Establishing the "Microsoft Dynamics NAV" ERP System at the Vexcel Imaging Corporation.

Diplomarbeit

von

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Statutory Declaration

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

Date

Signature

“Good reasons must of force give place to better.”

“Gute Gründe müssen den besseren weichen.“

William Shakespeare

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Zusammenfassung

Diese Arbeit dokumentiert alle Geschäftsprozesse der Vexcel Imaging GmbH welche die Warenwirtschaft betreffen. Darüber hinaus wird das Format von BOM Listen und Artikellisten definiert und deren Import in das Microsoft Dynamics NAV System beschrieben. Die Konfiguration der Baugruppen jeder Kamera wird in Struktogrammen bestimmt und festgehalten.

Die Arbeit stellt die Firma Vexcel vor und erklärt die Notwendigkeit der Dokumentation der Warenwirtschaftsprozesse und weshalb ein ERP System implementiert werden musste.
Alle Warenwirtschaftsprozesse von Vexcel, Struktogramme und Informationen welche das Microsoft Dynamics NAV ERP System betreffen werden in der Arbeit aufgezeigt.

Die gebräuchlichsten graphische Notationen zur Darstellung von Geschäftsprozessen werden miteinander verglichen und deren Pros und Contras zusammengefasst.

Abstract

This thesis documents all business processes regarding enterprise resource planning within the Vexcel Imaging GmbH. Furthermore, the format of BOM lists and article lists is defined and their import into the Microsoft Dynamics NAV ERP software is described.
The assembly configuration for each camera is identified and recorded in structure charts.

The thesis introduces the company Vexcel. It explains the necessity of the ERP process documentation and why an ERP system had to be implemented.
All ERP processes of Vexcel, structure charts and information regarding the Microsoft Dynamics NAV ERP system are highlighted in the thesis.

The most used graphical notations to describe business processes are compared with each other and their Pros and Cons are summarized.

Table of Contents

1 Introduction

This Chapter introduces the master thesis and the Vexcel Imaging GmbH – where the practical part of this thesis was made, states the objectives of Vexcel and explains how they planned to achieve them.

1.1 Introduction to the Vexcel Imaging Corporation

Vexcel is a company with its Headquarters in Boulder, Colorado, U.S.A. and was founded there in 1985 by Mr. Franz Leberl. At this time, Vexcel focused on Radar Image Processing, Close Range Photogrammetry, Terrain Information Engineering, Image Processing and Computer Graphics. In 1991 they developed the VX3000, a photogrammetric scanner, which could calibrate itself and was a piece of innovative technology at this time.
In 1992 Mr. Franz Leberl went to Graz to take a professorship at the Graz University of Technology and in the same year he also founded the Vexcel Imaging GmbH in Graz.
The Vexcel Imaging GmbH was founded because of the upcoming need of the industry to have these pictures in a digital format and not only on photo paper. They developed a huge scanner that is able to scan in pictures taken from an aircraft so that these pictures could be stored digitally (Gruber, 2009).

At this time, analog technology was still the current standard used for aerial photography. This made the photos very expensive and required a more expensive type of film or negatives. Furthermore, this film had a special format so that they could take photos from huge areas of the earth at once. So after taking the photographs the film had to be developed, like any other camera film. The only difference was that the pictures that were taken from an aircraft were much bigger than normal ones (Gruber, 2009).

The first achievements of the company came by selling these scanners and by offering a service to scan in pictures taken from an aircraft. The scanner became a total success on the market (Gruber, 2009).

In 2003 the Vexcel Corporation and Vexcel Imaging GmbH merged together.
In these days digital camera technology became more and more important and ousted analog technology from the market. This soon would change the whole core business of Vexcel. They developed their first digital camera that could be installed and used in airplanes, the “Ultracam-D”. It was introduced to the photogrammetry market in 2004, also with having a big impact on it. Over time there were more cameras sold than scanners. Scanners had become more and more obsolete because they were related to higher costs. The advantage was clear: Digital technology did not need camera films. A digital picture cost a fraction of an analog one. (Ponticelli, 2009).

There was an ever growing demand geographical/geospatial data on the market. Therefore, the Microsoft Management decided to invest in the Geo-data/photogrammetry sector. They decided to strategically buy Vexcel in 2006 (Ponticelli, 2009).

Since then several cameras were planned and developed by Vexcel.
Ultracam –G, -L, -X, -Xp, -Xpwa all were followers of the first model, not to mention that prototypes are constantly planned and constructed (Ponticelli, 2009).

Vexcel plans the cameras, tests them and constructs them with CAD software.
The production of a camera is completely outsourced and done by the company WILD in Völkermarkt, Austria. Vexcel orders cameras made after their plans and WILD assembles everything together (Ponticelli, 2009).

1.2 Goals of the company

Vexcel wants to get ISO 9001:2008 certified in the near future. Additionally, they want to establish the Microsoft Dynamics NAV ERP System in the company. Any business process from now on should work via this ERP software. To increase the quality of their products they sell, primarily digital aerial cameras, they want to be able to track all products and configurations they sell or repair (Gruber, 2009).

1.3 Scope of Analysis

Several meetings and interviews, particularly with people from the Operational Management section led to the designated outcome. Moreover, the scope includes the company “WILD” in Völkermarkt, which is responsible for the assembly of cameras after the plans from Vexcel and the company “ACP Solutions” in Graz, who is responsible for the technical implementation and the correctness of all functions within the Microsoft Dynamics NAV ERP system. Plenty of meetings were held with these companies to reach the designated objectives.

1.4 Objectives

According to Andreas Drumbl (2009) who is the head of the Manufacturing team of Vexcel and responsible for Enterprise resource planning within the company, the objectives of the thesis are to:

1.) Define and document all processes regarding ERP, ISO 9001:2008 compatible.
2.) Import lists of articles into the Microsoft Dynamics NAV ERP System.
3.) Import bills of material into the Microsoft Dynamics NAV ERP System.

To achieve these objectives, the following tasks have to be done:

- Conceive and compile all ERP processes (see Chapter 3):
    - Find out all processes regarding ERP.
    - Make a diagram of each of these processes.
    - Describe these processes in words.
- Conceive the structure for the camera types UCL, UCG, UCXp-wa and UCX and for each of these cameras (see Chapter 4.2):
    - Create a diagram of all main- and subcomponents.
    - Create a list of all parts of a camera that are installed in it (=article list).
    - Give all these parts a unique Vexcel internal ID number.

    - Put all these parts into the Microsoft Dynamics NAV ERP software with their unique ID.
    - Create a bill of material (BOM) list of a camera.
    - Make a list of all parts that need a serial number and establish a format for these numbers.
    - Define a number range for internal use and for external usage.
- Import created lists into the Microsoft Dynamics NAV ERP system (see Chapter 4.3.1):
    - Import article lists.
    - Import BOM lists.

2 Literature review

This Chapter contains fundamental parts of research for the thesis.
In the following sections, all relevant terms used in this thesis will be defined and then put into context. The definitions of different terms are kept to a minimum, so that the focus stays on the topic and the reader does not get the feeling of reading a dictionary.

2.1 Business processes (BP)

This Chapter defines the terms “business process” (BP) and “business process management” (BPM), and lists the modeling possibilities of BPs. It also gives a short overview of the origin of BP.

2.1.1 History of BP

The history of BP was developed in the 18th century, where Adam Smith analyzed the productivity of companies.

Smith (1776) examined the working processes of a pin manufacture. By observing these processes he found out that if a worker did only one task and brought the results of his task to the next responsible worker, it increased the product output by up to 24%.

After Adam Smith followed a period were business economics dealt mainly with the organizational structures of companies. Not till the 20th century did economic scientists care about what is made more so than how something is made.
Over time more and more voiced the importance of the processes for the company (Nordsieck, 1932). In the literature it is described as Process Orientation (PO) when a company focuses on BP instead of laying emphasis on functional and hierarchical structures (Reijers, 2006). A process-oriented organization tries to achieve the objectives of BPM (Kohlbacher, 2010).

The need of a process view of companies became more important in the 90s where many authors came up with a definition of BP.

2.1.2 Definition of a BP

According to Thomas H. Davenport (1993: 5), a BP "is a simply structured, measured set of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how work is done within an organization, in contrast to a product focus's emphasis on what. A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action".

Additionally Davenport (1993: 7) states that "taking a process approach implies adopting the customer's point of view. Processes are the structure by which an organization does what is necessary to produce value for its customers".

Hammer and Champy (1993: 38) defined a business process as "a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer".

To sum up the definitions of Davenport (1993: 7) and Hammer and Champy (1993: 38) in short, a BP is characterized by the following:

- A set of activities.
- Describes how work is done.
- Takes Input and creates output.
- Has a beginning and an end.
- Generates value to the customer.
- Implies adopting the customer's point of view.

Although, the definitions about BPs bring it to the point, but what is missing in all of the definitions is that business processes are always changing over time. The conditions of how the work is done within an organization changes over time. Products are built over a certain period of time one way and after a while, whether it`s caused by supply or demand, the

product evolves and is thereby produced in a different way. That leads to constant updating of already documented BP.

2.2 Business process modeling (BPMod)

There are many ways on how to model a BP and there is no clear consensus in the literature about which technique is best. All of them have their advantages and disadvantages. In fact, all techniques may be separated into two distinct ways of representation: textual and non-textual (graphical) representations. Nevertheless, graphical approaches are the best way to describe BPs because of the better overview and because changes can be made easier. There are no pure textual representations of BPs in the business world. They usually are used to give additional info to a graphical designed BP (Allweyer, 2008: 7).

BPMod is not a common term. It is actually called BPM in the literature. As this may lead to confusion with "business process management" which is abbreviated the same way, the term BPMod is used instead in this thesis.

BPMod is the first step in the BPM lifecycle and therefore the most important one (W. van der Aalst, 2003). If errors occur during the modeling phase, the error grows through all further phases of the BPM lifecycle.

Many graphical representations of BP are based on business process modeling languages (BPML), an XML based language specification to describe BP. BPML is developed out of 2 major formalisms: Graph based and rule based ones. Graph based formalisms developed out of graph theory and rule based ones out of formal logic (Sadiq, 2007). Graph based languages are easier to learn from scratch, they are more intuitive than logic based languages. Famous representatives of logical languages would be BPMN and UML.
The advantage of logic based languages is that they can be executed by a program and that there is a clear interface between graphical and logical presentation of the BP (Bassam Atieh Rajabi, 2009). Event-driven process chains and Petri networks can be mentioned as the most common representatives for rule based languages.

In the following sections these languages are examined in detail. To emphasize the differences between these languages, the same example of a BP is modeled by using all these different techniques.

2.2.1 Event-driven process chain (EPC) charts

An EPC chart models a chain of actions. EPC was conceived to model BPs. They were built on the basis of Petri networks and were extended with symbols and semantics (Becker, Mathas and Winkelmann, 2009: 43).

2.2.1.1 Introduction to EPC modeling

An EPC chart answers questions to a BP and represents a BP through symbols that are shown in Figure 1.

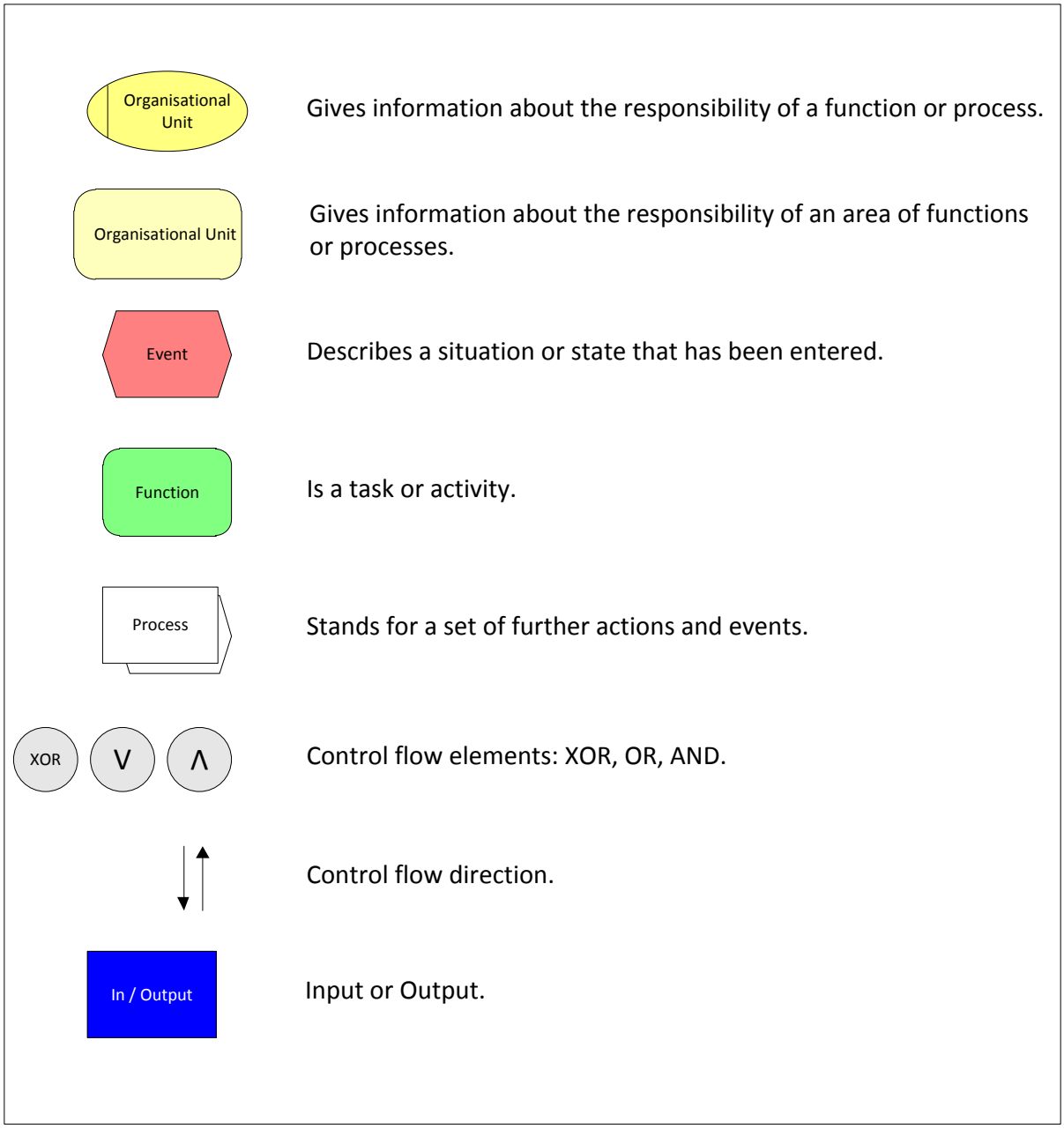

Figure 1: Basic elements of an EPC chart (symbols from MS Visio 2007).

The starting point of a process within an EPC diagram is always an event, represented by an event symbol and explains what has caused the process to start. An event is then followed by a function (Gadatsch, 2008: 202).

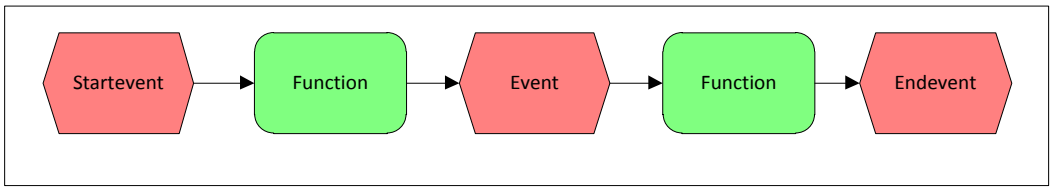

Figure 2: Data flow of an EPC diagram (Gadatsch, 2008: 202).

An event means that a certain state has been entered which triggers further activities. If a function triggers more than one event, then a Control Flow symbol is needed (Seidlmeier, 2006).

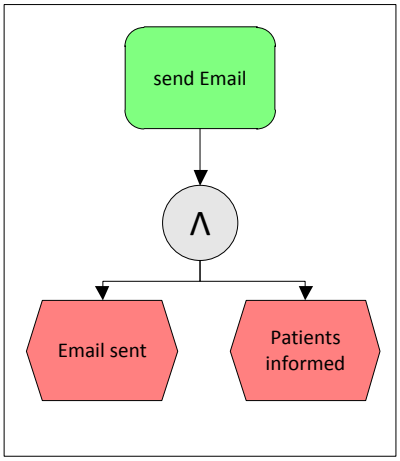

Figure 3: Function triggers 2 events (logical AND).

The AND Control Flow followed after a function means that all following events are triggered. AND connected events are entered parallel at the same time (Seidlmeier, 2006), like shown in Figure 3.

The OR Control Flow means that all or only some of the following events can be triggered by the anteceded function. All triggered events are executed parallel as well. (Lehmann, 2007).

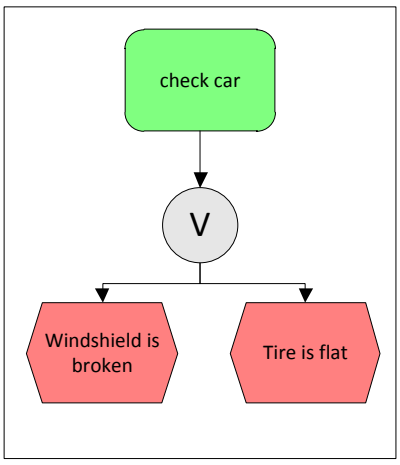

Figure 4: Function triggers one or more events (logical OR).

AN XOR means that only one of the following events can be triggered, depending on the situation. The decision which event occurs can have environmental, internal or external reasons. An example of a function that only triggers one event is illustrated in Figure 5 (Lehmann, 2007).

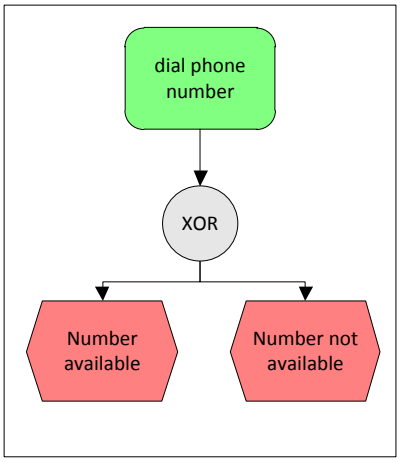

Figure 5: Only one event can occur (logical XOR).

Using a Control Flow the other way round so that an event starts several functions is only possible for AND connections. An event is a passive component; it does not have decision authority (Scheer, 1992: 11). This means that when a certain state has been entered, it has to be 100% clear which further tasks have to be executed. This is why an event cannot be followed by a Control Flow symbol like “OR” or “XOR”. The only possible Control Flow symbol that can follow after an event is “AND”. All functions that are connected via “AND” have to be executed, no decision has to be made. Figure 6 illustrates that an event can only be followed by an AND Control Flow symbol.

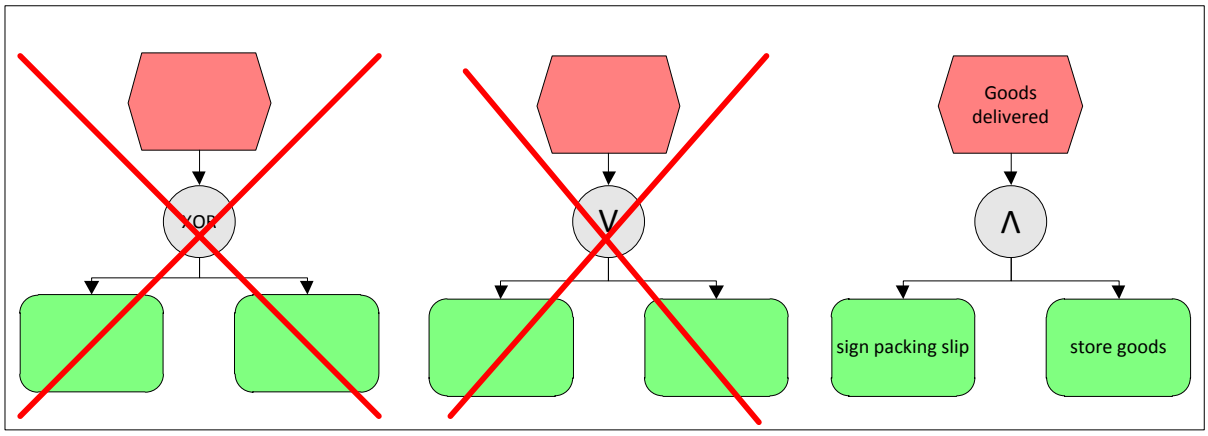

Figure 6: An event can only be connected to an “AND” Control Flow symbol.

A function fulfills goals of a company and describes certain company procedures. It transforms incoming states to output states. It is an active component and has decision authority (Scheer, 1992: 10).

2.2.1.2 Reference BP modeled with EPC

Figure 7 shows the imaginary flow of a contract in an imaginary company. This process is also modeled by using other design techniques in the ongoing sections.

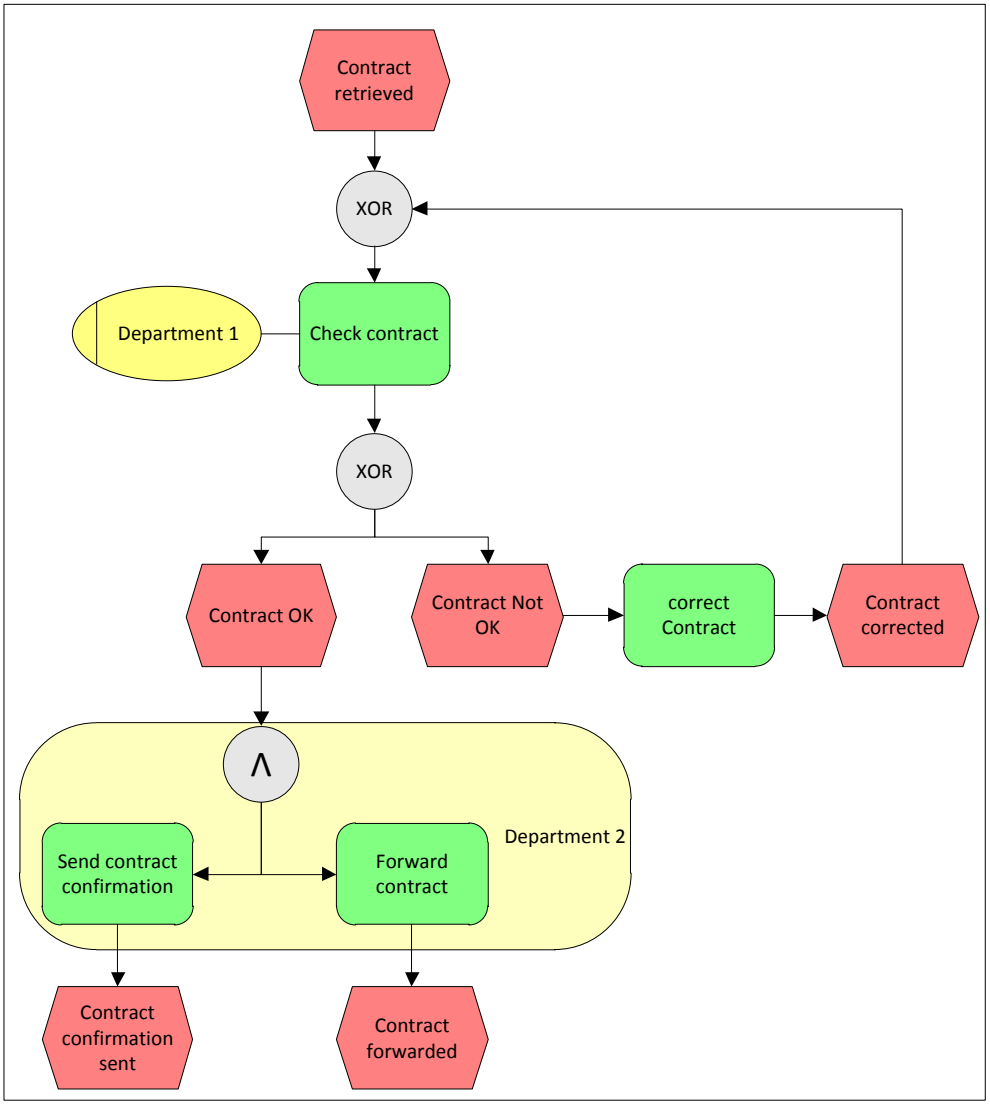

Figure 7: Example of an EPC chart (Becker, Mathas and Winkelmann, 2009: 44).

The upper first event – "Contract retrieved" is the starting point of the process that triggers several other activities. The first event is then followed by a XOR Control Flow symbol,

followed by the “Check Contract” function. It has an “Organizational Unit” symbol attached which means that a contract is checked by “Department 1”. The first XOR is for formal reasons and does not have a special meaning. Any EPC symbol can only have one Control Flow input arrow and one output arrow (Lehmann, 2007). Using a Control Flow symbol like this can easily lead to confusion since it has no special meaning. Therefore, this rule of formality is not followed in the EPC charts of Vexcel shown in Chapter 3.

Checking a contract can lead to two possible results, it can be valid or not valid. If the latter is the case, the contract is being corrected and checked again until it is valid.

If a contract is valid, it triggers 2 functions, “Send contract information” and “Forward contract”. This time department 2 is responsible to carry out these tasks. These 2 functions are preceded by an “AND” Control Flow element. This means that both functions have to be executed parallel, but it does not necessarily mean that they have to be synchronous or have to start simultaneous (Becker, Mathas and Winkelmann, 2009: 44).

2.2.1.3 Advantages and disadvantages of EPC

EPC charts are very easy to understand for everybody. The palette of symbols is kept very short, which makes it easy to explain to newcomers. Another big advantage of EPC charts is that a process can be easily refined. The level of detail of a BP can be chosen from micro to macro design.

2.2.2 Business process modeling notation (BPMN)

BPMN is one method to model a BP in a graphical way (Havey, 2005).

BPMN consists of flow chart symbols that are actually very similar to EPC charts.
BPMN consists of event-, Gateway- (like Control Flow symbols in EPC charts), Activity-symbols (like functions in EPC charts) and even Control Flow symbols like AND, OR and XOR. In BPMN Control Flow symbols are called Gateways (Allweyer, 2008).

The BPMN was originally invented by the “business process management initiative” (BPMI), which was a consortium of companies in the software industry. Their plan was it to build a graphical notation for the “business process modeling language” (BPML), a language based on XML. BPML was an already established standard which was specified and used to describe processes (Allweyer, 2008: 8).

The first version of the BPMN specification was published in 2004 by “Stephen A. White” from the company IBM. Later on BPMI merged together with the “Object Management Group” (OMG) under the same name. OMG was also responsible for the development of the UML standard. BPMN is under constant improvement, the current version is 2.0 (Allweyer, 2008: 9).

2.2.2.1 Introduction to BPMN modeling

Unlike EPC, BPMN has many symbols.

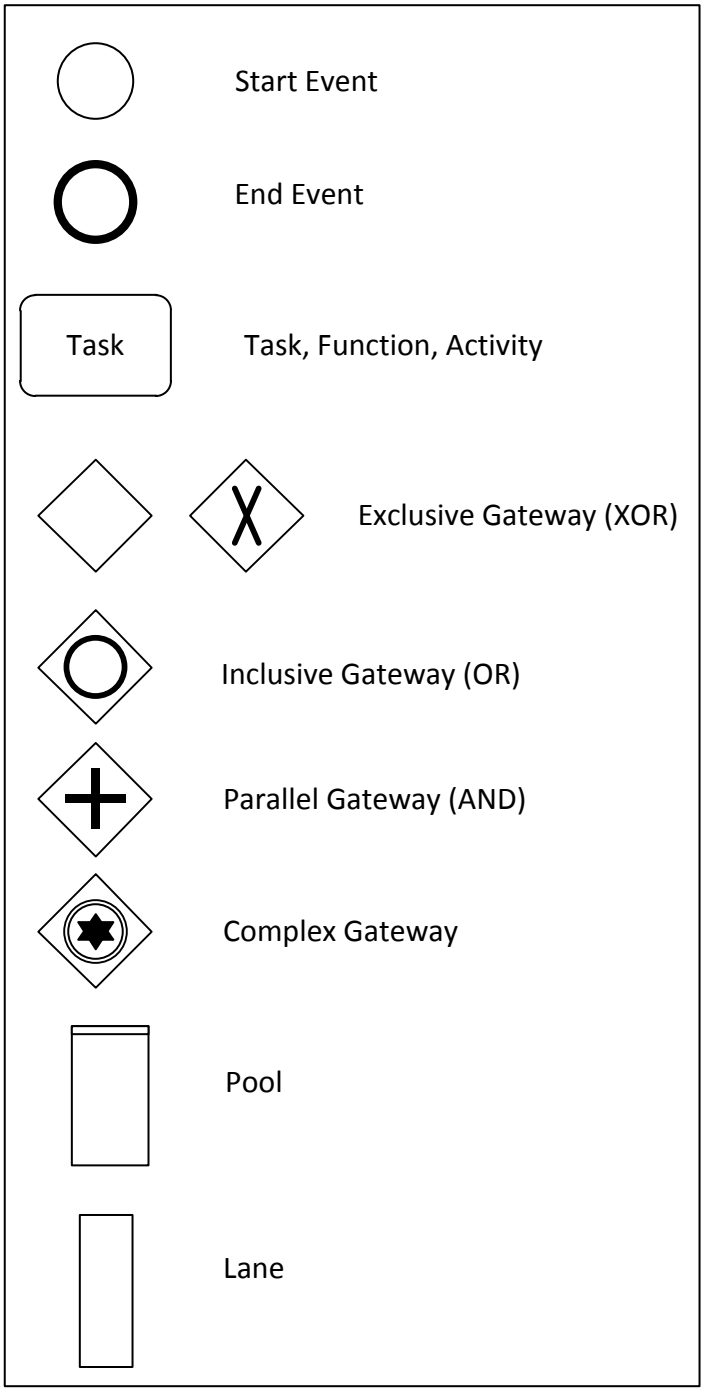

Figure 8: Most important BPMN chart symbols (Allweyer, 2008).

The start and end event are characterizing the beginning and the end of a process. All activities between the beginning and the end are designed by using task symbols. The whole sequence of symbols is called message flow (Freund, Rücker and Henninger, 2010).

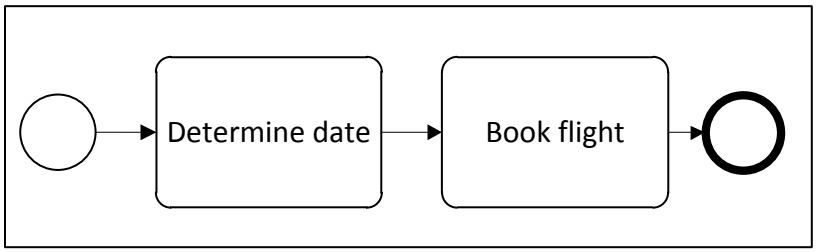

Figure 9: Message Flow of a BPMN chart.

Decisions that are made during a BP are influencing the Control Flow (Allweyer, 2008). Very similar to EPC charts, BPMN uses logical Gateways to design the Control Flow.

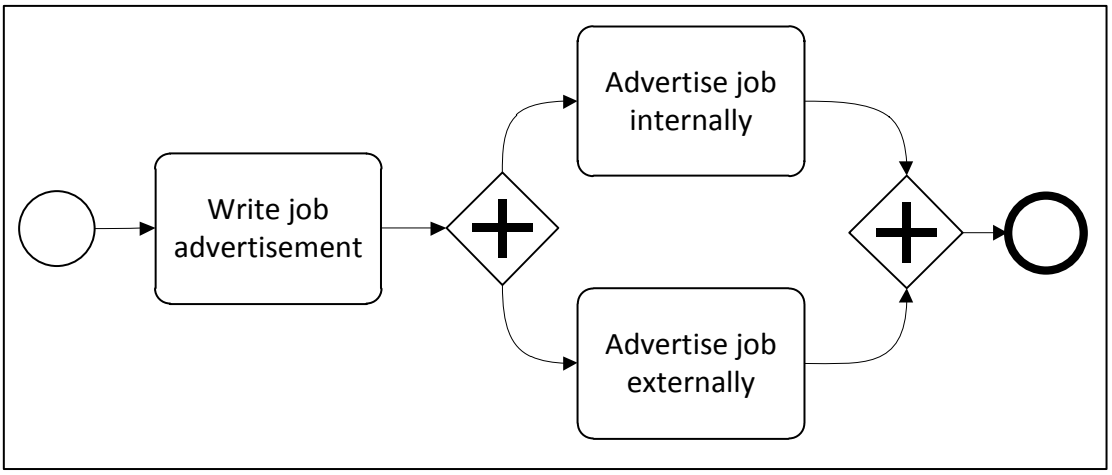

Figure 10: Example of a Parallel Gateway.

The symbol of a Parallel Gateway is a diamond with a plus sign in the center. The Parallel Gateway splits the message flow into two or more paths and then it merges all paths together again. It is used to design parallel activities in a BP and equals a logical AND. It does not mean that the parallel activities have to start at the same time, but they all have to end before the next sequence in the message flow can start. The logical AND implies that all of the parallel activities have to be done (Allweyer, 2008).

The Inclusive Gateway corresponds to a logical inclusive OR, therefore its symbol is a diamond with an 'O' in the center. The Inclusive Gateway can select one or more activities to be done in parallel (Havey, 2005).

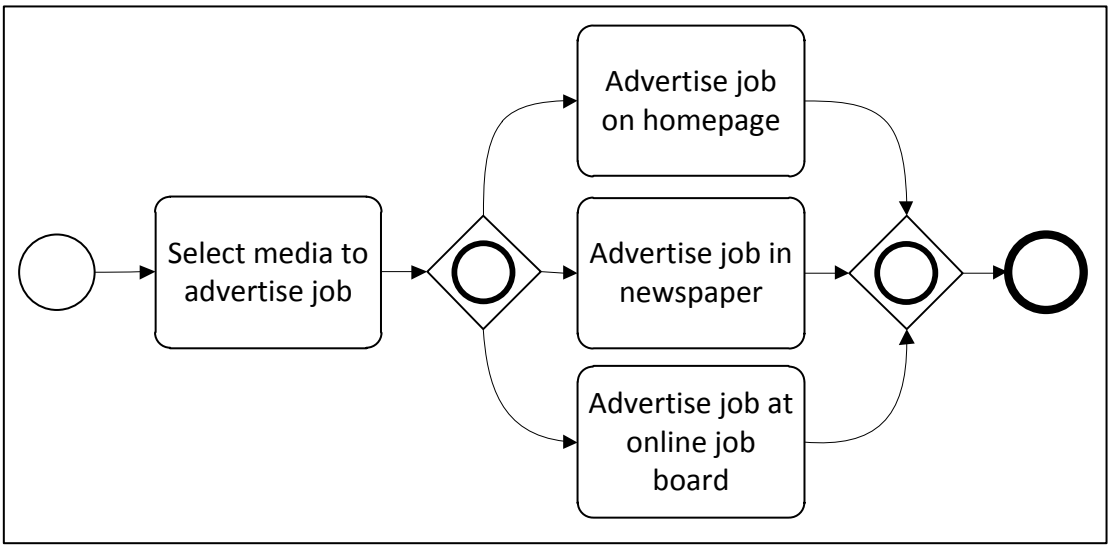

Figure 11: Example of an Inclusive Gateway.

The Exclusive Gateway corresponds to a logical XOR. The symbol of the Exclusive Gateway is a diamond with an X in the center, an empty diamond or a diamond filled with text.
Which format is preferred depends on the designer of the BP (Havey, 2005).

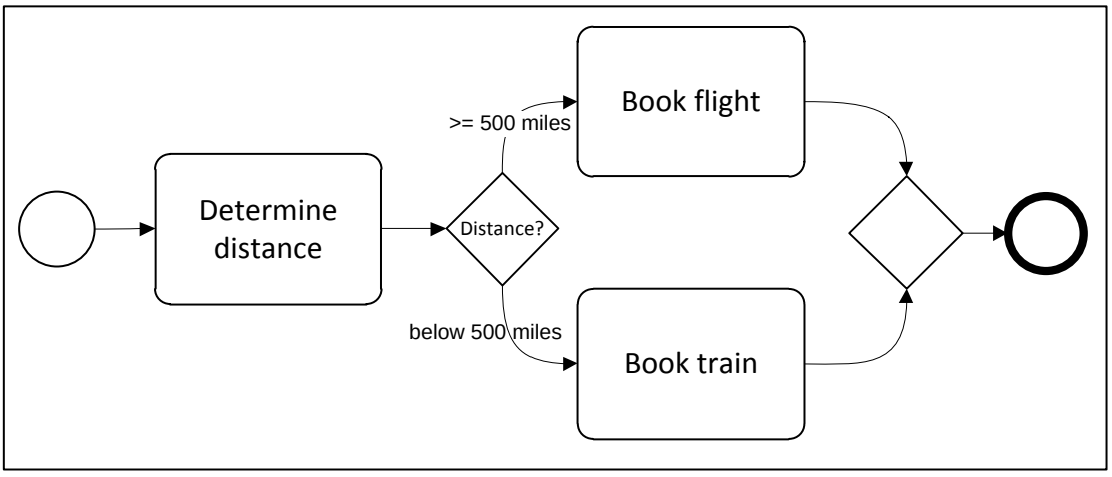

Figure 12: Example of an Exclusive Gateway.

The additional Complex Gateway is used very seldom. It is used for logic that is difficult to describe by using the Gateways mentioned before (Allweyer, 2008).

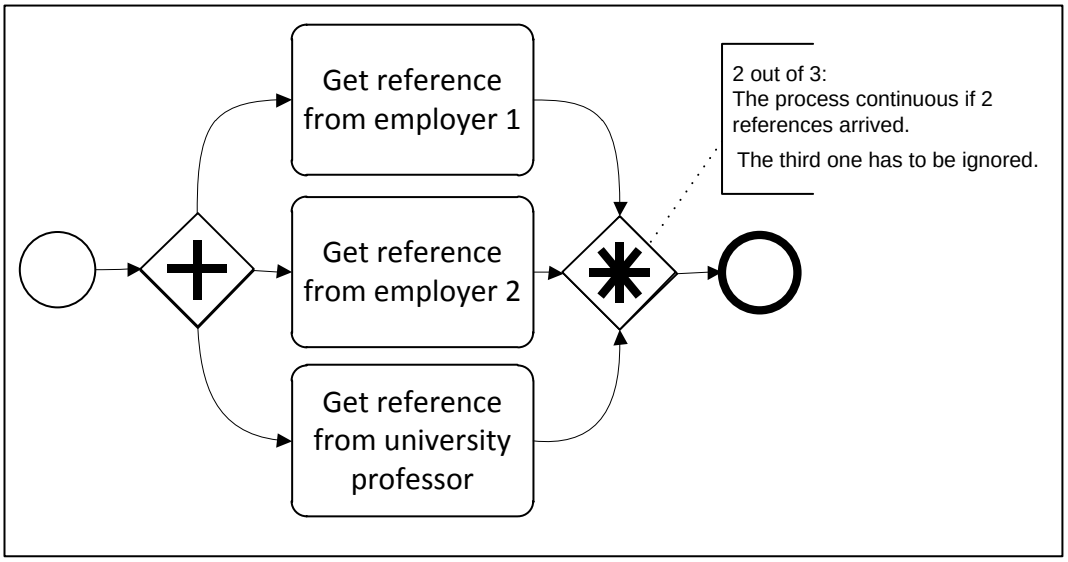

Figure 13: Example of a Complex Gateway.

The Organization and Organizational Units in which the activities take place can be identified via Pools and Lanes. A Pool is a container for a BP and can have several (swimming) Lanes. Lanes describe an Organizational Unit; a Pool describes something that contains these units. Pools and Lanes can be arranged vertical or horizontal (Allweyer, 2008).

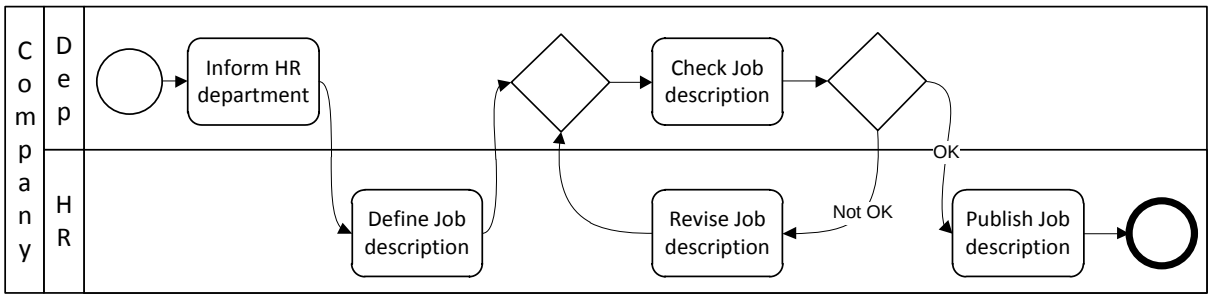

Figure 14: Example of a Pool with 2 Lanes.

2.2.2.2 Reference BP modeled with BPMN

Figure 15 shows the reference process that was modeled with EPC and BPMN in the Chapters before. For a complete description of the activities in this BP see Chapter 2.2.1.2.

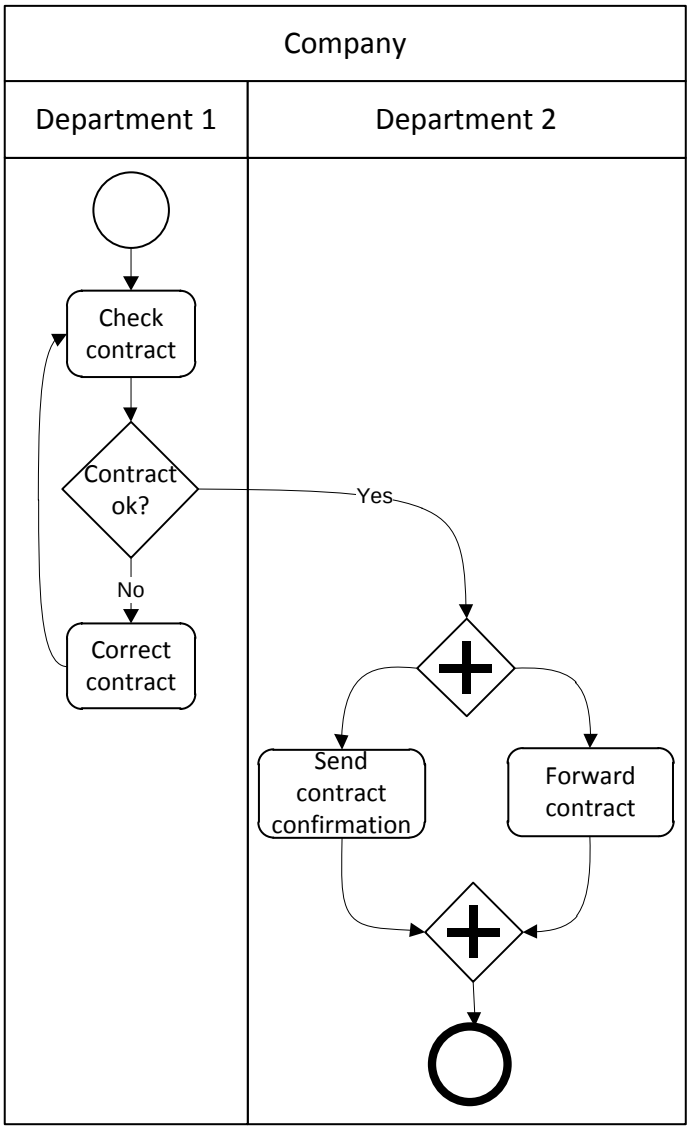

Figure 15: Reference process designed in BPMN.

2.2.2.3 Advantages and disadvantages of BPMN

BPMN uses Swim Lanes to indicate the Organizational Unit in which the tasks are done, which brings a good overview. The disadvantage of Swim Lane models is that they are keeping the organizational model at a very abstract level (Becker, Mathas and Winkelmann, 2009).

BPMN uses a big but still manageable palette of symbols. BPMN is a graphical notation. It can be translated into BPML, an XML based Meta language at any time. This has the clear advantage that BP can be automated over the whole supply chain, saving time and money for a company.

2.2.3 UML 2.3 – Activity Diagrams

Like BPMN, UML is owned and developed by the OMG Management group (OMG, 2010). UML is also under constant development and is now available under the current version 2.3 (Specification, 2010). The focus is laid on UML Activity Diagrams because BP are modeled with them. For exact specifications please refer to the Superstructure Specifications document from OMG (Superstructure, 2010).

2.2.3.1 Introduction to UML 2.3 Activity Diagrams

Designing a BP with UML seems to be very similar to the BPMN standard at the first moment. The most important symbols needed during designing a BP in UML are listed in Figure 16.

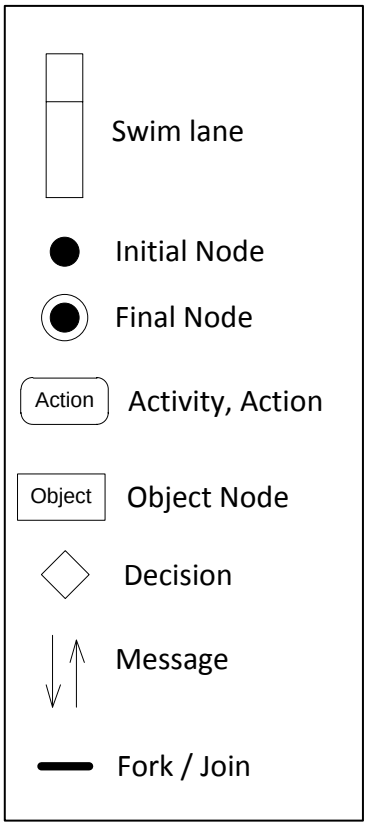

Figure 16: Compilation of important UML Activity Diagram symbols (Specification, 2010).

Like in BPMN, Lanes or Swim Lanes are used to give information about the Organizational Unit in which a set of activities takes place (Eriksson and Penker, 2000). The beginning of a

BP is indicated through the Initial Node symbol and the Final Node symbol is used to indicate the end of a BP. Like in BPMN, rounded rectangles stand for activities or actions in a BP. The message flow is indicated through arrows like in all of the other presented modeling techniques (Podeswa, 2010: 65-66).

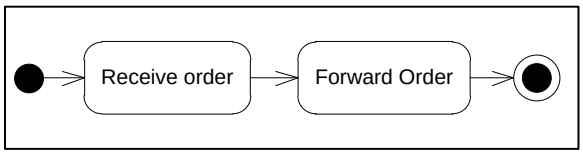

Figure 17: Activities between an Initial and a Final Node (Eriksson and Penker, 2000: 39).

Decisions are marked through diamond symbols. The difference to other design techniques is that in UML they have only logical XOR meaning. This means that only one path can be selected, depending on the condition of each path (Grässle, Baumann and Baumann, 2005).

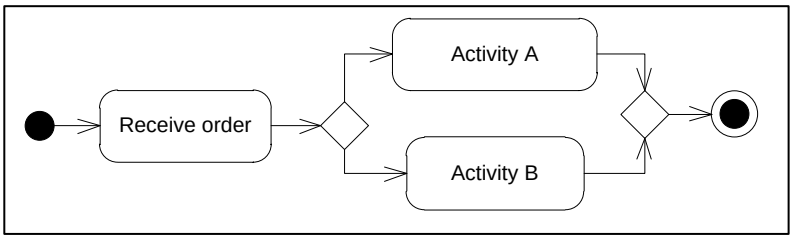

Figure 18: Decision: Either activity A or B is done.

The Fork or Join symbol splits one path into two or more paths and can join these paths together again. A fork is used if activities are executed parallel (Podeswa, 2010: 66).

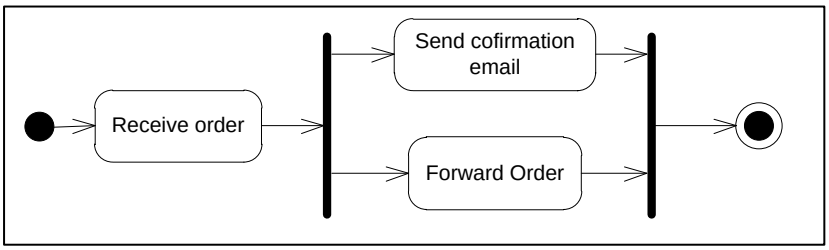

Figure 19: Fork and Join.

Objects that are passed or used in activities are indicated through rectangles. They are used as input or output of an activity (Maksimchuk and Naiburg, 2004). Figure 20 shows a small example of a BP that uses all UML symbols that were presented until now in an UML 2.3 Activity Diagram.

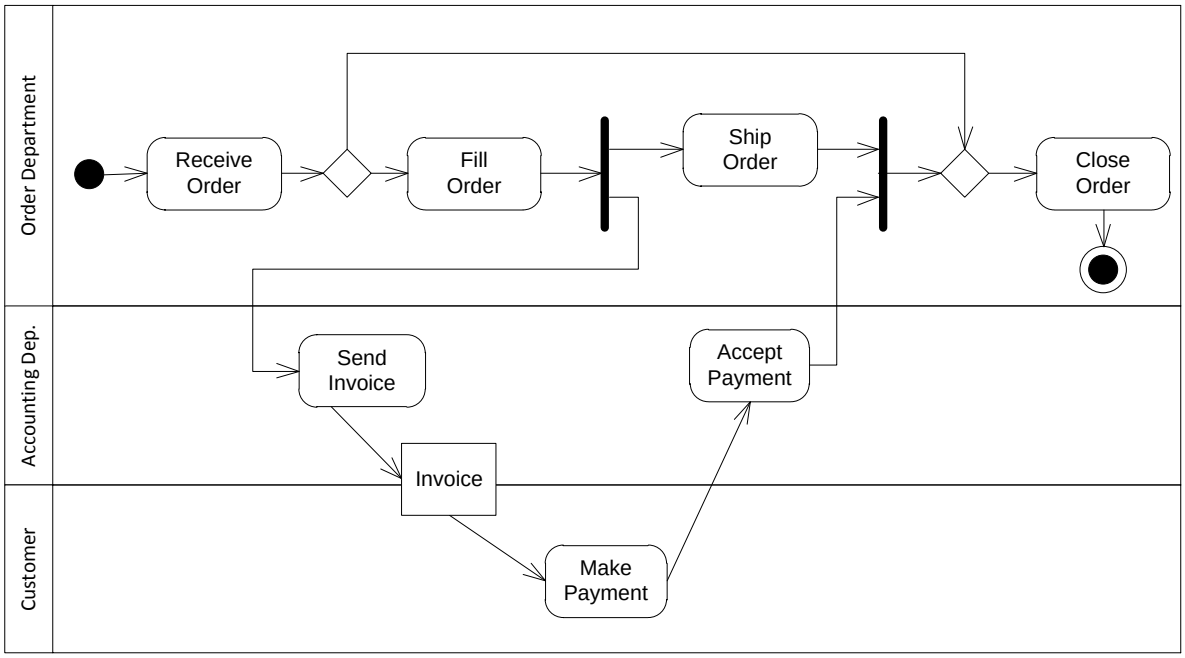

Figure 20: BP modeled with UML 2.3 (Superstructure, 2010: 369).

2.2.3.2 Reference BP modeled with UML 2.3

Figure 21 shows the reference process that was modeled with EPC and BPMN in the Chapters before. For a complete description of the activities in this BP see Chapter 2.2.1.2.

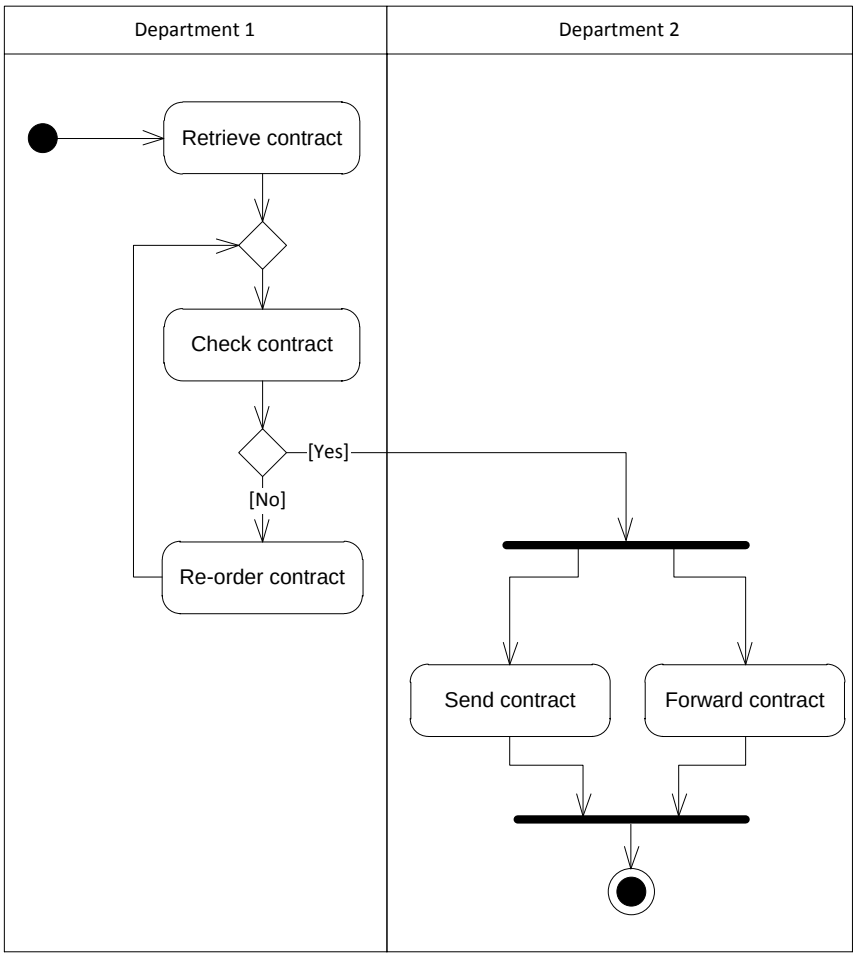

Figure 21: Reference BP modeled with UML 2.3.

2.2.3.3 Advantages and disadvantages of UML 2.3

Separating a BP into Swimming Lanes makes a BP more readable. UML has the biggest symbol palette of all design techniques. Therefore, the designer has the advantage to have more freedom during designing a BP. This also leads to the disadvantage that it is hard to get familiar with UML design. The biggest disadvantage of using a huge symbol palette is that BP can be designed very differently. If different persons in a company design their BP also differently, this could lead to incompatibility of the charts.

2.2.4 Petri nets

Petri nets were invented by the German mathematician and computer scientist Carl Adam Petri (Havey, 2005). Petri introduced these Nets in his dissertation in 1962 (Brauer and Reisig, 2010). These original Petri nets are known as the classical Petri nets. Since the upcoming of Petri nets, some researchers enhanced the classical model and added dimensions like time or hierarchy (Desel and Oberweis, 1996).

The different kind of Petri nets can be categorized into a basic, intermediate and high level layer. In the first layer there are basic nets like Elementary Net Systems to investigate concurrent systems. The nets in the intermediate layer focus on better representations than the nets in the basic layer. A representative of the intermediate layer is Place/Transition (P/T) Nets. In the third layer there are real life applications taking place. Predicate/Transition Nets and Colored Petri nets are the most common high level models (Rozenberg and Engelfriet, 1998).

Designing BP can be accomplished by many variants of Petri nets. There is no clear consensus which Petri net is best. This is why one technique out of many had to be chosen. The decision fell for P/T Nets because they are easier to use and better explainable than other Petri net techniques and the tools that these Nets provide are powerful enough to design a BP.

2.2.4.1 Introduction to (P/T) Petri nets

A Petri net is a directed graph and consists out of 2 different kinds of nodes: Places and Transitions (Gadatsch, 2008). The Control flow is built through arrows that are used to link a Place to a Transition and vice versa. In a classical Petri net these directed links are also called “Arcs” (Gadatsch, 2008). Tokens, displayed as black dots in a Petri net, move from one place to another. They represent the current state of a process (Havey, 2005).

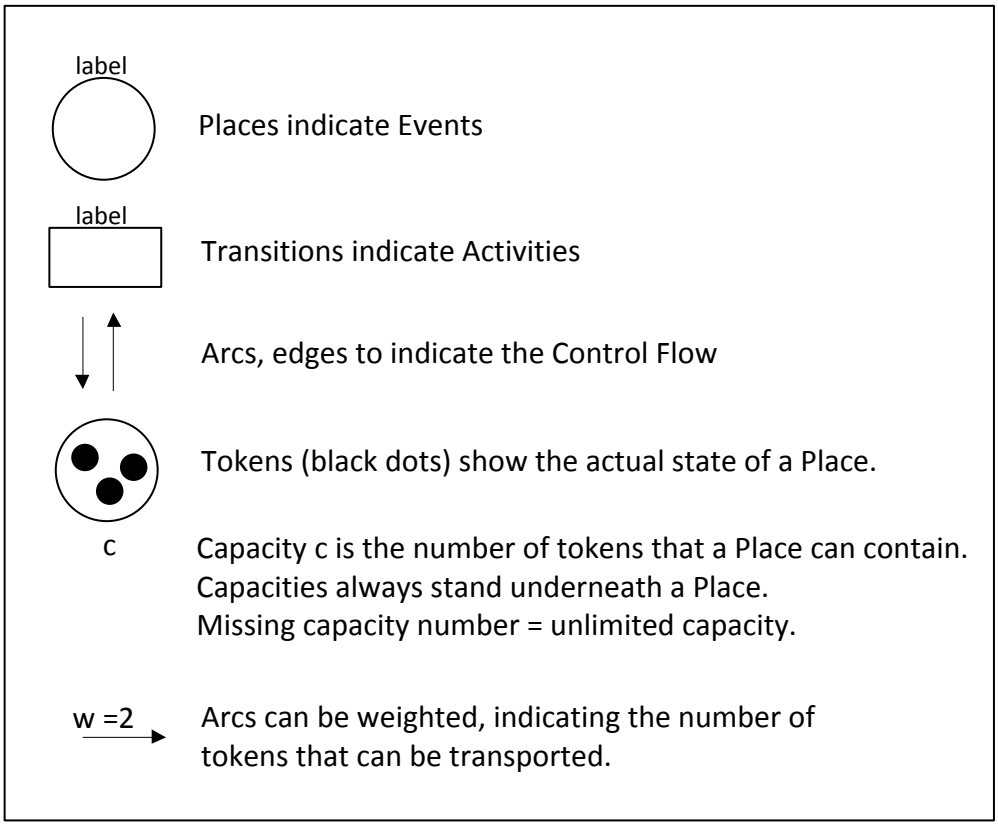

Figure 22: symbols of a P/T Petri net (Havey, 2005).

Petri nets can be seen like a machine that can be started and stopped anytime by turning a switch. Therefore, a Petri net has a pre- and a post condition, before and after a switching operation took place (van der Aalst, 2010). Tokens are transferred from one Place to a Transition. If the switch is turned on, Tokens start to transfer from a Place to the Transition that it is connected to, but only if the Place holds enough Tokens to fulfill the weight condition of the specific Arc.

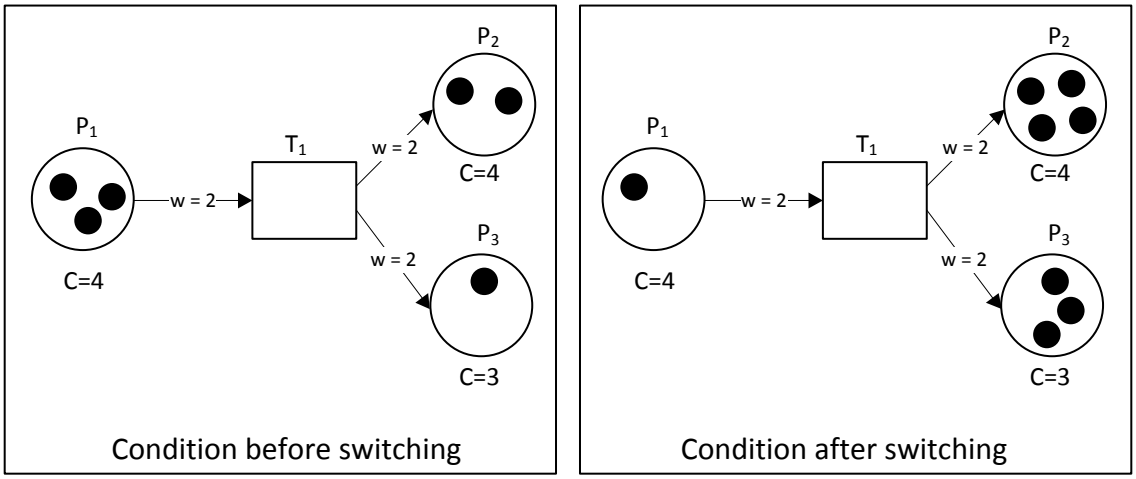

Figure 23: Example of switching operations in a P/T Petri net (Gadatsch, 2008: 93).

Figure 23 shows an example of a switching operation. The process starts in Place P1 that contains 3 Tokens. The Arc that leads to T1 has a weight condition of 2, meaning that a pair of Tokens can pass. If 2 Tokens arrived at Transition T1, it fires 2 Tokens at P2 and 2 Tokens at P3 (Weske, 2007). After that, P1 contains only 1 Token. It does not have enough Tokens to meet the first weight condition so that Transition T1 cannot be activated to fire again and the process stops (Gadatsch, 2008).

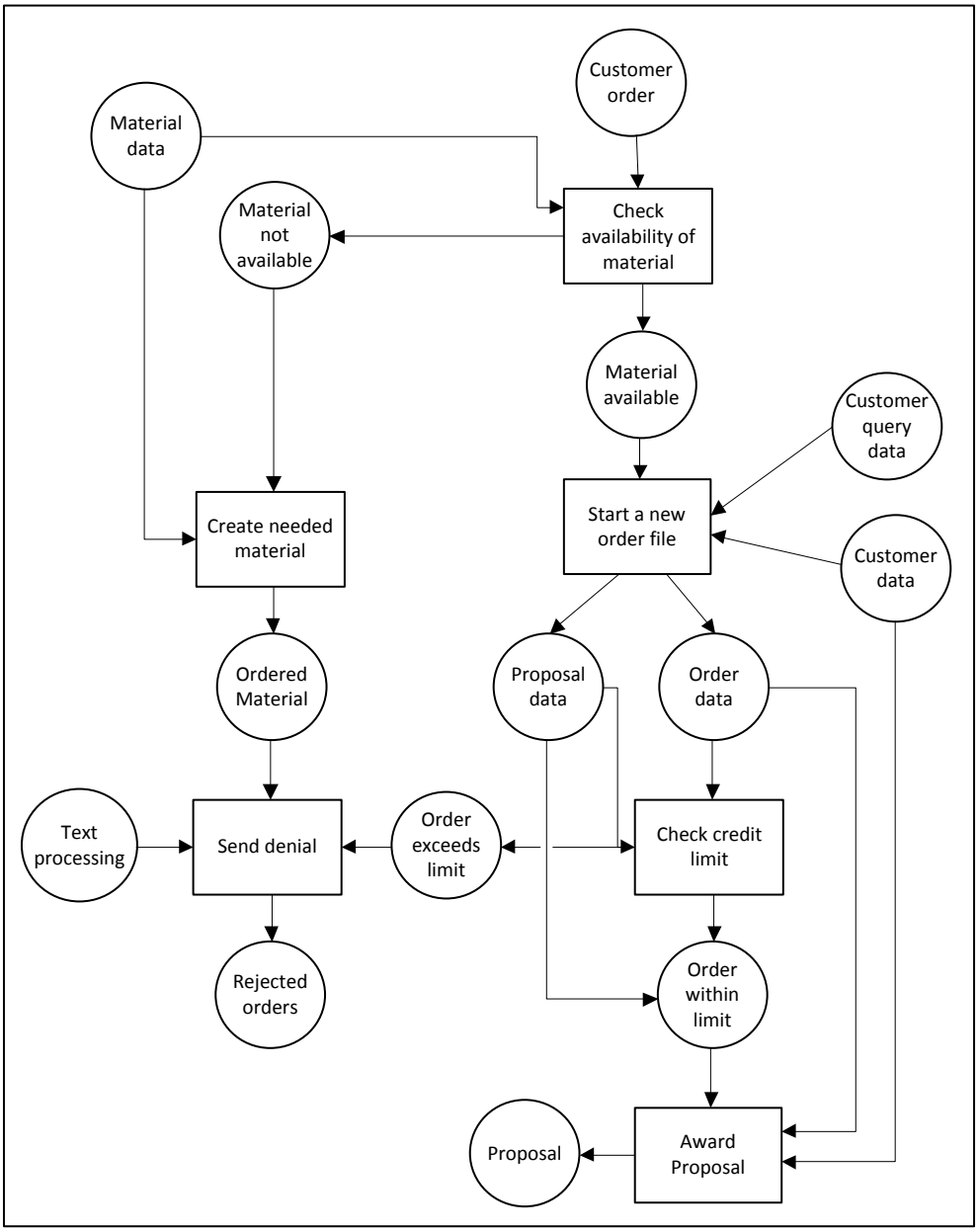

Figure 24: A simple P/T Petri net example (Gadatsch, 2008: 94).

Tokens, Labels, Weights and Capacities are not necessarily a must have in Place Transition charts. If these exact details are not needed to describe a BP, they can be left out as shown in Figure 24.

2.2.4.2 Reference BP modeled with a Petri S/T net

Figure 25 shows the reference process that was modeled with EPC and BPMN in the Chapters before. For a complete description of the activities in this BP see Chapter 2.2.1.2.

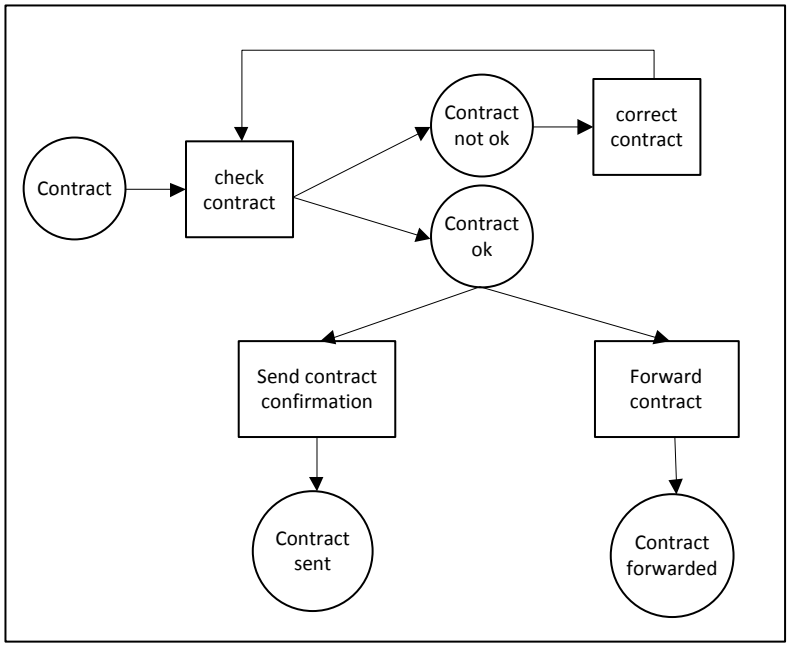

Figure 25: Reference BP modeled with P/T Petri net.

2.2.4.3 Advantages and disadvantages of P/T Petri nets

P/T Petri nets have the clear advantage over other design techniques that they need less symbol elements. Although they have fewer symbols, they are more complex and harder to read than other techniques.

The fact that there are so many Petri nets and different restrictions makes Petri nets hardly useful for BP design (Gadatsch, 2008).

2.2.5 Conclusion

To realize the project many employees at Vexcel are going to be asked to design their activities with a BP modeling technique in the near future. One modeling technique has to be set as company standard; otherwise the different BP cannot be linked together. Therefore, the different design techniques had to be evaluated.

The differences between the methods lie in their complexity, palette of symbols and ease of use. Petri nets for example are a good first approach to the matter but they are not very readable and the Token system is hardly used. UML 2.3 is far too complex; it is suited for designing software processes but not for designing BP. People who have never heard of BPMod before may have problems using this technique.
BPMN and EPC are suited very well to design BP and they are very similar. They both are very clear and understandable. The event-function-event chains of EPC are easy to explain to people that have never been confronted with BPMod. BPMN is also easy to explain to newcomers, but the bigger palette of symbols compared to EPC could lead to confusion.
The biggest advantage of EPC is that the level of detail of a BP can be selected by choice and the different BP can still be linked together. This is why it is recommended to Vexcel to establish EPC charts as company standard to design BP.

2.3 Business process management (BPM)

BPM provides concepts, methods and procedures for controlling business processes (BP). BPM means to collect BP, to analyze and to optimize them, to implement them in software and to control and measure them and their performance numbers. BPM builds a closed lifecycle, known in literature as the business process management lifecycle (BPML), see Figure 26 (Scheer, 2005: 36).

BPM consists out of concepts and methods that provide techniques to design and enhance BP (Weske, 2007: 5).

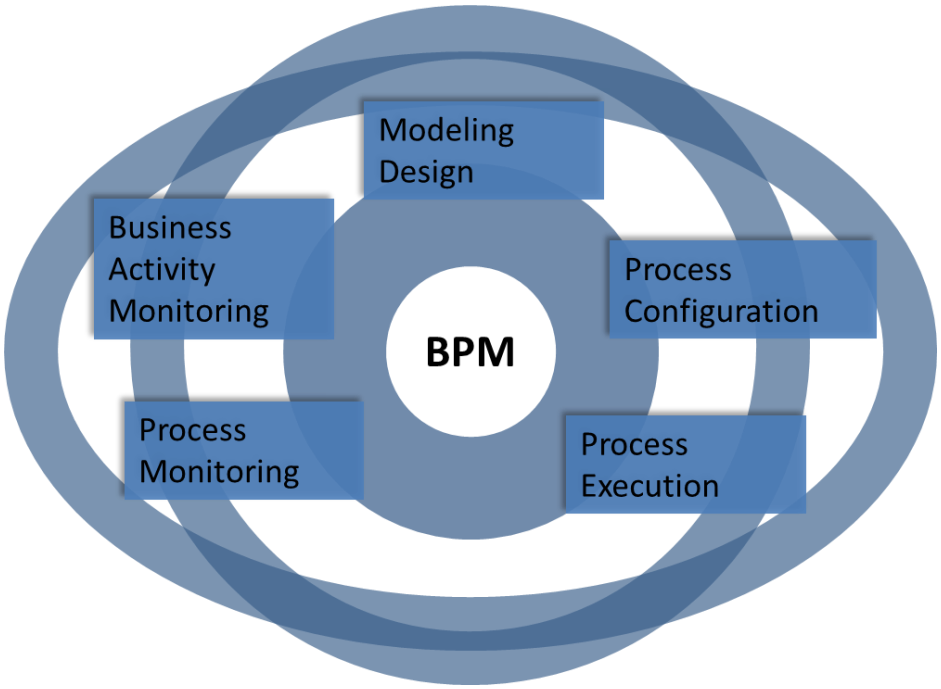

Figure 26: The business process management lifecycle (Scheer, 2005).

BP can operate across company boundaries. A company can be linked to all its suppliers and build a network with them. The whole supply chain can literally become part of the company. This can be accomplished by BPM technologies and can save time and money for a company (Poirier et al., 2004).

2.4 Quality management (QM) and quality management systems (QMS)

The best way to introduce quality management is to start at the beginning. Why is there so much talk about quality after all? What is its origin?

2.4.1 Origin of quality

Before defining quality, let's spend a few introductory words about quality in general. Etymological quality comes from the Latin term *quālitās* ("Characteristic", "Consistency", "Condition"), from quālis -"of what kind" (Wiktionary, 2009), (Etymonline, 2010).

Historically speaking, the term quality has existed since people started trading and exchanging goods, if they were aware of it or not. Someone could not sell goods that did not meet the expectations of the customer. As this was clear for everyone, it was not discussed with the same emphasis that we do today. In the past, goods were sold in a more direct way to the customer. The customer, most of the time, would usually approach the person who produced or hunted the product himself, and would buy it directly from that very same person.
The customer could give feedback to the seller/producer. If the customer didn't like a product, he would tell the seller/producer, who then could make adaptations to the product so that it fulfills customer needs and the product could be sellable once again.

Ever since the industrial revolution or more precisely since Henry Ford and the modern assembly lines, things became more complicated. Thousands of products of the same kind (mass production) were produced on an assembly line; many people just did one task out of many, and had no clue if the product as a whole was working or had failures - or speaking in terms of quality – was good or bad.

So companies had to reconsider quality as a concept to make their products more marketable, and this led to big talks about quality management, industry norm definitions

and many books about quality. This is why several definitions can be found for “quality” in the literature and on the Internet. To give a better overview just the most important definitions are mentioned in this thesis.

2.4.2 Definitions of quality

The German industry norm (short DIN) from 1995 defines quality as the entirety of characteristics of a unit (product, process, service), regarding their qualification to fulfill defined and prerequisite requirements (DIN8402:1995, 1995).

The ISO norm 9000:2005 defines quality as degree of which characteristics fulfill requirements.
Beneath this definition there are two notes in the ISO document:
Note 1: “The term quality can be used with adjectives such as poor, good or excellent”.
Note 2: “’Inherent’, as opposed to ‘assigned’, means existing in something, especially as a permanent characteristic” (ISO9000:2005, 2005).

2.4.3 Definition of QM

QM is to manage an organization by having quality in mind (ISO9000:2005, 2005).
QM consists of 4 main parts (ISO9000:2005, 2005):

- Quality planning (focused on setting quality objectives and specifying necessary operational processes and related resources to fulfill the quality objectives).
- Quality control (focused on fulfilling quality requirements).
- Quality assurance (focused on providing confidence that quality requirements will be fulfilled).
- Quality improvement (focused on increasing the ability to fulfill quality requirements).

2.4.4 Reasons to do QM

QM is made in organizations to (Brunner and Wagner, 2008):

- have advantage over competition
- satisfy customers
- produce products that are:
    - Reliable
    - Available
    - Maintainable
    - Safe
    - Supported in their maintenance by the organization
- Making products better sellable and worth more
- Enhance products, internal employee and customer relationships
- Make processes comparable for benchmarks
- Let other organizations know, that management cares about quality and even improves it

2.4.5 Definition of a QM system (QMS)

A QMS provides you with management tools and ideas to spread the thoughts of quality in the company. It helps you fulfill the requirements of the product characteristics (Geiger and Kotte, 2008).

2.4.6 The QMS "ISO 9001:2008"

The ISO 9001:2008 is one of the most widespread QMS in the world. It is kept very general, it states what an organization must do to be certified, and it does not say how or with which tools they should incorporate into the company or how your business processes has to look. This is up to the operational management of an organization.
Its aim is customer satisfaction through continuous improvement of the quality of the product. Figure 27 describing a QMS that is ISO 9001:2008 compliant states this:

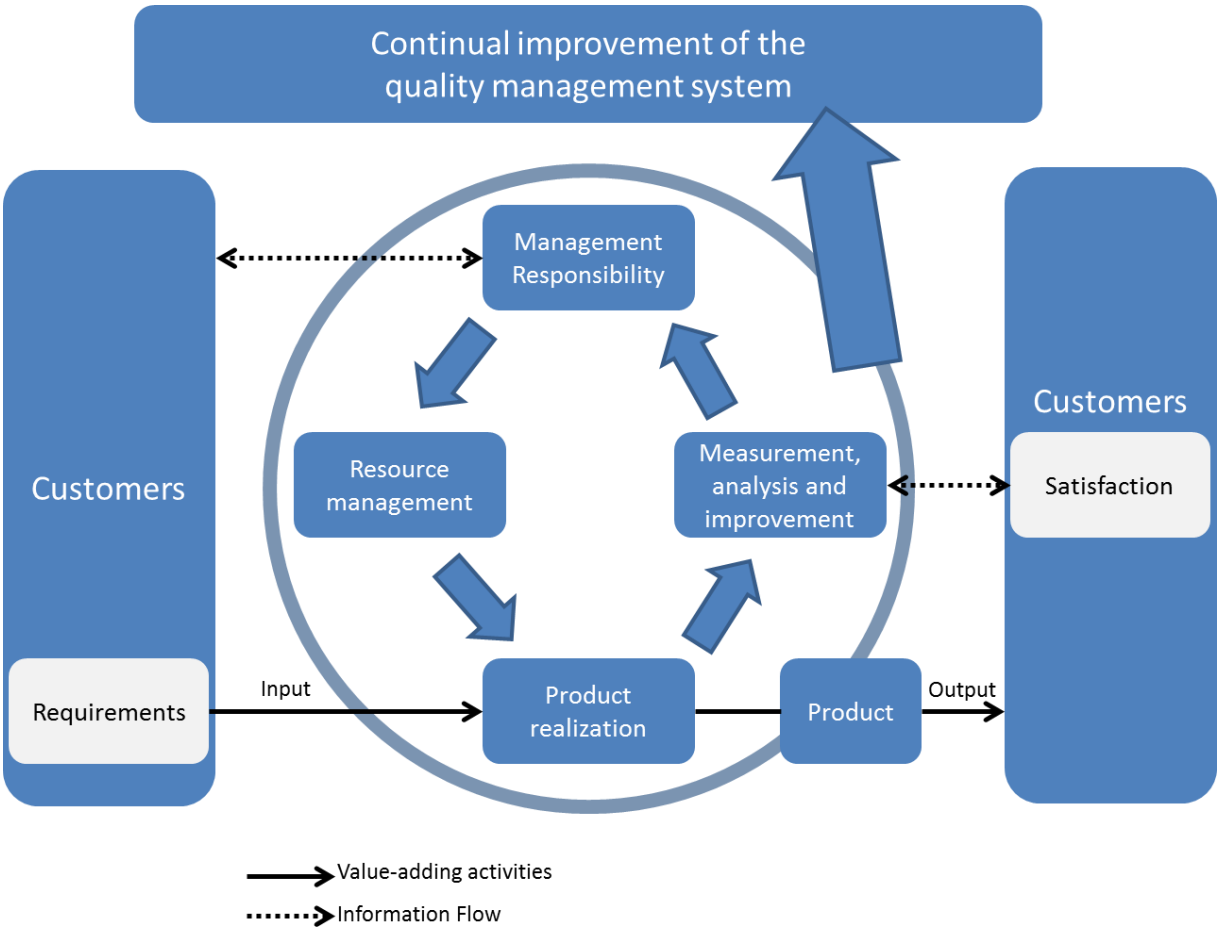

Figure 27: Model of a process-based quality management system (ISO9001:2008, 2008).

Figure 27 shows that customers play an important role and it covers the requirements of the norm in a rough outline (ISO9001:2008, 2008).

2.5 Enterprise resource planning (ERP)/ ERP software

2.5.1 Definition of an ERP system

The core function of an ERP system is to connect all data from different departments to one single database. Furthermore, ERP systems serve to map business processes throughout departmental boarders (Luszczak and Singer, 2009: 18).

An ERP system is a huge software package, everybody within an organization uses the same database, the same software to receive and input information (Fiona Fui-Hoon Nah, 2002). ERP software consists of several software packages that are representing the most important business processes in a company (Jacob, 2008) .

2.5.2 Advantages of ERP systems

ERP systems offer several advantages. They are a central source of information, beyond company or department boarders. Therefore, the company could be rationalized after implementing an ERP system. Departments can be laid together and work flows can be changed. Furthermore, ERP allows you to automate workflows so that they can be faster by minimizing the chance of failures at the same time. New employees can be instructed faster and easier because of the easier workflows of the ERP system. Another advantage lies in efficiency. With only a few mouse clicks the inventory can be checked (Diffenderfer and El-Assal, 2008).

The main ability of ERP systems is the centralization of information. Information can be presented to anybody who has permission rights, breaking geographical and departmental boarders (Ptak, 2004).

2.5.3 Contents of ERP systems

For Thomas Wallace and Michael Kremzar (2001), ERP does not stand for just software. They distinguish between ERP and ES (Enterprise Software). ES stands for software packages that a company needs in aspects of information, and ERP offers different business functionality than ES. Figure 28 gives a rough overview of typical package contents of ERP, ES and both combined.

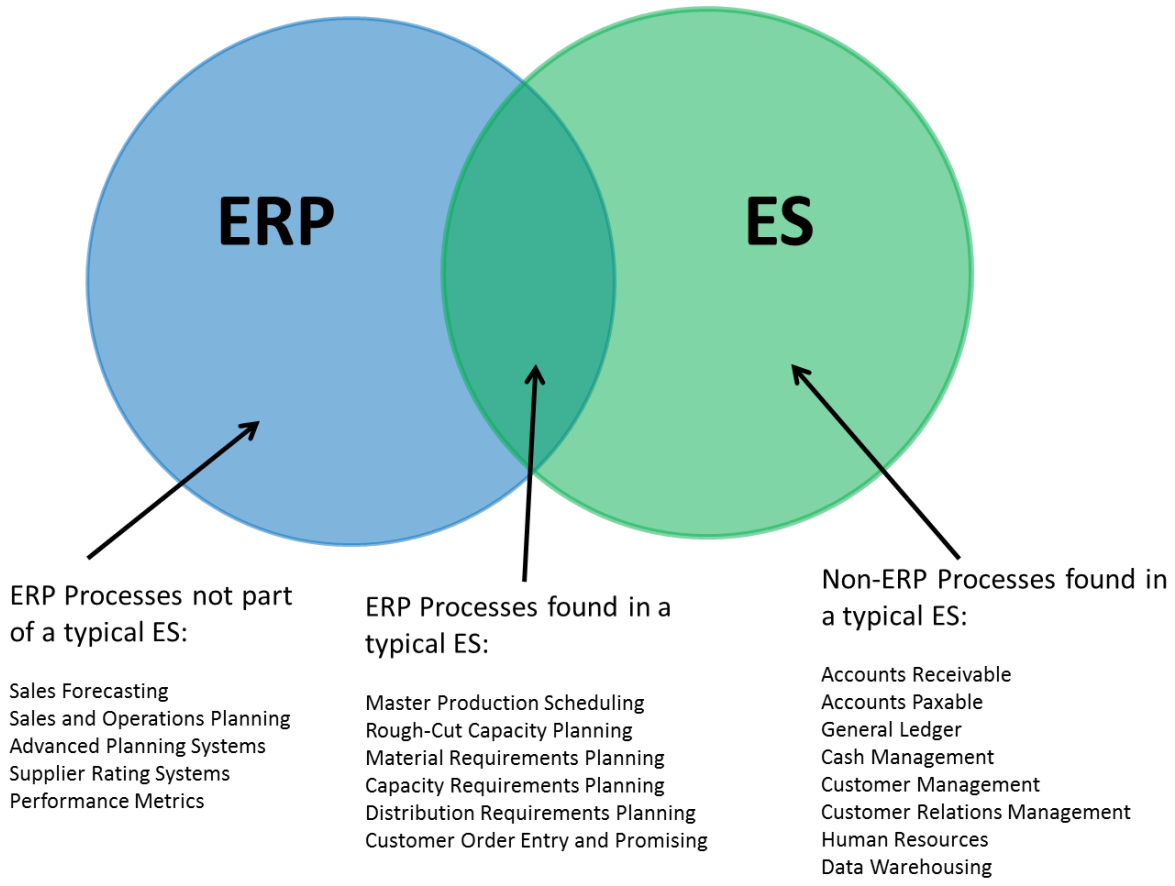

Figure 28: ERP versus ES. Software modules covered by typical ERP and ES systems (Wallace and Kremzar, 2001).

2.5.4 The “Microsoft Dynamics NAV” (MDN) ERP system

Microsoft Dynamics NAV 2009 is a fully integrated software solution, meaning that it can be used in every section of a company and in all areas. It can be used for all business processes of a company (Luszczak and Singer, 2009: 17).
Therefore, it can be concluded that business processes and ERP software systems are tightly related.
Vexcel decided to implement MDN because it is a Microsoft product and they do not pay license fees for the software, although MDN has other advantages as well.
The advantages and thus keys of success of MDN compared to other ERP systems on the market are on the part of Microsoft the ease of use, the ease of configuration and the ease of implementation for the customer (Microsoft, 2010).

3 BP at Vexcel

The goal was to document all BP regarding Enterprise resource planning (ERP) and to do this in an ISO 9001:2008 compliant way. As stated in Chapter 2.4.6, this ISO norm does not force you to design a process in a special way. It is just a collection of guidelines. The ISO norm specifies that all processes should be documented but not how, like I have mentioned in Chapter 2.4.6. It does not specify the "how". Any design technique is available to choose from. Any type of diagram is also allowed to describe the processes. The only thing is that it should be continuous. This means using only one design technique because of the different meanings of symbols and terms related to processes in different diagrams.

To be consistent an attempt was made to establish just the EPC diagram style as a standard within the company, so that every manager can design his/her BPs by using the same technique. Thus the differently designed charts would be linkable and understandable for everybody.

At the beginning of this thesis there was nearly no written information about BPs regarding the department that was responsible for ERP or any other department. The upper management built a BP roadmap, a diagram that showed the workflows of the company. It gave a rough overview over the BPs regarding ERP.

After finding out what to do and where to start, several interviews, meetings, and phone calls were conducted to achieve desired result. During the interviews people responsible were asked about what exactly they do when they e.g. order, buy or store things.
To get an overview of the company the decision to have small interviews by following a top-down strategy was made. So starting with the highest level of Management and working down through the hierarchy from one level to the next was done.

Other interviews followed with persons who were in overall charge of ERP processes. The department "Operations & Management" is responsible for most of all of the ERP processes. After each interview the work flows were documented and numbered. The BP were designed in Visio for the making of the EPC diagrams. The use of Visio was decided due to its

minimal cost factor since it is a pure Microsoft product and was easy to use. Furthermore, using EPC diagrams has its advantages due to its ease of use and ease of explanation of the workflow of the BP.

After the first initial interview another meeting was set up and the results of that first interview are presented to them. During this second meeting an as-is analysis is created. A discussion about if the process is correct, detailed enough and understandable for everybody. After each meeting an increase in the BP file revision was made. The goal was to come from an alpha version 0.1 to a release version 1.0.
Release version in this case means that everybody agreed on the structure and flow of a BP that was on paper. It was particularly necessary that the Manager approved the BP, meaning that the workflow was agreed upon.

3.1 Roadmap of BP at Vexcel

The overall Roadmap shows the main BPs and how they are connected to each other. As stated in Chapter 2.1.2, a BP implies adopting a customer's point of view. When taking a look on the BP Roadmap in Figure 29 it is easily noticeable that everything is seen from that angle.
All communication between the customer and the company that has started by the customer is seen as input for the company.
All inputs from customers, which are displayed on the left hand side, are causing further internal workflows. On the right hand side there are all outputs from Vexcel to the customer. Output in this case can mean any interaction or communication going out from Vexcel to the customer.

On the upper part of the diagram there are some management processes and at the bottom part some support processes are listed. They are visually separated from the rest of the processes because of their gain for the customer or the product cannot be measured in a direct way, or cannot be measured at all. In other words, they are not directly related to inputs from the customer or products of the company.
The processes that were most complicated to document, related to ERP and therefore to this thesis, were "OP03 - Procurement" and "UP08 - Change Management". The processes "OP04 - Storage" and "UP07 - Control of nonconforming products" are also related to ERP but are not approved and still under planning. Therefore, these processes are not further mentioned in this thesis. In the following sections the procurement process and the change management process are shown and explained.

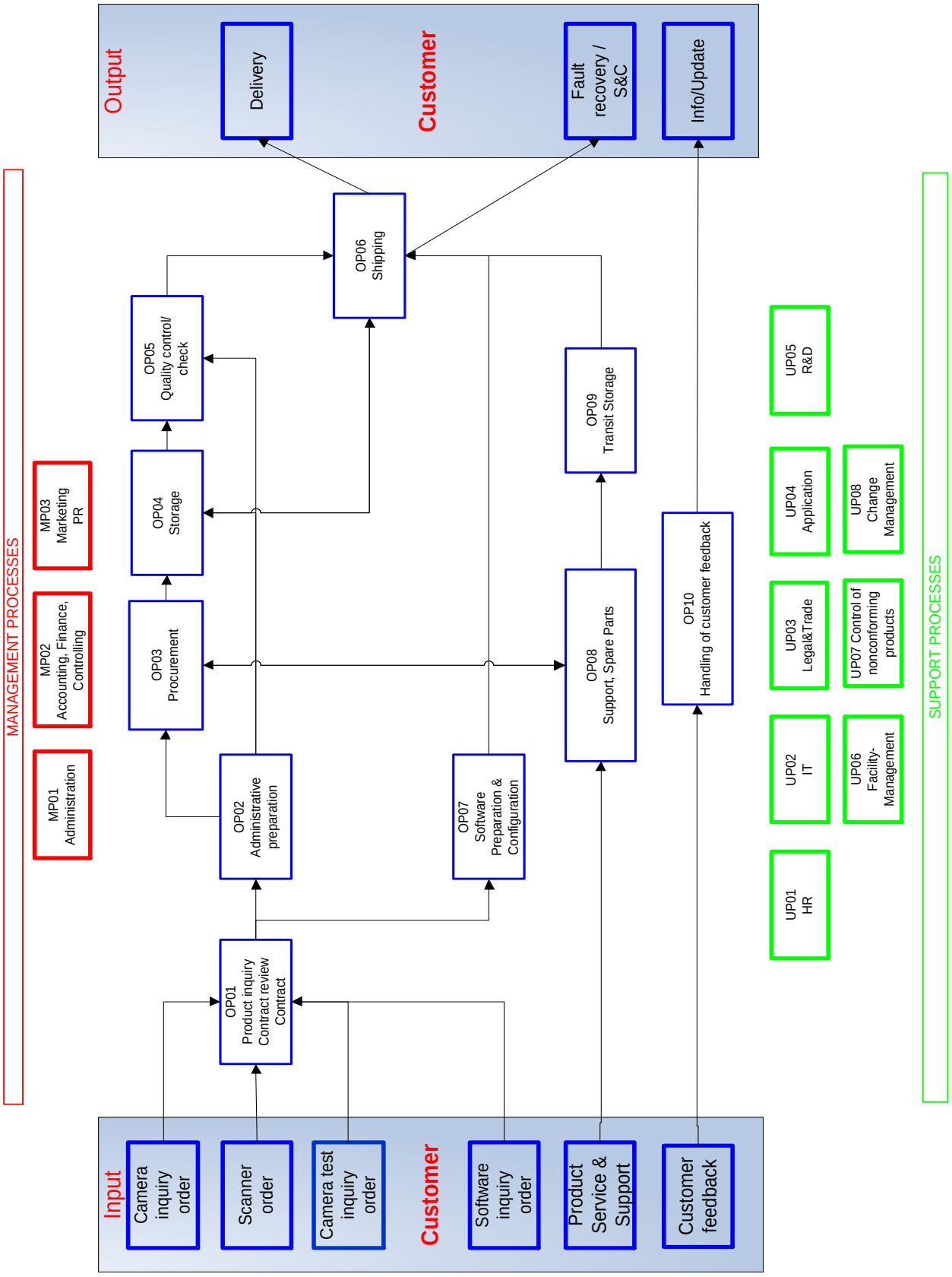

Figure 29: The BP Roadmap of Vexcel.

3.2 Process “Procurement”

The procurement process describes the workflow of how Vexcel purchases a camera. All processes are under constant change and construction as mentioned in Chapter 2.1.2. This is why process diagrams should never be printed out or printed in a document. It should be clear that the processes that are shown in the following sections are only valid for a short period of time. However, all processes that are shown are valid and built from the latest insights within this certain snapshot of time.

The procurement process “OP_03 Procurement” is split into 3 parts, distinguished by additional letters at the end of the process number. The starting process is always “OP_03_a” followed by “OP_03_b” and so forth. This way the processes can be split apart in order to keep a better overview.

In the following section I will explain every process in words, followed by an EPC diagram. To see how EPC charts work, please see Section 2.2.1.

3.2.1 Process “OP_03_a Purchasing of a camera”

This beginning process explains how Vexcel purchases a camera. Please see the next page for comparison with the EPC diagram.

First, an annual main meeting takes place where the Sales and Management team of the company decides the amount of cameras to be ordered. Afterwards, contracts are drawn up with each manufacturer and are ready to be signed.

Finally, after the contracts are signed, the production of camera components is started by the manufacturer. Once the Camera components are produced and the camera is assembled, the manufacturer delivers the camera to Vexcel.

A precise description of how a delivery is accepted at Vexcel can be found in the process OP_03_b. The delivery is now stored at Vexcel and in the next step the quality of the product has to be assured, for further details see Process OP_04.
If the camera fulfills all the acquired quality criteria then the camera is ready to be shipped to the customer.

A more precise description of the shipping process can be found in the process OP_06. Whereas, if the camera's quality criteria are now fulfilled it is going through the reclamation process.

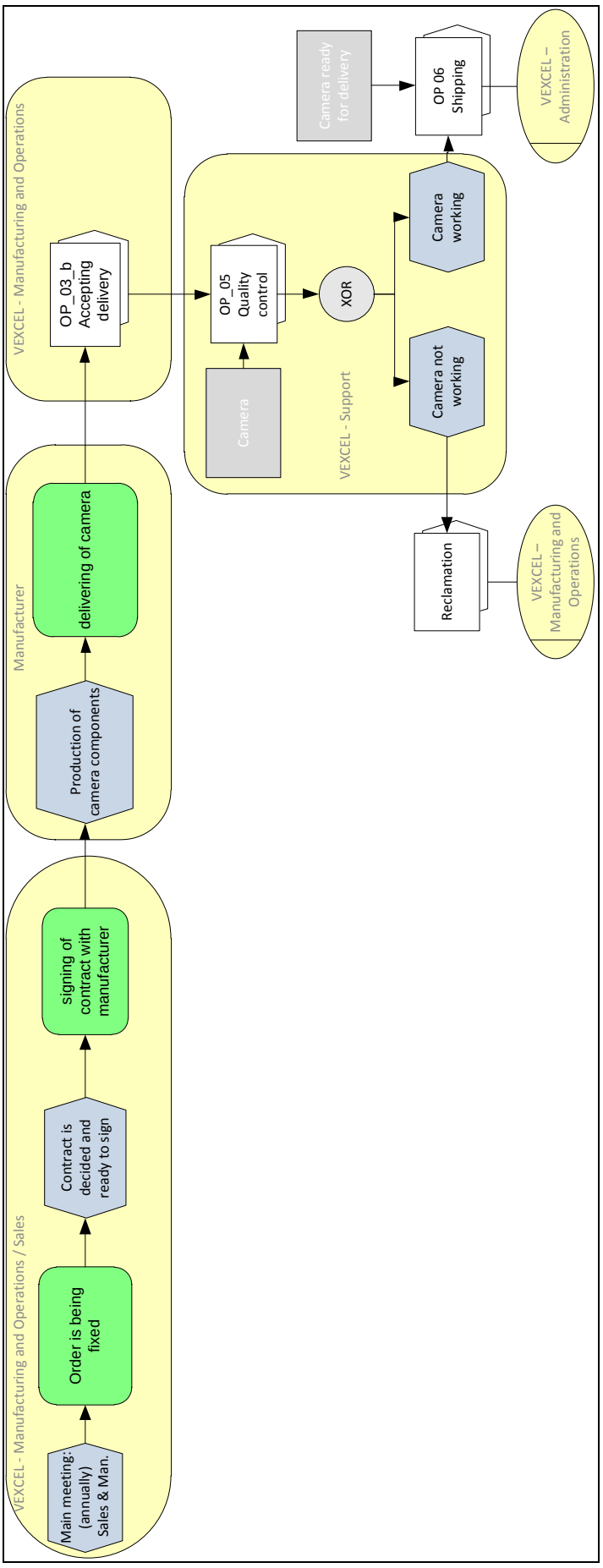

Figure 30: Process OP_03_a - Purchasing of a camera.

3.2.2 Process “OP_03_b Accepting Delivery”

The second procurement process explains how Vexcel accepts a delivery. Please refer to the next page for a comparison to the EPC diagram.

Delivered goods can be accepted on the ground floor or directly at the front desk on the fourth floor of the bureau building. The company’s internal action is that the delivery has to be received, or in other words the goods and bill of material list are handed over. Furthermore, the packing slip has to be accepted and signed. If the delivered goods consist of several items, the packaging slip has to be scanned in and this digital copy has to be sent the Manufacturing & Operations Team (MFT) before it goes to storage. If the delivery consists of only one item, it can be taken directly to storage. A detailed description of the storage process can be found under “OP_04 Storage”.
After storing the goods, the original packing slip has to be brought to office no. 419 where it can be handed over in person or if no one is in the bureau, can be deposited in the tray labeled “Lieferscheine Fertigungsteam”, where all bills of deliveries can be found that have not been added to the ERP system.
Finally, the delivery information has to be put into the “Microsoft Dynamics NAV” ERP system. The entering process of how delivery information is put in and stored in the ERP system is described in the process “OP_03_c Input of delivery information in the ERP system”.

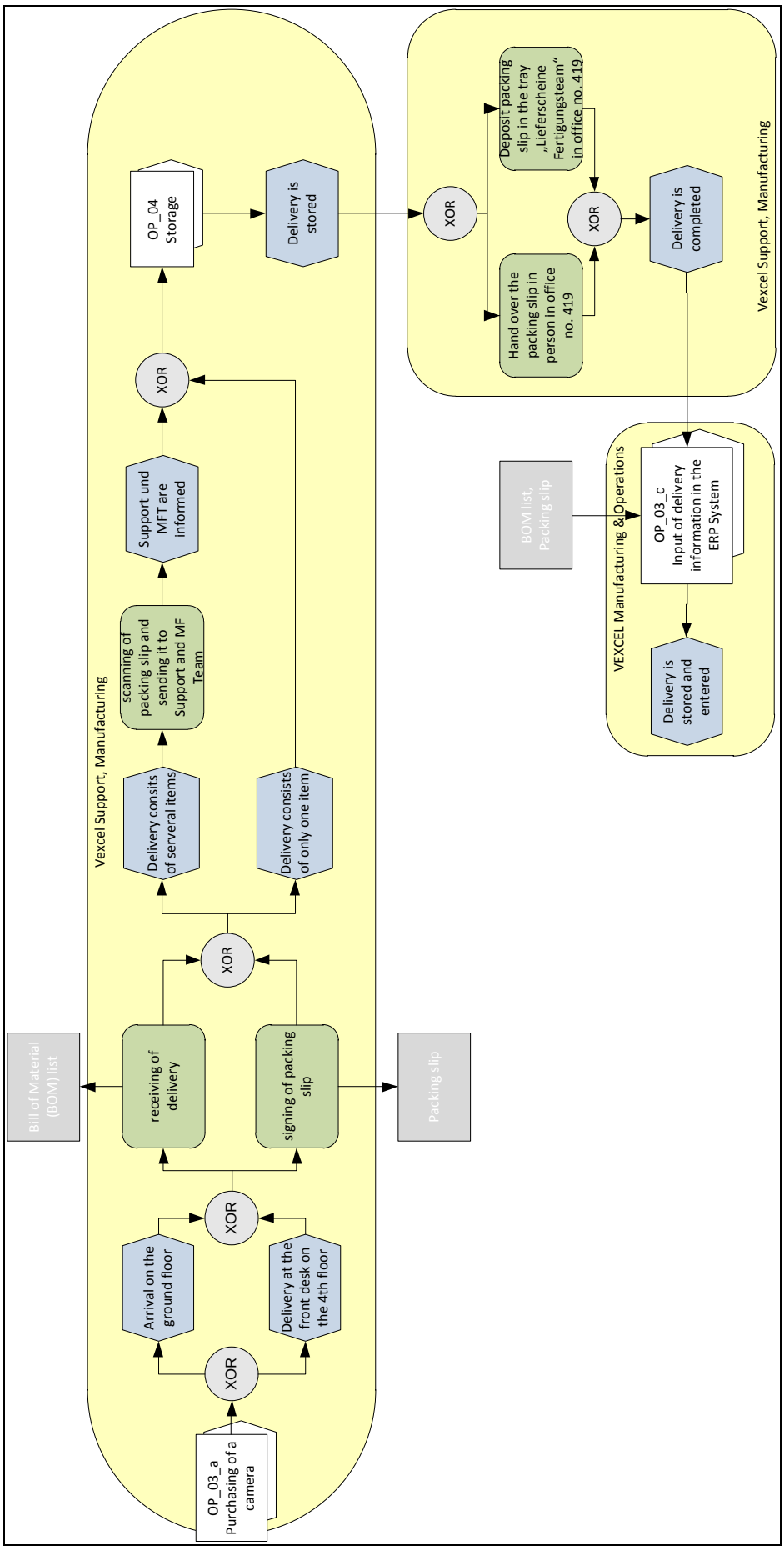

Figure 31: Process OP_03_b - Accepting Delivery.

3.2.3 Process “OP_03_c Input of information about deliveries in the ERP system”

The last process of procurement explains how to store the delivery into the ERP system. Please see the next page for comparison with the EPC diagram.

After the goods have been delivered, the bill of material (BOM) list has to be transferred via automatic import to the ERP system.

Furthermore, especially pre-ordered sensor parts and other pre-ordered items that have entries in the BOM list and are also already in stock have to be taken out of the system before the delivery can be booked to the system via a BOM list.

After approving the packing slip and transferring the BOM data to the ERP system, the purchased items have to be invoiced. Finally, the ordered items have to be revalued by using the “Neubewertungsbuchblatt” within the ERP system.

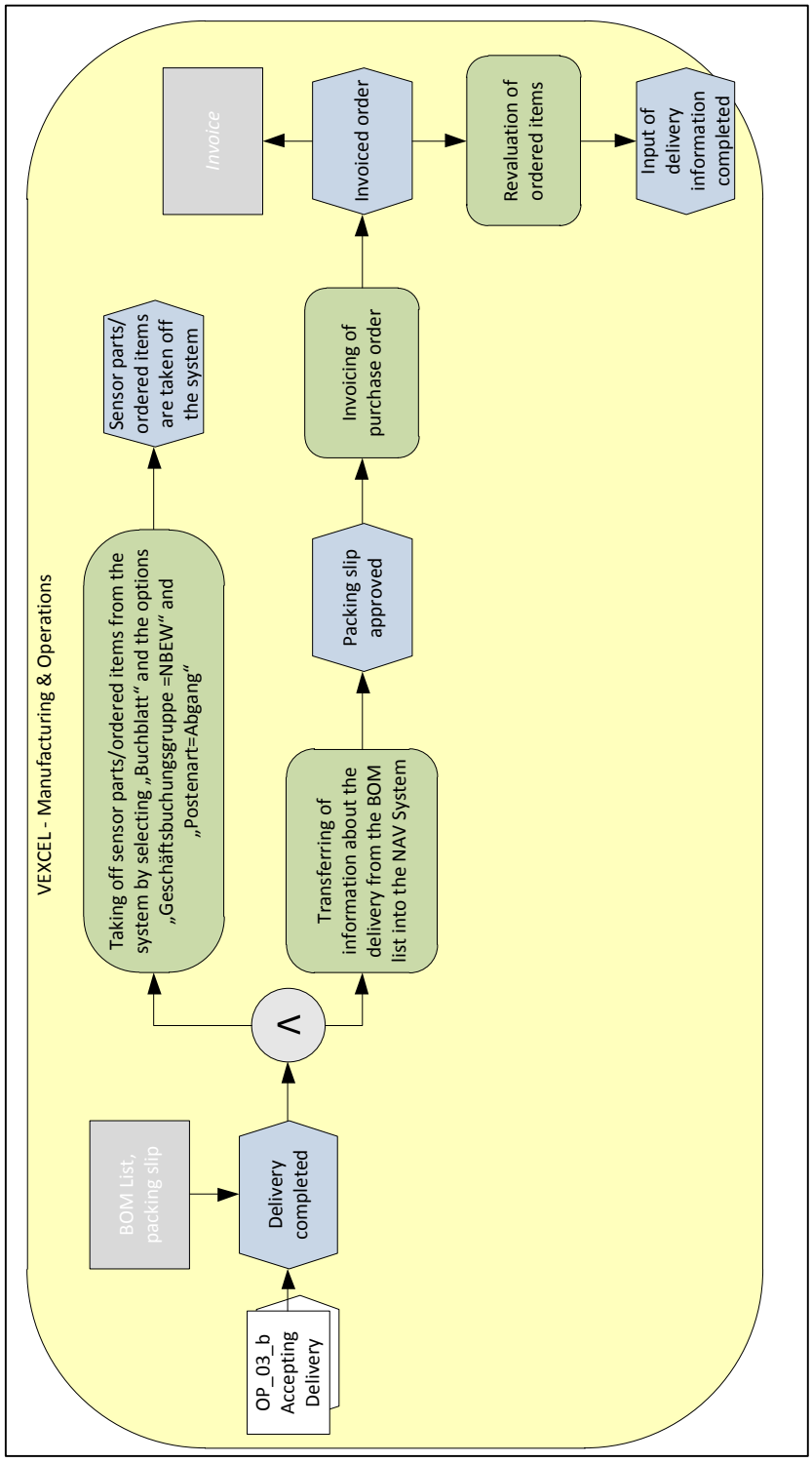

Figure 32: Process OP_03_c - Input of information about deliveries in the ERP system.

3.3 Process “UP08_Change management”

Changes to existing products are discussed in a manufacturing/project meeting.
The amendments then are brought to discussion and are submitted for approval.
If the amendments are granted, sketches are drawn which show the changes of the prototype and/or the prototype is being directly ordered at the same time from the appropriate manufacturer.

The Manufacturer then checks the feasibility for the changes to be made. If the changes are not feasible, some revisions will have to be made to the volitional changes. The pre-drawn sketches are adapted and changed again so that they are compliant with the recommended adaptations from the manufacturer. The adapted sketches then again are sent to the manufacturer who then checks the feasibility again. If they are again not feasible, they recommend other adaptations to the sketches and so on and so forth, until the changes are feasible.

In the next step an internal check is made if the changed components are compatible in size and shape with other components they depend on. In case they are not compatible, the revision numbers of all involved components that have to be adjusted have to be increased.

In case the changes are compatible, just the revision number of the component that had changed has to be increased. The changed component is now checked technically and its release is granted. If the release is not granted, again new sketches have to be drawn and further adaptations have to be made.

Once the release is granted, the manufacturer is informed of the changes regarding batch production. If the manufacturer has made the adaptations a response is given to Vexcel and the process of change of one component is over.

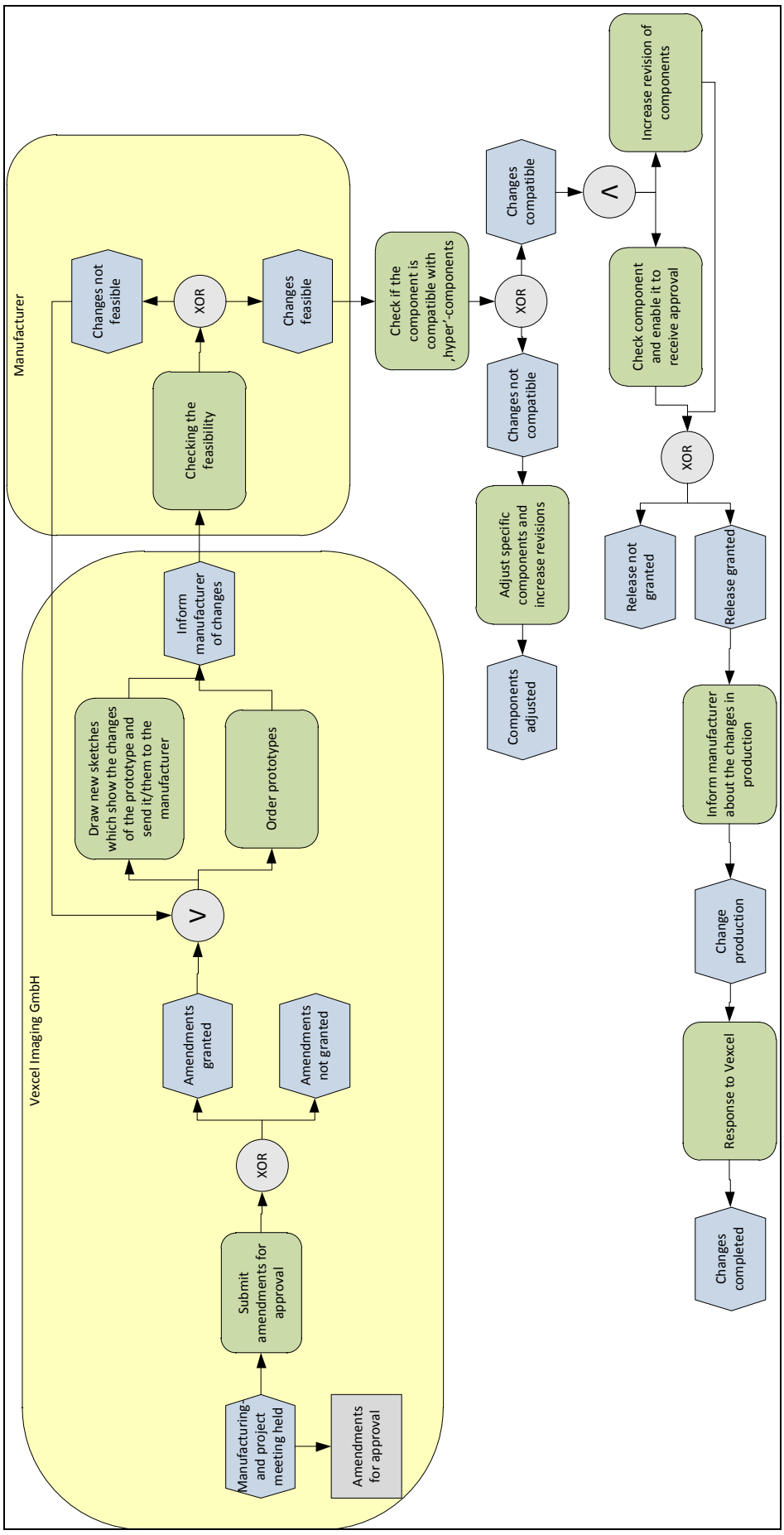

Figure 33: Process UP08 - Change management.

4 ERP with MDN

This Chapter is about the MDN ERP system used by Vexcel. In the course of the implementation of the QMS system, the MDN software came into practice.
The question remains why an ERP system is the answer in questions of quality.
The main reason an ERP system was established to be able to track down components that were sold to customers and broke during the use of the camera.

The situation before the ERP system was the following: Many components had no serial number, did not have the same name at the manufacturer and Vexcel and had no article number. This had many disadvantages.
If for example a main memory chip like an SD-RAM was broken in a camera, it could not be tracked if it was still within the warranty period. It also was not traceable as to which exact camera configuration the broken chip came from neither when it was assembled for the first time or if it was a replacement since this exact memory chip never showed up in reclamation before.
To improve the quality of the camera, Vexcel needed to track that information. The logical answer was to establish an ERP system. The decision for MDN came from the upper management since MDN came from an already familiar company i.e. it is a Microsoft product. The software did not increase any of Vexcel costs because the company is a 100% daughter of Microsoft. Although it must be stated there are no disadvantages to other ERP systems on the market. For general advantages of ERP systems see Chapter 2.5.2.

The beginning of the thesis meant also the beginning of the ERP implementation. Implementation work was made by the company “ACP”, but they had to be discussed and tested by Vexcel. In the following Chapters MDN set up will be explained as well as all the adaptations made to the MDN that relate to this master thesis.

4.1 Setting up MDN

In MDN articles (= components, parts) have to be created first before you can do something with them. This makes sense because this way you cannot sell or buy articles that are not known to the system. At the beginning there are no articles in the system. So the first step was to feed the system with some articles. Therefore, we had to agree on an article ID format, because creating an article in MDN also means giving it a unique number first. Figure 34 shows the adapted input mask of MDN to create a new article. The “Nr.“ field is the first field where the Vexcel ID has to be put in. There is also a second number field “Nummer 2” where the ID of the component from the manufacturer can be put in.

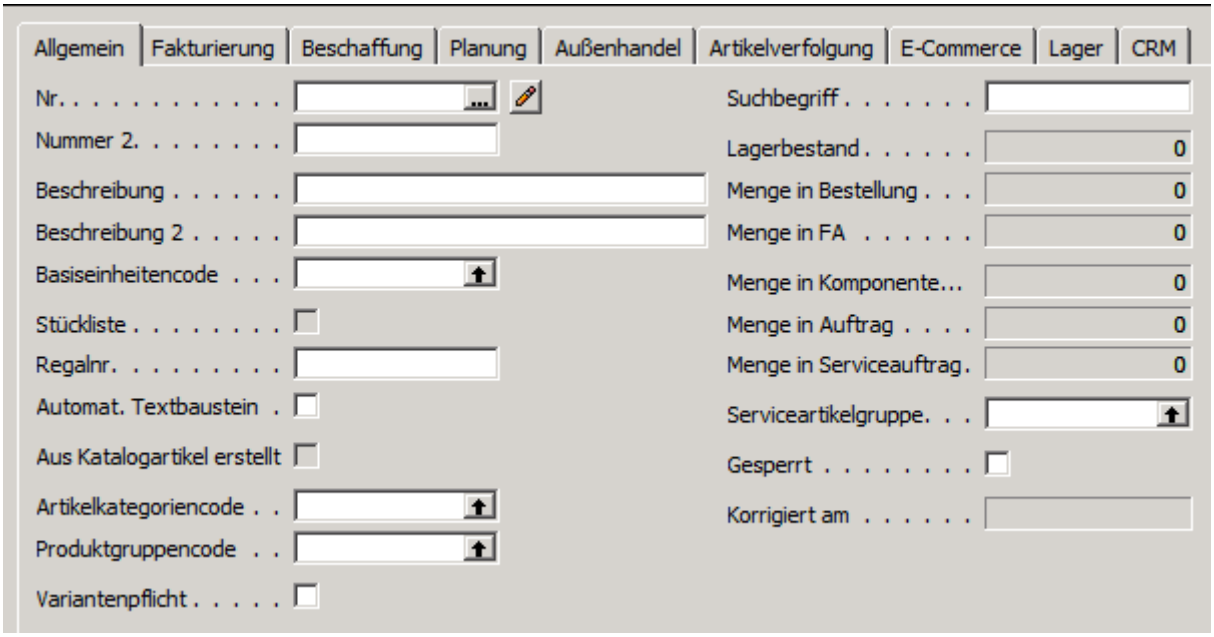

Figure 34: The adapted input mask of MDN to create a new article.

4.1.1 Types of products

In meetings with the responsible persons from “ACP” together with ”Andreas Drumbl” – leader of the “Manufacturing and Operations” team and chief of the project to establish MDN in the company and myself, it was discovered that the product types were different:

- Main components, Assembly group, collection of articles.
- Components that have to be purchased by us or the manufacturer.
- Components that have to be assembled by us or the manufacturer.

- Services and other diverse things.
- Prototypes.
- Components related to IT or Marketing.

To make articles better distinguishable from each other by their article ID's we decided to put different letters in it, depending on the types of articles mentioned above. We specified to let the article ID's all start with the same first letter, a 'V' for Vexcel, followed by a different second letter that stands for their type, followed by two zeros and a continuous 4 digit number. For example, main components look like "VB00XXXX", whereas 'X' stands for any digit between 0 and 9. In this case 'B' stands for "Baugruppe" which means that it is a main component. This article stands for a collection of articles and holds further sub-articles in itself.

To give an overview of all the different articles with their article ID code they are summed up in Table 1.

Article type	Article ID code	German expression
Assembly group	VB00XXXX	Baugruppe
Purchased	VZ00XXXX	Zukauf
Production	VF00XXXX	Fertigung
Service	VD00XXXX	Dienstleistung
Prototype	VP00XXXX	Prototyp
IT, Marketing	VV00XXXX	EDV, Marketing

Table 1: Shows all articles with their corresponding article ID codes.

Every assembly group was specified and has to have a unique serial number. Every serial number later on would be traceable by the ERP system.

Once all the ID's were specified the new articles from the MDN ERP system's point of view were ready for input. For further tests of the ERP system all articles from one whole camera was inserted into MDN. We decided to take the "UCL" camera as our first object, because it

consists of fewer parts compared to other cameras. But at first, the structure had to be specified.

4.1.2 Specifying the structure

In specifying the structure, two things were problematic. All articles that are assembled in a UCL camera needed be known and the complete structure of it as well. All assemblies and their correlating sub-assemblies of a UCL camera had to be known too. It took a long time to determine which exact parts of the camera made up an assembly group and which parts where sub-assemblies. Only after several discussions, meetings, phone calls and many emails with the manufacturer and internal team members of the "Manufacturing and Operations" (= M&O) department was the structure build able. The logical structure was received from the manufacturer, how they physically assemble the UCL camera. But the internal M&O Team had some other ideas and regarding the structure, at least for some components of the camera.

For example M&O wanted quality critical things like sensors that are screwed together with a sensor board to be an assembly group and thus to become a serial number.
As mentioned before, articles with a serial number can be traced. This is very important because of reclamation and other quality issues. Important components became an assembly group or just became a serial number. Components that were important but not critical received a dummy serial number. More details to serial numbers and dummy serial numbers can be found in Chapter 4.2.

Because of these internal wishes of traceability the M&O team had to interfere at some points with the pure physical assembly structure that came from the manufacturer. This is why the structure of the camera had to be adapted because of internal wishes and then to discuss with the manufacturer again to make sure that both parties were in agreement.

4.2 Camera structures

4.2.1 Serial numbers of a camera

Before all the results on camera structures can be shown, the different kinds of serial numbers have to be explained, in order to make these charts readable. Some components needed to have a unique serial number. For this reason, some of these components needed to receive a number after a set number scheme. Three different kinds of serial numbers were decided upon:

- Real serial numbers.
- Dummy serial numbers.
- Reel numbers.

Real serial numbers because they have to be physically put on the component that is serial number obligatory. If the number was stamped, etched or put on the component by any other method was up to the manufacturer, because they knew best how and where exactly to put these numbers on. All components of a camera that could be dismounted for service reasons or replaced by one of the Vexcel support persons received a real serial number.

Dummy serial numbers were also needed these were not put on the parts physically. They only had to exist virtually. They were established mainly to reduce the complexity for the manufacturer.

Reel numbers are also numbers that have to be physically put on the component, with the difference that they have predefined ranges. The idea was born because there are some components that are built together by the manufacturer and also by Vexcel.
So the problem was that Vexcel and the manufacturer could produce the same serial number for these components. Consequently, as to not come into conflict with one another, the manufacturer and Vexcel were given a range of numbers and so the reel numbers came into use.

To give an overview of the abbreviations used in the following structure diagrams of the cameras, Table 2 shows all of them in a nutshell. All types of serial numbers are some letters followed by numbers. The diagrams only show the specified first letters of each serial number, the part that is always the same for each component.

Abbreviation	Serial number type	German expression
ESN	Real serial number	Echte Seriennummer
DSN	Dummy serial number	Dummy Seriennummer
BND	Reel serial number	Band Seriennummer

Table 2: Serial number types and abbreviations in structure diagrams.

4.2.2 Structure of a camera

Every camera has an assembly group “Sensor Unit” in which there are assembled some cones. In these cones there are the objectives of the camera and the sensors to process the signals coming from the objectives. The Sensor Unit is like the power supply unit (PSU) part in all cameras. Some cameras have more assembly groups in common, some do not have as much in common. Actually it depends which cameras are compared together.

4.2.3 Structure charts

In this Chapter the symbolism and meanings of some cryptic numbers of the camera structure charts will be explained.

Every rectangle in the structure charts stands for an assembly group. Every group consists of one or more sub-components. Hierarchically speaking it is also possible that an assembly group has other assembly groups underneath it. The hierarchy is shown by unidirectional arrows leading from the higher assembly group to the lower ones underneath it. The colors of the rectangles have no deeper meaning than just to better separate the assembly groups visually. The numbers starting with a ‘V’ are Vexcel ID’s, all other numbers like “8.9…” are ID’s used by the manufacturer for the same component.

In the following Chapters about structure charts the functionality of the cameras will not be explained neither the meanings of all of the assembly groups because the thesis would lose its focus.

4.2.4 Structure of a UCL camera

The UCL Camera is the light version of all cameras. In comparison to other cameras it has only four object lenses. Therefore, the UCL is cheaper than other cameras and is mainly thought to be the entry level camera for new customers.
The UCL is a medium format camera. This means that it does not have a large resolution.
In comparison to other cameras it weighs nearly nothing which makes a flight easier and more cost-efficient.

It is possible that there is a second flash data unit (FDU) ordered with a UCL camera. This optional FDU is not part of the camera itself, as it can be ordered additionally if the customer decides to buy it.

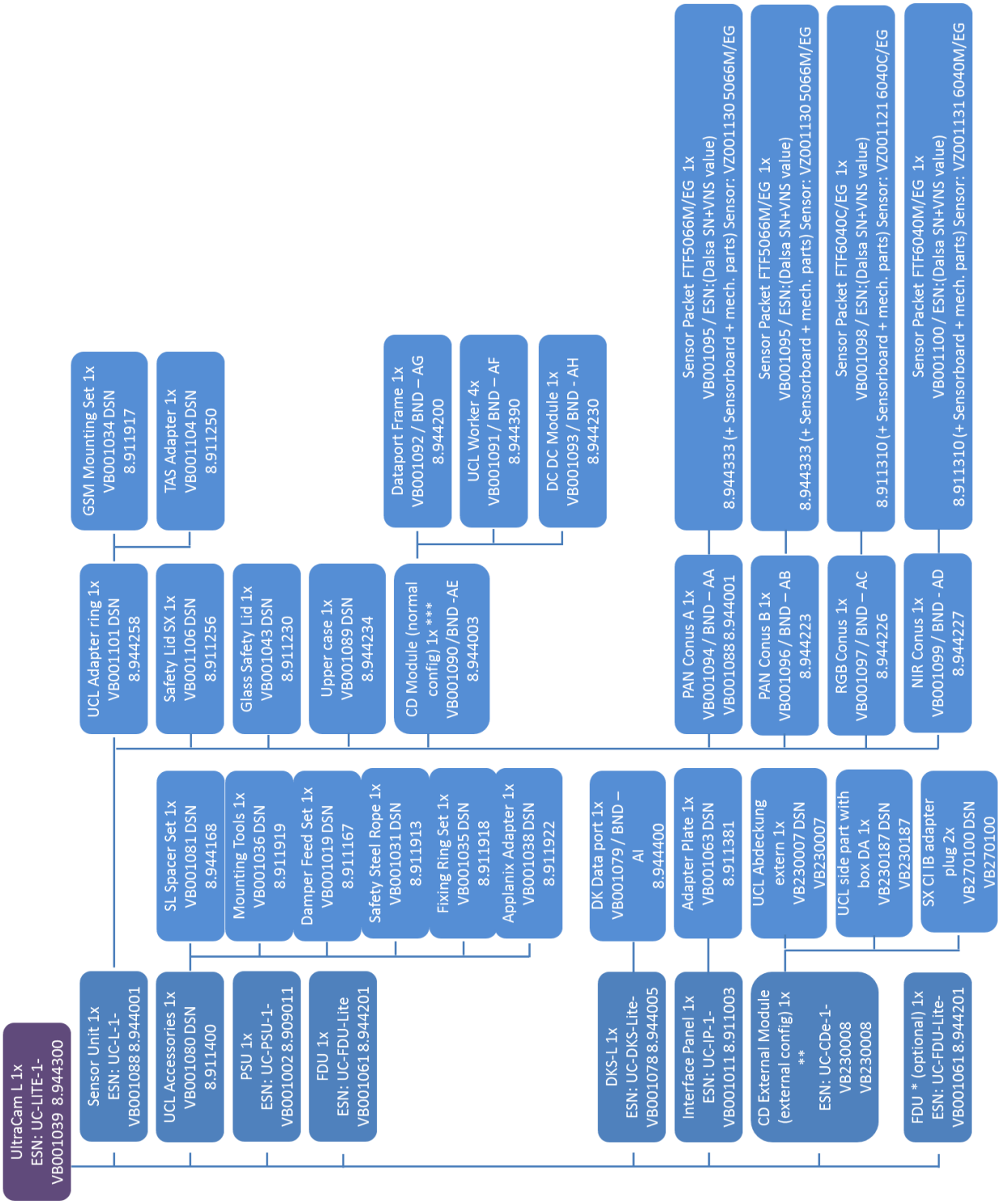

Figure 35: The assembly structure of a UCL camera.

4.2.5 Structure of a UCG camera

The G stands for „giant“. It is thought for internal use only, not for sale and therefore not explained in detail. The main structure is similar to other cameras.

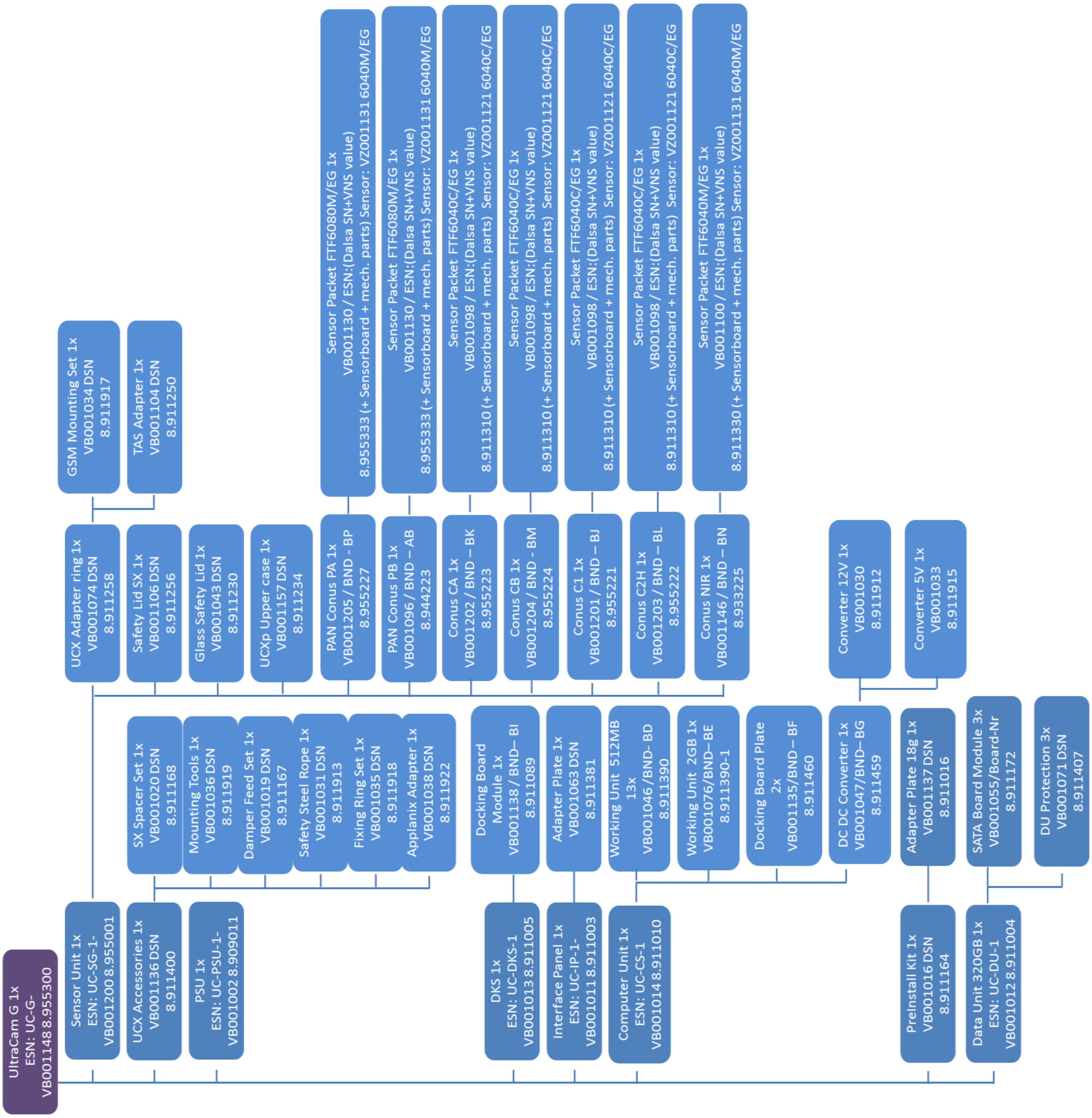

Figure 36: The assembly structure of a UCG camera.

4.2.6 Structure of a UCX camera

The UCX camera is the follow-up model of the first camera of Vexcel, the UCD.
It has a better memory workflow than its predecessor. The data transfer from the camera to local hard discs was improved and is much faster. It has a bigger sensor and thus more Megapixels resolution.

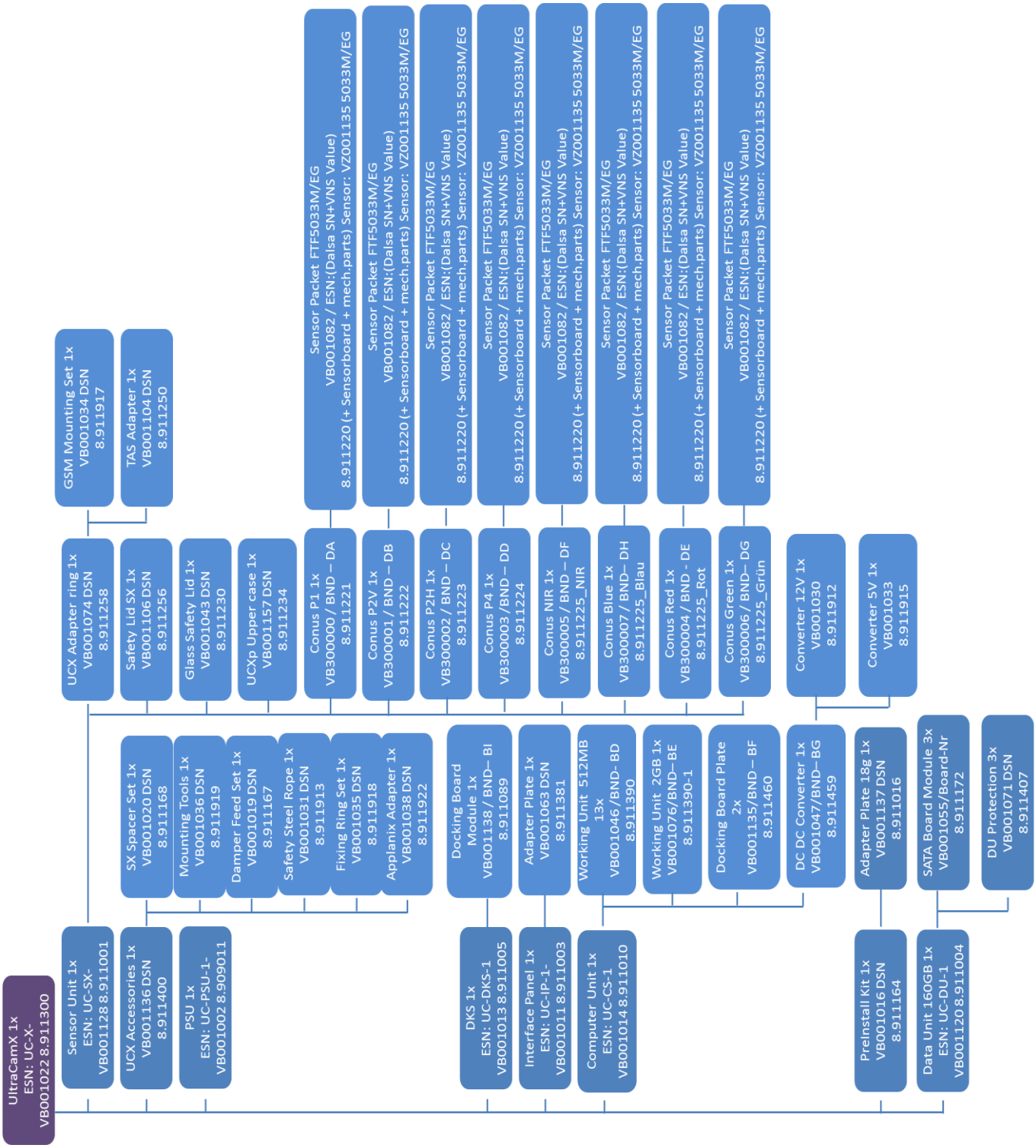

Figure 37: The assembly structure of a UCX camera.

4.2.7 Structure of a UCXp camera

The UCXp camera is the follow-up model of the UCX.
It has an enhanced sensor unit, more Megapixels resolution and thus it is more expensive than a UCX camera.

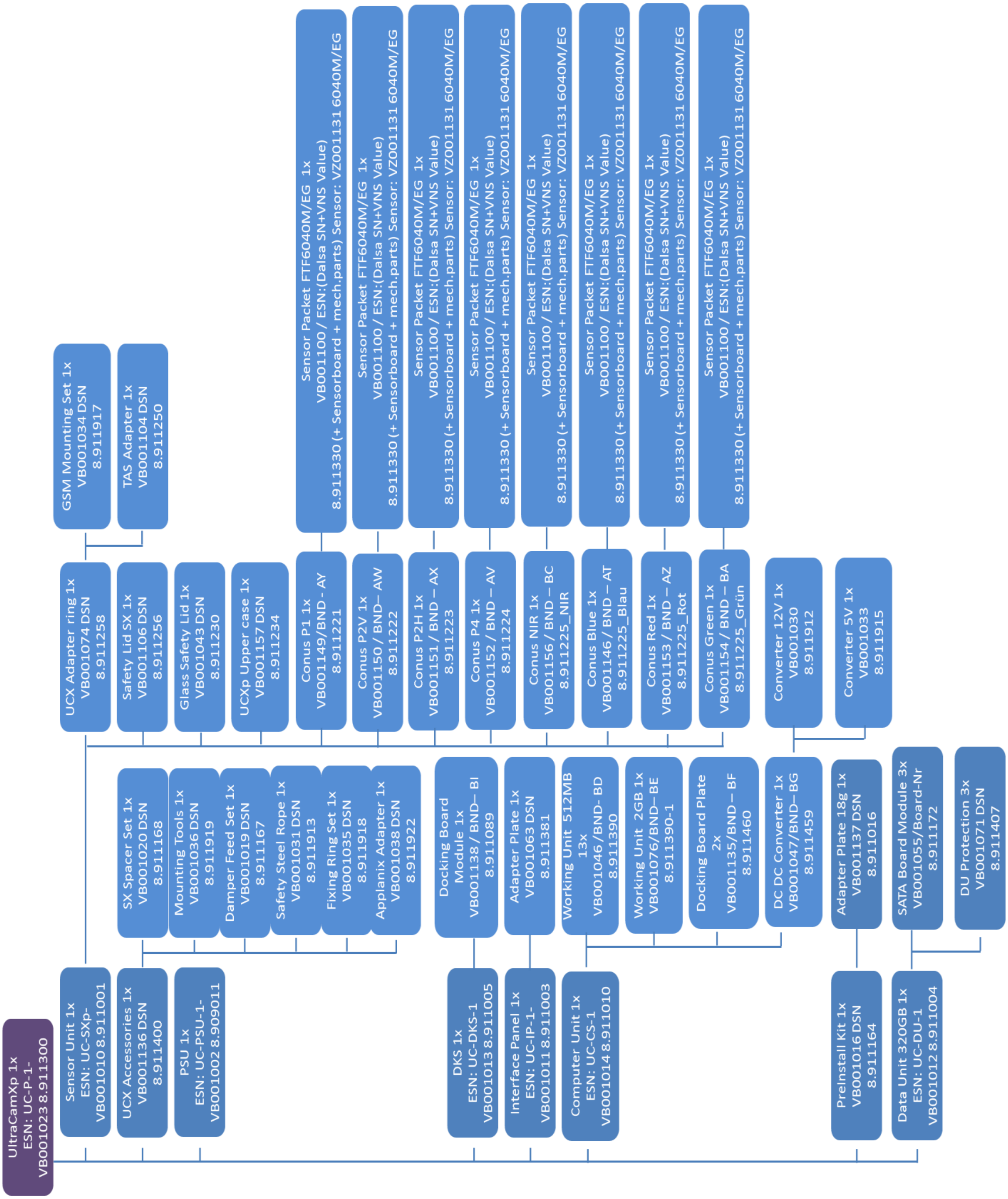

Figure 38: The assembly structure of a UCXp camera.

4.2.8 Structure of a UCXp-wa camera

The “wa” stands for wide-angle and was thought for customers who can only afford smaller aircraft like prop airliners. Prop airliners cannot fly very high, so the objective has a wide angle that allows wide angle shots at for lower flying aircraft. Furthermore in some areas of the world the heights for photogrammetric flights are restricted so it has to be flown lower, which would not be possible with a camera that has a normal angle.

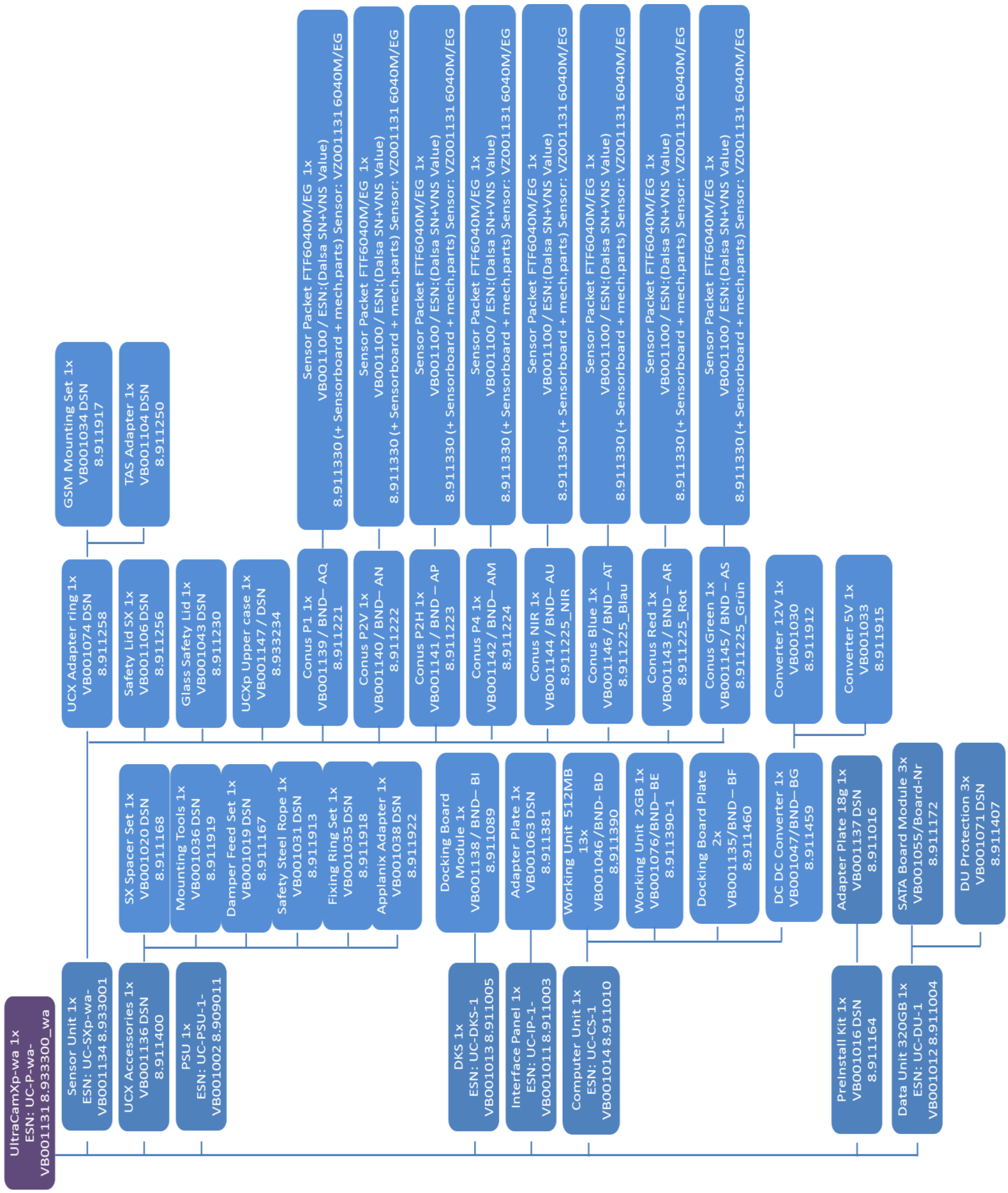

Figure 39: The assembly structure of a UCXp-wa camera.

4.3 Adaptations made to MDN

After specifying the structure of a camera as mentioned in Chapter 4.1.2, the first articles had to be put in manually into the MDN system. The reasons why this had to be done are explained in Chapter 4.1.

During discussions all components of a UCL camera were added to the system first, because it “only” has ~400 components assembled in it and therefore is not as complex as other cameras. Afterwards we then would be able to simulate the delivery of the whole UCL camera.
The goal seemed logical but there was hard work to be done. Every component had to be put in via input mask of MDN like the one shown in Figure 34 in Chapter 4.1. To unravel the complexity, to minimize failures during input and time that was spent by manually input of the data, importing all articles automatically via comma separated value (CSV) files was implemented.
More details on automatic import of article lists in CSV format can be found in Chapter 0.

The MDN system is aware of assemblies and sub-assemblies. It is designed to handle products and sub-products. What was not within basic functionality was the automatic import of lists that represented assemblies and their sub-assemblies.

So it was decided to make an adaptation to the MDN system so that it was able to import a bill of material in CSV format. Internally we referred to a bill of material as “BOM list”. A BOM list is a hierarchical built and nested list. It shows all assembly groups and their sub-assemblies. They were important to Vexcel because with them they could keep track of all of their products. More details on automatic import of BOM lists in CSV format can be found in Chapter 4.3.3.

4.3.1 Import lists

There was the need to input so much information to MDN, that the automated import of lists that hold that kind of information was a necessity. In these lists there was the same information as there was to put them into the system manually. The advantage to import these lists was that it was much quicker and easier to put in the information.

4.3.2 Automatic import of a list of articles

A list of articles consists as the name says of articles or of parts if preferred, as shown in Figure 40. It can contain 1 up to an infinite number of articles. The articles are independent of each other.

Figure 40: The structure of an article list.

MDN does not care if these parts in the list belong to a camera or something else. MDN just needs to know all articles before it can work with them. So, all that is to be done is to import articles so that a pool of articles is in the system. Of course every article requires very much information about itself. Table 3 shows a small cut-out of an article list.

No	No.2	Description	Description 2	DescENU	DescENU2	Vendor Item No
VB001200	8.955300	UltraCamG	UCG Camera System			8.955300
VB001400	8.911016	Adapterplatte				8.911016
VF001402	8.105503	Miniaturgleitschiene 1	Länge 180mm			8.105503
VF001403	8.105504	Miniaturgleitschiene 2	Länge 250mm			8.105504
VF001404	8.911034	SX-Schraubdeckel				8.911034

Table 3: A small cut-out of an article list.

Actually an article list has more columns than shown above. Table 4 shows all columns of an article list in correct order for the import. Furthermore, it shows if the information is optional or not and the field length that MDN is able to import. If the field length of the input is too long or a non-optional field is missing, MDN would abort the whole import.
It is very important to know how exactly import lists have to look to be import compliant, otherwise MDN would just show a cryptic error message during import and nobody knows where to find the error in the article list. Another tricky thing is that MDN cannot handle quotation marks in import lists. Quotation marks in any import field were leading to errors.

No.	Column/field name	Description	Optional [Yes/No]	Field length
1	Vexcel ID	The internal ID of the article.	No	20
2	No. 2	The ID of the article of the Manufacturer.	Yes	20
3	Description	The name of the article.	No	30
4	Description 2	Further description of the article.	Yes	30
5	Description ENU	The name of the article in English.	Yes	0
6	Description ENU 2	Further description of the article in English.	Yes	0
7	Vendor Item No.	The ID of the article of the vendor.	Yes	20
8	Variant code	Revision number of the article.	Yes	10
9	Variant Code Description	The description to the revision.	Yes	30
10	Vendor No.	The ID of the vendor who sells the article.	No	20
11	Base Unit of Measure	The unit in that the item is measured.	No	10
12	Purchase Unit of Measure	The unit in that the item is purchased.	No	10
13	Purchase Quantity	The quantity of one purchase.	No	10
14	Last Direct Cost	The price of the article.	Yes	0
15	Item Tracking Code	If the article needs to have a serial number or not. Two inputs are possible: “SNRALLE” if yes or “KEINE” for not.	No	0
16	Product Group Code	The product the article belongs to.	Yes	0
17	Search Description	The search keyword for the article. If left empty, the “Description” field is automatically put into this field instead.	Yes	30
18	Item Category Code	The Category of the article. “WCAM” if it belongs to a camera.	No	0

Table 4: Import fields needed for an article list.

4.3.3 Automatic import of bill of materials (BOM)

Like shown in Figure 41 BOM lists are hierarchical nested lists. Each camera has a different configuration of assemblies and sub-assemblies.

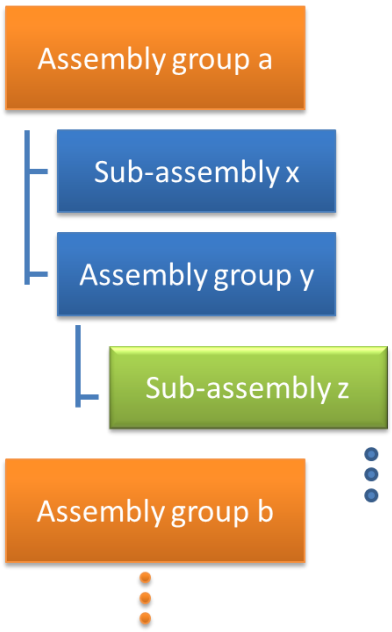

Figure 41: The structure of a BOM list.

Every time a camera is delivered, sold or restructured, Vexcel wanted to be able to track all of the assemblies and sub-assemblies of that camera. Because a camera can consist of thousands of sub-components, manually inputs of these would be impossible to manage. This is why it had to be assured that it was possible to import cameras automatically.

A practical example of a BOM list is shown in Table 5.

UC-LITE-1-00410036	VB001039		UC-DKS-Lite-50514048	VB001078			DKS Lite		1
UC-DKS-Lite-50514048	VB001078			VF001038	0.0		Typenschildblech DKL		1
UC-DKS-Lite-50514048	VB001078			VF001039	1.0		DKL Blende		1
UC-DKS-Lite-50514048	VB001078			VF001040	0.0		Winkel DKL Blende		2
UC-DKS-Lite-50514048	VB001078			VZ001173			Scheibe DIN 125 A4	3,2x7x0,5	2
UC-DKS-Lite-50514048	VB001078			VZ001176			Zyl.-Schraube M3x8	DIN 912 A2	2
UC-DKS-Lite-50514048	VB001078			VZ001177			Mutter ISO Stahl verzi	selbstsichernd Aerotight	2
UC-DKS-Lite-50514048	VB001078			VZ001178			UCX-Power Cable EU 2m	RS 305-784	1
UC-DKS-Lite-50514048	VB001078			VZ001047			Mini SAS Cable 2m	Host auf Multilane screw	1
UC-DKS-Lite-50514048	VB001078			VZ001179			ESD Versandschachtel		1
UC-DKS-Lite-50514048	VB001078		01-90006272	VZ001180			CRU Dataport 2 Bay	SAS/SATA Enclosure	1
UC-DKS-Lite-50514048	VB001078			VZ001181			Internal SATA Data Cab	200mm	2
UC-DKS-Lite-50514048	VB001078			VZ001182			Floppy Disk Drive Power Cable	SPC 19800	1
UC-DKS-Lite-50514048	VB001078			VZ001183			Zyl.-Schraube M3x5	DIN 912 A4	4
UC-DKS-Lite-50514048	VB001078			VZ001402			PCIe Card LSI-SAS3801E-SGL		1
UC-DKS-Lite-50514048	**VB001078**		**AI00001**	**VB001079**			**DK Dataport UCL**		**1**
AI00001	VB001079			VF001041	0.0		DP Bindeblock		2
AI00001	VB001079			VF001042	1.0		DP Seite		2
AI00001	VB001079			VF001043	1.0		DP Abdeckung		1

Table 5: A BOM list.

The first and second columns are for hierarchy reasons. The first column is the serial number of the assembly that one component is built into. The second column is the Vexcel ID of the assembly that the component is built into. As mentioned before in Chapter 4.1.1, every assembly group that has sub-assemblies has a unique serial number. The third column is obsolete and has to be empty for the import.
Each row holds one component. If in one row there is no entry in the first and second column, it means that the component is the absolute main assembly. In this case the absolute main assembly is a camera, the UCL, short for “Ultracam L”. Every yellow marked row means that this component is a main assembly group. Every green marked row is a sub-assembly of a main assembly group.

4.3.4 Product groups

The product group codes had to be specified for each article to associate an article to a product. The advantage of this was that in MDN all articles that belong to a product could be filtered out. All product group codes that were specified during this thesis are shown in Figure 42. The product group code was one field in an article list, see Table 4.

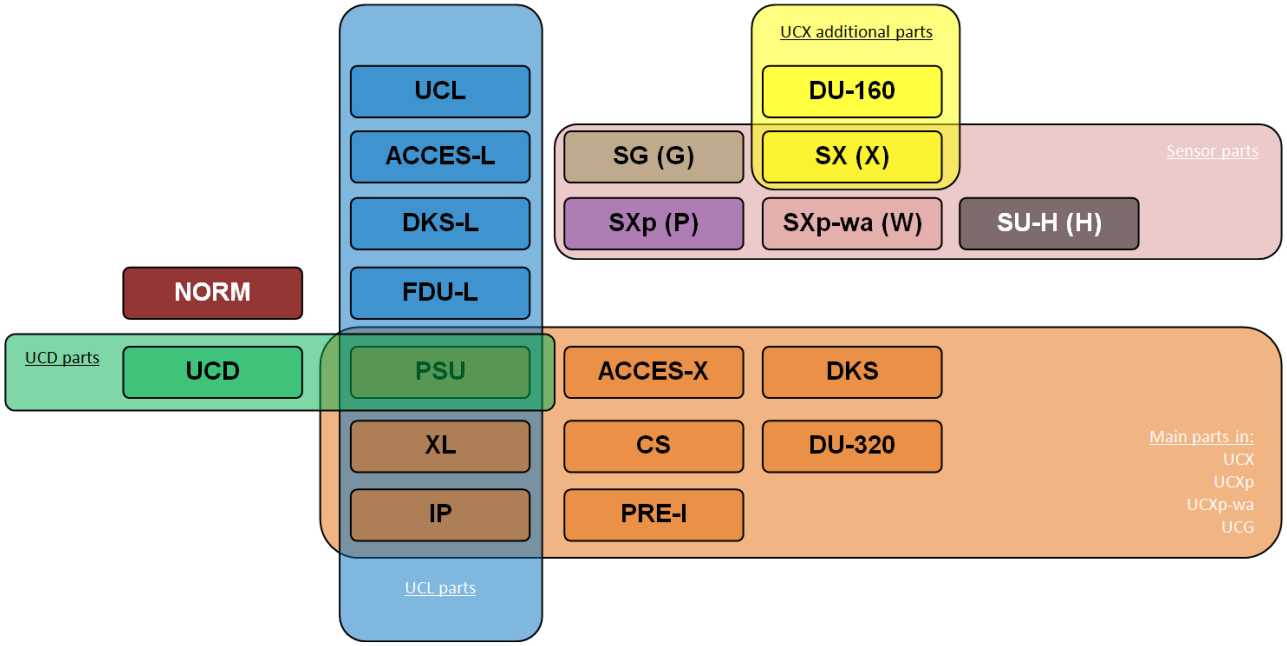

Figure 42: Product group codes of Vexcel.

5 Summary

This thesis is the first step for the Vexcel Imaging Corporation that leads it closer to the realization of the Microsoft Dynamics NAV ERP system.

It summarizes the most important concepts of graphical design techniques to design business processes. The concepts are compared to each other and their Pros and Cons are stated. The ideas behind quality management, business process management and ERP systems are brought to the point. Additionally it is shown how these terms are related together.

All business processes of the Vexcel Corporation regarding ERP are documented.
The ordering process of cameras and goods, the delivery process and the process of how new cameras and assemblies are made from scratch is described.

Assembly structures of different camera types are highlighted in graphical charts.
Article lists, which are lists of assemblies that can be put into the Microsoft Dynamics NAV ERP system per automatical import, are described. Also BOM (bill of material) lists that represent the structure of camera assemblies are described in detail.

Furthermore, all assembly specificiations that had to be made to initialize the Microsoft Dynamics NAV ERP system at the Vexcel Corporation are summarized.

Additional information like assembly specifications, number formats and product group definitions are highlighted to provide better understanding to the matter.

6 Outlook and further research

Once the Microsoft Dynamics NAV ERP system at the Vexcel Imaging Corporation is up and running, the remaining step is to automate certain business processes.

When new orders are entered into the ERP system, manufacturers or delivery companies could get informed automatically about new orders that have been made in the ERP system.

Also the delivery process could be handled automatically. Assemblies like cameras or spare parts that are delivered to the Vexcel Corporation could be delivered automatically in the future.

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9 List of Abbreviations

Abbr.	Explanation
ACP	The “ACP IT Solutions GmbH”, company responsible for MDN implementation.
AND	And, logical operation.
BOM	Bill of material, English for “Materialstückliste”.
BP	Business process.
BPM	Business process management.
BPMI	Business process management initiative, company name.
BPML	Business process management lifecycle; Business process Meta language.
BPMN	Business process modeling notation.
BPMod	Business process modeling (in the literature abbreviated BPM).
CSV	Comma separated value, a computer file format.
EPC	Enterprise process chains – a standard to design BP charts.
EPK	“Ereignisgesteuerte Prozesskette”, German for EPC.
ERP	Enterprise Resource Planning.
ES	Enterprise software or Enterprise system.
FDU	Flash data unit.
ISO	International standardization organization.
ISO 9000:2005	An ISO norm describing all technical terms regarding quality.
ISO 9001:2008	An ISO norm describing a QMS.
M&O	The “Manufacturing and Operations” department of Vexcel.
MDN	Microsoft Dynamics NAV (ERP software).
NAV	Navision, ERP System, full name is MDN.
OMG	Object Management Group, company name.
OP	Operational Process.
OR	Or, logical operation.
P/T	Place/Transition (Petri net).

PO	Process orientation.
PSU	Power supply unit.
QM	Quality Management.
QMS	Quality Management System.
UCG	UltraCam G, a special camera type.
UCL	UltraCam L, a special camera type.
UCX	UltraCam X, a special camera type.
UCXP	UltraCam XP, a special camera type.
UCXP-wa	UltraCam XP-wa, a special camera type.
UP	“Unterstützungsprozess”, Supply process.
Vexcel	Vexcel Imaging GmbH (company name).
WILD	Wild GmbH, company name, manufacturer of the Vexcel.Corporation.
XOR	Exclusive or, logical operation.

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