FACULTY OF TECHNOLOGY

ERP SYSTEM IMPLEMENTATION

Jari Rankinen

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ABSTRACT

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Jari Rankinen

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Supervisors at the university: Jyri Porter, Heikki Pirkola

The aim of the thesis is to implement Odoo Enterprise Resource Planning (ERP) system to cover the operations of the target company as widely as possible within the schedule. The ERP system will be utilized in areas such as purchasing, warehousing, manufacturing, product development, and documentation.

Based on the literature review, the scope and the schedule of the implementation is defined and a plan for the implementation process is created. The scope of implementation is defined by identifying the most important functions and processes in the target company and getting acquainted with the new ERP system. The transition plan consists of customizing the new system to suit the operations of the target company, transferring data between the old and the new database, and training employees to use the new system.

ERP implementation was carried out on time after an early adjustment of the implementation schedule. The implementation process required in-depth studying of ERP system and reviewing of company's processes. Document management was improved, and company's stock can now be managed through the ERP system. The implementation process had little disruption on operational activities. The results of this study can be used to further develop the ERP and the company's processes, and the plan is to continue to develop the ERP system to integrate more of the company's processes into the ERP.

Keywords: enterprise resource planning, implementation, inventory management

FOREWORD

In this work, the methods by which Noptel Oy switched to using the ERP system are presented. The reason for the introduction of the ERP system was, among other things, the need for better monitoring of the inventory levels due to the problems caused by the global shortage of components.

Action in planning and implementing changes was strongly emphasized. Things can only be thought up to a certain point until something concrete must be done. The task was challenging and interesting. The work was started in February 2021 and was completed in June 2022.

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Jari Rankinen
Author

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LIST OF ABBREVIATIONS

BOM	Bill of Materials
CPC	Collaborative Product Commerce
cPDm	Collaborative Product Definition Management
EDM	Electronic/Engineering data/Document Management
ERP	Enterprise Resource Planning
MRP	Material Requirements Planning
PDM	Product Data Management
PIM	Product Information Management
PLM	Product Lifecycle Management

1 INTRODUCTION

Noptel Oy is replacing their old Microsoft Access-based ERP system with Odoo ERP system. The new system will introduce real-time inventory management as well as new tools for product data management and production monitoring.

The need for a new system has arisen from variety of reasons. The general availability of components has been considerably lower than normal over the past year. Delivery times for processors range from six months up to a year, and delivery times for large batches of flex-rigid PCB blanks are currently about four months. There has also been a shortage of laminates in the market for some time, which has increased the prices of printed circuit boards.

So far, the risk of component shortages has been minimized by ordering materials several months in advance and ordering material in large batches. There have been some cases where production has been delayed because of component shortages. Also, materials for more irregularly manufactured products have to be ordered and stored in larger quantities for safety. Due to ever-increasing flow of material and the lack of real-time inventory management tool in the old system, there is a constant risk that something critical in material procurement will go unnoticed, which will cause problems down the line with delivery reliability.

This means that the company is moving from its old product information system to an ERP system. In addition to the migration of old functions, new functions such as inventory management will be introduced.

1.1 Presentation of the target company

Founded in 1982, Noptel Oy specializes in design and manufacture of optoelectronic products comprising its technological know-how in the measurement of distance and position. Noptel’s key customers are system integrators who manage their own applications. Noptel is a technology provider that deals exclusively with system integrators who serve end users with integrated products for a wide range of applications.

Noptel's core competence relies on know-how dedicated to exploit opto-electronic measurement technologies.

Since 2011, Noptel Oy has been a subsidiary of FN Herstal, an integral part of Herstal Group. (Noptel Oy, 2022)

Figure 1. Compact ultra long range laser rangefinder module designed and manufactured by Noptel. (Noptel Oy, 2022)

Noptel Oy had a turnover of EUR 9.1 million on 2021 and employed 34 people. (Taloussanomat, 2022)

1.2 Defining the research problem and research questions

The target company's goal is to move from the old product information system to a new ERP system. The ERP system will be used to centrally manage the company's core functions, such as product information, order backlog and inventory balances. The aim of the study is to find out how the implementation can be carried out in time and on a large enough scale to enable the desired functions to be implemented. Additionally, the impact of the ERP system implementation on the company and its operations will be observed.

Currently the main issue with the old system is the lack of active inventory management and tracking especially amid a global component shortage.

The study aims to answer the following questions:

RQ1: What should be taken into consideration for implementation of an ERP system?

RQ2: How to define scope and schedule for an ERP implementation?

RQ3: How does ERP implementation process impact company and its operation?

1.3 Stages of the study

The literature review presents ERP systems in general and the essential issues in the implementation process. The literature review also includes some discussion of basics of database design. Typical problems encountered during the different phases of implementation process are discussed to avoid these problems during the actual implementation. The development of ERP systems after the initial implementation is also discussed. The literature review aims to answer the first research question.

The literature review is followed by a presentation of the old product data management system of the target company, and the limitations of the old system are discussed. The activities of the target company and how they should be centralised under a single ERP system are discussed. The ERP system will be studied in order to outline the need for possible customisation or if review of target company's processes is needed. This is followed by an analysis of the system and its functions. Functions that are to be introduced into the ERP system at the initial implementation, the development ideas that were implemented and why these solutions were chosen are also discussed. Procedures used for allowing a smoother migration from one system to another are explained. This part of the study aims to answer the second research question.

Finally, the results and conclusions will assess the success of the ERP implementation, the challenges faced during implementation, and the impact which it had on the company's operations, especially during the early stages of deployment. These will be used to make suggestions for future process and/or ERP system development. The aim is to make the ERP system to work in the target company as an efficient tool that will benefits the entire company's operations, and this section will aim to answer the third research question.

2 LITERATURE REVIEW

This section introduces ERP systems and their implementation process. The aim is to acquire sufficient level of understanding of ERP systems and their implementation process to enable the ERP project to be successfully carried out in the target company. Basics of product information management, database related terms and production management will be covered to support the topic of ERP implementation.

2.1 ERP systems

Enterprise Resource Planning (ERP) system covers all the company's key functions, and financial management and cost monitoring are integrated into the system. Processing the transactions aims to be as real-time as possible. (Vilpola & Kouri, 2006, p. 86). ERP system aims to manage the vast amounts of information generated by planning and controlling operations activity. It is important that all relevant information that is spread throughout the organization is brought together, so that the ERP system can communicate planning and control decisions such as when activities should be done, where they should take place, who should do them, how much capacity is needed, and so on. (Slack, et al., 2010, p. 407)

ERP system typically consists of tightly integrated modules. Modules are often focused on at least the following four major areas: finance, manufacturing and logistics, sales and marketing, and human resources. Every module has the same user interface, creating a seamless transition between them and making the use of different modules easier for users trained on the system. Diagram in figure 2 depicts how ERP works as the core or backbone of a comprehensive information system. (Vollmann, et al., 2005, pp. 111-112)

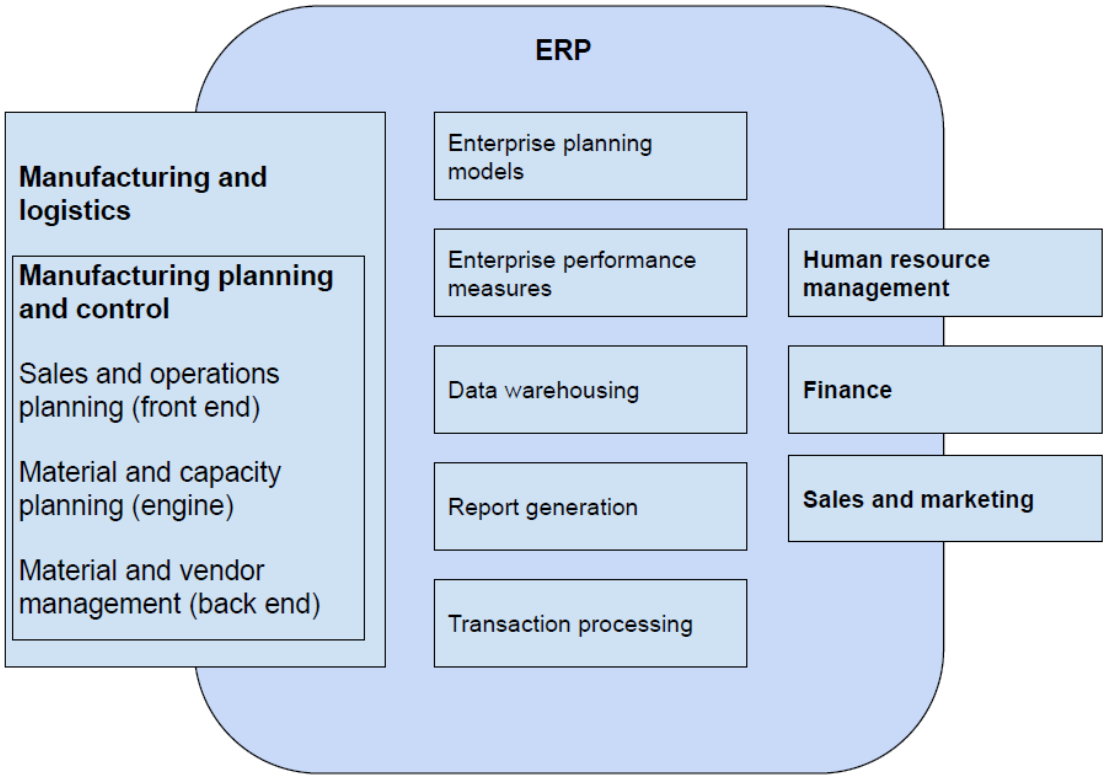

Figure 2. Scope of ERP applications. (Vollmann, et al., 2005, p. 112)

Typically, each department in a company has its own computer system, each optimized for the particular ways the department carries out its work. ERP's goal is to integrate all of them into a single software program running off a single database. This allows the various departments to share information and communicate with each other more easily. This integrated approach has a lot of potential for improving the company's operations if implemented correctly. (Stevenson, 2002, p. 664)

Different functions, such as order management or inventory and material management, use this common database. In modern ERP systems, these functions are often separate modules that can be deployed as required and in stages. (Reijo Rautauoman säätiö, 2021) Single database means that all functions use the same data, and because of this, coordination between departments is facilitated. Popular client-server environment, where users have personal computers on their desks and a large centrally kept database, allows reasonably easy expansion of the system at low cost. (Silver, et al., 1998, p. 620)

2.2 Benefits of ERP systems

All the relevant information of the organization can be centralized under one database. This eliminates duplicate data entries, and anyone with the right permissions can see and modify this data. When combined with internet, the database can be accessed by anyone and anywhere the organization allows. (Ptak & Schragenheim, 2004, p. 18)

The enhanced visibility that information integration gives can significantly improve the performance of a company in many different sectors. This is generally seen as the potential of ERP. ERP allows best practices to be implemented uniformly through the business via the discipline that ERP demands, sharpening up the management of processes within an organization. Software communicates through all functions of the company giving visibility to what is happening in different parts of the business. More sophisticated communication with customers, suppliers, and other business partners is enabled by more accurate and timely information. (Slack, et al., 2010, p. 411)

2.3 Basic concepts of product information management

The concept of product information management may have originated in the U.S. military aerospace industry in the 1970s and has since spread to the mainstream of industrial companies to diversify and parallel product development both within and between companies. Different information systems need to be better integrated than before, and all the product information needs to be accessed via the web. Nowadays a lot of attention is being paid to PDM (Product Data Management). Other approximately similar terms include e.g., PIM (Product Information Management), EDM (Electronic/Engineering Data/Document Management), PLM (Product Lifecycle Management), cPDm (Collaborative Product definition Management), and CPC (Collaborative Product Commerce). This confusion has arisen as system vendors and consultants have had commercial pressure to come up with new concepts to promote differentiation. The basic idea and functionality of the above terms are the same as with the concept of product information management, despite the differences in emphasis. Today, a term often used is PLM (Product Lifecycle Management), which attempts to emphasize the management of product and product information from the very beginning of product definition to the scrapping of the last individual. (Martio, 2015, p. 47)

Using a PLM system to manage product information and integrate and automate business processes generally leads to efficiency gains, allowing companies to develop more new products, reduce time to market, reduce costs, increase productivity and improve product and process quality. (PLM Technology Guide, 2021)

2.3.1 Product information

Product information can be roughly divided into three distinct categories: Product specification information, product lifecycle information, and metadata describing product information.

Product configuration data uniquely defines the physical and functional characteristics of the product being produced. This category includes both very specific technical information and abstract and conceptual information related to the nature of the product. The wide range of the nature of the information can cause problems due to different interpretations.

Product lifecycle information always relates to the product and the stage of the product or customer process, such as research, product design and product manufacturing, usage, maintenance, disposal, and sometimes also official regulations. (Sääksvuori & Immonen, 2002, p. 17)

2.3.2 Items

Vilpola & Kouri (2006, p. 86) define an item as following: “An item is any product, material, semi-finished product or consumable of a company that is managed in the ERP system as its own unit”.

Sääksvuori & Immonen (2002, p. 19) state that a well-functioning nomenclature (items) is the basis of various product information management systems. An item is a systematic and standard way of identifying, coding, and naming a physical product, part or component of a product, material, or service. Each company’s practices and the products manufactured by the company will affect what is considered to fall within the scope of nomenclature. Documents are also identified through nomenclature. Packaging, installation supplies, moulds, fasteners, and embedded software may also be included in addition to the above.

For product information management it is essential that the nomenclature is uniform and in line with the company's own standard. It is also important that the nomenclature groups the headings into different categories and subcategories at convenient and appropriate level of detail. (Sääksvuori & Immonen, 2002, p. 19)

In ERP systems, items are identified with item codes. An item can have multiple different nicknames or identifiers in addition to the item code, such as trade name, electric code, and customer or supplier code. Generally, an item code is generated from a running sequence of numbers. In some cases, an item such as an end product, may have their own series of numbers, where some of the numbers in the item code serve as identifiers. (Vilpola & Kouri, 2006, p. 87)

2.3.3 Bills of materials

Bill of materials defines the quantity of each component required to make or deliver a finished product. Various operations or steps needed to complete a production process can also be included. It is a listing of all the assemblies, subassemblies, parts, and raw materials needed to produce a finished product. Bill of material is linked to a particular product, and sometimes a product can have multiple bills of material. (Odoo S.A., 2022; Stevenson, 2002, p. 643)

Bill of materials is hierarchical, and it shows the quantity of each item to complete the following level of assembly. A hierarchy is clear when a product structure tree is considered; it provides a visual depiction of the subassemblies and components needed to assemble a product. A product structure tree is depicted in figure 3.

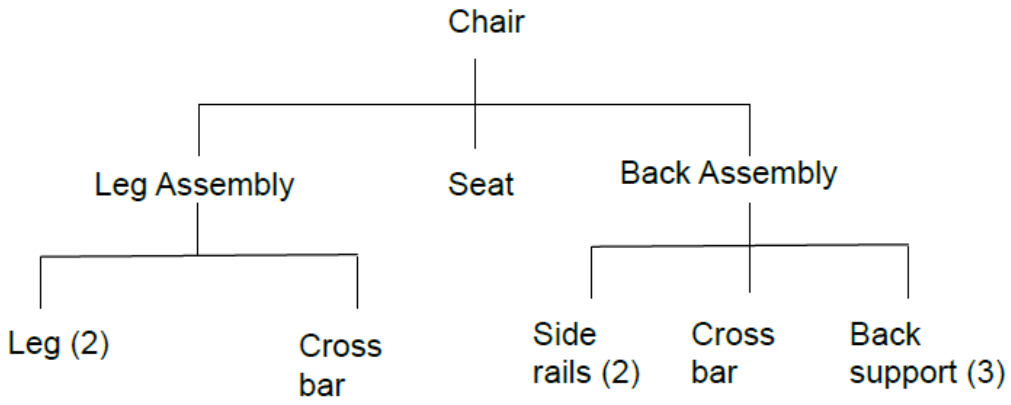

Figure 3. Product structure tree for a chair (Stevenson, 2002, p. 644)

The chart in figure 3 is a product structure tree of a chair. The chair is the end item, which is shown at the top of the tree. Below it are the subassemblies and major components required to make the end item. The product structure tree illustrates how the bill of materials is used to calculate the quantity of each component needed to produce a certain number of end items. (Stevenson, 2002, p. 643)

2.3.4 Data record accuracy

Data record accuracy is needed to have an effective ERP implementation, and the lack of data record accuracy is either a prime or a contributing factor of a failed implementation. Users will not trust the information from the system if the data is inaccurate, and they will begin to second-guess the information coming from the ERP system. When data are not trusted, the data will not be maintained since users do not bother with something they will not use. Inventory records, bills of materials (BOMs), routings, sales orders, work orders, purchase orders, and execution transactions all require data accuracy. When the system contains accurate data, everyone in the company does. Correct data eliminates cost of inaccuracy, which is higher inventory, lower profits, and a significant amount of nonvalue-added work by a large group of people. An ongoing process of improvement and validation is required to assure the quality of the data. At its core, the enterprise planning system is a communication system providing distributed information from a centralized database. (Ptak & Schragenheim, 2004, p. 30)

Ptak & Schragenheim (2004, p. 306) list mass balance, physical inventory and cycle counting the three most common methods used to ensure inventory record accuracy.

Mass balance adds up all the incoming receipts and deducts materials used based on what has shipped to the customer. The quantity that should be found in inventory is the resulting mass balance.

2.3.5 Item versioning

Versioning is one of the most important areas of product management and can be found in some form in all PDM systems. As often in product information management, the vocabulary considering the subject is variable. The terms version, revision and variant may mean something quite different in another context.

An item may be associated with a set of versions, which describe two separate but related phenomena. An item may have successive revisions describing its development over time and parallel variants with different characteristics. A new revision always replaces the older on in production after a certain transition period, while the development of a new variant has no effect on the production of other variants. In general, there is no single right way to organize versions, and even within the same company it is possible to treat versions of different types of items differently. (Martio, 2015, p. 79)

2.3.6 Compatibility of revisions

If the version planned as a new revision does not meet the compatibility rule agreed within the company or cannot replace the original version, a new item or a variant must be made. In this case, a new version does not replace the old version, which remains a parallel title for the new version. Similarly, a version designed as a new variant may become a new revision if it is no longer desirable to keep the old version alongside the new version. (Martio, 2015, p. 82)

2.4 Material requirements planning

Material requirements planning (MRP) calculates how many parts or materials of particular types are required based on forecasted need, which are based on customer orders and forecast demand. They are input to materials requirements planning, and MRP performs its calculations based on these. (Slack, et al., 2010, p. 422)

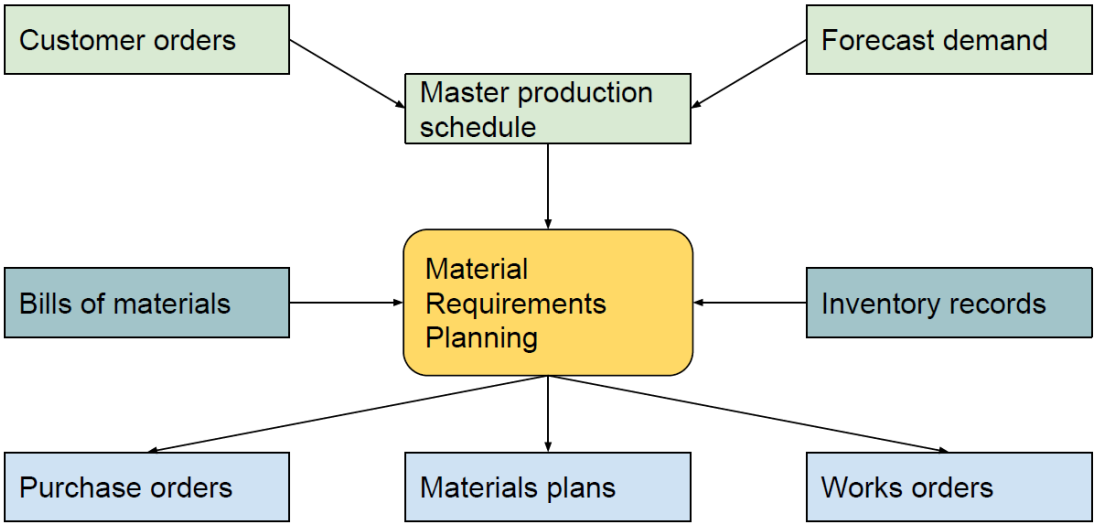

Figure 4. Materials requirements planning (MRP) schematic (Slack, et al., 2010, p. 422)

The inventory level is reduced by the planned consumption of the item. It is based on a production or delivery plan for the products for which the item is used. This top-level plan is based on either actual orders or projected demand. A safety margin must be defined for an item. When its inventory level reaches the alarm limit (emergency inventory limit) in the future, the system proposes a replenishment period equal to the delivery or replenishment time. Actual consumption may be higher than planned, in which case the emergency storage will be used before the replenishment batch arrives. (Reijo Rautauoman säätiö, 2021)

2.5 Common relational database related terms

In a relational database, data is organized in tables that can be linked, i.e., related to each other on the basis of common data. This capability allows a retrieval of an entirely new table from the data in one or more tables with a single query. It also allows a better understanding of the relationships between all the available data. (IBM, 2019)

Relational database has its own terms, which are used to express and define the specific ideas and concepts of the relational database model. Many of the terms are derived from the first order predicate logic and set theory in mathematics. These terms are commonly used when talking about relational databases. (Hernandez, 2002, pp. 33-34)

2.5.1 Data and information

The values stored in a database are data. Data is static in the sense that it remains in the same state until it is modified by some manual or automatic event. Data by itself does not tell much. It is hard to figure out what number “1” means in a database just by looking at it. Information is data that has been processed in a way that makes it relevant and useful to the person using it or viewing it. Information is dynamic in the sense that it is constantly changing in relation to the data stored in a database and can be processed in many ways. (Hernandez, 2002, p. 35)

2.5.2 Basic structure-related terms

Table (also known as a relation in relational database theory) is the main structure of a relational database. It consists of fields and records, and it always represents one specific subject, which can be either an object or an event. (Hernandez, 2002, p. 39)

When a table represents an object, it represents something concrete, such as a person or a place. An object has a set of properties that can be stored as data, which can then be processed as information in many ways. (Hernandez, 2002, p. 40) In this case, examples of object-type tables are vendors, customers, products, and documents.

When the subject of a table is an event, it represents something that happens at a particular point in time. (Hernandez, 2002, p. 40) Examples of these in ERP environment are purchase orders, sale orders, stock moves such as receipt or delivery of a product, and manufacturing orders.

A table is called a data table when it stores the data that is used to provide information. These types of tables are the most common in relational databases. The data in this table is dynamic because it is manipulated and used to form information. Users are constantly interacting with these types of tables. (Hernandez, 2002, p. 41)

When a table contains data that is used to implement data integrity, it is known as a validation table. A validation table can represent subjects such as city names, occupational classifications, and product codes. The data in this type of table is static because it does not change very often. Users do not have much direct interaction with these tables, but they are often used to indirectly validate values that the user enters into the data table. (Hernandez, 2002, p. 41)

Field (also known as an attribute in relational database theory) is the smallest structure in a relational database. A field is used to store data in a database, and it represents a particular attribute or feature of the subject in the table in which it exists. (Hernandez, 2002, p. 41) For example, **Products** -table can have **Weight** -field in it. It is a property that describes or explains a record or an entity. Attributes allow a record or an entity to be identified, and they should cover all the data a business needs to operate. (Väre, 2019, p. 14)

Record is a structure within a table that represents a specific, unique instance of a table subject. It consists of all fields in the table, regardless of whether the fields contain values. (Hernandez, 2002, p. 42) For example, a single stock move is a record in the **Stock moves** -table.

View is a pseudo-table consisting of fields from one or more data or confirmation tables. A view is considered pseudo-table because it does not store data itself but derives its information from the tables on which it is based. (Hernandez, 2002, p. 43)

A view provides a mechanism to process data from two or more tables simultaneously. It does not store data, so only its structure is stored in the database, and the view is recreated each time it is used, and they convey up-to-date information. They can be tailored to the needs of a specific person or group. For example, they can provide information for a specific report or a way to view a specific information that is common to several departments in an organisation. For this reason, they can also be used for security and confidentiality purposes. A particular user of group of users can be restricted to see only certain fields from the tables on which the view is based. (Hernandez, 2002, p. 360)

2.5.3 Connection related terms

A connection between two tables is known as a relation. A relation exists when two tables are connected by a master key and a reference key or linked together by a third table. A relation helps to reduce redundancy and duplication of data. (Hernandez, 2002, p. 46)

There are three types of relations between two tables: one-to-one, one-to-many and many-to-many.

One-to-one relation between two tables is defined if a single record in the first table is related to one and only one record in the second table, and a single record in the second table is related to one and only one record in the first table. (Hernandez, 2002, p. 276) This is depicted in figure 5.

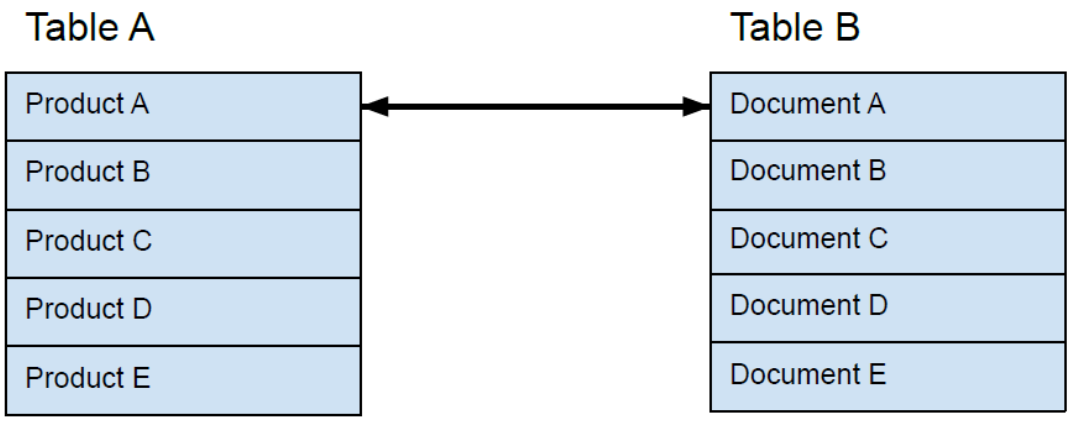

Figure 5. A general example of one-to-one relation. (Hernandez, 2002, p. 276)

One-to-many relation is defined as a connection where a single record in the first table can be related to one or more records in the second table, but a single record in the second table can only be related to one record in the first table. Figures 6 and 7 describe this relation. (Hernandez, 2002, p. 277)

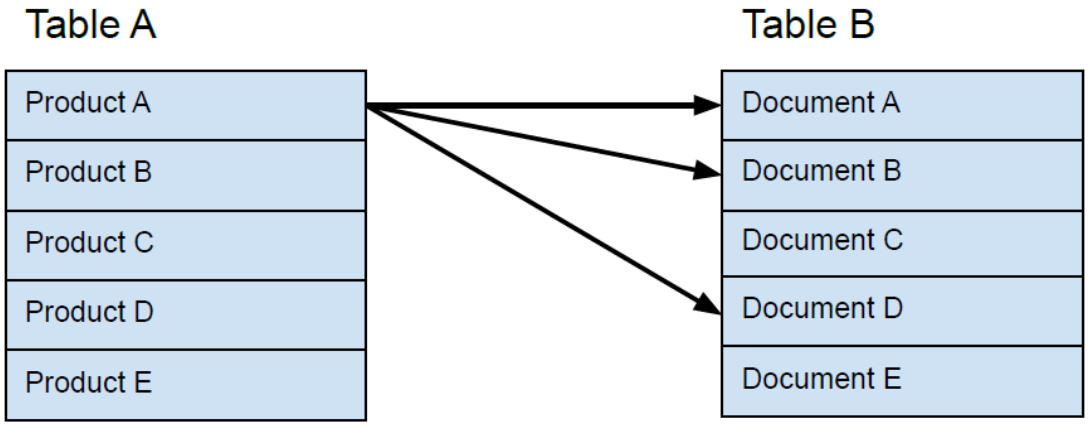

Figure 6. One-to-many relation from Table A record A's perspective. (Hernandez, 2002, p. 278)

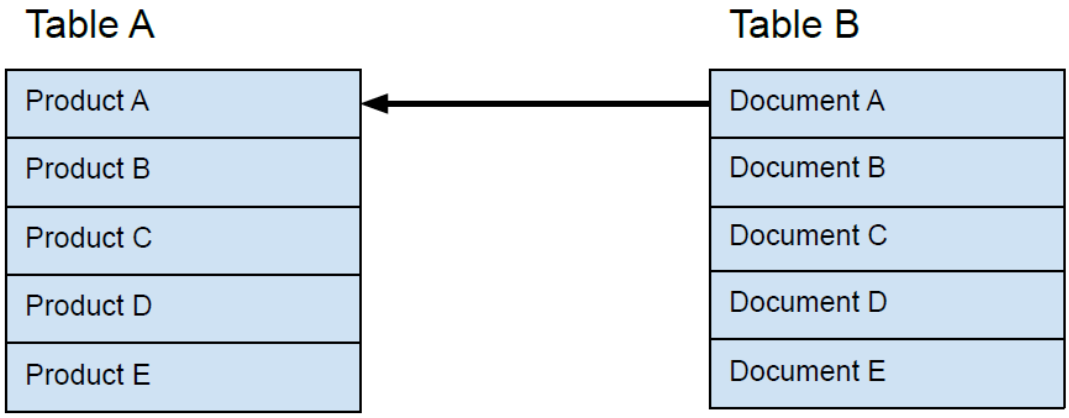

Figure 7. One-to-many relation from Table B record A's perspective. (Hernandez, 2002, p. 278)

There is a one-to-many relation between Table A and Table B, since a single record in Table A can relate to one or more (but not necessarily all) records in Table B, and a single record in Table B can relate to only one record in Table A. (Hernandez, 2002, p. 277)

This is the most common and easily identifiable relation between the two tables. (Hernandez, 2002, p. 277)

Many-to-many relation exists between two tables if a single record in the first table can relate to one or more records in the second table and a single record in the second table can relate to one or more records in the first table. This relation is illustrated in figures 8 and 9.

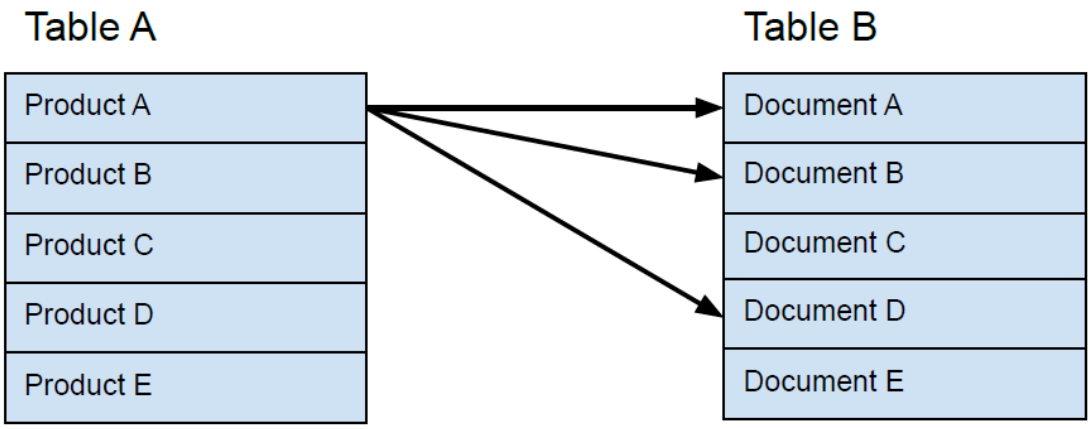

Figure 8. Many-to-many relation from Table A record A's perspective. (Hernandez, 2002, p. 279)

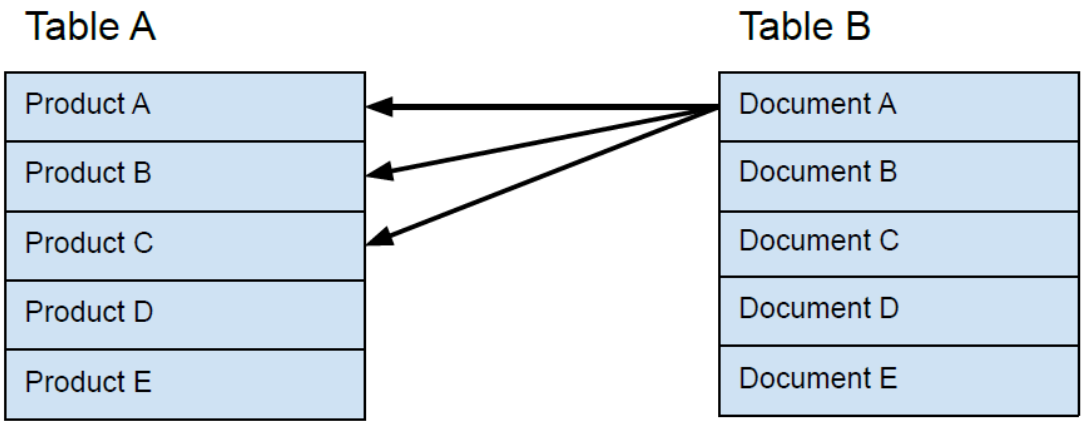

Figure 9. Many-to-many relation from Table B record A's perspective. (Hernandez, 2002, p. 279)

There is a many-to-many relation between these tables because a single record in Table A can be associated with one or more records in Table B (but not necessarily all of them) and a single record in Table B can be associated with one or more records in Table A (but not necessarily all of them). (Hernandez, 2002, p. 279)

2.6 ERP system implementation

ERP systems are designed to address information fragmentation and problems related to it. Crossing organizational boundaries and integrating internal processes are involved in implementing this type of system, and therefore it will be complex and difficult to get right. Moving everyone to a single, integrated system can be potentially unpopular. It is likely that each existing function has its own set of processes and a well-understood system that has been designed for its specific needs. ERP asks almost everyone to change how they do their jobs, and few people like change. (Slack, et al., 2010, p. 415)

Vilpola & Kouri (2006, p. 75) divide an ERP project roughly into three phases: selection, implementation and operation. The risks of all three phases should be considered at the beginning of the project. Considering the risks of deployment and operation provides better opportunities for successful selection. When choosing a system, critical requirements are set that cannot be easily and cheaply changed in the future.

Large scale and complexity of ERP systems mean that few companies use all the features and functions included. Due to the challenges in the initial implementation and

deployment, the scope of these is often limited to the most necessary features for the operation of the company. Once the implementation is complete and the system runs smoothly, ERP system is often continued to be updated and expanded from the original. (Monk & Wagner, 2013, p. 204) It is important that a clear statement of scope of the project must be included in the overall implementation as scope creep is a very common phenomenon in ERP implementation. The implementation project can easily spiral out of control as the implementation team becomes more familiar with the software tool and begins to see the application for other functionalities within the company that were not originally in the project scope. For this reason, the in scope and out of scope modules and business processes of the implementation should be defined. (Ptak & Schragenheim, 2004, p. 329)

According to Vilpola & Kouri (2006, p. 77), the implementation process of an ERP system involves the greatest risks in terms of quantity. The most significant risks are related to change management. The change needs to be communicated clearly and in a timely manner so that people have time to adjust to a new idea. Leadership and the commitment of staff to a new operating model are key challenges in an ERP implementation project. The role of the project team and the manager are critical, as is training and guidance for different staff groups. The following risks have been listed by Vilpola & Kouri (2006, p. 78) as the most likely and with the worst effects related to the implementation of the ERP system: No change in the management model and the leadership required for it, insufficient commitment from staff or that orientation towards using the system is not sufficiently supported, cost increase compared to initial estimates, the implementation of the required information in the system is not successful, and that performing other tasks takes time from the ERP project and it is not possible to invest in it as desired. Monk & Wagner (2006, pp. 40-41) list similar issues: Not enough time taken by executives and IT managers for a proper analysis during the planning and implementation phase, skimping on employee education and training, not enough commitment from executives and inefficient management of change for users of the new system.

2.6.1 Factors in successful implementation

Managing critical success factors to increase the chances of a successful implementation is one of the key issues in ERP implementation. Many success factors could be appropriate for any kind of complex implementation, and ERP implementation practice

is very similar to other complicated or sensitive implementations. What sets ERP implementation apart is that it is enterprise-wide, and therefore there will be different stakeholders, each with their own concerns, to consider. Prospect of good system performance is achieved by effectively addressing all relevant groups and their concerns. (Slack, et al., 2010, pp. 415-416)

2.6.2 Common issues in implementation

Purchasing an ERP system cannot be viewed as a necessary evil and then be delegated to lower-level personnel. Management support may be assessed as a small risk in terms of probability, but in practice the situation may be different. Genuine management support and commitment is a prerequisite for a successful project. When difficult times arise in the implementation process, resources and motivation must be provided by the top management. Lack of active participation and support from top management will ensure failure of the implementation. (Ptak & Schragenheim, 2004, p. 346; Vilpola & Kouri, 2006, pp. 76) Slack et. al (2004, p. 417) point out that both time and effort to implement, and total cost, is likely to be underestimated.

The most significant risks are related to change management. The change needs to be communicated clearly and in a timely manner so that people have time to adjust to a new idea. Leadership and the commitment of staff to a new operating model are key challenges in an ERP implementation project. The role of the project team and the manager are critical, as is training and guidance for different staff groups. The implementation will face problems if an ERP system's integrated approach as a tool is not properly understood. A common understanding of an integrated system, how it works, and why it will make a difference for the company is part of the education. (Vilpola & Kouri, 2006, p. 77; Ptak & Schragenheim, 2004, p. 349) One of the biggest failure points for ERP implementations is that the need for change management is recognized too late and the changes required are underestimated. (Slack, et al., 2010, p. 417)

Consultants can provide insight and experience to the implementation and are a valuable resource in a successful implementation. However, hiring outside people to do the implementation may lead to it not fitting the specific needs of the company. This also makes change management more difficult and will be met with resistance by the people who must change their procedures without understanding how the changes fit their needs. (Ptak & Schragenheim, 2004, p. 347)

Almost every implementation requires outside expertise and guidance. A knowledgeable outsider can save far more expense than a cost saving measure trying to implement an ERP system without any outside help. (Ptak & Schragenheim, 2004, p. 349) It is typical that the level of outside expertise required will be more than anticipated. (Slack, et al., 2010, p. 417)

Critical data elements include item masters, on hand balances, BOMs, customer demand, work orders and purchase orders. If this data is inadequate, information provided by the system is inaccurate (Ptak & Schragenheim, 2004, p. 347). Data accuracy is discussed in more detail in chapter 2.3.4.

Certain costs are more commonly overlooked or underestimated. Training is often underestimated, and training expenses are high because workers must learn a new set of processes in addition to a new software interface. ERP integration is recommended to be done from a process-oriented perspective, and testing is to be run using a real data through the system, instead of dummy data. Data migration needs to be done and it may cost money to move corporate information, such as customer and supplier records, and product design data from old systems to new ERP system. (Stevenson, 2002, p. 666)

2.7 Synthesis of theory

To answer the research question 1 of what should be taken into consideration for implementation of an ERP system, it can be concluded that ERP system implementation is a difficult and risky project for any company. ERP has the potential to be a powerful tool in managing company's processes and operation when implemented properly. However, ERP systems can be vast and complicated pieces of software, since they integrate different aspects of a company under one system. Sufficient resources need to be allocated to an ERP project in order to minimize the chance of failed implementation process. Resources in this context mean personnel, time, and money. The ERP project must have the support and backing of the company's management if and when difficult situations are encountered during the project. Getting to know the ERP system requires studying, planning and time. Unexpected challenges and difficulties may be encountered during ERP implementation, and it is good to be prepared for these by making a realistic schedule for the project. A realistic schedule for deployment can be created if the scope of ERP implementation can be defined early enough.

It is not enough that an ERP system is implemented and at a stage where it is up and running. ERP system needs to provide value for its users. Users need to know how to use the system, and the system needs to have accurate information that the users can trust and use.

3 EMPIRICAL STUDY

In this section the activities of the target company and how they should be centralised under a single ERP system are discussed. Old product data management system and its limitations will be studied. The ERP system will be studied in order to outline the need for possible customization or if review of target company's processes is needed. This is followed by an analysis of the system and its functions. Functions that are to be introduced into the ERP system at the initial implementation, the development ideas that were implemented and why these solutions were chosen are also discussed. Procedures used for allowing a smoother migration from one system to another are explained.

3.1 Current state of processes

The current state analysis focused on outlining the company's operations and their dependency on the old product information system. At the same time, the operations that would preferably be able to be performed in the ERP system were mapped. This made it possible to limit the scope of the modules to be implemented in the ERP system, as well as to estimate the implementation schedule.

It is important to identify the core functions that need to work in the new system from the time of implementation. Functions that are desired but not essential can be implemented into the system in the future due to the modular nature of the ERP system.

3.2 Core functionalities of Noptel Access database

Following functions are available in the old Access system. These functions, such as product data management and recording purchase transactions, are essential for the company's operations.

3.2.1 Product data management

Noptel Access database contains information from every product in production or in R&D. This includes, but is not limited to, parts, bills of materials, documentation, and related version management.

At Noptel versions refer to the different manifestations of products, software and their documents made by product development. A new version usually causes the old version to be phased out, although different versions may be in use at the same time during the transition phase.

All available products can be found and selected for viewing from a list of products. The bill of materials and documentation related to the product are viewed separately. In both views, an indented list is used to view all the subassemblies of the product in question. Selecting a subassembly will display a list of components related to the assembly. In this view assemblies, components and related documents can be edited.

Products and/or components have a few defining and describing attributes. **Product code** is a five-digit unique identifier for each component. **Value/Dnum** is document number for drawing parts (more on this in section 3.2.2 Document management), and an additional information field for other parts. **Material** refers to the material or coating of a component.

3.2.2 Document management

Products have their attribute and feature fields defined on their respective records. This is the information that is important for the system. Product, part or assembly can have different types of documents that describe and define the part in more detail. Different types of documents may include assembly and part drawings, schematics, production and manufacturing instructions, specifications, or marketing related documents. Ideally it should be easy to create, find, assign, and use documents related to a product or a part.

In Odoo the documents module is used to manage and store the data table containing the record of each document. A document has following properties, or fields, that give information about the document:

Document number is the unique identifier of the document. Two different documents cannot have the same document number. The template for document number is AXXXXXB, where A is type, X is five-digit numerical sequence and B is version of the document.

Type of document is determined by the subject matter of the document. For example, a document may be a manufacturing instruction, an assembly drawing or a specification report. The type identifier is a letter A to X.

Numerical sequence of the document is a five-digit sequential number. Each new document is assigned a new sequential number. In the case of document describing a part, the same numerical sequence may be used if a part contains several documents of different document types.

Version indicates which iteration of the document is in progress. The version changes when changes need to be made to the document. Version identifier is a letter A to X, or AE to XE for English documents.

3.2.3 Purchase orders and product receipt

The purchase order system allows purchasing products or services and record them as received. In addition, the purchase order system can be used to generate a purchase order to be sent to suppliers in PDF format. Receipt inspection and related instructions can also be found in the Noptel Access database.

3.2.4 Minimum manufacturing value calculation

Minimum manufacturing value calculation is used to estimate the manufacturing cost of a product. It is especially useful for products that are in R&D phase. Products in R&D often include new components that haven't been purchased in bulk before. Experienced designers are able to estimate the cost of different manufacturing quantities with sufficient accuracy. When a product contains several such components, a good estimate of the manufacturing and material costs of the product is obtained before the product enters production.

3.3 Desired functionalities

Inventory management was one of the main reasons to move away from the old system, as it lacked the tools to keep track of inventory in real time. The inventory module and its operation were thoroughly studied in order to determine the necessary operations that need to be recorded in the ERP system in order to keep the stock levels in the system true

to the actual situation. Every stock move must be recorded, and product information must be up to date to ensure the information provided by the system is correct.

Stock moves include, but are not limited to, receiving, delivering, manufacturing, and scrapping of products.

Purchasing a product will result in the receipt of the product, and this will increase the amount of goods in stock. In ERP, purchase order automatically generates a receipt, which must be recorded as completed when the goods arrive at the warehouse.

Deliveries of goods reduce the amount of goods in stock. Sales order automatically generates a delivery, which must be recorded as completed when the goods leave the warehouse.

Manufacturing of products transform components into a finished product, assembly, or subassembly. This reduces the number of components and sub-assemblies and increases the number of finished products and assemblies in stock. The number of consumed components and subassemblies is determined by the product parts list, bill of materials. The completion of manufacturing orders can be recorded depending on the level of detail needed: recording the completion of finished products or recording the completion of every subassembly. In the initial phase of the implementation, the recording of manufacturing orders set to be introduced by recording only the completion of finished products.

3.4 Studying the new ERP system

The target company had chosen Odoo ERP in its ERP selection phase. The selection process took place before the start of the thesis.

A general introduction to the functions of the new ERP system has been made during the ERP selection phase, but before the scope of the implementation of ERP can be fully defined, ERP system needs to be studied in depth. It is important to understand such as how the different functions are related to each other, how the system's database works, and what changes can be made to the system and on what timescale. Good understanding of the way the ERP system works will help to define the scope and schedule of the implementation.

In Odoo ERP, different functions take place in different modules. Odoo ERP is open source and is developed by Belgium-based Odoo S. A., and they offer a wide range of their own modules for the ERP system. Odoo's official app store also offers paid and free third-party applications and customizations. In practice, determining the scope of the implementation means deciding which modules to select for the deployment. In figure 10, the modularity of the new ERP system is illustrated.

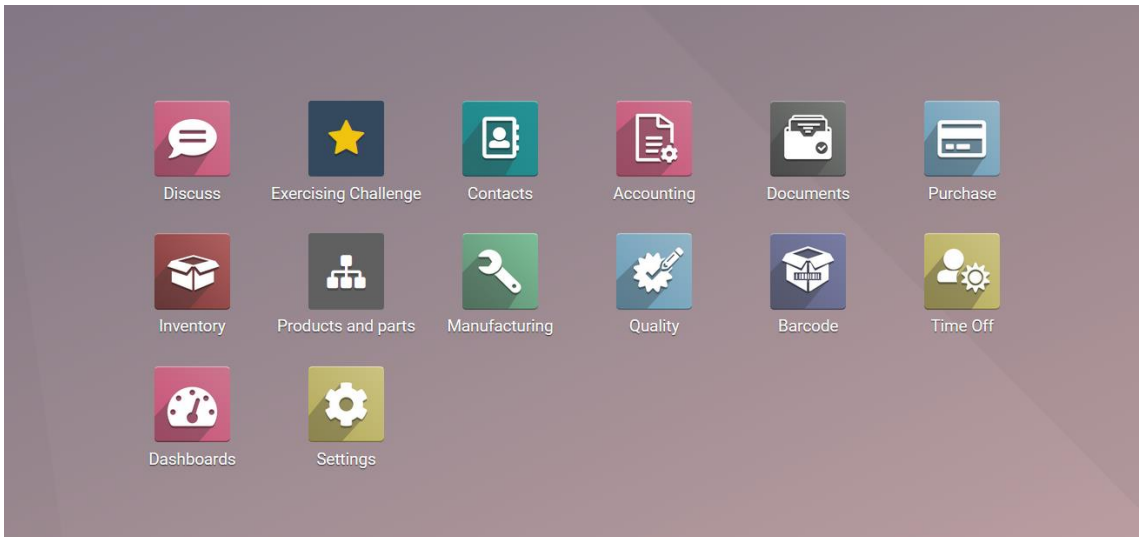

Figure 10. Different ERP system modules accessible from the main menu.

Two databases will be set up to test functions and customizations: production and test database. The test database acts as a sandbox where it is safe to test changes without fear of the production database facing problems. This also allows new processes to be tested and functions to be exercised before they are put into production. Before deployment of the ERP system, this does not matter so much, but once the production database is online, it is important to be able to test new features securely off-site from the production database.

3.5 Defining scope and identifying need for customizations and changes

The operation of the two different systems and databases may differ greatly in some respects. Occasionally data can be transferred directly between the two databases without the need to make any changes to the new system. In other cases, more thought may need to be given to customization.

Another issue that may need to be considered beyond just transfer of data is the transfer or implementation of operations and functionality into the new system. The creation, modification or deletion of data may differ to varying degrees between two systems, depending on the subject. Some functionality may be only found by default in the old system. On the other hand, there may be different ways of doing something in the new system that is used to being done in a certain way in the old system. Often the same operations are found in both systems, but the different user interface will cause differences in the usability itself.

One thing that must be given thought, case-by-case basis, is whether the new system needs to conform to a particular feature of the old system at all. Familiarity may make it easier to adopt a new system, but the way of doing things may have been more a limitation of the old system that users have learned to live with than the optimal way of operation.

The modules chosen to be implemented at the initial implementation are Documents, Purchasing, Inventory management, Manufacturing and Quality. Some of these modules require additional modules to be installed, such as Accounting and Contacts modules. In addition to these, modules such as maintenance and repairs were considered, their implementation was decided to be left to a later stage.

3.6 Data import

To be able to transfer all the relevant data between databases, the new database must have fields corresponding to the old system. For each record type, there are several fields describing the record. Many of these fields are found in Odoo by default, but some fields are exclusive to Noptel's Access database. Missing and/or needed fields must be created in the Odoo database.

The information transferred between databases includes product information, document information and contact details. The product information also includes stock balances, which are calculated and entered into the system in the year-end inventory.

3.6.1 Documents

The document files themselves, whether a pdf, word, excel, or a design software file, are located on a local storage drive system. The database therefore does not contain these files, but links, through which documents can be opened.

In this sense documents behave like any other record in the old database. A document has fields that have been assigned values that reflect a property of the document. This means that exporting data to the new database is reasonably straightforward. Care must be taken to ensure that the same fields exist in the document as in the old system, and that the corresponding fields to be imported are selected carefully.

3.6.2 Existing fields

Below is an explanation of the most relevant fields relating to a document were imported from the old database.

Document number. Consists of type, sequence and version as follows: DNNNNNX, where D = Type, N = sequence and X = version number.

Document type. The first letter of the document number is the document type identifier. The type can be selected from a predefined list consisting of accepted document types in Noptel.

Sequence. A sequential number between 50000 and 89999.

Version. A letter from A to X, or AE to XE for English documents.

Description. Document title or a short description of the content of the document.

Date (created). Date on which the record was created in the database.

Author. The author or creator of the document.

Reviewer.

Date (published). The date which the document is approved and published.

State. Status of a document in draft, drafted, under review, approved or archived.

Directory. Indicates the location of the document file on the local storage.

File. Name and extension of the document file.

3.6.3 Newly created fields

Not all fields were exported from Access database as they were. Some changes were made to the fields in Odoo to make it easier to manage the information and associated functionality of the records.

URL. This field was associated to a document by default in Odoo, so the Access database fields **Directory** and **File** were combined into one and imported into this field.

Filename extension. A new field **Filename extension** was created to able to see at a glance which program is needed to open a certain document. **Filename extension** -field is formatted from the **URL** -field**.**

Product ids. This many-to-many relational field was created between documents and products. This was done to be able to assign relevant documents to products and vice versa. Many-to-many field is required in this instance because a document can belong to one or more products, and a product can belong to one or more documents. For example, from document's perspective, a document named "Lens gluing instructions" is useful for all products that require lenses to be glued in place, meaning this document must be able to relate to a lot of products. From product's perspective, a lot of different documents must be able to be related to a it, such as a part drawing or a manufacturing instruction.

3.6.4 Products, parts, and parts lists

All items from the parts lists of active products were imported into the ERP database.

Name. Name of a product.

Product code. A unique sequential code given to every part in the database at the point of creation.

Value. Provides additional information about the part, such as size, type or document/drawing number.

Material. Used for parts where material is essential information.

Part lists for products could have been imported the same way as other imported data. However, a decision was taken not to import the part lists. There were two main reasons for this: training users for the new system and ensuring the accuracy of the data in the old system. Part lists for some products are large and can contain tens or hundreds of parts. Compiling these part lists is good exercise for using the new system. At the same time, users responsible of the products can check that the part lists coming into the new system correspond the current situation.

3.6.5 Relations between products and documents

A product can have multiple related documents. A document can also relate to many different products. Therefore, a many-to-many relation was created between products and documents. This relationship worked differently in the old system, and it was not possible to be imported. A simple logic was created in the ERP system to aid making these relations a little easier for the users once all products and documents were imported.

3.6.6 Stock balance

The annual stock count was carried out at the end of the year. On this basis, a starting value was entered for each item to be inventoried. Items that are not needed to be inventoried, for example because they are easily available or difficult to count, are marked as consumables in the system. This means that inventory tracking is not activated for these items. However, this can be changed in the future if necessary.

3.7 Deployment

At the beginning of the project, deployment was planned for the end of the summer, but it was soon realized that it was not a realistic time frame. A decision was made to postpone the deployment so that it would take place by the end of the year. There were several factors influencing the decision.

Deployment of ERP system was planned to be done in two steps. At the start of December of 2021, the current product information and documentation was to be transferred to the new system. This includes products, their parts lists and all documentation relating to these and the company's operations. Product information and documentation are at the core of the company's operations, and users were able to start transitioning to the new system. Warehousing operations and purchase order system are planned to be introduced at the end of the year to coincide with the annual inventory count. This will let users start interacting and getting more familiar with the system. This will also give time for the project team to fix and improve usability on some potential unforeseen issues.

Old system was left available as a back-up archive in case of a critical malfunctioning event. However, updating data in the old system was disabled.

When the ERP goes live, it is important that the information provided by the system is up-to-date and keeps that way. This is done to allow for smoother deployment experience and to build trust and confidence in users using the new system. In order to ensure the accuracy of the information obtained from the system, the following aspects have been taken into account.

3.7.1 User involvement and training

Users in the planning and development of ERP deployment received training and expertise throughout the deployment project. Efforts made to consult and involve all users in the development of the ERP system in their area of the company's processes. Especially important was to train users outside of the ERP project team, so that all users are ready to use the new system efficiently when the transition from old system to the new is made official.

Users were trained collectively and individually to use the new system. At the beginning of the project, a meeting was held for all the personnel of the company to explain the ERP system in general and the reasons for the transition to the new system. Once the scope of the implementation had been clarified, a general presentation on the ERP system and its features was held for the staff, where topics such as user interface, modularity and general usage of the system were demonstrated. In addition, several in-depth training sessions were held and targeted at specific groups, such as buyers, mechanical designers and production workers.

3.7.2 Ensuring data accuracy

When the ERP goes live, it is important that the information provided by the system is up-to-date and keeps that way. This is done to allow for smoother deployment experience and to build trust and confidence in users using the new system. In order to ensure the accuracy of the information obtained from the system, the following aspects have been considered.

Purchase orders and receipts need to be recorded in a timely manner. Same goes for sales orders and deliveries**.**

Product and document management. Document management had to be significantly customized to fit the company's operations. The way the ERP system handled documents by default was too different and limiting compared to the old document management system. However, the change of system provided an opportunity to implement an already planned change to the document management and sorting system. During the import process the documents were sorted and named as necessary according to the revised document management rules.

Stock balance. One of the reasons to schedule the deployment of ERP at the turn of the year was the annual inventory count. This will ensure the stock balances are correct when the system's inventory functions are implemented and ready to use.

Bills of materials for manufactured products. Manufacturing orders use components based on the products' bills of materials. During the transition phase in December, every product in manufacturing and their bill of materials was checked and corrected as necessary. There are a lot of products and parts lists, and this served at the same time as a good exercise in managing product information in the new system for the users involved.

In Odoo ERP, all operations in the Inventory module are stock moves between locations. Locations can either be physical, virtual or partner locations. Physical locations are where products, components, consumables, material or equipment and spare parts are stored. Virtual locations are used to adjust and keep the inventory data up to date. When a manufacturing order for an assembled product is completed, a stock move of all the components listed in the product's BOM is made from the warehouse into the production

lot, a virtual location, consuming the materials or the work order. Then, another stock move is made from production lot to a physical location in a warehouse, returning an assembled product. The ERP uses the same principle for all the operations that affect inventory, which include but are not limited to, manual inventory adjustments, receipts, and deliveries. Recording all storage operations in the system is vital for the accuracy of the data presented by the system.

Initially, inventory transactions and related balanced are monitored manually to detect any errors in a timely manner. Incorrect data can then be corrected as necessary. In such cases, care must be taken to correct any issues related to the incorrect information.

3.7.3 Access rights

Access rights are defined at user group level. A user belongs to a user group, and the scope of access rights for a user group is defined on a per-module basis. Users were then assigned to groups based on their role in the company. The user groups consist mainly of read, write and admin user rights. Read-access allows user to see data and write-access allows user to modify data. Admin-access allows user to configure settings and functionalities in the system. Only the members of the project team who were most involved in the development of the ERP and who have the best overall understanding of the various functions and settings of the ERP system were given administrator-level access rights. Rest of the access rights for groups, such as buyers, mechanical designers and production workers, were created and defined based on target groups within the company. Access rights help securing the system by restricting the information individual users have access to. This can also be used to reduce the amount of unnecessary information displayed for users that do not need it.

3.8 Synthesis of empirical study

This section answers research question 2: How to define scope and schedule for an ERP implementation?

In order to determine the scope and schedule of the implementation process, it is necessary to identify what the company needs and wants from the system. In an implementation, the appropriate scope of deployment can depend on a number of factors. It must be possible to define the need for the functions used by the company. In the case

of this work, it has been possible to determine the need on the basis of what functions need to be transferred from the former system that is being decommissioned, and what new functions need to be ready in the new ERP system at the moment of deployment. The scope of the system to be deployed is influenced by the modularity of the system, i.e., which parts of the system can be left out if they are not needed or necessary.

Defining the implementation schedule is linked to defining the scope of the implementation. In the early stages of a project, it can be very difficult to define or even estimate the overall project schedule, as it takes time to define the scope of the implementation, but the defined scope will also affect the schedule. For this reason, it is advisable to allow sufficient time for the project in the early stages of an ERP project. As the project team becomes accustomed to the new system as the ERP project progresses, it becomes possible to define the scope and hence the schedule more precisely. In addition to the implementation of the ERP software and getting the functions and processes working, the project schedule should include important ERP project support activities such as training users, defining user access rights, data import between databases, and ensuring the accuracy of the data migrated to the ERP system.

4 RESULTS AND CONCLUSIONS

The acquisition and selection phase of the ERP system had started at the end of 2020. At this point, the company did not have a resource to commit full-time on ERP implementation. A thesis worker was hired for this purpose. At the beginning of the thesis in February 2021, the ERP system had already been selected and the groundwork of getting to know the system had begun. Implementing an ERP system requires a lot of studying, time and planning. At the beginning of the year, the implementation was planned for August, but it was realized early on that this was not a realistic timeframe, and the deployment was rescheduled for the end of 2021, which was successfully reached. A critical factor for the success of the implementation project was that sufficient resources had been allocated to the project.

4.1 Observations of the implementation process

Many issues posed challenges in the implementation of ERP. Particularly time-consuming was the implementation of processes in which the default method provided by the ERP system differed significantly from the old way of operating. Solving such problems required deeper study for possible customization of ERP system functions and review of the company's own processes. Although time-consuming, these methods helped to find suitable solutions to the problems.

Consultancy service proved to be important particularly in the early stages of the project. Consultants may have ready-made solutions especially to the generic problems encountered in the implementation of ERP. If these solutions couldn't be used as such, they often provided tools and ideas for solving the company's specific problem.

The importance of user training was perceived as very important. User training significantly speeds up the use of the system. At the same time, a few points were noted about the views of the system used by users. The views should be designed in such a way that they contain as little as possible unnecessary information for the user, such as buttons or fields containing information about a record. Minimizing unnecessary information will improve the clarity of the views and will speed up the learning process. This was sometimes overlooked by the project management team who developed the system, since

they were already so familiar with the system that they were not distracted by the extra information. This is a matter that can be configured by view design and user access rights.

4.2 Impact of the implementation on the company's operations

The month-long deployment phase proved to be particularly important for deployment, as users had access to ERP functions for a month before deploying inventory functions. In a management review meeting, it was stated that the implementation process had little disruption on operational activities. Low disruption was achieved through adequate user training in the use of the new system and user involvement in the implementation process. In case of any problems, the project team was quickly available.

During the initial phase of the deployment, varying observations were made in different areas of the company. Clarity was gained especially in retrieving documents. All the documents that are important for the company's operations can now be found and managed in ERP system's document management module. The module also includes a powerful search function. This is major improvement compared to the old system, where a user needed to know the location of a document in the folder hierarchy in order to find it.

After deployment, the project team encountered some planned and unplanned work. These were mainly related to advising and training users, when they faced problems using the new system. This could have been avoided by holding more training sessions prior to deployment. On the other hand, it can be difficult to go through every special situation encountered in system during training, and situational advice was found to be an effective way of resolving problems. In addition, some unplanned system operation was encountered. This could have been avoided by a more detailed understanding of specific functions that were implemented. However, unplanned system operation was rare and could be resolved before it became a hindrance to operational activities.

4.3 Conclusions

This study is likely to be more useful to the target company than to the academic audience, due to the case-style nature of the study and generalizing the conclusions may be challenging. However, the results of the study are in line with theory. The study was used

to identify the important factors in ERP implementation, and this helped to define the scope and timeline for ERP deployment. In practice, the ERP implementation process can vary quite a lot between different companies and the organization of the company has an impact on the progress of the implementation project. This in turn can influence conducting a similar study. Examining the functions of the old and new systems and how they fit into the company's way of operating provided information relevant to the study in order to make company-specific deployment plans.

The results of this study can be used to further develop the ERP and the company's processes. The plan is to continue to develop the ERP system to integrate more of the company's processes into the ERP. For example, service and warranty, sales, quality inspections, and product tracking is still done separately from the ERP. These activities were deliberately excluded to limit the scope of the initial deployment, and these will be essential areas for further development.

4.4 Proposals for further action

The aim is to further develop production control and planning operations. The deployed version introduces users to recording and completing work orders in a simplified way, while providing important functions for inventory management and keeping real time stock in check. The system shows the current inventory situation and forecast for each part, based on forecasted arrivals and departures of goods. However, the stock situation for the parts must still be monitored manually, as no alarms have been set for minimum stock limits for the goods in stock.

To support the users of the ERP in the future, further work is needed on the development of instructions for the different functions. The instructions for using the ERP have been prepared for the most important and common functions, but for many functions the instructions are still in work-in-progress stage or incomplete. In particular, the documentation related to the development and administrator functions is partly undocumented and depends on the expertise of the current project team.

The company aims to implement a PDM system for SolidWorks 3D CAD design software used by mechanical designers. This could enable better integration between the design software and the ERP, where product data does not have to be created manually again in

the ERP after designing a part in the design software. Based on this thesis work, project team engagement, the use of consultancy, user training and change management will play a major role in the success of this project.

As users' skills in the new system improve over time, the focus of user feedback will change. Changes to usability will be made accordingly based on user feedback.

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