SAP, called FISAP. This is already in use in three business units Drives, Relays and Distribution Automation. The rest of the business units will change to new ERP in waves so that the first ones will go live at the beginning of year 2009 and the last ones in the summer 2010. The corporate supportive business units like HR and Domestic Sales are already using SAP (ABB 2008 d).

4.1. Introduction to case company's current ERP

This chapter introduces the current system of the case company and the history of why it was chosen. The benefits and the pitfalls are also discussed so that they can be thought out in the upcoming project. The aim is to take all the benefit possible from the current system and bring it to the upcoming one. The pitfalls have to be examined and they need to be blocked from the upcoming system.

Changes in the ERP system were made just two years ago when the case company was going through the organizational change process. Both former business units that were later incorporated into the current Transformers business unit were using Baan, but it was separately tailored for both of them. Key personnel of that implementing process are still working for the case company, so a lot of internal know how can be used for this project. The ideology of the earlier project was that the ERP system was tailored exactly for the case company's processes and the target was to merge two separate systems into one common system. The new project will be managed just the opposite. The main target is to change the internal processes to fit the upcoming ERP so that as little tailoring as possible has to be done and a fully new system will be taken into use.

Baan is one of the first ERP software's and a major competitor of market leader SAP. It was founded in 1978 in the Netherlands. According to Davenport (2000: 305) Baan is primarily focusing on manufacturing companies. They have more than 3 000 customers which are mainly complex manufacturing firms, like their most known reference customer Boeing.

Baan software has had a colourful history and it does not exist anymore with the name of Baan, so the history should be quickly walked through. In the end of 1990's Baan struggled with worsening financial difficulties and lawsuits. In May 2000 it was sold to Invensys for USD 700 million (BusinessWeek: 2000.). Invensys did not have the capital to turn Baan around. They wanted to reduce huge amount of debts, so they sold the system to SSA Global technologies for USD 135 million (Cnet News: 2003). Through this trade Baan was renamed SSA ERP. SSA was acquired by Infor Global Solutions in 2006 (Infor: 2006 a). After this integration Infor calculates to be number three in ERP markets after SAP and Oracle (Infor: 2006 b). The system is now known as Infor ERP but in this thesis it will be called Baan since the case company still uses a version named Baan ERP.

The preceding system to Baan had been taken in use in 1970´s. The old system was a mainframe system first developed by IBM and then highly tailored by ABB. Later on Baan was chosen as the ERP system. It was implemented to Power Transformers in 1996 and to Distribution Transformers in 1997. In 2006 these business units were merged and the ERP systems had to be merged as well. (Jessen 2008)

Current version of Baan is highly tailored for the case company. The system has been in use for over 10 years so a lot of know how can be found from inside the case company. Jessen (2008) states that Baan is originally designed for project based manufacturing companies and therefore it is highly suitable for the case company. As an ERP Baan is highly flexible, it serves project based businesses. Unfortunately the future of Baan is not clear or highly credible, so there is concern about how the customer service and development will be maintained in the future. Despite of that Jessen states that without the global decision on implementing SAP, there would be no need for changing the ERP in the case company. Globally Baan has one more major disadvantage which is that Baan is not fully suitable to ABB SOX conduct. SAP on the other hand is directly fully suitable for SOX and therefore major savings can be achieved by changing to SAP as the common global system.

4.2. Introduction to upcoming ERP system

The first company to introduce an ERP system was German SAP AG (System, Anwendungen, Produkte in der Datenverarbeitung – Systems, Applications, and Products in Data Processing) in 1972. Five software engineers of IBM had an idea of a cross-functional information system, which they introduced to IBM. IBM however rejected the idea and the employees formed their own company. SAP´s first integrated product was SAP R/2 and it ran on mainframes. The client/server version of the system was introduced in 1992; this was named R/3. Nowadays SAP has over 46 000 customers in over 120 countries (SAP: 2008 a.)

SAP is more than double the size of its largest competitor Oracle and it invests much more in R&D than any of its competitors. According to Davenport (2008: 304) it is most likely to introduce a new functionality as a result. Manufacturing industries represent over 60%, service industries 23%, financial services 6% and public services 10% of SAP’s customers measured by turnover.

According to Davenport the strength of SAP is the breadth and extensive capability of its software’s functionality. Davenport (2008: 304) thinks that shortcoming can be the complexity of the system and its implementation. SAP was chosen to be the common ERP system for ABB because of the breadth (ABB

2008 d). The case company has to change the functioning system because of the common decision made by the corporate headquarters.

Jessen (2008) states that the project would not be done without the OsA project and the case company is satisfied with the current system. SAP will intimidate the case organization to more strict processes so that no mistakes can be done. Current system is tailored so that the mistakes can be fixed afterwards. These mistakes are inflicting many operations, but they are silently accepted.

4.3. What does a successful ERP implementation mean for the case company?

The concept of a successful implementation is always dependent on what is expected from the project. In order to get a clear picture of the goals of the implementation project in the case organization, participants of the OsA project were interviewed. A clear definition of the goals will then serve as a reference line against which the progress/outcome of the project can be compared. The overall impression from the interviews was that the case organization is satisfied with the current system. As a matter of fact, the author was not able to find one person who was not of the opinion that this project was just an unnecessary task bestowed upon them due to a corporate decision. The old system is seen as fully functional and serving the needs of the case company.

In order to determine the most significant failures of the existing system, discussions were held among the project personnel and operational management. The result of these discussions was the discovery of two main problems. First one is that material control and material handling methods are not exactly determined and there is no guidebook for material handling in the case company. This causes inaccuracy in ERP calculations because the results can vary. Another issue that came up was that the inventory levels are inaccurate. The current system reports consumption of materials which in reality were never even purchased. Also, cases can be found in the current system where material that was never consumed was purchased. ERP systems are designed to process accurate processes and misconsumption causes errors in inventory levels. In worst cases the projects cannot be ended if the system still holds material that was not consumed.

The current system is very flexible, and inaccurate data can be fixed afterwards. The upcoming system on the contrary does not handle corrupted data as flexibly. As a matter of fact, these issues may cause various problems in SAP. Thus it is clear that the problems listed above need to be solved before the new system is implemented. Getting these issues corrected or at least diminished through the implementation of the new system can be considered as indicators of a successful implementation project in the case company.

5. CURRENT STATE OF MATERIAL HANDLING

Material is mainly purchased directly to projects via MRP calculation. This is called purchasing to sales order in SAP. Case company has also two warehouses, which are called GTW and GTH. This chapter begins with introducing the processes of the case company in order to understand the impulses the ERP will receive.

5.1. Production and purchasing methods

The case company had earlier an MRP based push principle. In 2002 they started a large project for re-engineering the processes into Engineer-to-Order (ETO) environment. The project was finished in the end of 2004 and large changes were seen. Production was re-engineered and nowadays it is controlled by the pull principle based on the Theory of Constraints (TOC) system. Currently the factory is divided into three production lines depending on the size and complexity of the transformer. KTI production line is for large transformers that are most specific and therefore the slowest to produce. KTN production line produces large transformers that are not that complex but because of the size they are not wanted to be transported a lot in the production. The third production line is called CT and the products that are smallest and fastest to produce are manufactured there. Currently most of the production is based on the ETO production where every sold project is designed specifically for the customer. About 50% of transformers in the KTN and KTI production lines are manufactured in full ETO environment. Average customer order consist two identical transformers so the second product can be manufactured as Make-to-Order (MTO). Manufacturing in CT production line is divided so that about 10% of the production is ETO and 90% is MTO.

The basic elements of TOC are controlling gates, pull system, CONstant Work In Process-cards (ConWIP), buffers, shift numbers, load regulations, freezing points and traffic lights. In 2006 the controlling model was developed to cover the whole order-delivery process by implementing a TOC principle controlled

Critical Chain-controlling method. (Ylipulli 2008) Next each of the basic elements of TOC are introduced in form that they are used in the case company.

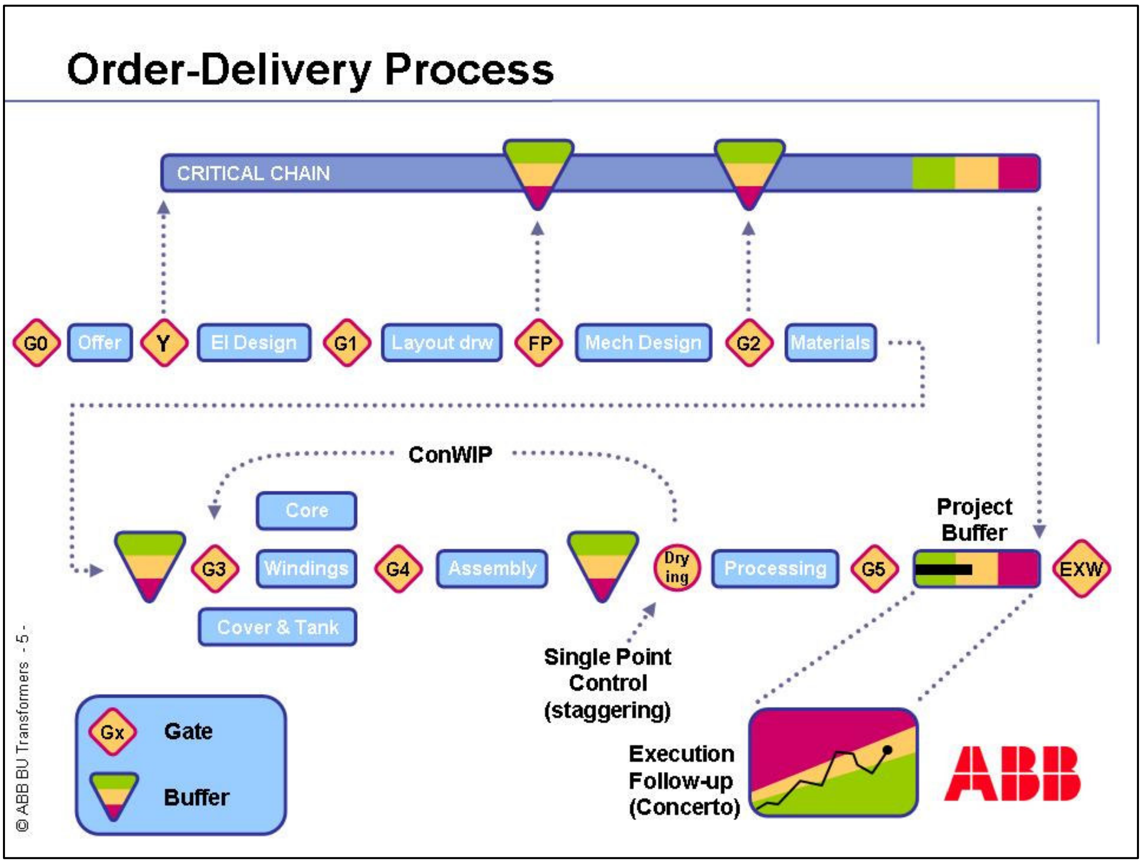

Figure 5. The principles of the elements controlling the case company.

5.1.1. Controlling Gates

The process is divided into seven gates. Each gate is a controlling point, where preceding processes are examined. If all the previous processes before the gate have been performed, the gate opens and the project can continue to the following phase. If the project does not pass all the criteria the gate will stay closed and the project cannot continue before the preceding phases are completed. Each gate has specified questions (Figure 6) and these questions are meant to make sure that process would not have distractions.

The first gate is Gate 0 (G0) where decision is made whether the case company can produce the product the customer is inquiring for. The offer is made at the moment of G0. The contract is made and Gate Y (Y) stands for agreement. The electrical calculation (El Design) is started immediately after the contract is made so that the functionalities of the product sold can be introduced to the customer. Gate 1 (G1) is for controlling that the parties involved have common understanding of the product sold and that there is capacity in production. All long lead time components are ordered at the moment of Gate 1. Before the final agreement also the mechanical design is made and the layout drawings are presented to the customer. Freezing point (FP) is the final point when changes can be made to the order. Customer orders are collected into a buffer from where they are taken into mechanical design. The rest of the material is ordered when mechanical design is finished. Gate 2 (G2) is for controlling that the design is finished, properly documented and all the material needed is ordered. Gate 3 (G3) examines that everything needed for the first phases of production has arrived and the production can be started. The structure of a Transformer can be seen from figure 4. The Gate 4 (G4) controls that everything needed for assembly is ready. It is mandatory that there is no moisture inside the transformer so every product has to be dried by heating it in a furnace (Drying). The final assembly takes place immediately after it comes out of the furnace. The Gate 5 (G5) examines the whole project once more and checks that everything is made according to the customer order. Ex works date (EXW) is the final gate, where the final product is delivered to the customer.

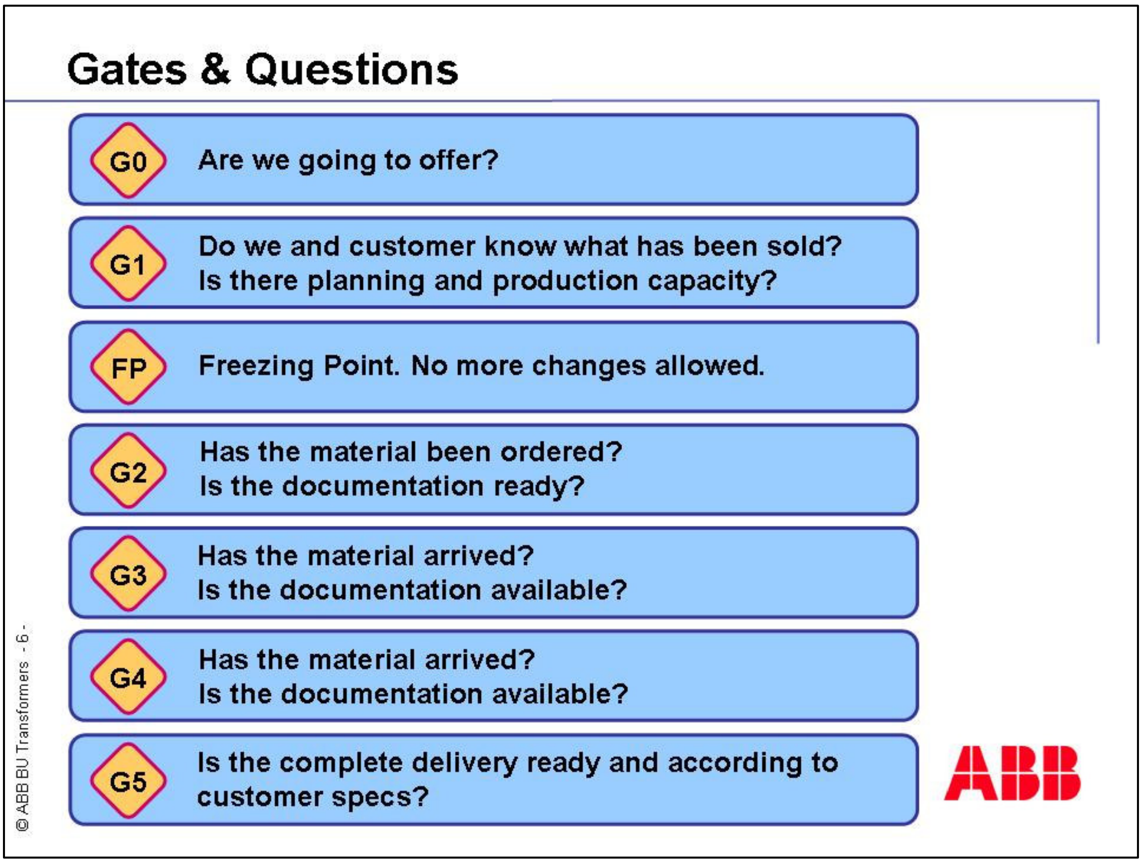

Figure 6. Questions inside gate model in case company.

5.1.2. Production philosophies

Basic production philosophies can be divided into two main categories push system and pull system:

In ***push system*** every work centre produces as much as it can. The aim is to maximise the capacity utilisation in every work centre. This is made without caring if the following phase can make good use of it or not.

In ***Pull system*** the sequence and manufactured items are determined by the customer. In production the customer stands for following phase. When following phase has finalized current work, they will send a signal to the previous phase so that they know to start their work. The following phase pulls the work from previous ones. Figure 7 will describe the differences between push and pull systems.

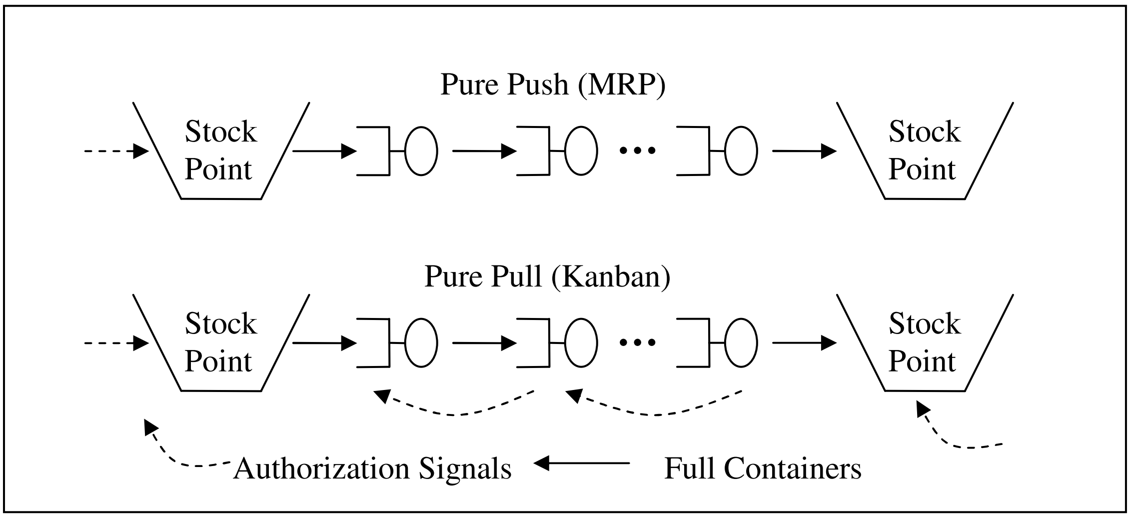

Figure 7. Principles of Push- and Pull systems. (Hopp & Spearman 2000: 163.)

It is vital to understand the differences between these systems because they have a high impact on the work in process (WIP). Push system is like a downhill, the items will flow by themselves to the following phase. Because of this, WIP will start accumulating in front of the work centres. Pull system is like an uphill, where the items have to be retrieved and carried uphill. This makes sure that only as much is moved as is needed.

Little's law shows that WIP is directly proportional to output of the factory (Hopp & Spearman 2000: 651):

Equation 5. Little's law. $WIP = TH \cdot CT$

Where:

WIP	=	Work in process (pc)
TH	=	Output (pc / day)
CT	=	Lead time

5.1.3. ConWIP

Pure pull system (Kanban) requisites buffers between each work phase to smooth possible distractions. As can be seen from equation 5 the limitation for cutting down the lead time is the amount of work in process. ConWIP is an abbreviation from Constant Work In Process. The target in ConWIP is to reach constant and harmonized amount of work in process.

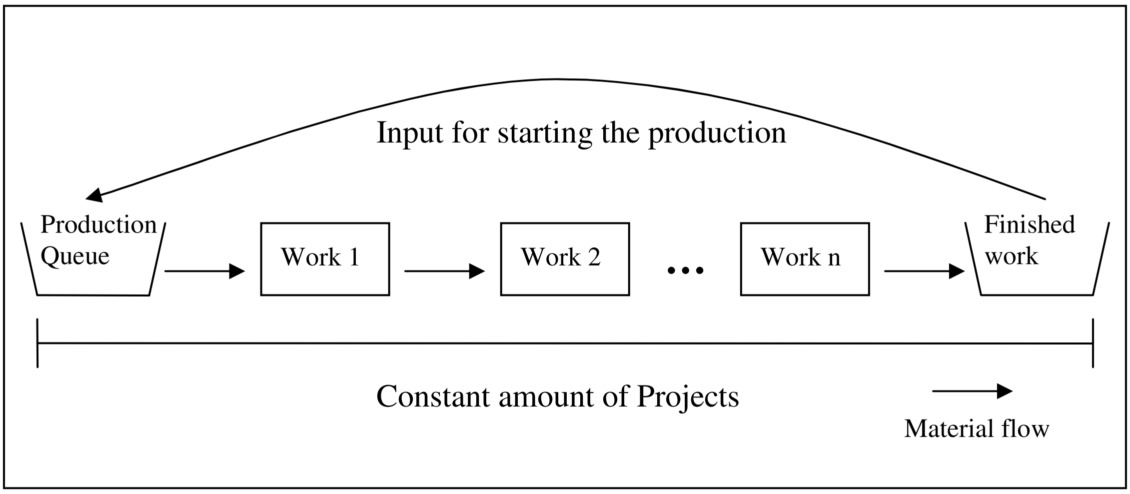

Figure 8. Principles of using ConWIP card. Card is signaling to start the process. (Hopp & Spearman 2000: 351)

ConWIP, like the Kanban method, gives permission to start the production by sense based impulses. Case company uses cardboards (preproduction factory), winding carriage in CT-production line and work centers in KT-production lines. The impulse alone is not enough to start the production. To start the production a project needs impulse that the required material has arrived and the project is next in line on the production queue.

5.1.4. Buffers

Buffers are used for queue principle so that they will receive the input (material, project, drawings etc.). They prevent and cut down the possible distractions in processes. Buffer can be either a time buffer or a material buffer. Time buffers adapt themselves to customer changes better than material buffers. The right size for a buffer can be calculated, but it can also be found quite easily by experimental tests (Figure 9).

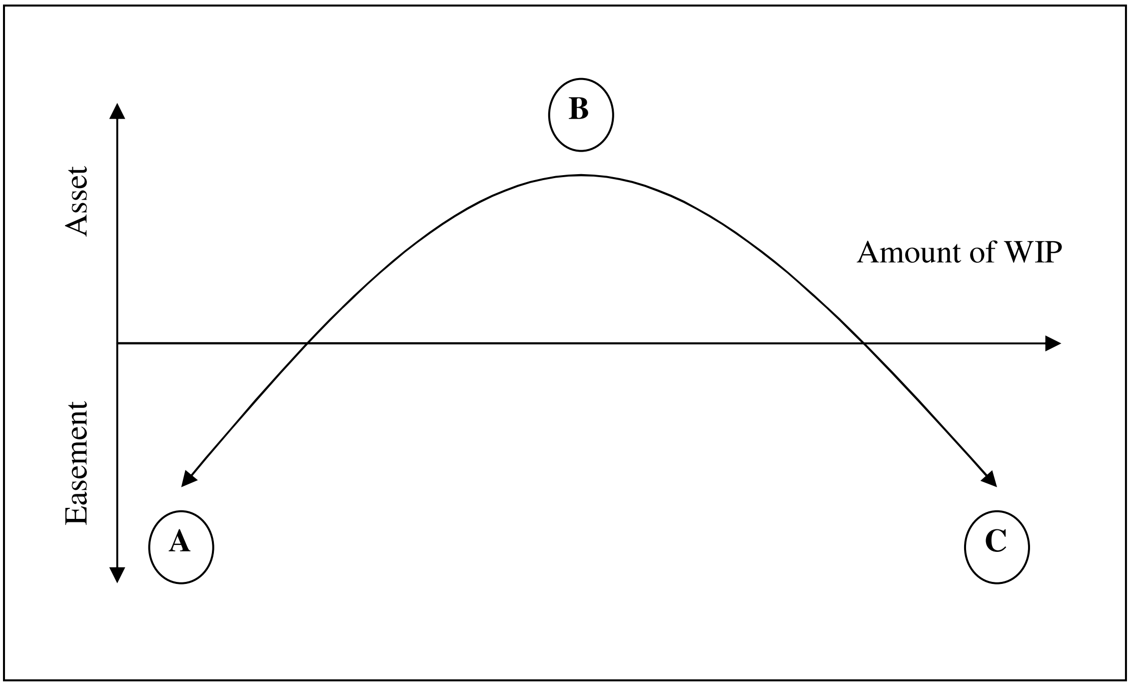

Figure 9. Principles for determining the right amount of buffers. (Hopp & Spearman 2000)

A) When there is not enough WIP, there will not be enough work for constraint.
B) The level of WIP, where the constraint can be secured the best.
C) The constant flow to constraint will stop, when the amount of WIP is too large.

The case company uses both, time buffers and material buffers. Gate 5 (G5, see figure 5) is a delivery buffer for completed transformers (so called project buffer, according to Critical Chain -principle). Gate 4 (G4) is a buffer for semi-finished products. Gate 3 (G3) is a material buffer and between gates 2 and 4 (G2-G4) is a finalized mechanical design buffer. Gate 1 (G1) is a buffer for finalized electrical designs.

5.1.5. Shift numbers

Production of special transformers is assembly production of winding, core and container. The production will stop if the right sub complexes are not at the assembly line at the right time. It is mandatory that right complexes are done at the assembly line because furnace time (Drying, refer figure 5 Drying) is defined as a constraint.

Production throughput (TH) is agreed to be x furnace in KTI-production line, y in KTN-production line and z in pillar winded products (CT). So each day has x, y or z starting slots for furnace. These slots are started from the first day of the year, which gives queue numbers x for KTI, x and y for KTN and x, y and z for CT. Each transformer receives a unique queue number, which tells the position in production queue, and the sort order in production line and in the subassemblies. Even the subcontractors have to send their deliveries at the sequence of sort order. This ensures that the production has prerequisites for starting the work.

5.1.6. Model Transformers

One task in the ETO project was to create 28 model transformers for distribution transformers. At the time of merging the distribution transformers and power transformers the amount of model transformers was increased to 46. Model transformers have predefined estimates (e.g. labour hours and machine time) for each stage in work centre. For creating these estimates real data from previous projects was used for calculating standard deviation and deviation analysis. The complexity of the manufactured transformers has been increasing and therefore the current approximates for work hours and load limitations do not exactly take the unbalanced production load into consideration.

The use of model transformers makes it possible to try to optimize the production plan by scheduling the projects according to their production load. The production queue is stepped so that the projects with similar production load estimate do not follow each other. Whenever possible, projects with an inverted load are produced successive in order to balance out the load. However, examination of the project load does not have to be exact because of the buffers. Limitation is set to be inside a week.

5.1.7. Load regulations

Special transformers are called special, because they have an uncommon structure and they are manufactured in unique sequence. This causes large deviations in labour hours. Furnace is selected to be the constraint, but the true constraints can be winding in production and mechanical engineering in design. Each department has its own load limitations for reducing the deviation and for settling the load. These rules are based on the model transformer structure and the possible unbalanced workload they may cause for production.

5.1.8. Freezing point

Freezing point (FP) is set on a certain date, after which it is no longer possible to make customer specific changes into the order-delivery process. The aim is to ensure the distraction-free flow of the production. The date will be given to the customer at the time of order confirmation. It should be noted that in the case of wide and challenging projects changes can come from the customer and they can be accepted even after the freezing point. However, these changes can have an effect on the pricing and delivery time of the project.

5.2. Mechanical Design System (MDS)

MDS system in placed is an in-house product created in the case company and it is commonly used inside ABB. The Structure of every sold transformer is designed in the MDS. MDS is based on reference products that can be tailored to customer’s specific needs. Baan maintains the material master data for stocked items and they are transferred from Baan to MDS via an interface. Project materials are created in the design phase and they are maintained inside MDS. It is also common that the project material can be standardized for transformers, and it is therefore reclassified as a stock material. In that case the material will be transferred to Baan via an interface. The MDS cannot be compensated in SAP so there is need for a similar process as is currently in use and an interface between MDS and SAP has to be built.

5.3. Concerto and Traffic lights

Concerto is a production timing system developed by Realization Inc. It is based on TOC/Critical chain principles. It provides synchronized task priorities to all departments and it enables early warning signals to all levels of management.

Traffic lights (Figure 10 is a subprogram of Concerto specially tailored for the case company. The idea of the software is to visualize the state of the production in a simple form. Each row describes one transformer/project in the production queue order and each column describes a production phase in the order of the gate model.

Figure 10. Example from Traffic lights system.

The Traffic lights list is the only list needed for the production planning at the factory facilities. It visualizes which projects are ready from assembly, which are currently worked on and which have not been started yet. Assembly (or any work phase) takes the next orange light project with the smallest queue number under work. The orange light means that the material has arrived to buffer and previous sequences are finished. The red lights at the buffer zone stand for distractions which have to be solved immediately. Green lights are for finished projects.

5.4. Setting / Kitting

The setting / kitting is understood in the case company as an allocation box, where purchase items of a project are allocated according to the corresponding production sequence. The distribution to sets is done only for project purchased material, not for stock items.

The purpose of setting is to assist material handling at the production area. The suppliers bundle their delivery into project specific sets. When these supplier sets are received, they are bundled together with other supplier's kits forming bigger sets which then are stored until production starts. When the production starts these kits are brought to the assembly lines at the right time. A Unique set-id has to be given for the project before making a purchase order and the purchase order has to be divided into set orders. (ABB 2008 b).

At the moment the setting is done inside Baan with a tailored module. The setting principle is very important for the case company. Standard SAP does not have functionality where the setting could be done, meaning that external software will have to be purchased. The research for upcoming method is unfinished at the moment.

5.5. Milk train concept (Period batch control)

The case company uses a so-called Milk train concept for transporting sets and timing for their arrival. It is agreed with the subcontractors that they have sets ready for pickup on every Thursday and a truck will start from one European country on Thursday. This single truck will drive through all the subcontractors of the case company. On Monday the truck arrives to Vaasa and the production starts a week from that (see figure 11). One week is kept for buffer time (ABB 2008 c).

The goal of milk train is to reduce the total cost of the material process (of which transportation accounts more than 20%), improve performance of the supply base, reduce WIP and improve the on time delivery (OTD) of suppliers. Material and internal logistics should be simplified and information should be available earlier. in case of deviations. The objective will be achieved by developing a Gate-Model-based schedule for follow up with collection concept of materials from Europe to Vaasa (Ruhkala 2008).

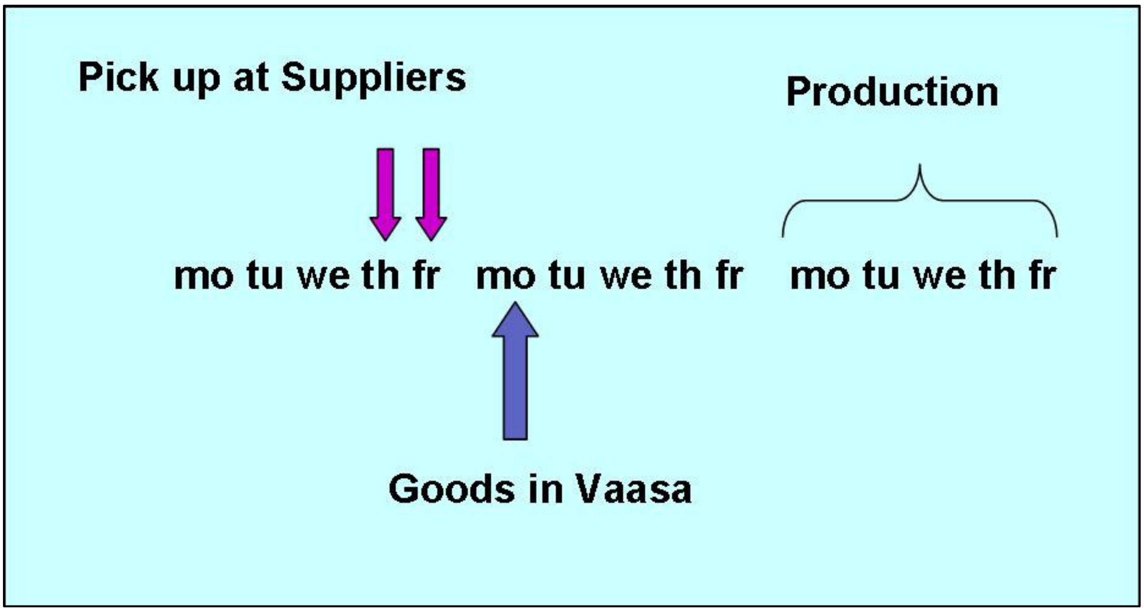

Figure 11. Milktrain timing.

Pick-up timing is predefined for every supplier. Booking for transportation must be done 2 days before the pickup date. Every week, the Gate-Model-based schedule of deliveries for the following week is given to the transport service company. The transport service company ensures that the supplier's will book transports as planned. If not, the transportation services company will contact the supplier for clarification and inform ABB in case of late delivery for immediate actions (ABB 2008 c).

5.6. Warehousing

The case company has a stock called *project stock* for project specific material and two warehouses which are called *GTW* and *GTH*. Material is mainly purchased directly to projects, this is called purchasing to sales order in SAP. This thesis concentrates on the issues how sorting of material should be made, which materials should be stocked and which should be purchased on the ground of sales order. It also answers the question how the material inside of GTW and GTH warehouses should be managed.

Project Stock
Manufacturing of special transformers is mainly unique production, where every product is manufactured only once. Therefore the most items bought are purchased directly to the project. MRP calculation is used for determining the right moment of purchasing. Long lead time components or critical material, e.g. components which have a lead time of over 30 days, are purchased first at the moment of Gate 1 (refer figure 5). One specific buyer is responsible for critical material.

After determination of critical material the rest will be managed by the MRP calculations. Production start date and lead time will give the impulse for the system to make the purchase requisition for the buyers. The purchasing function is divided so that there is always only one purchaser responsible for one project.

GTW Stock
Material is standardized all the time and when it is made, the item will be transferred as stocked material. GTW Stock is used for inventory materials. Materials that are in continuous use and are wanted to be controlled by the case company are stored in the GTW stock. At the moment the GTW stock has more than 450 item lines and the purchasing is controlled by a purchaser through the limitations installed in Baan. Currently used limitations are safety stock, minimum order quantity, order quantity multiplier, order interval, order lead time and safety time.

GTH Stock

GTH stock is used for company's own non-valuated materials and Vendor Managed Inventory (VMI) stocks. GTH is a stock for bulk material which serves the production but it has minor value or such a structure which cannot be valued, e.g. screws and bolts. The impulse for re-order is made visually, by two-bin-system or by the vendor.

6. ANALYSIS AND PROPOSALS FOR MATERIAL HANDLING INSIDE SAP

SAP will provide numerous new possibilities for material handling in the case company. For example, SAP will provide an automated ABC analysis which can be run continuously for determining right parameters for MRP calculation. However, this can only be done after the system has enough data and after some guidelines have been drawn up. The case study proves that the parameters in the current system should be updated. The ERP system cannot work efficiently without accurate data and automated processes will not come without given guidelines. MRP will calculate the need and timing for required material but the inventories will be inefficient without determined methods. The case study started by examining the impulses for materials management. The research and the proposals will be introduced next.

The research was started by examining existing data from the current ERP system. Consumption of year 2007 and existing lot-sizing rules were taken as the reference values and they were compared to the methods introduced in the literature review.

6.1. MRP parameters

In SAP the MRP parameters are given in the phase of material creation. These parameters can be changed afterwards. The case company will bring the existing data from Baan via data transfer so the existing parameters will follow the data. The consultants recommended researching this existing data so that the parameters could be newly inserted after the data transfer. Afterwards when the new system is in use the material creation will be mainly done in MDS and the data will be brought to SAP via interface. SAP will maintain the material master data for stocked items and they are transferred from SAP to MDS via interface. Project materials are created in the design phase and after that the material is created inside MDS. Project materials will be maintained inside MDS.

Material master data in SAP is a fixed value and it cannot be easily changed. One issue to be solved is that who will and who can be in charge of creating material master rules and in which phase. Case company does not have a Product Data Management system (PDM) in use. MDS is used as PDM but it does not have all the same functions that PDM has. Research of the benefits of PDM system would be recommended for the case company.

Concerto (refer chapter 5.3.) will provide the production timing information to SAP and the production planning module (PP) in SAP will give the timing information to MRP calculations. The MRP header level information concerning the case company and this thesis in SAP are introduced in appendix 1. They will be referred in the text when needed. The case company has two physical and one virtual warehouse where purchased items are stored. Each of these warehouses was researched separately and the results will be introduced next.

6.2. Project stock

Unique item purchasing to projects is named purchasing to Sales order in SAP. The material will be created in MDS and transferred from MDS to SAP via Interface. MDS will provide material parameters needed. External software is needed between MDS and SAP for kitting (refer chapters 5.2. & 5.4.) so that kitting code can be inserted into purchase orders. For MRP calculation in project materials MDS will give inputs for only lead time (refer appendix 1 section 1.4.2). After Gate 1 (refer figure 5 firstly the long lead time components will be recognized and preliminary MRP run will be made for those critical components. The MRP will do the calculation for remaining materials and release the purchase requisitions for purchasers in a secondary MRP run. Project stock is for independent unique material which is consumed only once. So there is no need for setting up parameters in MRP calculation.

Purchasing to sales order is quite straight forward procedure and no special needs were recognized for the case company. Purchasing will be made on the lot for lot principle (refer chapter 3.4.1) from the impulse of the lead times. The lead times have to be adjusted with the milk train concept timing (refer chapter 5.5).

6.3. GTW material

GTW material (refer chapter 5.6) will be fully controlled by SAP so it created the biggest challenges for this case study. The volume of this stock can be considered as significant so also savings can be achieved through efficient materials management. Case company considers material shortages as the biggest challenge at the moment so finding solutions for cutting them down was the main target.

Materials are moved from project material to GTW material continuously when the material can be standardized for production. Each new material has to be examined when it is changed into a stocked material. Consumption cannot be exactly known so first smaller batches and shorter timed replenishments have to exist. Afterwards the parameters can be adjusted when enough valid data has been found.

Research for current material was made. First dirty data was cleared out so that it would not affect the research. At the moment GTW stock has more than 450 unique item codes from which 50% is controlled by order interval cycle. 75% of the material had determined safety stock. Over 29% of the material in GTW stock is manually controlled and the rest by MRP. During the data examination conflicting rules were found from current system. About 6% of manual controlled materials have order interval system as controlling method and 50% of manually controlled material have safety stock. This kind of conflicting rules can affect the system so that it will calculate by other parameters than it was thought to.

The analysis of the sufficiency of the safety stock was made by calculating the average sufficiency by first calculating the average daily consumption and comparing that with the lead time added with safety time. Interesting observations were made when examining the sufficiency of the safety stocks. Over 34% of the material reached negative sufficiency; about 3% were calculated for zero days, and over 51% exceeded 15 days. Out of these 51% over 49% exceeded one year. The biggest safety stock would cover the need for approximately 82 years. Fortunately the materials with the biggest coverage were manually controlled so the system did not control them. But the materials with negative coverage are believed to cause shortages. The result of this examination had already proven that the parameters were clearly obsolete and the controlling parameters had to be readjusted. No further examination was needed for historic data.

Next step was determining the right tools for managing this stock. First ABC analysis was made for the whole stock. The results were that two main materials make up almost 80% of yearly consumption measured by value. These two materials were taken out from the rest of the data and examined separately so that they would not cause minor importance for the rest of the material. These two materials are also critical materials with a long lead time so they have their own controller in the purchasing group. These materials will have the ABC indicator A and they will be controlled as they are now, fully manually with safety stock indicator.

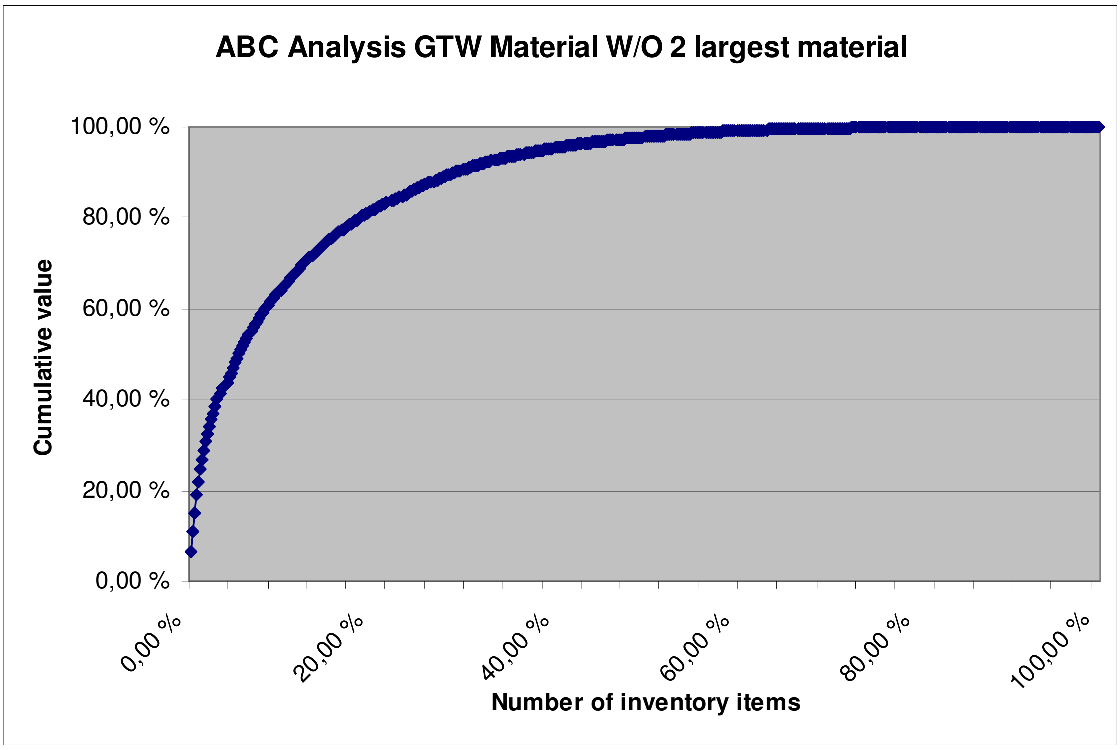

Figure 12. ABC analysis for GTW Material without two largest materials.

The remaining materials build quite standard deviated form in ABC analysis, where about 80% of the value comes from 20% of the material. This group of material is proposed to represent group B in ABC indicator. Still items inside this category had quite large variability so the category was divided into B1 and B2 so that about 17% of the items formed group B1. The rest of the material (about 80% of the items in that particular group) formed only 5% of the yearly consumption so they could be considered as insignificant value material and they formed group C.

Next step was to analyse the lead times of the material so that the parameters for safety stock could be determined.

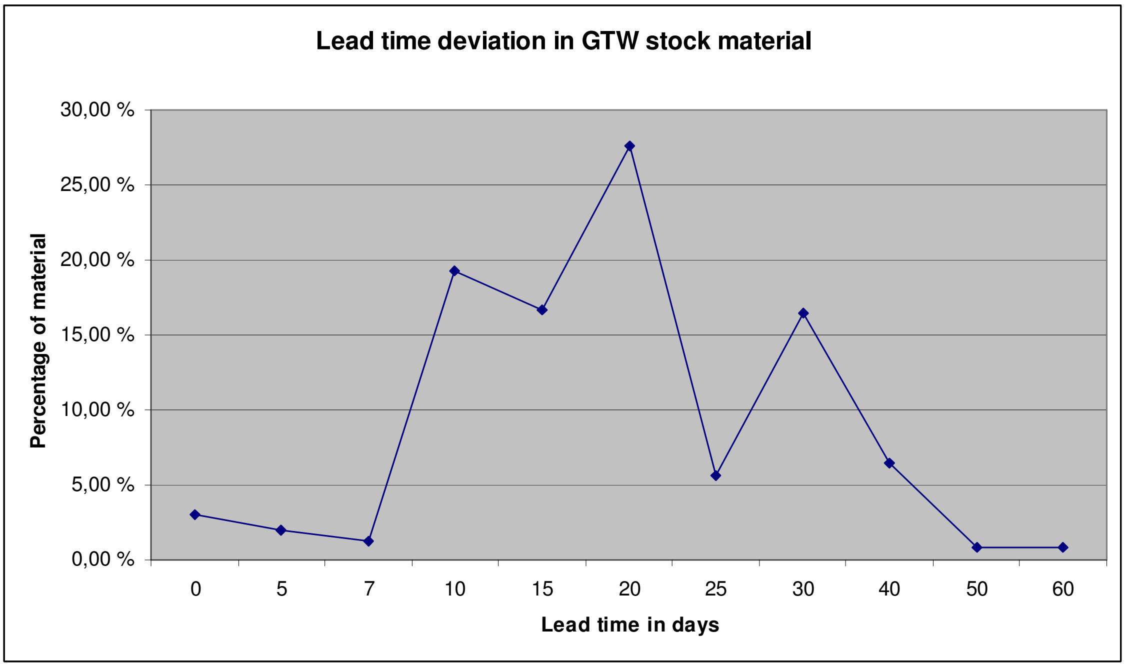

Figure 13. Lead time deviation in GTW stock material.

The result showed that over 75% of the material have more than 10 day lead time. Materials with longer than 30 days lead time are considered as long lead time material. About 10% of the whole GTW material fell into that group.

Since the amount of material in group B1 is reasonable (approximately 3,5% of the total amount of material) and the importance measured by yearly consumption is high (about 42% by calculating without the two largest materials) effort can and should be given for controlling this material. According to this case study the most suitable lot sizing method for this material would be the least unit cost (LUC) from the heuristic methods (refer chapter 3.4.4.). LUC is cost effective and will provide near optimal lot-size with a reasonable amount of effort. It will also decrease the value of the tied capital by creating more frequent purchase orders for valuable material. Safety stocks can be decreased because the method will calculate the upcoming need as far as it is economical. Reorder point level has to cover the replenishment time.

The proposed lot sizing method for B2 material is the Optional Replenishment system from dynamic lot sizing methods (refer chapter 3.4.3). The larger safety stock will be needed for this method to be efficient. The reason for recommending this method is mainly because of the simplicity in maintaining the parameters for larger number of items. It also seems cost efficient with right-sized safety stocks. The proposal for the right size of safety stock for B2 material according to this research would be that it should cover the material need for the time replenishment (lead time + safety time) added with additional 7 days buffer. This additional 7 days extra buffer causes the value of the safety stock to increase by 26%. But it is believed to cover most shortages caused by delay. SAP will provide new tools for On Time Delivery (OTD) calculation so after the case company has data for analysing suppliers' delivery accuracy the extra buffer date can be adjusted or totally removed. The new safety stock would be almost 32% larger than it is now. So the renewal would seem as inefficient. But the total value of the safety stock would then be around 10% of the total value of the stock currently in hand and therefore after cutting down the shortages it will create savings and an improvement of the customer service level for the case company.

It is also proposed that lead times, safety times and minimum order quantities would be manually examined for each material so that the efficiency of the calculations can be proven and the data will surely be real time. A spread sheet was made for the case company so that all changing parameters can be given and the results will be adjusted by them. At the time of this research only a sandbox version of the upcoming system was available. The researcher would recommend the parallel system approach (refer chapter 2.3.) for testing the new system by simulating the real parameters. After that the results could be compared against the data from current system and adjustments could be done parallel.

7. CONCLUTIONS

This chapter introduces thoughts that occurred during the research. It also gives proposals for future research and development for the case company. There were four main observations. Each of them is introduced next.

Through this research a need for Product Data Management (PDM) software was seen. Another result could be improvement of MDS. The MDS system is functional and serves the needs of the case company. But the problem of MDS is that it does not have highly developed search functions so that the design engineers could find the old components quickly. Often it is faster to design a new component than search for the one used before. This raises the size and complexity of the data storage. The suitability of a PDM system for case company should be researched together with internal processes in design phase material creation. It is believed that a PDM system would provide more accurate data of the consumed materials by forcing to more structured way of creation of new material. This would have a positive effect on material shortages.

The second observation was that the buyers rely too much on silent knowledge. The current purchasers are professionals and they know the products. Purchasers also correct the mistakes designers have made with regard to material. This results in the time of orientation for new employee being very long. The other issue this causes is dirtier material master data. A handbook for material handling should be made so that the employees could be empowered for continuous development.

The third observation was that case company is highly relying on the accuracy of the suppliers. The case company should improve the information channel between them and suppliers. Advanced Supply Chain Collaboration (ASCC) project should be started as soon as possible so that real time information could be given. Parallel with ACSS the internal logistics should be examined. Case company has ordered another thesis work which will examine the internal logistics and it will provide answer if Radio Frequency Identification (RFID) would be suitable for the case company for call offs.

Fourth observation was that SAP cannot handle Kitting at all. Through examination result for importing data to SAP was found and the current Kitting process can be maintained. However this means need for ordering totally new tailored software that will provide the distribution for materials according to the case company's needs.

8. SUMMARY

Implementation of an ERP system is risky but when the background work is properly done it can have wide effects on the efficiency of the company. This thesis was made for a local business unit of ABB as part of global process harmonization project in ABB. The largest benefits are collected by the parent company but the largest pitfalls can occur in the sub units. Therefore it is mandatory that all the local business units make extensive research to their processes so that possible defects can be found before the implementation. Implementation project gives also exquisite opportunity to examine current processes critically because inefficiency can be found.

This research oriented in the materials management processes and its first objective was to describe the current processes of the case company. The second objective was to compare the current processes of the upcoming ERP and give solution proposals for the conflicting parts. The third objective was to research why the case company has material shortages which affect the functioning quality of the current ERP. Through these three steps the overall objective could be achieved: successful predefinition for the Materials Management module in the case organization.

The research can be considered as success because all of the processes were examined comparing the processes used in the SAP and conflicting processes were reported. Solutions for most of the conflicting processes could be found and only issues in Kitting could not be solved inside the system. Material consumption was analysed with qualitative and quantitative methods. Through the analysis, conflicting rules and inefficiency in material handling and MRP calculation were found. The conflicting rules and inaccuracy in MRP parameters are affecting material shortages and therefore a solution for cutting them down was created. The developed spreadsheet can be used for examining the adjustments of the stocked items with different MRP parameters. Proposals for future studies were given so that the observed issues could be fixed also.

Through this case study it can be stated that the case company is quite qualified for ERP change process from the system point of view. The processes used are based on common methods and they can easily be transferred to new system.

The challenges are on the corporate harmonization issues mostly on the side of master data. However, there is need for more structured ways of working and standardization for processes. For cutting down the pitfalls in materials management the change process has to start from the product design. Nowadays dirty data is produced because of the ways of creating new material. The results of improving processes in the end of the process will not have a big difference in the whole picture. The case company has started a harmonization process where modularity is examined. Modular, more standardized production will have widespread effects for the production and for the materials management. Inventory levels will rise at first because more material can be taken to stocked material but the material shortages and the ordering costs will be cut down.

The generalization of this research for other similar projects is not axiomatic. However the theory used is general for all ERP projects. Also the process descriptions can in a help for determining the suitability for SAP ERP.

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Jessen, Esa. Data Administrator Architect. ABB Transformers, Finland

Manner, Matti. Manufacturing Manager. ABB Transformers, Finland

Niskanen, Jani. SAP MM Consultant. TietoEnator Oyj, Finland

Nylund, Hans. Purchaser. ABB Transformers, Finland

Rangarajan, Achuthan. SAP MM Functional Module Consultant. TATA Consultancy Services LTD, India

Rautakoski, Leena. IS Manager. ABB Transformers, Finland

Ruhkala, Pekka. Supply Manager. ABB Transformers, Finland

Ylipulli, Jyrki. Operations Manager. ABB Transformers, Finland

APPENDIXES

Appendix 1. Relevant MRP indicators for case company and this thesis in SAP

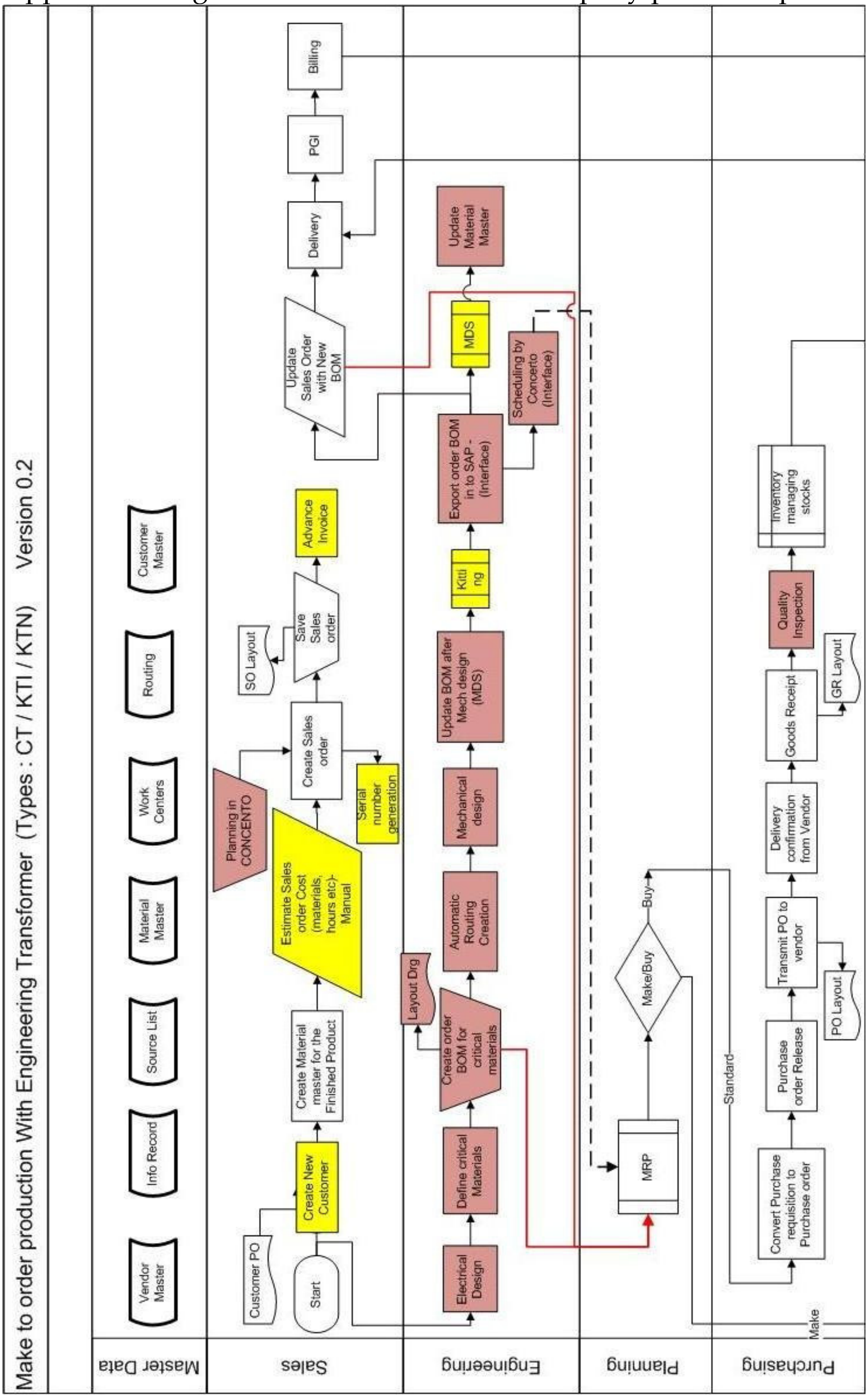
1. MRP 1
   - 1.1. General data
     - 1.1.1. ABC indicator
     - 1.1.2. MRP group
   - 1.2. MRP Procedure
     - 1.2.1. MRP type
     - 1.2.2. Reorder point
     - 1.2.3. Planning cycle
   - 1.3. Lot size data
     - 1.3.1. Lot size
     - 1.3.2. Minimum lot size
     - 1.3.3. Maximum lot size
     - 1.3.4. Maximum stock level
     - 1.3.5. Fixed lot size
     - 1.3.6. Ordering cost
     - 1.3.7. Storage cost indicator
     - 1.3.8. Assembly scrap (%)
     - 1.3.9. Takt time
     - 1.3.10. Rounding profile
     - 1.3.11. Rounding value
   - 1.4. Scheduling
     - 1.4.1. Goods receipt processing time
     - 1.4.2. Planned delivery time
   - 1.5. Net requirement calculation
     - 1.5.1. Safety stock
     - 1.5.2. Service level (%)
     - 1.5.3. Minimum safety stock
     - 1.5.4. Coverage profile
     - 1.5.5. Safety time indicator

Appendix 1. Relevant MRP indicators for case company and this thesis in SAP

1.5.6. Safety time / act.cov
1.5.7. Safety time period profile
1.6. Deployment strategy

2. MRP 2
   2.1. Forecast requirements
      2.1.1. Period indicator
   2.2. Planning
   2.3. Availability check
   2.4. Plant-specific configuration
   2.5. BOM explosion
   2.6. Discontinued parts
   2.7. Repetitive manufacturing / assembly
   2.8. Storage location MRP

Appendix 2. Big Picture Visio of the case company processes part 1/2



Appendix 2. Big Picture Visio of the case company processes part 2/2