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Efficient Processes and Transparent Information Flow in Supply Chain Through Use of RFID

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Master of Science in Computer Science
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Problem Description

Development of solutions and systems for electronic product tracking and supply chain control through RFID technology (Radio Frequency Identification) and EPC (Electronic Product Code) is an area of high progress. An increased number of global businesses are already using this technology in their supply and logistics functions to create improvements and competitive advantages. The master thesis is a part of the user guided innovation project "Smart Vareflyt: Smart, effective and safe product flow through intelligent packaging and electronic tracking", that deal with how RFID technology and EPC in connection with packaging shall increase the competitive advantages in Norwegian grocery sector by creating:

- Faster product flow and reduced use of resource
- Safer and real-time transfer of information between supply chain actors
- Increased food safety through improved access to relevant and correct tracking information

The BIP project is done in a collaborative network with central companies in the Norwegian grocery market, all engaged in the profit and competitive advantages RFID tagging and EPC may create in supply chain logistics.

The master thesis will focus on research challenges in future product and information flow when using RFID to exchange information and improve efficiency in supply chain processes.

Main question and tasks:
How to create efficient processes and transparent information flow in supply chains using RFID?

This main question shall be answered by performing the following tasks:
1. State-of-the-art – Use of RFID in supply chains relevant to Smart Vareflyt.
2. Map out which processes impacted, find the information needed and how information flow will become.
3. Describe possibilities given by RFID when considering data collection and use of this information in a supply chain
4. Introduce recommendations concerning use of RFID to create efficient processes in product and information flow in value chains

Assignment given: 21. January 2007
Supervisor: John Krogstie, IDI

Abstract

RFID is an up-and-coming technology holding promise of closing information gaps in the supply chain. Information is probably the biggest driver of performance in supply chains today and information control is seen as a huge advantage in management. This report addresses how RFID may contribute to improve management and supply chain within warehouse management. By doing a case study of three Norwegian businesses the report finds processes in management and logistics. An evaluation of where a theoretical RFID implementation may impact show that RFID increases data and data collection in almost all identified processes. Both management and logistics in general have the potential of automating several processes and collected data results in increased information sharing. When businesses handle identified challenges in the technology RFID have huge possibilities in improving warehouse management and the supply chain in general.

Preface

This report is the result of a Master thesis in TDT4900 Computer Technology, Information Systems at Norwegian University of Science and Technology (NTNU), Department of Computer and Information Science (IDI).

The project was given by SINTEF Technology and Society, Department for Operations Management, and is an integrated part of one of their internal projects, Smart Vareflyt. The Master thesis wants to find possible impacts when introducing RFID to logistics and supply chain. SINTEF provided knowledge, resources and business cases necessary to complete the project. The work started in January and ended June 2007.

The report contains an evaluation of how RFID may influence business warehouse management. This is done by a literature study of state-of-the-art in RFID technology, modern logistics and supply chain terminology, and analysis of three Norwegian business cases, Norplasta, Gilde and NorgesGruppen.

Working with this project has been interesting and informative. The work area is up-to-date and Norwegian businesses are starting to realize that RFID technology and its influence to supply chain are considerable. Hopefully this report will increase the knowledge and interest for implementing RFID technology in Norwegian businesses.

I want to thank my advisors John Krogstie and Heidi. C. Dreyer from NTNU for professional contributions and commitment to the project. I also want to thank the contact persons Rolf Solberg, Knut Gjønnes and Bjørn Weiby from Norplasta, Gilde and NorgesGruppen, and all employees answering my questions. Without you this master thesis would never be completed.

Trondheim, June 22, 2007

Anita Sørensen

Content

1 Introduction

Radio Frequency Identification (RFID) has existed for almost 60 years, but it was not until 10-15 years ago businesses discovered the value of using the technology. In this time it has been tested thoroughly and implemented in many marked segments. In 2003 Wal-Mart required one hundred of its suppliers to use RFID to tag cases and pallets sent to some Wal-Mart distribution centers. With this announcement Wal-Mart was the first chain store to demand RFID in its supply chain [ROBERTI1, ROBERTI2]. Big actors as Wal-Mart, Metro Group and several research centers all over the world join in the race of finding and implementing solutions that give advantages and increase business benefits.

Electronic Product Code (EPC) provides a global product identification and numbering system that makes it possible to tag and identify objects down to item level. EPC will enable computers to automatically recognize and identify everyday objects. It will contribute to create what is referred to as an "Internet of things". UTI[1] describes the "Internet of things" to be dynamic networks of networks, consisting of small communicating "gadgets", and is a part of the future ubiquitous computing environment [UTI]. RFID and EPC is an essential part of bringing manufactured products and its data into this environment.

Some interesting areas in RFID environments in the last few years are process visibility, warehouse management and supply chain improvements, but research has not been published in large extent. Simchi-Levi points out that RFID provides complete visibility throughout the supply chain and an implementation will improve both accuracy and speed of data collection [SIMCHI-LEVI]. He also states that both retailers and manufacturers will benefit from significant reduction in the bullwhip effect[2] as inventory levels are reduced and better utilization of resources, e.g. manufacturing and transport resources, may be achieved. According to Rebecca Angeles [ANGELES] RFID hold the promise of closing information gaps in the supply chain. The potential of liberating manual tasks from certain workflows, as well as making information visible to all participants in a supply chain are also benefits described by Angeles.

Making products "talk" to each other, to manufacturers and customers will become a part of the ubiquitous future. It is not known how this affect the way businesses perform their work today. Chopra and Meindl [CHOPRA_MEINDL2007] states that information probably is the biggest driver of performance in the supply chain. It is clearly that RFID can not be implemented without understanding of how technology works and impacts supply chain processes and its related information. Finding changes in information and processes is the main motivation for this project as it is believed to be the root of RFID success in supply chains.

[1] International Telecommunication Union (ITU)
[2] Increased variability in demand when traveling up the supply chain [SIMCHI-LEVI_KAMINSKY2003]

1.1 Project Goal

According to Chopra and Meindl information is “the glue that allows for the other supply chain drivers to work together with the goal of creating an intergraded, coordinated supply chain. Information is crucial to supply chain performance because it provides the foundation on which supply chain processes execute transactions and managers make decisions” [CHOPRA_MEINDL2007]. Further they stated that information is probably the biggest driver of performance in the supply chain and information must have three different characteristics to be useful making supply chain decisions:

1. Information must be accurate
2. Information must be accessible in a timely manner
3. Information must be of the right kind

If managers have the right information they can become more aware of each and every process. It may improve management and facilitate decision making. The project wants to analyze three different businesses according to processes and data. By introducing increased data collection in each business the project seeks the following goal:

Investigate how RFID contributes to improve management and supply chain.

Improved management and supply chain implies that decisions are based on more accurate and reliable information, and done quicker than today’s solutions. Improved management and supply chain should facilitate work by less time and fewer manual tasks. Automating is a keyword to accomplish this. More automated tasks require more electronic information. RFID may contribute to this. Improved supply chain will give potential of quick adaptation of processes to counter the fast changes in demand and decrease the bullwhip effect. Shared information, as in earlier notifications of changes in demand, is necessary to avoid this unwanted phenomenon. An aspect relevant to information sharing may be food safety. Surveillance of product storages and/or product flow, together with information sharing, will contribute to achieving the project goal. This may also be known as track and trace of products. Supportive goals to the former project goal are:

1. *Present how RFID technology may increase the amount of electronic data.*
2. *Find management processes where automating are realistic and advantageous.*
3. *Find information advantageous to share between business partners.*
4. *Find strategic areas in chain to implement surveillance/track and trace.*

1.2 Contribution

This project addresses the issue of information and process change when implementing RFID solutions to a supply chain. Three different business cases forming a supply chain has been analyzed. Analysis is done using commonly known analysis techniques used in information system design. The analysis seeks to find internal processes and detailed data elements in each process. Each process is evaluated against known business cases from all over the world, and possible RFID solutions are found in every process. Data elements and process information are evaluated against solutions affecting every process. Changes

are taken out to show affected processes. The purpose is to concretize where RFID introduces contributions to increase the control of processes and management may be improved.

1.3 Project scope and limitations

Business cases used in the project are collaborators of SINTEF and only businesses predefined by SINTEF are used in the business case analysis. The businesses need to form a complete and dependent supply chain with several supplier/costumer relationships. Gildekassen is the product to be followed through the formed supply chain and evaluations are limited to relevance of this product. The project does not consider economical issues or technical aspects related to solution implementation.

1.4 Outline

The rest of this text is structured as follows. Chapter two presents the research method and tools used in this project. Chapter three gives an introduction to RFID and information possible to collect using this technology. Chapter four introduces the reader to logistics definitions and supply chains while the fifth chapter describes a general supply chain using the process reference model SCOR. The sixth chapter presents research questions and selects a research area relevant to the project goal. Chapter seven describes an overview of data and information in the chosen area, used as comparison in business case descriptions. Chapter eight, nine and ten presents the business cases, solutions found for each case and an evaluation of how these solutions affect data, information and processes in the businesses. Chapter eleven concludes the work of this master thesis.

2 Research Method

Robert K. Yin [YIN2003] states that the choice of research method is influenced by three conditions:

1. Types of research questions
2. Extent control of behavioral events
3. Degree of focus on contemporary events

To find an answer to the project goal descriptive business case analysis is required and no control of behavioral events was possible. Further Yin says that direct observations of events being studied, and interviews of the persons involved, are two sources of evidence usually included in cases study, both sources important parts in business analysis. The project used theory and state-of-the-art to form research questions, which implied that point one in Yin's conditions would not be possible to answer until after this part was completed. However, is seemed that case study was an adequate research method for this project and after completing the theory section this was confirmed by the concrete problem formulations.

2.1 Case study

According to Yin a case study is an empirical study covering contextual conditions. "It investigates a contemporary phenomena (in this case the phenomena is data elements and changes in data elements) within its real-life context (in this project the context is business and RFID implementation), especially when the boundaries between phenomenon and context are nor clearly evident". Further Yin states that "case studies can be based on any mix of quantitative and qualitative evidence. In addition, case studies need not always include direct, detailed observations as source of evidence."

Companies implementing RFID try to reach different goals. Some goals are quantifiable and measurable, such as faster transportation, fewer goods in storage and less storage time. Other goals are qualitative and may be creating better processes or easier management. It is not possible to quickly implement suggested solutions, and investigating impacts over time requires more resources than this project holds. Therefore qualitatively changes are the focus in the case study.

A case study in general consists of four steps, when not counting reporting. Figure 1 below shows these steps.

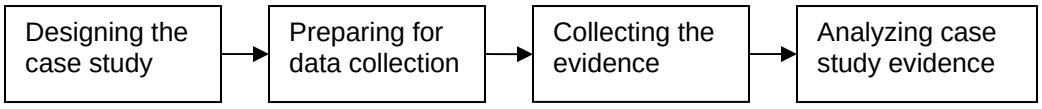


Figure 1: General case study steps

All these steps are used in this project, and a specialized view is given in figure 2.

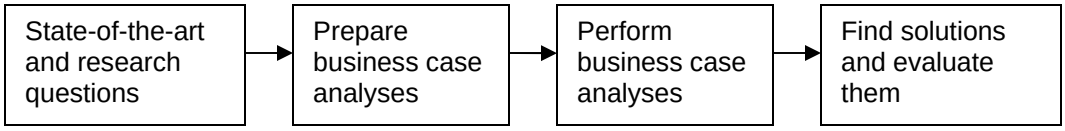


Figure 2: Specialized case study steps

Case studies can be exploratory, descriptive and explanatory. The business analyses are descriptive as it investigates how businesses have chosen to perform their supply chain processes and handle data elements. The solutions and evaluation are exploratory, as it is impossible to give quantifiable results that prove solutions to be feasible, and based on empirical studies.

2.2 Theory and state-of-the-art

Theory and state-of-the-art is created by doing a literature study of up-to-date articles, books and international business cases. Articles and books are used to find technical descriptions, usage areas, terminology of RFID and supply chain, and information relevant to logistics processes. Business cases reveal possible process improvements, business changes and technology implementation speed. In addition to written material some sections with small amounts of background material has been complemented and verified by regarded researchers with relevant professions.

2.3 Business analysis

Business analyses were completed using known process analysis and data extractions methods common in information systems design. They are based on I. Hawryszkiewycz's book of systems analysis and design [HAWRYSZKIEWYCZ], together with different modeling languages. Hawryszkiewycz describes techniques to collect data from a business environment when doing requirements analysis. The project is not doing a requirement analysis, but the collection methods are also significant for general data extraction. Collection methods used in this project is observation, document revision and interview with employees working in relevant business areas.

2.3.1 Data collection

Observations were done by visiting each business. During the visit businesses introduced themselves, business goals, processes and challenges. A guided tour in relevant work areas and document revisions confirmed the business description and processes. From this data elements from the introduction were supplemented. When a first sketch of business analysis finished a chosen employee at each business revised it and following interviews gave corrections and new supplements.

2.3.2 Process and data modeling

The business processes are modeled in a general value chain model, activity diagrams [FOWLER] and dataflow diagrams (DFDs) [DEMARCO] to show lower level decompositions and data elements. A description and symbol explanation of both modeling languages is found in appendix C. As described in the appendix it is possible to model a business in to different ways using DFDs; Logical and physical. The project uses logical DFD to model how the business operates, and the data registers is therefore not limited to electronic storages, but also includes paper and human knowledge. Data extracted from DFDs are displayed as tables of information and data since lower level diagrams are confidential. Data in each business is summarized in ER-diagrams [AMBLER], a description of this model also included in appendix C.

To answer the question of improved management processes and simplified warehouse logistics the project has identified management processes and logistics processes in each business. This is done by using the distinguished processes in section 5.2, Process Choice, and chapter 6, Data and Information in Warehouse Management, in addition to known logistics literature [CHOPRA_MEINDL2007, SIMCHI-LEVI_KAMINSKY2003] and experience achieved through the project.

2.3.3 Evaluation method

Evaluations is solely based on empirical investigations of implemented RFID solutions and known process changes in information system design. Solutions for each business are extracted from appendix D, Logistics and RFID in SCOR. The last section of this appendix consists of an overview of RFID solutions the literature study showed to be relevant in each lower level process of SCOR. Solutions described in each business and process is based on this.

3 RFID

3.1 Historical View

The known bar code has a history from 1948 [SHEPARD2005] when Norman Woodland at Drexel Institute of Technology in Philadelphia had his first thoughts of a universal method for product registration. From this moment and until a few years ago the bar code was leading in this marked, but RFID has evolved simultaneously.

The idea of RFID was according to Jeremy Landt [LANDT] and Steven Shepard formed in the middle of the 1900s, about the same time as the radar. One possible first description of RFID was written by Harry Stockman in 1948, but at the time the technology needed was inadequate to realize his vision. The next half a century the technology made great progress. In the 1990s RFID applications for tracking animals and vehicles, access systems for employees, but mostly automatic toll payment for cars, made great success.

3.2 Technical description

RFID technology is build up of two main components; the tag and the reader [LEWIS, SHEPARD2005, HEINRICH2005]. The principle of reading information from tags is similar to bar codes. A tag will be attached to an object and the information is gathered by a reader. In addition to these two components a data collecting application needs to be present, see figure 3. This is a special application with built-in screening, or a middleware that manages data before it is sent to the business application.

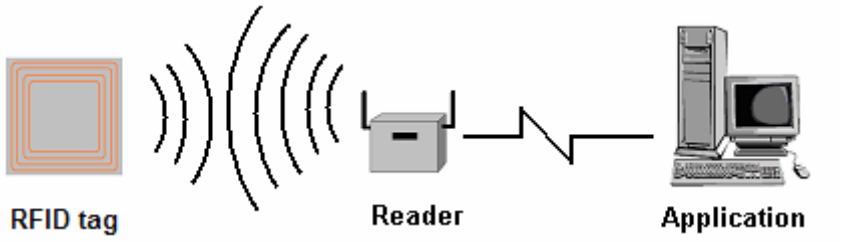


Figure 3: RFID system in operation

3.2.1 Tags

The tag contains information sent through the supply chain. Each tag has a certain amount of memory where information about the object it is attached to is stored. The tag's main task is to maintain this data until it may be read by an electronic reader.

Tags are constructed in different ways but usually consist of an antenna, a microchip and in some cases a battery. From its technical construction the tag is classified to be passive, semi passive or active. A passive tag uses incoming signals from the RFID reader to gather enough energy to be activated and give a response. A tag sending radio transmissions without being activated by a reader is defined to be an active tag, and

usually contains a battery for power supply. Semi passive tags are a combination of both techniques. These tags have a battery used by the microchip to function, but still use the incoming signal as energy source for communication. The different constructions give the tags different characteristics, like life time and environment disturbance. A short overview of characteristics is shown in table 1.

Table 1: Differences in passive, semi passive and active tags

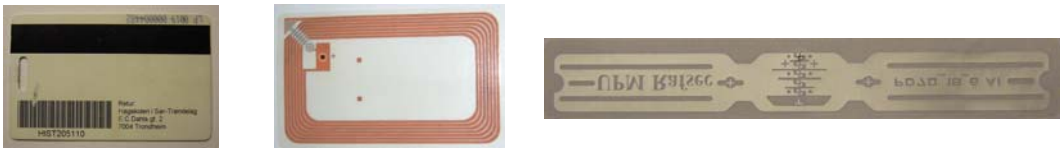
	advantages	Disadvantages	Comment
Passive	Longer life time Low cost Mechanic flexible	Relative short read range Strict requirement to transmissions	The most widely used in RFID applications (LF, HF and UHF)
Semi passive	Higher communication distance Can be used to manage other devices like sensors	Higher cost Irregular battery life time Higher environment disturbance	Used mainly in real time systems to track high value materials or equipment throughout a factory (UHF)
Active			Used in logistics for tracking containers (UHF and microwave)

Source: [LEWIS, LAHIRI2006]

The choice of read/write capabilities will impact the flexibility of re-using tags and the business implementing RFID must discover what is necessary to optimize their solution. The tags may be manufactured to be *read only*, *write once and read many (WORM)* or *read write*. The first can be programmed only once in its lifetime and is done at the manufacturer by burning information permanently on the tag microchip. The second can be written to only a few times and is done by programmers at implementation time. The third and last may be written to several times by applications and readers.

The sizes of tags vary with the choice of technology and continually get smaller and smaller while memory capabilities get higher and higher. In its simplest form the tag is just a label similar to bar codes. Glass cylinders can be implanted under the skin of animals, and even humans, to track movement or give access to certain areas. See examples of tag shapes in figure 4 below.

Source: [INTERMEC]



Source: Private pictures

Figure 4: Tag design

3.2.2 Readers

A RFID reader, often called an interrogator, is necessary to collect information and write data to the RFID tag. Reader is a generic term for the antenna, transmitter and receiver needed to communicate with the tag, and generates electromagnetic fields when data is transmitted or received. The reader has two main responsibilities; first, and most important, to collect information from the tag, and secondly, to pass the information to an application for further processing. Data collected is sent to an application that analyses, converts or transforms it to useful information, which generates a human readable representation and alerts if any abnormalities occur. An application like this may be within Data Mining, Knowledge management, Customer Relationship Management (CRM) or Enterprise Recourse planning (ERP).

In addition to these main responsibilities, the reader also has other tasks. It is assigned the task of powering passive tags which then will be capable of returning its information. The reader is also able to store information once or several times on tags. It may have intelligence to handle data collisions and make tags send their information one at the time, or authenticating itself to tags in accordance to security requirements.

As with tags, readers come in different shapes. Some are formed like big portals where pallets are transported through to be read or like small handhold devices similar to handheld bar code readers. Others are shaped like a panel where employee identification cards can be read when they are held close enough. Figure 5 shows some examples of how the reader may look like.

Source: [INTERMEC]

Source: Private picture

Figure 5: Reader design

3.2.3 Communication

RFID communicates by radio waves. A radio transmission is done at a certain frequency and RFID has been assigned four different main groups of transmission ranges. Not all four groups are accepted worldwide and the frequencies vary in different regions and/or continents.

The frequency and tag type chosen gives the technology different qualities which makes them suitable in different usage areas [LEWIS, LAHIRI2006]. At higher frequencies you get longer read range and faster data-transfer. The number of tags red per second also increases with higher frequencies. Unfortunately these frequencies also make it harder to read in environments with high energy absorbency, like in metals and liquids. The

reading ability is also affected by battery power. The more information a passive tag has to transmit the longer time it needs to charge energy in order to complete the transmission. Therefore, for the time being, the greater information transmissions are reserved active tags. All this is summarized with the main groups of transmission ranges in table 2 below.

Table 2: RFID transmission frequencies

	Low frequency (LF)	**High frequency (HF)**	**Ultra high frequency (UHF)**	**Microwave**
Frequency	125 or 134 KHz	13,56 MHz	Ca 400(1) or 900 MHz(2)	2,45 or 5,8 GHz
Read range	< 0,5 m	1m	3-5 m	10 m <
Tag type	Passive	Passive	Active(1) and passive(2)	Passive and active
Typical applications	Access control and animal tagging	Access control, item level tagging and baggage control	Supply chain pallet and box tagging, baggage control and electronic toll collection	Electronic toll collection and Real time collection of goods
Multiple tag read rate	Slower ⟷			Faster
Energy absorbing	Lower ⟷			Higher
Passive tag size	Larger ⟷			Smaller

Source[3]: [LEWIS, LAHIRI2006]

3.3 Tag information

Information can be stored in the tag or in shared information systems and the information stored is different for every need. The most important information in supply chains is the *Electronic Product Code* (EPC). This code makes it possible to identify every unique object transported in the supply chain. RFID-based supply chain systems are today usually limited to monitoring the movement of entire containers or pallets, but the EPC allows for every item to be counted and tracked in every step.

In addition to the EPC as an identifier, tags may contain or connect to information collected from sensors while passing through the supply chain. The sensors may be integrated in the tag or tags may be connected to external sensor systems responsible to monitor physical factors other than movement, e.g. temperature, pressure and humidity.

3.3.1 EPC

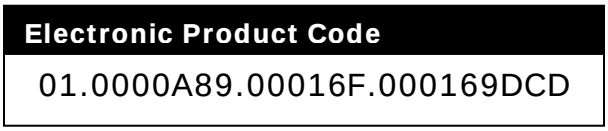
The Auto-ID center was established in 1999 and early discovered the problems with RFID adoption. The tag was complicated and had no mutual communication protocol [LEWIS]. This led to the idea of the EPC. EPC provides a global product identification and numbering system that makes it possible to tag and identify objects down to item

[3] The table shows the general tendencies, but the information will vary in different literature.

level, compared to bar code UPC, *Universal Product Code*, that only identify objects at product level.

The initial goal was to create a passage and ease the alteration from bar code to RFID, but is now an open and flexible standard already used in many industries. EPC itself dose not contain any explicit information, but links to a computer system on the Internet. This link gives EPC the potential to provide detailed information about the item or product everywhere in the supply chain, without storing all information inside the tag. This solution is known as EPC Network or EPCglobal Architecture Framework [EPCGLOBAL]. EPCIS (Electronic Product Code Information Service) is the part of the framework that stores, hosts and provide access to product information enabled by RFID. EPCIS describes both interfaces for data exchange and specifications of data EPCglobal subscribers wish to share.

EPC's composition is almost the same as UPC and contains an alphanumeric[4] string that ranges from 64 bits to 256 bits with four distinct fields, as shown in the figure 6.



Source: [LEWIS]

Figure 6: Electronic Product Code configuration

Field one: Header
Define type of EPC and length of code. The code in the figure is type one and is defined to be 96 bits in length.

Field two: EPC manager
Typically describes the objects manufacturer

Field three: Object Class
Contain information about the exact type of product

Field four: Serial Number
This is the unique identifier for items

3.3.2 Sensor Information

There are several types if information and two main integration methods for sensors in a RFID system: integrated inside the tag or external sensor systems. According to Heinrich [HEINRICH2005] tags with built-in sensors is more theory than practice because of its cost and huge power consumption. A tag with integrated sensors may consume 10 to 1000 times more energy than a passive tag. Therefore integrated sensors are

[4] An alphanumeric string may hold both numbers and characters.

recommended in active systems where tags have their own power supply, but still the cost has limited the extensiveness of this technology. SINTEF also point out that the components needed for this to be realized are too big and needs more development to be practical in use [SINTEF].

With integrated sensor the data collected from sensors will follow the same communication path as usual, see figure 7.

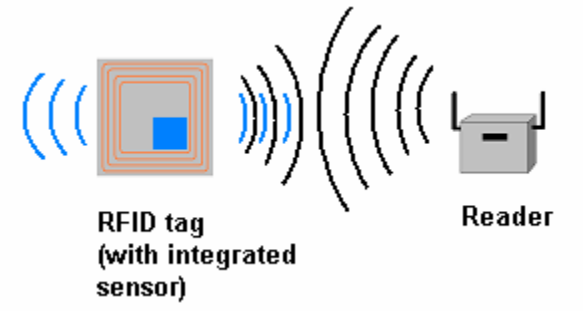


Figure 7: Communication with integrated sensor

External sensor systems will provide the same features as internal sensors. The difference is mainly the technology used to store information. External sensors systems will collect data and give the task of writing/storing information on tags further to a reader, or contain the data in an application, see figure 8.

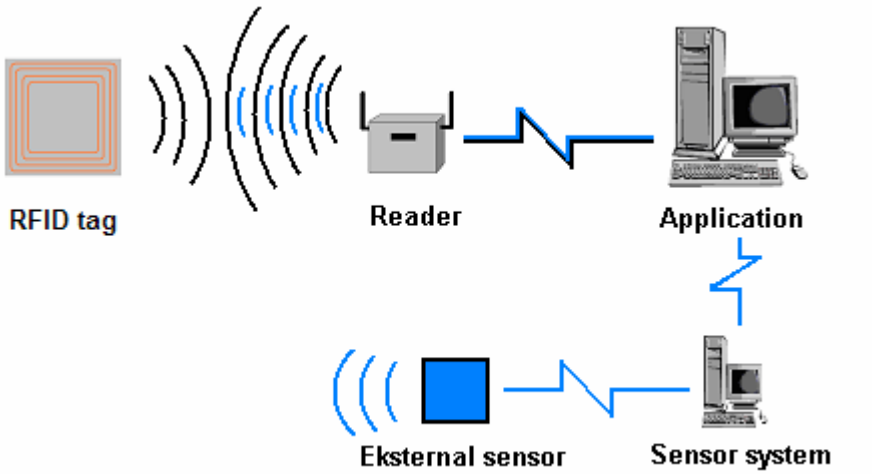


Figure 8: Communication with external sensor

The reader may send information to all the tags in a certain area, or to a pre-selected assembly. Tags connected to any kind of sensor have the ability to keep physical sensed data and provide it to an RFID reader when possible and/or wanted. Some tags and sensor systems are intelligent and may compare readings at separate times, compare the differences and send an alert signal whenever needed. These tasks may also be done by a business system after the data is read.

IntelliSense
A Group of Nordic research organization, including SINTEF as the leading organization, is developing a multi-protocol RFID device with built-in sensing capabilities. The project is called IntelliSense and lasts for two years, 2006-2007. Its goal is to integrate HF and UHF standards and sensors in one single tag. By the end of 2007 the IntelliSense project presumes to have finished sensors for pressure, temperature, humidity and pH. The two former is finished and the two latter is in development to day [WESSEL]. Table 3 below shows information possible to gather with smart tags like IntelliSense.

Table 3: Possible sensor information

Temperature	Conductivity
Moisture	Humidity
Light	Pressure
Flow	Shock
pH	Acceleration
Gases/odors	Chemicals
Voltage, Mag.field	Biological substance

Source: Bård Myhre, SINTEF ICT

Sensor Applications
Heinrich [HEINRICH2005] points out some applications where sensors and RFID collaborates. He says that one of the most promising applications for sensor-equipped tags is in the area of preventative maintenance. RFID and sensors, integrated or external, can detect a failing mechanical component early in its decline, before any real damage has happened. One example of this feature may be detecting the depth of a tires wheel track, and will tell the driver when to change tires before any accidents happen. Other cases may be detecting vibrations or chemical substances in a motor, and tell when to change or refill certain parts.

A system including active RFID with integrated sensors, also called iRFID or *intelligent RFID*, are developed by MachineTalker and Sense-Comm Technology [BACHELDOR]. The tags have built-in sensors for measuring temperature, battery level, vibration, light, fluid levels and other environmental conditions. This information can be communicated between tags and together create an automatic response to critical data from tanks, machinery and other equipment. Responses may for instance be turning off equipment if the strain is too high, or including more fluid in the formation of oil based chemicals like gasoline.

There are also many tests with RFID in the food supply chain. The most important aspect here is to maintain the food freshness and guarantee the quality to customers. Center for Food Distribution and Retailing at University of Florida is testing how RFID and sensors may be used to keep perishable food from spoiling [COLLINS1]. One of the cases they have been studying is monitoring shipments while transported. Here they constantly collect information about temperature in the cargo room and decide if the food has been transported by legal means. It is possible to modify the temperature during transport and avoiding spoiled food arriving at retailers.

3.4 Advantages and disadvantages

As seen in the cases presented in the section above there are several benefits with RFID in the supply chain, but there are also disadvantages by implementing and using the technology. This part of the report shall give insight to possibilities and problems with RFID in the supply chain. The report presents an overview of advantages compared to bar codes characteristics, and advantages in supply chain and processes. It also gives an introduction to disadvantages that needs to be managed by the business when introducing a RFID system.

3.4.1 Advantages

Many researchers and businesses has tested the technology and found that when compared against bar code systems, RFID has significant advantage. Hallie Forcinio [FORCINIO] presents the list below:

- Tags do not have to be in line of sight of the reader to be read
- Tags can be read in bulk almost simultaneously
- Tags generally can carry more data than bar code
- Reading can be completely automated (no human operator)
- Data accuracy is extremely high
- May identify individual items
- Data ca be more granular due to the potential for more frequent collection
- Tagged objects can be counted automatically
- Read/write tags can receive new information throughout an item's life cycle

When using RFID to track inventory it is always possible to know where the tagged items are. With this in mind it is also possible to know when an item is removed from the usual supply chain, e.g. when it is lost or stolen. The tag can also hold information to secure branding of certain products.

Other advantages not mentioned are flexibility and process improvements. With RFID it is possible to get data of sales and demand continuously and in real time. With this data it is possible for businesses to meet demand with more accurate production, and may transform the supply chain into a push-based chain, rather than a pull-based (more about these strategies when presenting supply chain). Involved supply chain processes must be revaluated and be partly automated, fully automated, or even removed completely. Forcinio include these examples of process improvements, see table 4.

Table 4: Process improvements identifies by Forcinio

RFID Data	Process Step	Improvement
Retailer's product availability data generates an automated – and more accurate – purchase order	Order Capture	More accurate ordering means less inventory in supply chain and lower carrying costs
Manufacturer's shipping and receiving data can be used to locate inventory in the supply chain	Order Routing and Tracking	Incremental benefits can be limited when bar coding already does a good job and instant data is not required
	Order Fulfillment	
Manufacturer's shipping data creates more granular ASNs that include case EPCs	Shipping	Customer service levels increase with higher shipping accuracy
Manufacturer's shipping data generates invoice that includes case EPCs	Billing	Fewer instances where shipment doesn't match invoice
Retailer's receiving data generates receipt of goods that includes case EPCs	Payment Receipt	Invoice and receipt can be checked against one another for greater accuracy and less administration time

Source: [FORCINIO]

In Heinrich's book David Simchi-Levi, an acknowledged professor of engineering systems, has made a statement of business benefits with RFID [SIMCHI-LEVI, HEINRICH2005]. He includes several of the already mentioned benefits. He points out that RFID implementation will improve both accuracy and speed of data collection. Accuracy is possible through reduction in scanning errors, better prevention of theft and diversion, and earlier detection of spoilage. Speed is achieved by less product handling and ease of performing an inventory count.

Simchi-Levi has also differed in benefits for retailers and manufacturers, and claims that retailers are expected to have the main benefits from RFID implementation. Retailers can expect benefits in three main areas, and manufacturers, depending on the type of business, in three other areas, see table 5.

Table 5: Main benefits identified by Simchi-Levi

Retailers	Manufacturers
Reduced inventory	Inventory visibility
Store and warehouse labor reduction	Labor efficiency
Reduction in out-of-stock items	Improved fulfillment

Source: [SIMCHI-LEVI]

Further Simchi-Levi states that both manufacturers and retailers will benefit from a reduction in the bullwhip effect. Visibility in the supply chain reduces variability, and is one of the main benefits with RFID. Reducing the bullwhip effect will also benefit

retailers because of improved service levels, and manufacturers will indirectly benefit from reduction in out-of-stock products from retailers.

3.4.2 Disadvantages

Most of the problems in RFID systems lay in the technology. The right components and frequency most be chosen according to what's to be tagged, what material it is and in what environment the readings must be performed. Implementing RFID into a business require thorough planning and testing.

The data and information wanted must be found and the right medium must be chosen. Information can be carried inside the tag or registered in a database connected with the RFID system. This database has to be of right scale to handle the huge amounts of data that RFID produce. The business system processing RFID data must be adjusted and manage situations where abnormal readings are done. The information is also of more value if it is shared with partners in the supply chain, but it is not wanted to share it with unauthorized peoples or systems. Persistent security technologies are required and established partnerships is a necessity.

Both Forcinio and Simchi-Levi introduce many of these disadvantages. A part of Forcinio's description of challenges is shown in table 6 below, only the most relevant aspects included:

Table 6: Challenges when implementing RFID

Established bar coding infrastructure:	In many manufacturing facilities and distribution centers, bar code systems have been used for many years. Since bar code systems are efficient and represent a substantial investment, it can be difficult to justify a change to RFID
No one-size-fits-all:	A successful implementation typically requires considerable experimentation to achieve adequate read rates and the delivery of actionable information to appropriate recipients
Lack of skilled personnel:	RFID-knowledgeable IT personnel are hard to find. Many organizations, regardless of size, will discover they have no qualified IT personnel in certain locations
Data overload:	An RFID reader will continuously scan each tag several times per second as long as it remains in its read range, so the potential for data overload must also be considered
Data noise:	The torrent of RFID data (called "noise") can overwhelm readers or cause ambiguity, especially in dense reader environments where scanning areas may overlap
Lack of integration:	Lack of integration and isolated islands of automation can pose other problems for those considering RFID. Manufacturers' enterprise resource planning systems may not be linked in real time to shop floor systems. Currently, integration with back end systems generally requires creation of custom interfaces, an often time-consuming and expensive undertaking

Evolving standards:	Managing multiple readers and related hardware can be a challenge, especially across multiple facilities. That's because global standards governing how RFID devices communicate with higher level systems are evolving
Multiplicity of vendors:	No single vendor does it all, so most RFID systems must be assembled from multiple sources
Privacy issues:	Some privacy advocates claim RFID will violate consumer privacy and have become vocal opponents of the technology. Although much of what they fear isn't currently practical (or in some cases, technically feasible) these critics are being heard

Source: [FORCINIO]

4 Logistics and Supply Chain

Companies need to place their products at the right place at the right time with the proper marketing to create a cost-effective business. A logistics system needs to be dynamic and change at every demand to make the most out of its potential. Different definitions of logistics are in this chapter evaluated and given an unambiguous definition for further work in the project. It is found that logistics and logistics management are equal terms.

A supply chain is a collection of activities between collaborative businesses needed in sourcing and procurement, and to get products from the manufacturer to the customer. Supply chain and value chain are two concepts with many similarities. The terms are discussed and given distinct definitions. The main supply chain strategies are given a small introduction before the report looks at different cases where RFID has changed logistics and supply chain and improvements in processes are discovered. At the end of this chapter a process reference model named SCOR[5] is introduced to show standard processes in production value chains. Appendix D combines SCOR with the earlier determined logistics definition to discover relevant logistics processes, and further finds solutions to each lower level process in SCOR.

4.1 Logistics

The first know user area of logistics is in the military where soldiers, supplies and weapons needed to be transported from on place to another at the right time to have a strategic advantage [BANKEN_AARLAND2003]. All the experience from this area has been transferred into the mentality of modern logistics management and is widely used to achieve competitive advantages in businesses. The definition of logistics depends on who is addressing the issue. In resent years logistics has been used to describe both logistics and material administration, but this is not always the case. Banken and Aarland define logistics as follows:

Logistics is strategic management and control of product and information flow from supplier to end customer, and include supply, flow, storage/stock and organization, and shall be carried out in a way that maximizes the business's economical result and added value.

Simchi-Levi and Kaminski agree with Banken and Aarland and also define logistics as a management discipline. On the other hand, they also compare logistics with supply chain management and do not distinguish between the areas [SIMCHI-LEVI_KAMINSKY2003]. They use the same definition for logistics and logistics management and conclude with the definition given by the Council of Logistics Management[6] at the time:

[5] Supply-Chain Operations Reference model

[6] Council of Logistics Management is now known as Council of Supply Chain Management Professionals (CSCMP), http://www.cscmp.org/

The process of planning, implementing and controlling the efficient, cost effective flow and storage of raw materials, in-process inventory, finished goods, and related information from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements.

The Council of Supply Chain Management Professionals (CSCMP) on the other hand does no agree that logistics is similar to supply chain management, but rather a part of it. The definition of supply chain management given by the CSCMP is:

Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all Logistics Management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, Supply Chain Management integrates supply and demand management within and across companies.

The definition of logistics management given by the CSCMP is:

Logistics Management is that part of Supply Chain Management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements

This last definition has many similarities with the definition given by Banken and Aarland. It tells us that logistics is managing all the movement and storage activities that are associated with product and service flows, and focuses on inbound and outbound flows of goods, services and related information. Logistics include management functions and is defined as a management discipline. Therefore it is concluded that logistics and logistics management is equal terms. Logistics and supply chain management is on the other hand not equal in a modern definition. Supply chain management includes several processes not relevant to logistics and logistics is therefore separated from supply chain management. This master thesis will use CSCMP’s definition of logistics management when discussing and using logistics processes.

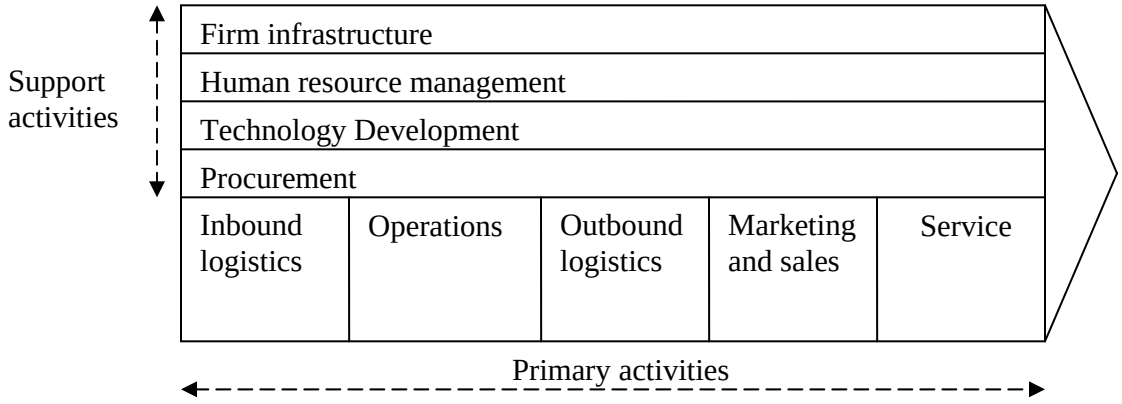
4.2 Supply Chain

Supply chain and value chain are two words closely related. There are different opinions of definitions and in some cases their meanings are identical. The report needs to make a clear definition to get an unambiguous understanding of the terms for further work. It is found that value chain consist of the internal chain while supply chain is the term when several business partners connect their value chains to connect one dependant supply chain.

The choice of supply chain strategy influences how an information system will react and give improvements to different parts of the supply chain. A supply chain strategy shows how a business chooses to manage its inventory according to customer demand. The main strategies, push and pull, have different influence on how the supply chain is managed and the most important aspects are presented. The strategies are introduced to give an understanding of how supply chains function according to demand, and get insight of how a supply chain is managed.

4.2.1 Definition

A value chain describes the activities needed to produce a product and increase the customer value in each part of the supply chain. Kotler uses Porters value chain to describe this in more detail [KOTLER2003]. Porter identifies nine primary and supportive activities, shown in figure 9.



Source: [KOTLER2003]

Figure 9: Porters value chain

Simchi-Levi and Kaminski [SIMCHI-LEVI_KAMINSKY2003] says that a supply chain may be referred to "as the logistic network and consist of suppliers, manufacturing centers, warehouses, distribution centers, and retail outlets, as well as raw materials, work-in-process inventory, and finished products that flow between the facilities". Further they describe a typical supply chain as where "raw materials are procured and items are produced at one or more factories, shipped to warehouse for intermediate storage, and than shipped to retailers or customers".

From this it is possible to conclude that each collaborator has its own value chain. All value chains together form an external network where resources, products and information are transferred, also known as a supply chain. Many supply chains have specific partners who together create a chain like figure 10 below.

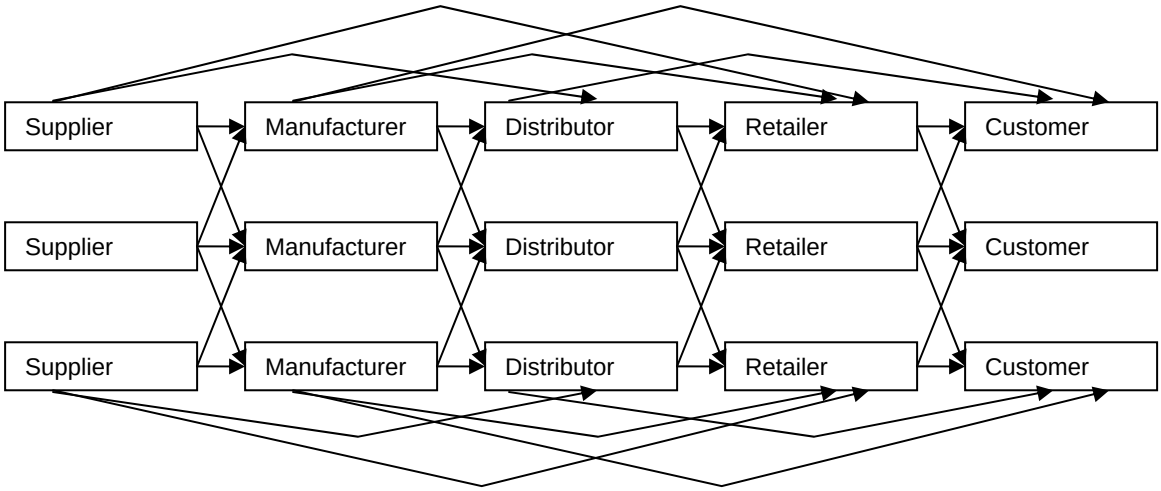
Source: [KOTLER2003, SCOR]

Figure 10: Supply chain partners

Chopra and Meindl also have a similar definition of the supply chain, but this is focused on fulfilling a customer request [CHOPRA_MEINDL2007].

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. Within each organization the supply chain includes all functions involved in receiving and filling this request.

In addition to the definition of supply chain they point out that a supply chain usually does not consist of one single player at every point of the chain, but are rather networks of several actors at each stage. This network may be a large and complex constellation as seen in figure 11. Chopra and Meindl would like to describe this network of supply chains as a *supply network*. This is similar to what has already been described from Kotler and Simchi-Levi.



Source: [CHOPRA_MEINDL2007]

Figure 11: Supply network

This master thesis will not look deeper into this issue, and to avoid any further discussions of the terms this report will use the following description of a supply chain, deduced from the conclusions above and definition given by CSCMP for supply chain management:

A supply chain includes the value chains of collaborative organizations, like suppliers, intermediaries, third-party service provider and customers, with their information and resources, services and products, and all the activities involved in sourcing, procurement

and conversion of raw materials into a finished product that is delivered and sold to the next part in chain.

With this definition the project is able to identify each part of a supply chain, what role a certain business has in a supply chain and where its value chain starts and ends.

4.2.2 Supply Chain Strategies

The choice of supply chain strategy show how a business react to demand, its delivery and storage capacity, and how the business choose to administrate logistics in its value and supply chain. Implementing RFID may dramatically change the strategy and the project needs to understand the impact this may give.

There are two main strategy categories in the supply chain, push and pull [SIMCHI-LEVI_KAMINSKY2003]. A push-based supply chain are mainly working with long term predictions and typically bases the demand forecast on received orders. This makes the reaction time longer when it comes to changes in the marked, and may lead to inability to meet changing demand patterns and accumulation of supply chain inventory. The variability in demand may again lead to the need of excessive inventories, larger and more variable production batches, production obsolescence and unacceptable service levels. The variability in demand from retailers and manufacturers is also larger than at customers and increases the effects further. This is also known as the "Bullwhip effect" where the variability in demand increases as we travel up the supply chain.

A pull-based supply chain is working with real demand and wish to avoid doing any forecast about the marked. This strategy is what many businesses want to work in accordance with because it leads to decreased inventory levels at both retailers and manufacturers, a decrease in lead time because of better ability to anticipate incoming orders, and a decrease in variability and also less bullwhip effect. Still it is not possible to react quickly if there are long lead times or big scale productions, and harder to utilize scale in manufacturing or transportation because of the short planning time in the production.

To avoid the disadvantages of push and pull it is possible to combine the strategies to take advantage of the best from both. This combined strategy is called push-pull and implies that both push and pull is used, but in the most suitable areas. The parts of supply chain most efficient with push make use of this strategy and likewise with pull. With this strategy it is possible to increase the efficiency even more, e.g. finding the most suitable customer order decoupling point[7]. On the other hand this strategy is harder to administrate than compared to push or pull.

[7] The point where products become modified to suit a specific customer order

4.3 RFID and Logistics

As defined above logistics deals with planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information. Logistics has many challenges that need to be addressed to gain the goal of the definition. Information technology is a tool to help logisticians perform logistics in a more reliable and accurate way. Technical tools in logistics have the purpose to increase visibility, capacity and control in the supply chain, and RFID systems offer a data collecting solution with potential of doing all this. This section introduces several business cases where different RFID systems have contributed to this and known cases like Wal-Mart and METRO Group are included. This is done to give an understanding of how benefit may be gained with these implementations.

4.3.1 RFID Cases

There are formed new RFID cases in logistics all the time. One of the first and well known cases is Wal-Mart and its first one hundred suppliers to adopt RFID in their supply chain. Still there are several other companies which also find this the right time to do research and implement RFID to gain competitive advantages. Four cases from different industries, which all discovered benefits in value chain and logistics, are presented here. There are solutions where RFID is the main reason for the benefits, but there is also presented a case where the management system using RFID is the key to success.

Case 1: China International Marine Containers (CIMC)
CIMC is a worldwide supplier of containers and have 20 factories and 40 different container yards for further distribution, all in China [GAMBON]. Every container is unique and is a made-to-order product. Their traditional tracking method was performed with optical character recognition technology (OCR), paper and pens, walkie-talkies and binoculars. There were often misplaced containers, lost or delivered to the wrong customer. CIMC used a lot of time and money to find the locations after such a misplacing. A lot of manual paperwork had to be done before the container could be transported to the customer, a time consuming process often resulting in queues. The main driver of implementing RFID was to reduce time used at placing and collecting containers, in addition to avoid misplacing and sending the wrong container to the wrong customer.

After adopting RFID much of the work accounting for the containers has been automated. Information of the containers location is stored in a management system and helps tracking every container in the yard. The yard-management system provides a three dimensional mapping and task-management for CIMC to know where all the containers are in a specific yard. The old “write down location and loose it”-method slowed down the storing and collecting process. Now the forklifts use the yard-management system to find the right container. The tags incorporate container identification information, weight, the date and time of manufacture and the intended customer, which is stored in the central database. This information is now easily read when the container is to be transported and makes no unnecessary queues at distribution exits.

The forklifts are also tagged and the yard-management system can tell which forklift moved which container. The system is capable of making alerts when the information calls for this. An alert may be called if a container is placed at the wrong site, or a forklift picks up the wrong container. The system is able to define the best routes and schedules to move containers from one place to another, and tell when to move a certain container based on shipments in the system.

Case 2: METRO Group

METRO Group is the largest retail company in Germany and the fourth largest retailer in the world. Their vision is to create a digital supply chain through every step, from manufacturers, producers, customers and all distribution centers along the chain [COLLINS2].

In 2003 they started an initiative called The Future Store; a supermarket which also serves as a test area for new technologies. Here they first tested RFID solutions with smart shelves and automatic processes at distribution centers [WOLFRAM]. The shelves tell the staff when it needs refilling, and automated processes make suppliers send more products when needed. Goods are tagged at a distribution center and read as they leave and then again when they arrive at the stores storage area. Each delivery is automatically compared with the order, and then registered in the inventory management system.

After some time with RFID in The Future Store METRO reported improvements in process efficiency, reduced loss and theft, and increased merchandise availability. They also reported several other benefits, summarized in table 7.

Table 7: Improvements discovered by METRO Group

Efficiency	**Transparency**	**Real-time**
Reduced time for receiving goods Optimized inventory management Reduced warehouse costs Automatic monitoring	Tracking and tracing of merchandize in the Supply Chain Reduced shrinkage Simplified processing of warranty claims Targeted recall measures	Event-driven notification Decision-making on actual, real time information

Source: [WOLFRAM]

The results where so promising that in January 2004 METRO Group announced that 10 distribution centers and 50 stores would use RFID by November the same year. In addition 100 of METRO's suppliers would start tagging pallets sent to METRO. This goal was not reached and today they still have problems accomplishing this. However, the distribution centers, stores and suppliers who did implement RFID reported large savings and possibilities with the technology. EPC is used to trace and manage the pallets

along the supply chain. The solution focused on ingoing/outgoing goods portals, stock refill and automatic data reconciliation, and they are able to verify the goods and completed a goods receipt in seconds. It also improves order picking and reduces time in both sending and receiving goods.

In 2005 METRO did a large review of the solutions and collected new knowledge about problems and improvements. Most problems originated from technical or human behavior and where solved by adapting and training. They found considerable process success rates and time savings. Concrete results in work processes where accelerated goods receipt, less idle time, improved process flow and fewer shelving errors.

The next step in the change to RFID systems is to test new standards and tagging on the case and item level. METRO have several ideas and solutions ready to be tested, including an RFID-enabled glove that will speed up the picking process. This glove will automatically update the warehouse management system as cases is picked and moved. They are also testing a cold-chain tracking system to find the potential of RFID tags equipped with temperature sensors. This will make it possible to supervise fresh food traveling in the supply chain.

Case 3: Wal-Mart

Wal-Mart is the biggest retailer in the U.S. and has more than 2660 stores in fourteen different countries around the world [WALMART]. In June 2003 Wal-Mart required one hundred of its suppliers to use RFID to tag cases and pallets sent chosen Wal-Mart distribution centers by the start of 2005. With this announcement Wal-Mart was the first chain store to demand RFID in its supply chain. The goal was to use the technology to reduce out-of-stock and make the employees spend less time in the storage room and more time on the sales floor [ROBERTI1, ROBERTI2].

With the old system employees had to walk the aisles to find empty shelves. If an empty spot was discovered the bar code on the shelves was scanned by a handheld scanner. The bar code indicated how many items are left in the storage room or in transit to the store. The employee then had to go to the storage and find the items needed. They could use 15 to 20 minutes looking for the items, and if it was not found the employee could change the on-hand inventory to zero and order more, even though cases might still be in the storage somewhere. When inventory then arrived at the store the cases was not scanned into the on-hand inventory list, which would be a time consuming process, but the order sent was simply assumed to be arrived at the site.

Today goods are registered at arrival at the store by reading RFID tags as the cases are moved from the trucks and into the storage, and once again when each case is moved to the sales floor. The tag is also read when the case is returned to the back room and when it is placed by the trash compactor. The technology and the created information is used to create automated “pick lists”, which is lists of goods that needs refilling on the shelves. The list is used by the staff to quickly pick products at the back room and refill the shelves. When the employees wants to get a case from the back room they use a hand held RFID reader to find the case faster. With this routine Wal-Mart is more able to

provide available products for the consumers. Data about cases brought into the store also shared with the suppliers, who are able to respond quickly when new supplies are needed.

The system showed to be successful. After a 29-week study published in September 2005 Wal-Mart reported reduction in out-of-stocks by 16 % [ROBERTI3]. Further modern analyses have also found greater impact at certain products, up to as much as 62 % [COLLINS3]. The generated list also saves time because employees do not need to check the shelved regularly, or look for products that might not be in storage. In May 2006 Wal-Mart tells that registration of cases in the stores back room has made a phenomenal impact. Now the staff can't overlook cases and order more goods when not needed. With this system Wal-Mart now knows the exact amount of each product in storage and on the sales floor. With RFID Wal-Mart's suppliers are now able to see exactly how long it takes a product to move through the supply chain. This information may be valuable to suppliers that meet a certain demand.

Case 4: Hampton Products International

At the time Wal-Mart demanded RFID in the supply chain for hundred of its suppliers, another 37 smaller companies volunteered to join the program. Hampton Products International, based in Foothill Ranch, California, was one of these, a manufacturer of padlocks, door locks and outdoor lighting fixtures. The company wanted to join the program to better understand the technology and reveal benefits early in the process of RFID adoption. They also saw the benefit of implementing it consistently in their value chain before competitive pressure form rivals appeared [COLLINS4].

The distribution center at Foothill Ranch receives and stores cases manufactured in several other countries and process them into finished shipments for specific orders. Hampton included RFID in the processes of distributing products to Wal-Mart. The RFID system use order number, Stock-keeping-unit (SKU) numbers on each case and EPC on each pallet to track the products as they move through the supply chain. With this new system Hampton discovered several business benefits. The visibility of Hampton products has increased rapidly. With bar codes Hampton got information when the products left the building and next from Wal-Mart's POS[8]-system when it was sold. With RFID they are able to see when it enters the back room or the sales floor, even when the carton is destroyed. It is now possible to use this data to adjust shipments.

Hampton hopes this information will give them new insight to the flow of Hampton products throughout Wal-Mart's stores and distribution centers. It is possible to get a far more detailed picture of demand in each and every store, and over time in a specific area. The information will also tell the company which products are lost or stolen as they move through the supply chain. It is easier to control the number of cases received at Wal-Mart against the number sent, and therefore eliminating invoice disputes and quicker handling of invoices in general. Another benefit found, which may be a coincidence, is quicker order handling. Hampton speculates that this might have happened because of the special interest in the RFID shipments since there is no other reason for this benefit.

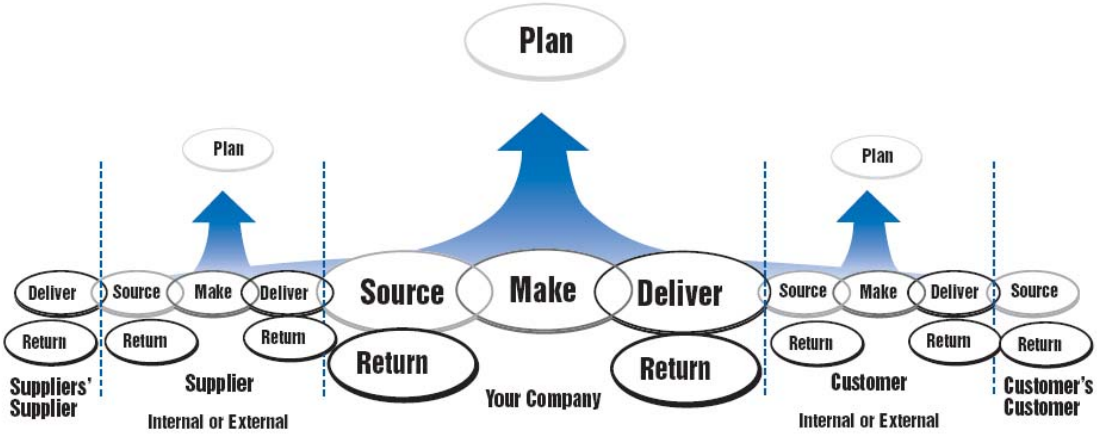
[8] Point-of-sale (POS) – Data commonly used by retailers and their suppliers to forecast demand. Historical data taken from cash registers, measures what is actually sold [SIMCHI-LEVI].

4.4 SCOR

SCOR is a process reference model that offers a framework for efficiency improvements of activities in the supply chain, especially in supply chain management and as communication support between business partners [SCOR1, SCOR2]. SCC[9] has created a definition of a process reference model; "Process reference models integrate the well-known concepts of business process reengineering, benchmarking, and process measurement into a cross-functional framework". This type of models contains standard descriptions of management processes, a framework of standard processes and relationships between them, tools for measuring process performance, management practices that produce best-in-class performance and standard alignments to features and functionality.

4.4.1 Description and definitions

SCOR identifies main and lower level processes in customer interactions, product transactions (physical material and service) and market interactions. This includes all actions from ordering to payment in both customer and supplier relations, and understanding and meeting aggregate demand in the marked. The figure below, figure 12, shows five main processes in the value chain defined by SCOR: Plan, Source, Make, Deliver and Return. The connection with external processes at customers, customer's customer, suppliers and supplier's supplier is also shown.



Source: [SCOR2]

Figure 12: SCOR

Earlier the report has established an understanding of the terms supply chain and value chain. The connections with external processes are a supply chain, and the internal processes are a value chain. SCOR uses supply chain for both aspects, and the report will use the SCOR's original description in this section. In addition to processes shown in the

[9] SCC (The Supply-Chain Council), creators of SCOR, was established in 1996 and 69 volunteered members joined at the time. To day the organization has over 1000 members all over the world [SCC].

figure, SCOR also describes processes for enabling the realization of the main processes. Table 8 contains SCC's definition of their processes.

Table 8: SCOR process definitions

SCOR process	Definition
Plan	Processes that balance aggregate demand and supply to develop a course of action which best meets sourcing, production and delivery requirements
Source	Processes that procure goods and services to meet planned or actual demand
Make	Processes that transform product to a finished state to meet planned or actual demand
Deliver	Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management
Return	Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support

Source: [SCOR2]

Processes in SCOR have four different detail levels. The top level describes process types and contains the five main processes and their relations. The configuration level describes process categories which companies implement for their own operations strategy. Table 9 shows the processes at this level. The decomposition level with process elements defines a company's ability to compete successfully in its chosen markets. The implementation level is not included in SCOR since this differs from business to business.

Table 9: SCOR processes at configuration level

Plan	Source	Make	Deliver	Return
P1 Plan Supply Chain **P2** Plan Source **P3** Plan Make **P4** Plan Deliver **P5** Plan Return	**S1** Source Stocked Product **S2** Source Make-to-Order Product **S3** Source Engineer-to-Order Product	**M1** Make-to-Stock **M2** Make-to-Order **M3** Engineer-to-Order	**D1** Deliver Stocked Product **D2** Deliver Make-to-Order **D3** Deliver Engineer-to-Order Product **D4** Deliver Retail Product	**SR1** Source Return Defective Product **DR1** Deliver Return Defective Product **SR2** Source Return MRO Product **DR2** Deliver Return MRO Product **SR3** Source Return Excess Product **DR3** Deliver Return Excess Product

Source: [SCOR1]

4.4.2 Limitations

The implementation level is not described in the SCOR model, illustrated in figure 13. SCOR is not trying to describe every possible business process or activity in the supply chain, but points out the most important processes for successful supply chain management. Processes in sale and marketing, research and technology development, product development and some parts of the post-delivery customer support is not described, but may be included in some parts of SCOR to give an unambiguous understanding. Training, quality, information technology and non-supply chain management administration is not included.

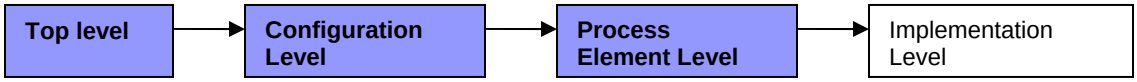


Figure 13: SCOR process levels

5 Research Questions and Process choice

Different aspects with RFID in supply chain are now elucidated by introducing RFID technology and defining value and supply chain. Appendix D evaluates solutions in each SCOR process and where goal accomplishment may be found. This chapter presents research questions which are based on previous work and project scope is limited by choosing the most relevant processes.

5.1 Research questions

Both automatic data collection and information creation is possible with existing technology, and many solutions with RFID are in use today. When technological aspects like portal placing and tag direction are solved the solutions are known to give possibilities. This is discovered by several companies, among others Wal-Mart and their supplier Hampton Products International. One question usually not answered thoroughly is how these solutions will affect management processes. Information is one important part of warehouse management and it needs to be at the right place, in right form and in right time to give effective execution of each process. Visible processes and information about them is highly regarded to gain understanding and predictability in the supply chain [CHOPRA_MEINDL2007]. Other factors like human resources and equipment rely on information to carry out parts of the process.

Value chains today already have great amounts of data and information and RFID is said to increase the amount further. What information that will be created with RFID and how this affects the management processes is an interesting research area. Information created with RFID has the potential to improve logistics and management processes, but how and why is not answered. There are also several other questions that may be asked, but project context mainly cover logistics and management. From this view these are the most relevant questions to ask and seek an answer to:

1. **How will RFID increase the information flow in business processes?**
   Information is already flowing nicely between processes and is executed without severe problems. Increased information flow implies both new data elements and more frequent data transfers. Which kind of information do businesses lack? Which kind of information may RFID potentially create and what impact may it have for the business value chain?

2. **How will management processes be impacted by implementing RFID?**
   The different management processes will be impacted in different ways by a RFID solution. Which management processes are impacted? How are they impacted and is this seen as a source to improved management?

3. **How will RFID simplify logistics?**
   There are several manual processes required to complete different processes in supply chain logistics. Are they still necessary when a potential RFID solution

manages information flow in these processes? Are the process unchanged, partly automated, completely automated or removed? Is supply chain logistics impacted by introducing an RFID system?

These questions will be answered by analyzing warehouse management at three different Norwegian businesses, Norplasta, Gilde Norge BA and NorgesGruppen.

5.2 Process Choice

This section takes a closer look at RFID solutions that businesses can implement in their value chain to accomplish the project goal. Products may be tagged at item/product level, case level or pallet level. Tagging of products at different levels will in large extent give the same information, but in different details and amounts. This project will concentrate on achieving its goal by RFID tagging product carriers as pallets or cases since this is the only relevant level in Norway today.

Appendix D, Logistics RFID in SCOR, evaluates SCOR's lower level processes according to what RFID solutions that may contribute to achieve the goal. The aspects used are: *Improved management*[10]and *Track and Trace*. As the document summarizes the result it found that all second level processes are more or less included in the goal accomplishment, but several third level processes are out of project scope or have no found solution.

5.2.1 Process review

The project goal, "*Investigate how RFID contributes to improve management and supply chain*", holds several processes relevant for the evaluation. This project can not cover all of them and will choose the most relevant parts. The processes chosen must have high potential of reaching the project goal or any of its supportive goals. The evaluations in appendix D describes what processes have most potential of reaching the goal. The more solutions found in the evaluation, the higher the potential of reaching the goal. The criteria of process choice are:

- Must be important in logistics and should be crucial to this area
- Have to be important in both value and supply chain
- Should have great improvement potential in the information flow
- It must also be possible to implement RFID in the process,

As seen in the appendix the implementation issue is not a problem as most processes have possible solutions. The processes below; Plan, Source, Make, Deliver and Return, are processes described in SCOR [SCOR1, SCOR2].

[10] Improved management also includes improved supply chain

Plan
Plan is extremely important when it comes to logistics. This is where all logistics activities are planned strategic decisions are made. The process has many improvement possibilities in information flow. However, Plan is a management process where RFID has no direct solutions. Solutions here are mainly based on how a business application analyses data coming from other processes in the chain. The project seeks to improve this entire process by changing operation processes. Data and information from other processes may impact Plan. The project needs to find possible solutions in the rest of the processes and discover what impact it has on Plan, and whether the impact can help the project reach its goal.

Source
Source is an important part of logistics. This is where all physical resources used in Make are ordered, received, registered and verified. Logistics is responsible for the resources to be at site and available for production at any given time. The process impacts both the internal value chain and the external supply chain. Information exchange between partners is a known problem. What information and what number of partners that should share information is a highly debated subject. Information is mostly available in the internal business, but also here there are possible efficiency improvements. The process evaluation show high potentials in reaching the process goal. This process is chosen for further work.

Make
Production (Make) is an internal process and needs internal logistics of both resources and finished products. Production processes are not available for customers. Performance time and product quality is important to both value and supply chain. There is a great need for better information flow for management improvements. However, the lower level production processes are usually not available for other supply chain actors and not relevant for this project. The process is not chosen for further work.

Deliver
Deliver is also an important task in logistics. All products needs to be collected, sorted, packed and sent to the right customers. Logistics is responsible for this to happen as smoothly and quickly as possible, and may be a bottleneck if logistics does not perform as planned. The process impacts both internal processes and external processes in the supply chain. As with Source, Deliver also has information traveling between business partners and the external flow may be improved together with the internal information flow. There are several solutions that may contribute to reaching the goal and the potential is high. This process is chosen for further work.

Return
Return is a reverse product flow and has many similarities with both Source and Deliver. This is an irregular process that holds the same solutions as other processes with product transfers. The process is not crucial to logistics, but information must flow between business partners and touches processes in both value and supply chain. The evaluation did not find any solutions unique to this process, hence it is not chosen for further work.

Still, the results of the project may be transferred into this process while the similarities with Source and Deliver are present.

5.2.2 Chosen research area

Looking at the former process choice the main result is Source and Deliver. These processes satisfy the choice criteria and both have high potential in goal accomplishment. They have many solutions that may contribute to achievement of the project goal. Logistics are important in these processes as they handle product transactions between businesses. It is therefore also important for both value and supply chain. The information flow may be improved in internal and mostly external operations. It is also possible to implement RFID directly in both processes. The project also sees Plan as a relevant process, but only parts relevant to Source and Deliver. Solutions in Source and Deliver will impact Plan and help the project to achieve its goal. Plan is important to management and logistics in the entire chain. The information flow has improvements potential, but RFID will not be implemented directly in the process. The process is dependent of information from other processes and not used in the main evaluation.

Further the project identifies the Source and Deliver to be part of storage or warehouse[11] management. Warehouse management holds both physical processes, like material flow and administrative processes. These processes are differentiated below since RFID tags follow the material flow. Management processes needs to be identified and evaluated against the information RFID solutions may create. In Plan all processes is part of the warehouse management planning and not distinguished here. There is no need to distinguish between physical and management processes in Plan, but in Source and Deliver the project needs to establish an understanding of which processes are management relevant.

As described in the evaluation in appendix D D1.8 to D1.12[12] is defined by SCOR to be processes included in warehouse management. The project further defines this to be physical processes because movement of material goods is the main task in these processes. Processes D1.13 to D1.14 also include movement of material goods and are physical processes relevant for the receiving customer. In addition there are administrative processes, defined by SCOR to be process D1.1 to D1.7, which needs to be performed before movements of products are an issue. Process D1.15 is invoicing customers and is defined by the project to be a management process since there is no movement of physical goods.

No warehouse management definition is made by SCOR in process D4 – Deliver retail Product, which treats storage management in “backroom sizes”. D4.2 to D4.7 is movement for material goods and can be defined to be physical processes, and is therefore included in warehouse management. Process D4.4 to D4.7 is not found relevant

[11] A warehouse is usually a separate site or building, compared to storage which is in the business’s internal facilities. In this context Warehouse management implies both solutions.

[12] The report uses the same grouping of processes as appendix D, which means that D1.8 to D1.12 also includes D2.8 to D2.12 and D3.8 to D3.12. Process D4 is treated independently.

to pallet or case tagging. These processes are not taken into further consideration. D4.1 des an administrative process needed for the rest of the processes to occur.

The same connection may be done in Source. Here process S1.2 to S1.4 describe movement of material goods and is defined to be relevant for warehouse management. S1.1 and S1.5 is an administrative process needed for the rest of the process to run without problems. The same is for S3.1 to S3.3. Enable Source and Enable Deliver consist entirely of management processes.

All non-enabling processes are presented in the table below, differentiating management processes by gray marking, see table 10, 11 and 12.

Table 10: Processes in Source

S1 – Source Stocked Product	S2 – Source Make-to-Order Product	S3 – Source Engineer-to-Order Product
S1.1 - Schedule Product Deliveries	S2.1 - Schedule Product Deliveries	Identify Sources of Supply
S1.2 - Receive Product	S2.2 - Receive Product	Select Final Supplier(s) and Negotiate
S1.3 - Verify Product	S2.3 - Verify Product	Schedule Product Deliveries
S1.4 - Transfer Product	S2.4 - Transfer Product	S3.2 - Receive Product
S1.5 - Authorize Supplier Payment	S2.5 - Authorize Supplier Payment	S3.3 - Verify Product
		S3.4 - Transfer Product
		S3.5 - Authorize Supplier Payment

Table 11: Processes in Deliver D1 to D3

D1 – Deliver Stocked Product	D2 – Deliver Make-to-Order Product	D3 – Deliver Engineer-to-Order Product
D1.1 - Process Inquiry & Quote	D2.1 - Process Inquiry & Quote	D3.1 - Obtain & Respond to RFP/RFQ
D1.2 - Receive, (Configure,) Enter and Validate Order	D2.2 - Receive, (Configure,) Enter and Validate Order	D3.2 - Negotiate & Receive Contract
D1.3 - Reserve Inventory & Determine Delivery Date	D2.3 - Reserve Inventory & Determine Delivery Date	D3.3 – Enter Order, Commit Resources & Launch Program
D1.4 - Consolidate Orders	D2.4 - Consolidate Orders	D3.4 – Schedule Installation
D1.5 - Build Loads	D2.5 - Build Loads	D3.5 - Build Loads
D1.6 - Route Shipments	D2.6 - Route Shipments	D3.6 - Route Shipments
D1.7 - Select Carriers & Rate Shipments	D2.7 - Select Carriers & Rate Shipments	D3.7 - Select Carriers & Rate Shipments
D1.8 - Receive Product from Source or Make	D2.8 - Receive Product from Source or Make	D3.8 - Receive Product from Source or Make
D1.9 - Pick Product	D2.9 - Pick Product	D3.9 - Pick Product
D1.10 - Pack Product	D2.10 - Pack Product	D3.10 - Pack Product
D1.11 - Load Product & Generate Shipping Docs	D2.11 - Load Product & Generate Shipping Docs	D3.11 - Load Product & Generate Shipping Docs
D1.12 - Ship Product	D2.12 - Ship Product	D3.12 - Ship Product
D1.13 - Receive & Verify Product by Customer	D2.13 - Receive & Verify Product by Customer	D3.13 - Receive & Verify Product by Customer
D1.14 - Install Product	D2.14 - Install Product	D3.14 - Install Product
D1.15 - Invoice	D2.15 - Invoice	D3.15 - Invoice

Table 12: Processes in Deliver D4

D4 – Deliver Retail product
D4.1 - Generate Stocking Schedule
D4.2 - Receive Product at the Store
D4.3 - Pick Product from the Backroom
D4.4 - Stock Shelf
D4.5 - Fill Shopping Cart
D4.6 - Checkout
D4.7 - Deliver and/or install

6 Data and Information in Warehouse Management

The problem area is narrowed down to warehouse management. The first section in this chapter gives an overview of data found in warehouse management. The following sections give a thorough insight of information flow through the chosen processes, differentiated by physical and management processes.

6.1 Data

At this point the report needs to describe entities and relationships relevant to warehouse management to get an introduction to the area of research. Figure 14 below is an ER[13] diagram describing this, and the data necessary to create information in the selected processes. The data necessary to secure product quality in warehouse management is usually different environmental factors depending on the product. This is described as "Condition" in "Product", "Environment" in "Transport", "Storage" and "Customer".

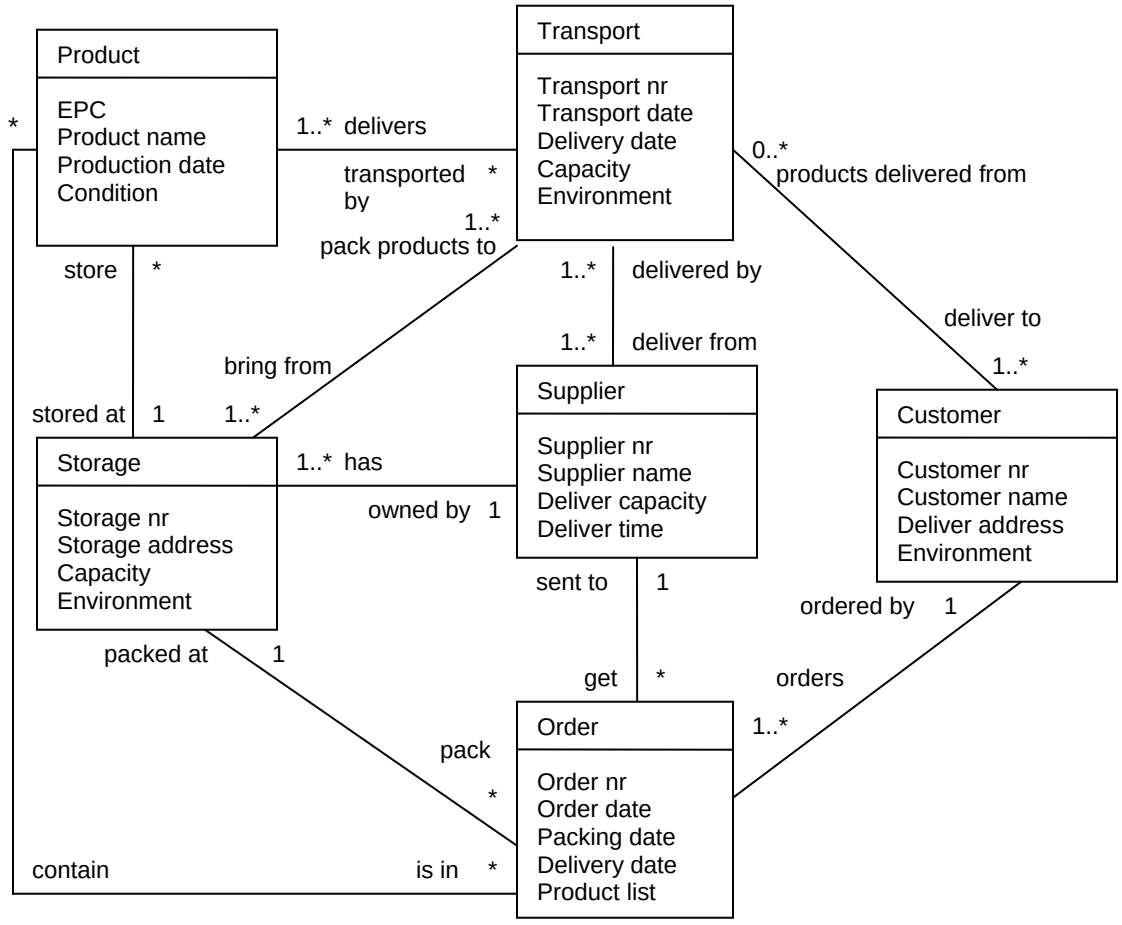


Figure 14: ER diagram - General view of data in warehouse management

[13] ER (Entity Relationship) diagrams is a conceptual data model often used in information system design to describe information needs

One condition for RFID to work in supply chains is the unique identification of each pallet or case. As mentioned earlier in the report EPC is a standard used in many different industries and a natural choice for identification of products in supply chains. EPC have fields to contain manufacturer identification and which object class the products belong to. A connection between the unique EPC and different data is necessary to create information. If a business share its data it is possible for other companies to deduce information relevant for their operation and contribute to make the entire supply chain more efficient.

6.2 Information

A process mainly has two kinds of information; information necessary to activate the next process in the chain, and information created in each process. The created information is often needed to activate the next process in chain simultaneously as management receives knowledge of process execution. Unfortunately solutions today are said to have big limitations. It's a fact that parts of information is collected manually and creates a possible source of error. Another problem is that information reaches its final destination a long time after it's collected; everything from a week to several months after the incident.

The representations below show physical and managerial processes, the information they need to execute and information the processes create. The results are based on information in different parts of Chopra and Meindl's, and Simchi-Levi and Kaminsky's books of supply chain management [CHOPRA_MEINDL2007, SIMCHI-LEVI_KAMINSKY2003]. In addition the content has been verified and completed with guidance from Heidi C. Dreyer, Senior researcher at SINTEF Technology and Society, department for Operations Management.

6.2.1 Information in Physical Processes

Table 13: Information in Source's physical processes

Process	Information needed	Information created
Receive product	• Products have arrived (or is close to arrival) • Confirmation of order • Delivery plan	• Which products have arrived and been unloaded • How many products have arrived and been unloaded • Which supplier/manufacturer did the products arrive from • Products ready to be verified
Verify product	• Products have arrived and is unloaded • Products need verification • Packing note	• Which products are verified • How many products are verified • How many products are NOT verified and why • Location of the verified and non verified products

Transfer product	• Products are verified • Where products are sited • Products need transfer • Transfer destination • Transportation is ready • Receiving inspection • In-registration • Location • Storage registration	Verified products • Where products are sited • What products are now resources and ready to be used in production • How many/much products are now resources and ready to be used Not verified products • Where the products are sited • Which products need to be returned • How many products need to be returned • Where are the products to be returned (supplier and destination)

Table 14: Information in Deliver's physical processes, D1 to D3

Process	Information needed	Information created
Receive Product from Source or Make	• Products have arrived (or is close to arrival) • Storage balance • Production plans • Transit volume	• Which products have arrived • How many products have arrived • If the products are ready to be picked • How long the products have been stored and under what conditions • When was the products manufactured or arrived at site
Pick Product	• Products are ready to be picked • An order has been registered • Sending/Receiving date is close • All products in the order are ready • Where the products are sited • Carriers are available • Transportation and carrier is ready • Pick list and location • Pick registration	• An order is collected • Which products the order contain • Where the order is sited • Which further transportation is needed
Pack Product	• An order is ready for packing • Packing device is available	• An order is packed • Where the packed order is sited
Load Product and Generate Shipping Docs	• Orders are packed • Shipping schedule is ready • Transportation is ready • Packing note	• Orders are packed, loaded and ready for shipping • Destination of orders • To whom the orders are going • Which products are in each transportation • How long the products have been stored • Shipping documents are ready
Ship Products	• Orders are loaded • Shipping documents are ready • Delivery date has arrived	• Which orders are on their way • Where orders are • Departure registration

Receive & Verify product by Customer	*See Receive product and Verify product in Source*	
Install Product	• Products are ready to be installed • What products needs to be installed • Storage location • Where the products are to be installed	• Which products has been installed • How many products has been installed • Updated inventory

Table 15: Information in Deliver's physical processes, D4

Process	Information needed	Information created
Receive Product at Store	• Products have arrived (or is close to arrival)	• Which products have arrived and has been unloaded • How many products have arrived • Are the products ready to be used in store?
Pick Product from Back Room	• Products have been unloaded and is ready to be used in store • What products are needed in store • Amount of needed products	• Number of products taken/moved • Number of products left in storage

6.2.2 Information in Management Processes

Table 16: Information in Source's management processes

Process	Information needed	Information created
Schedule Product Deliveries	• Product levels are low • Internal demand exceeds resource levels	• Which products have been ordered • How many products have been ordered • From which supplier/manufacturer • Anticipated delivery time
Authorize Supplier payment	• Products have arrived • Products are verified	• Authorization approved

Table 17: Information in Enable Source

Process	Information needed	Information created
Managing Sourcing Business Rules	• Internal businesses action and market plan	• Reaction profiles for different incidents relevant to Source
Assess Supplier Performance	• Deliver time • Product quality • Production rate	• Deliver capacity • Preferred supplier(s)
Maintain Sourcing Data	• Supplier contracts • Which products each supplier delivers • Amount of products delivered	• Supplier lists • Delivery lists • Product lists (resources) • Source history

Manage Product Inventory	• Products verified • Products not verified • Products in storage • Products ordered • Products in transportation • Future production plans	• Sourcing plan • Product inventory lists
Managing Incoming Product	*See physical processes*	
Manage Supplier Network	• Suppliers and their addresses • What product is delivered by which suppliers	• Network model • Possible communication channels • Possible transportation channels

Table 18: Information in Deliver's management processes, D1 to D3

Process	Information needed	Information created
Process Inquiry & Quote	• Amount of orders received • Products ordered	• Demand in time, area and amount
Receive, (Configure,) Enter and Validate Order	• Customer sent? order • Order contents • Customer information	• An order is registered • What products the order contain, and amount of products • Customer information
Reserve Inventory & Determine Delivery Date	• What products/resources needed to fulfill order(s) • Products at storage • Products to be produced	• If possible, inventory reserved • Production information • Available products at storage (updated) • Anticipated delivery date
Build Loads	• Orders are collected • Products to be sent • Amount of products to be sent • Destination of products	• Loads are built and ready for shipment
Route Shipments	• Orders are collected • Loads are built • Delivery dates • Productions plans (for future routing plans)	• Shipment route created • Delivery dates (updated)
Select Carriers & Rate Shipment	• Carriers available • Transportation needed • Loads to be sent	• Carriers reserved • Transportation reserved or ordered • Shipment rating
Invoice	• Products has arrived • Products has been verified • Products has been installed successfully	• Invoice is accomplished

Table 19: Information in Deliver's management processes, D4

Process	Information needed	Information created
Generate Stocking Schedule	• Product level is low • Internal demand exceed resource levels	• Which products have been ordered • How many products have been ordered • From which supplier/manufacturer

Table 20: Information in Enable Deliver

Process	Information needed	Information created
Managing Deliver Business Rules	• Internal business' action and market plan	• Reaction profiles for different incidents relevant to Deliver
Assess Delivery Performance	• Available finished products • Available resources • Production rate • Product quality • Deliver time	• Deliver capacity • Deliver quality
Manage Deliver Information	• Customer information • What products are ordered by which customer • Amount of products delivered	• Customer lists • Deliver survey • Deliver history
Manage Finished Product Inventories	• Products finished • Products verified • Products not verified • Products in storage • Products ordered • Products in transportation • Future production plans	• Storage plan • Delivery plan • Transportation plan
Managing Transportation	• Delivery plans • Customer information • Transportation available • Transportation capacity	• Transportation needed • Transport plan
Manage Product Life Cycle	• Where products are • How long products are at each site • What condition products are in at each site • Amount of time the products are in cycle	• Life Cycle model

6.3 Summary

When looking at the tables above it is found that information in physical processes usually have information that activates the next process in chain. However, this is not always the case in management processes, and is especially conspicuous in enabling processes (Enable Source and Enable Deliver). This means that these processes does not necessarily need information directly from the previous process described, but are triggered only by the completion of the last process in the chain. It is also found that large amount of information is used in several different processes, which makes these elements more vulnerable than others. This may be elements like orders and its content.

7 Business cases

Realistic business cases are necessary to find realistic answers to the projects research questions. When choosing businesses for further analysis the project wanted Norwegian actors in a complete supply chain with a continuously customer/supplier relationship. The companies Norplasta, Gilde and NorgesGruppen have a dependent supply chain and two customer/supplier relationships. Their relations are shown in figure 15 below.

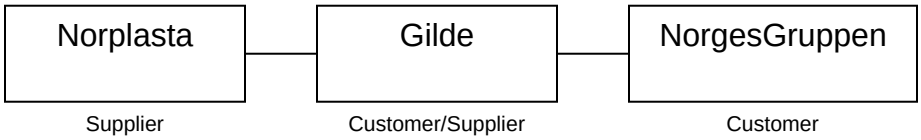


Figure 15: Business case supply chain

Norplasta produce and deliver plastic products for multiple use in several industries. Norplasta delivers a plastic box called Gildekassen to Gilde. Gilde is responsible for production and delivering of red meat products to Gilde‘s customers. Gilde uses Gildekassen as a transport device for its products in both internal and external chain. NorgesGruppen is a large Norwegian trading enterprise with wholesaling and retailing. Here Gildekassen is used as a pure transport device to get Gilde’s products from storage to retailers on.

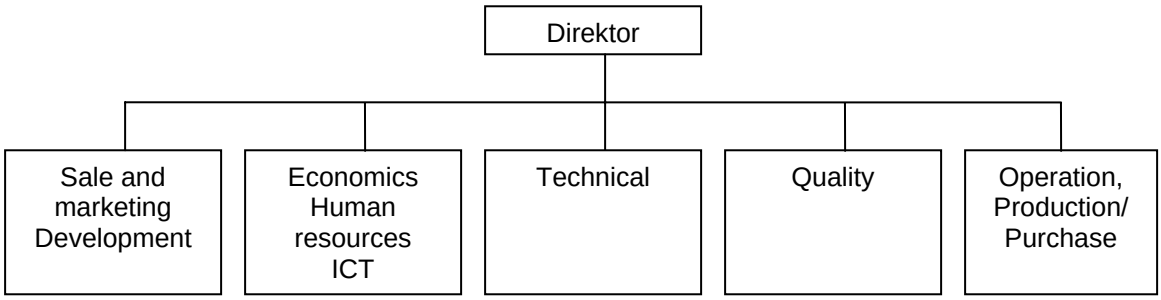
Gildekassen is an example of a product used in several parts of a supply chain. Norplasta produces it, Gilde buys it and use it in production and internal product flow, and NorgesGruppen uses it to get Gilde’s products to different retailers. Gildekassen is therefore a perfect example of how a product and information may flow between businesses. The businesses have a continuous product flow but the goal of use is different, and so is the need for information. The sections below introduce the businesses more thoroughly, and show an overview of information flowing in their businesses today.

Illustration given by Gilde

For confidential considerations the entire process decomposition can not be included in the report and only material relevant to information and flow in warehouse management and Gildekassen is shown. Background documentation has been verified and completed by each company.

7.1 Norplasta AS

Norplasta AS was founded in June 2003 and owned by local investors and a considerable number of employers. The company produces and sells transport and storage systems, technical systems etc made in plastic. Production is sited at the head office in Stjørdal, north of Trondheim. Sale and marketing is done from the head office, a sales office in Oslo and a sales company in Stockholm. Norplasta also have a highly educated development division and focus on quality in both products and production [NORPLASTA].



Source: [NORPLASTA]

Figure 16: Organization of Norplasta

Vision of the company is:

Through development of markets, human resources and technology shall Norplasta be a main actor in plastic production with emphasis in the Nordic countries.

The company is dedicated to develop products and processes to positioning itself as a producer of plastic products for multiple use in:

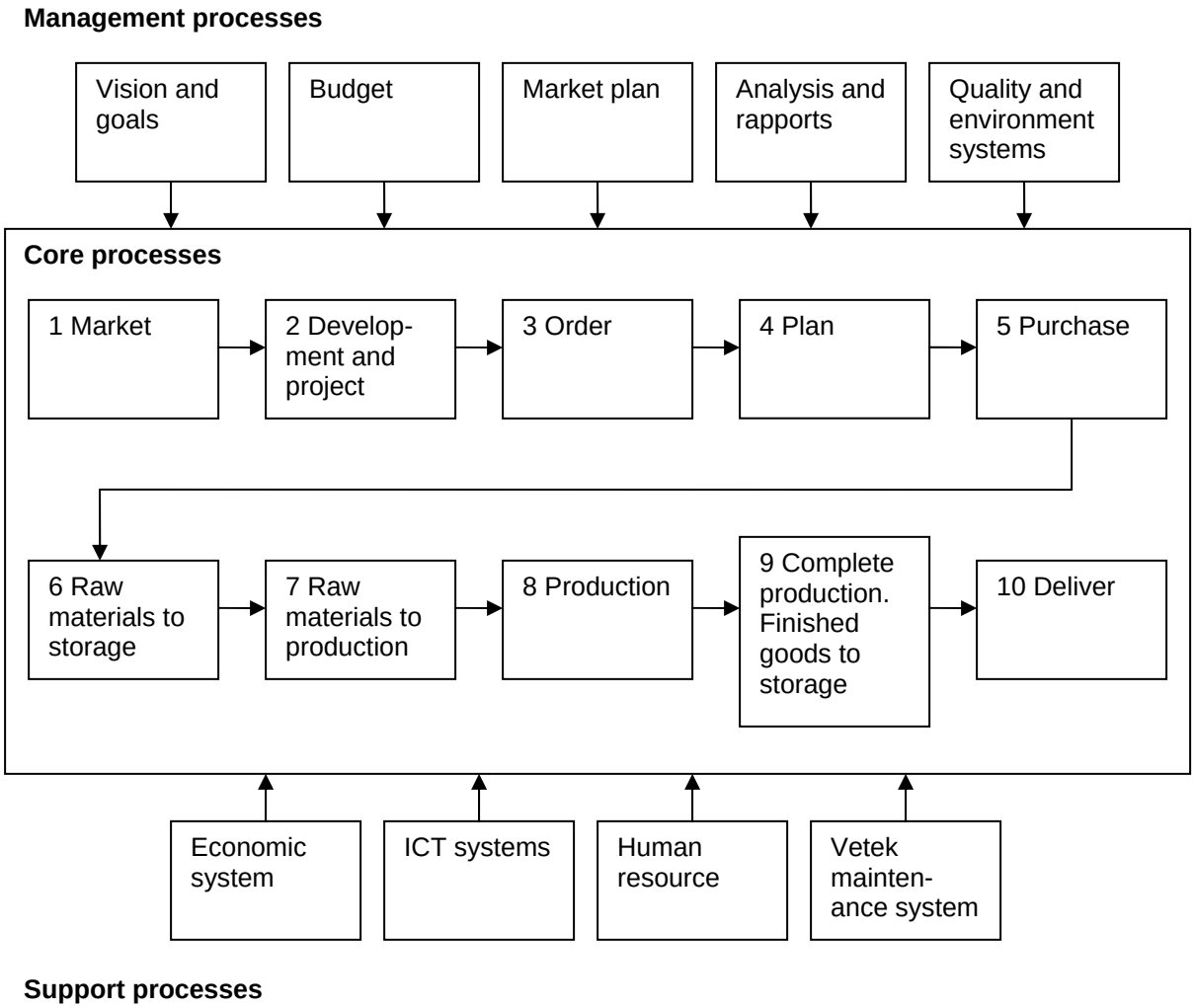
- food industry
- fishery
- Catering
- Storage systems and transport
- Technical products

Food industry *Fishery* *Catering* *Storage*

Figure 17: Product examples from Norplasta

7.1.1 Process Overview

The top level view of Norplasta's business processes is similar to a general production company. They identify management processes relevant to core processes, and support processes offering information to the same core processes. Figure 18 shows the top level view and the project identifies this as Norplasta's value chain.



Source: [NORPLASTA]

Figure 18: Core, management and support processes in Norplasta AS

This is a reproduced view of Norplasta's process diagram. The project needs those parts that are relevant to warehouse management. The processes Source and Deliver in SCOR guide the choice done. In addition the processes chosen must be relevant to Gildekassen, but in this chain the box follows the general material and information flow as the production is similar to production of every product in Norplasta.

After a thorough evaluation of the top level diagram, and its lower level decompositions, it is found that the following processes are included in Warehouse management and relevant for further analysis:

- Process 5 – Purchase
- Process 6 – Raw materials to storage
- Process 7 – Raw materials to production

} Source (SCOR)

- Process 3 – Order
- Process 10 – Deliver

} Deliver (SCOR)

7.1.2 Data Flow Diagrams

As described in appendix C the first model created using Dataflow diagrams (DFDs) are usually a context diagram. This only show external entities and its data flow, together with the information system as one process. In the context of business evaluation warehouse management information system is the main process in this model. Figure 19 shows the context diagram of Norplasta.

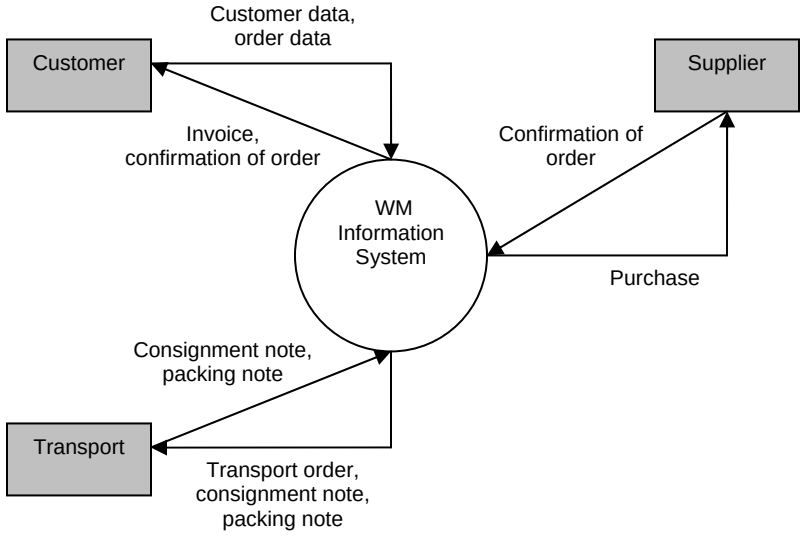


Figure 19: DFD context diagram of Norplasta

Three external entities are found; Customer, Supplier and Transport. Supplier delivers different material to Norplasta, e.g. plastic raw material and color substance. Norplasta orders new supplies when resource levels are low compared to estimated use. Planned production is the main basis for this estimate and suppliers confirm orders when they are received. When resources are delivered Norplasta gets consignment note and packing note from the delivering Transport. Transport also collects consignment note and packing note when transporting products from Norplasta to Customers. Planned production is also used to order transportation for delivering finished products to Customers. Customers

give Norplasta orders and information about themselves while Norplasta give confirmation of orders and invoices to Customers.

Figure 20 below shows Norplasta's DFD level 0. This is the first model showing more constructive information as top level processes together with its relevant external entities and data stores. In this model the processes identified have been given new numbering to ease the decomposition. Decompositions are restricted and not included in the report.

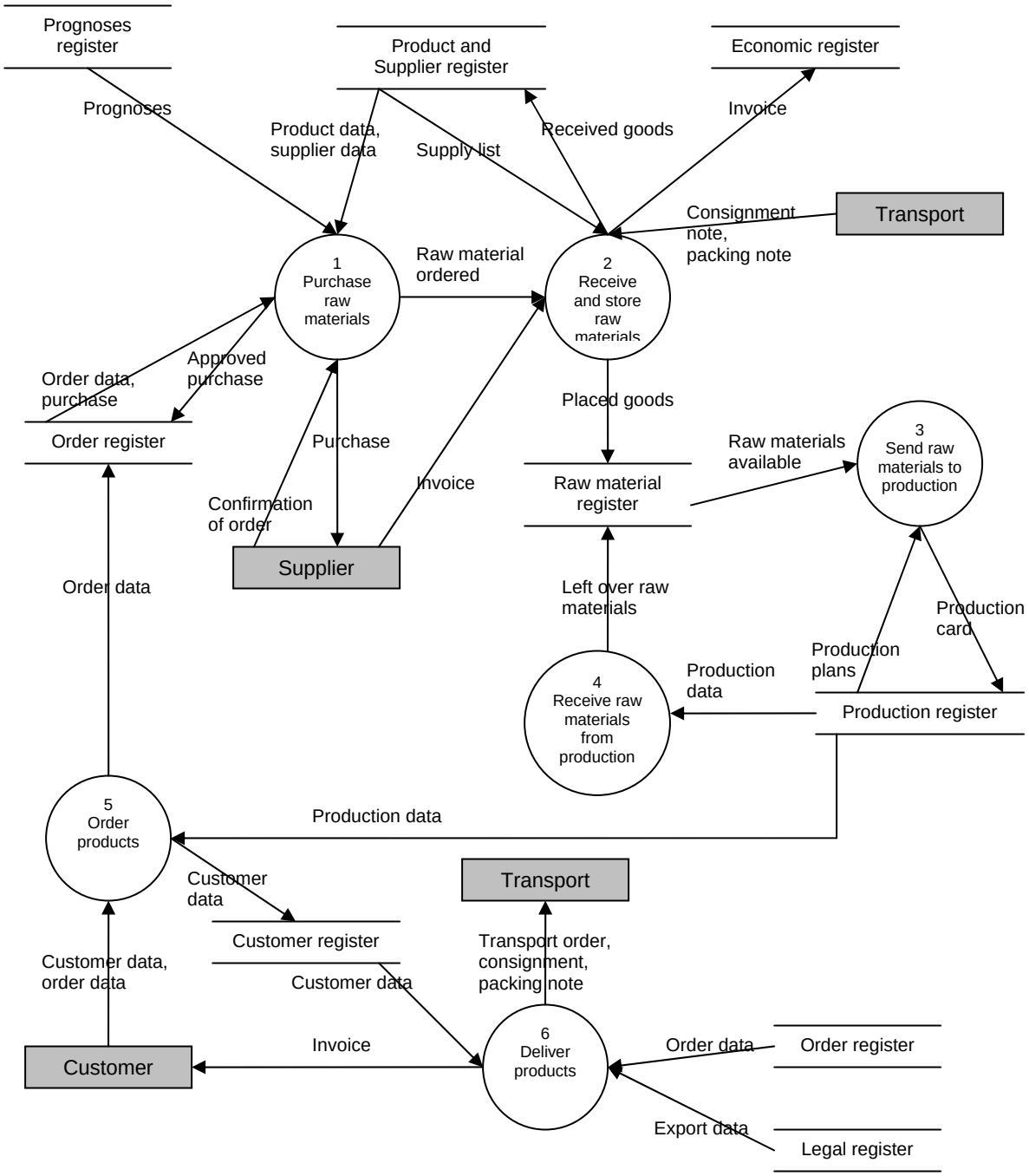


Figure 20: DFD Level 0 of Norplasta

The project has identified six main processes in Norplasta's warehouse management:

1. Purchase raw material
2. Receive and store raw material
3. Send raw material to production
4. Receive raw materials from production
5. Order products
6. Deliver products

These processes have been decomposed to DFD Level 1 and verified by Norplasta, but are not included in the report for confidential considerations. Data elements and information in each process are described further the following section.

7.1.3 Data Elements and Relevant SCOR Processes

Norplasta inform that all data elements is written or generated in the ERP-system. Detailed production plans are done in Microsoft Excel to easier visualize production over time. All processes have to be initiated manually in the ERP-system, but other connecting systems can catch storage transaction and use this data for relevant tasks like economic posting. A task in ERP often needs manual approval before moving to the next task.

The representations below show data elements in each main process and relevant SCOR processes, based on project analyses and verification done by Norplasta.

Purchase raw material

Purchase is done manually and bases its data on observations done by employees and purchase statistics. Most raw materials are materials with high granularity, like plastic raw material or color substances. Other resources are e.g. packing.

Table 21: Process 1 Norplasta – Purchase raw material

Information	Data elements and description
Order data	Production order (Make to order, Make to stock, manual market order)
Prognoses	Prognoses data (Usually based on experience of employees. New products/customers are know a time before orders are registered and this allows for simple prognoses)
Requirement data	Expected demand of each product, connected *Order data* + *Prognoses.* Product type, amount, expected customers
Product data	Products delivered by each supplier, product prize and/or delivery prize, product number, product type, product name, supplier number, deliver capacity, deliver time
Supplier data	Supplier number, organization number, address, phone number, fax number, e-mail, contact person
Purchase proposal	Supplier, products ordered, amounts, product prize, total prize, deliver time and date
Corrected purchase proposal	A corrected *Purchase proposal* (Same information, only corrected for errors or mistakes)
Purchase order	A *Purchase proposal* sent to current supplier

Confirmation of Purchase order	A *Purchase proposal* confirmed by current supplier (Same information, in addition a confirmation of deliver ability in wanted terms)
Confirmation	Confirmation to Norplasta's internal system that *Confirmation of Purchase order* is received

Table 22: SCOR processes in process 1 Norplasta

SCOR processes
S1.1, S2.1 and S3.3

Receive and store raw material

The raw material arrives in tank trucks and is stored in silos. The receiving process is mostly manual.

Table 23: Process 2 Norplasta – Receive and store raw material

Information	Data elements and description
Delivery list	Overview of products ordered to each day and from which supplier (to prepare storage to product arrival)
Deliver data	Products expected to arrive one certain day. Product numbers, product types, product names, amounts, supplier numbers, transporter, transport number
Consignment note	A note describing sender, receiver, and a list of contents in the delivered order. Customer, customer number, product numbers, product names, amounts
Packing note	A notification sticked to the product case or pallet. Receiver, destination, product number, product name, product type,
Updated Deliver data	Corrected *Deliver data* compared to *Packing note*, control of packing and transport
Transported products	*Updated Deliver data* combined with transport number, transportation route and location
Placed products	*Updated Deliver* data combined with local location in the storage
Received products	Register received orders. Order number, product numbers, product names, product types, amounts, date delivered
Received invoice	Orders ostensible sent from supplier, *Received products*, prize (total and unit prize), organization number, contact information, pay date

Table 24: SCOR processes in process 2 Norplasta

SCOR processes
S1.2, S2.2, S3.4
S1.3, S2.3, S3.5
S1.4, S2.4, S3.6
S1.5, S2.5, S3.7

Send raw material to production

Raw material is transported by automatic pipe systems to the production hall and production machines. Packing and other tangible resources are moved by fork lifts.

Table 25: Process 3 Norplasta - Send raw material to production

Information	Data elements and description
Production data	Product number, product name, product type, amount, production date, finished date, delivery date, production time, production capacity

Specified production data (production card)	Production card identification, product to be produced, amount, production machine number, production start, anticipated finish date
Raw material available	Resources at storage, amounts, product name, product type, product number
Necessary raw materials	Raw material type, raw material number, raw material name, calculated raw material requirement (amount), amount in storage

This process is not described in SCOR. It is debatable where this process belong, Source or the production relevant SCOR process Make. The process suits the chosen definition of logistics and is a part of warehouse management and is therefore included in the description and further evaluation.

Receive raw material from production

High granularity resources use the same pipe system and tangible resources are moved by the fork lift when it is transported back to storage.

Table 26: Process 4 Norplasta – Receive raw materials from production

Information	Data elements and description
Unused raw material	Raw material type, raw material number, raw material name, amount

As with process 3 this process is neither included in SCOR. It's included in the project evaluation due to same reason as process 3.

Order products

Customers mostly send their orders manually by phone, fax and e-mails. Orders are verified and sent to the production planning system.

Table 27: Process 5 Norplasta - Order products

Information	Data elements and description
Customer data	Customer number, customer name, invoice address, deliver address, phone number, fax number, contact person,
Order data	Order number, customer number, order date, products (product number, product name, product type) amounts, deliver date, status
Production data	Product number, product name, product type, amount, production dates, anticipated finished date, deliver date, production time, production capacity
Confirmation	Confirmation to customer. *Customer data + Order data + Production data*

Table 28: SCOR processes in process 5 Norplasta

SCOR processes
D1.2, D2.2, D3.3
D1.3, D2.3

Deliver products

Products are placed in the storage room while waiting for the rest of the order to finish, and when all products in an order have reached the storage they are combined and packed for further transportation. Transportation is ordered whenever needed and no regular transport is performed.

Table 29: Process 6 Norplasta– Deliver products

Information	Data elements and description
Order data	Order number, customer number, order date, products (product number, product name, product type) amounts, deliver date, status
Transport order	Product type, amount, destination, deliver date, deliver requirements
Transport data	Transport type, capacity, loading time, arrival time/date, shipment route
Cargo data	*Export data + Order data + Customer data* (information on consignment note, packing note and export papers)
Invoice	Orders sent, order received at customer, product number, product name, product type, amount, prize (total and unit prize), organization number, contact information, pay date
Customer data	Customer number, customer name, invoice address, deliver address, phone number, fax number, contact person,
Export data	Toll number (product type) addresser, recipient

Table 30: SCOR processes in process 6 Norplasta

SCOR process
D1.9, D2.9, D3.9,
D1.10, D2.10, D3.10
D1.11, D2.11, D3.11
D1.12, D2.12, D3.12

ER diagram

When comparing the found data elements with the general view of data in warehouse management (figure 14, chapter 6), the more specific diagram of data for Norplasta looks like figure 21 below. Compared to the general view there are many similarities. The entities Product, Supplier, Customer, Storage, Order and Transport are still present. In addition Purchase, Raw material, Production and Prognoses are present. A real data model like this is very complex, and this project only includes data relevant to warehouse management, logistics and Gildekassen.

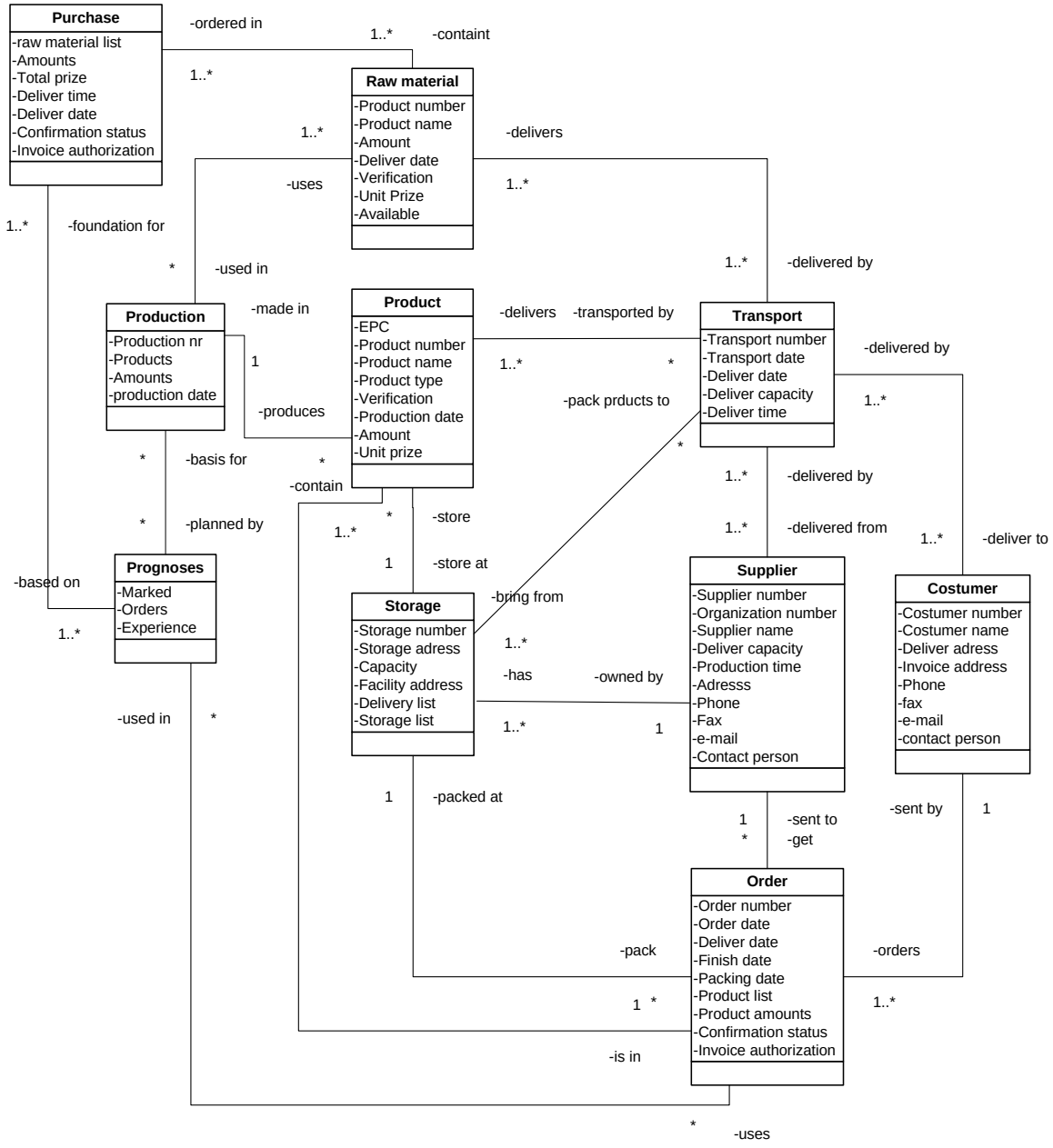


Figure 21: ER diagram – View of data in Norplasta's warehouse management

7.1.4 Processes Distinguishing

The project identifies several management processes. From SCOR Norplasta has:

1. S1.1, S2.1, S3.3 – Schedule Product Deliveries
2. S1.5, S2.5, S3.7 – Authorize Supplier payment
3. D1.2, D2.2 – Receive, (Configure,) Enter and Validate Order
4. D1.3, D2.3 – Reserve Inventory & Determine Delivery Date

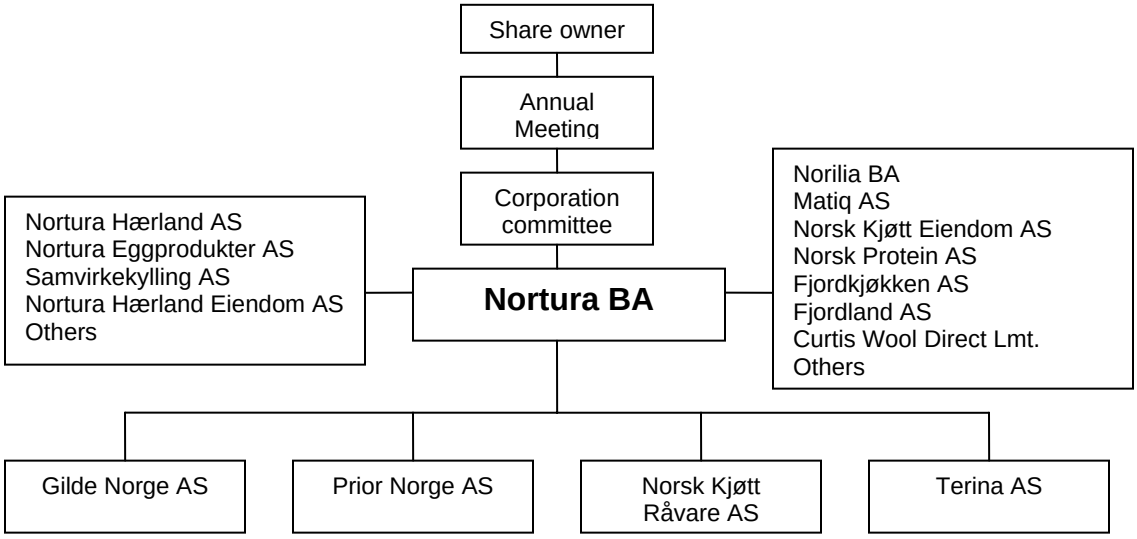
These processes are directly deduced during study of DFD 1 diagrams. In addition to these there are severe planning processes not covered in detail. These planning processes may be transport planning including shipment routing and carrier selection, authorization of invoices and managing supplier/customer networks. Some of these processes are not done at a daily basis, like transport planning and network managing, but invoices are usually a regular management processes.

All of these processes are relevant in logistics, but also processes where physical products flow are a main concern in logistics. These processes are summarized here:

1. S1.2, S2.2, S3.4 – Receive product
2. S1.3, S2.3, S3.5 – Verify product
3. S1.4, S2.4, S3.6 – Transfer product
4. D1.9, D2.9, D3.9 – Pick Product
5. D1.10, D2.10, D3.10 – Pack Product
6. D1.11, D2.11, D3.11 – Load Product and Generate Shipping Docs
7. D1.12, D2.12, D3.12 – Ship Products

7.2 Nortura BA – Gilde BA

Nortura BA was formed in 2006 and is the result of the fusion between Gilde Norsk Kjøtt BA and Prior Norge BA, Norway's leading producers and supplier of red and white meat, and eggs. The company is a co-operative owned by over 31.000 Norwegian farmers. Nortura has industrial operations in 41 municipalities and 18 counties in Norway [NORTURA1, NORTURA2].



Source: [NORTURA1]

Figure 22: Organization of Nortura

Gilde's original vision before they entered Nortura was: - *At the centre of the meal*. This has been carried on in Nortura's vision: *Our greatest values into the future.*

The company guarantees that the entire company's supply chain take place in Norway with Norwegian animals. Gilde Norge BA is responsible for product development, marketing and sale of Gilde marked goods. Gilde produce several different products, among others:

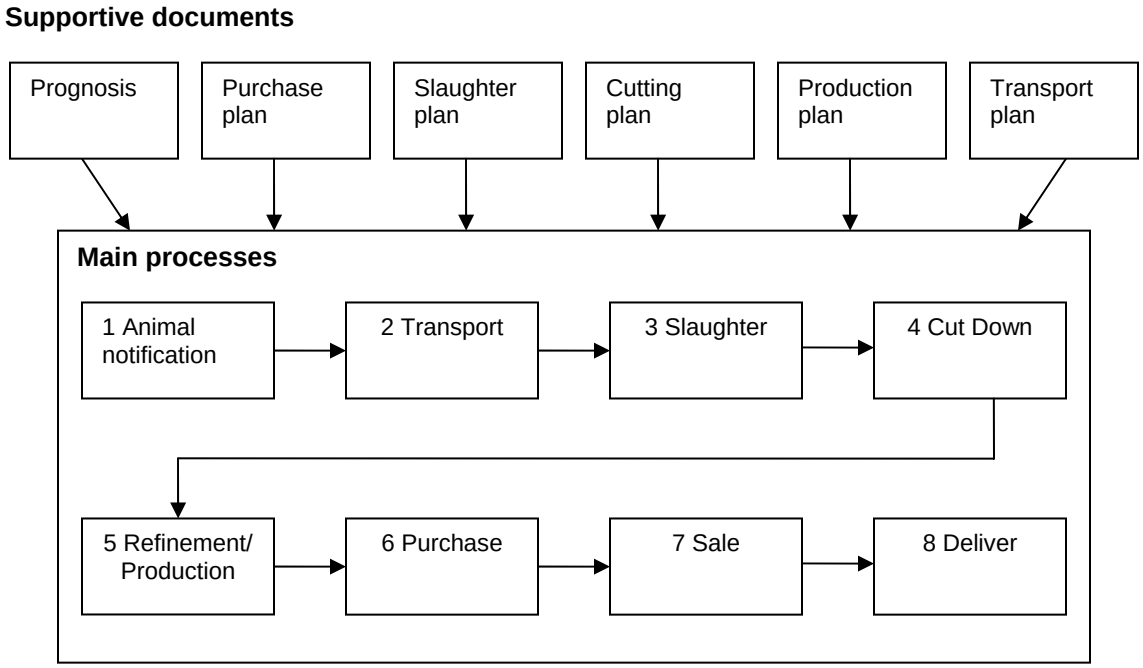
- Sausage
- Sausage meat
- Steak
- Cut meat
- Cured meats
- Treated (salted, cured, marinated)
- Pre-cooked food
- Spread

Sausage *Steak* *Cured meats* *Spread*

Figure 23: Examples of products from Gilde

7.2.1 Process Overview

As described the report focus on Gildekassen, one specific product developed at Norplasta AS on inquiry from Gilde. This box is a transportation device for almost all products in Gilde, from pieces cut from slaughtered animals to finished products packed for storage and transportation. A rough presentation of Gilde's production value chain is given below in figure 24.



Source: [GJØNNES]

Figure 24: Processes and supportive documents in Nortura's value chain

This value chain is different from a typical production chain. Gilde is obligated to collect and transport animals ready for slaughtering, either they want it or not. Gilde never order anything directly from farmers. The only way to comply with higher demand is to persuade farmers to grow more animals or increase marked shares on whole slaughtered animals[14]. Lower demand may be a problem to their storage capacity. Ordering of other raw materials like spices is done on rare occasions and randomly, depending on the production plan and/or seasons. Purchase is mainly done between internal expeditions who "buy" products from other expeditions to cover the total demand in one area. One production facility usually has one expedition, but one facility never produces all kinds of products.

Gildekassen

Through Gilde's use of Gildekassen it gets a life cycle similar to figure 25 below. All boxes are produced and delivered by Norplasta to the section responsible for wash and disinfection. The next step after washing and disinfection is production, where they get

[14] Slaughtered animals sold as one unit.

its finished or unfinished content. Then they are sent to storages, e.g. expedition's storage for finished products or other temporary storage rooms. When boxes are emptied for its items, section for washing will receive the boxes and make them ready to enter production again. Boxes with finished products are sent from expedition to customers, who also have to return boxes when finished using them. Wash and disinfect counts the boxes and orders more if necessary. Gilde do not know the exact number of boxes in production, storage and at customers, but in total they have between 2 and 4 million boxes. One box is used about five years before its sent back to Norplasta for destruction.

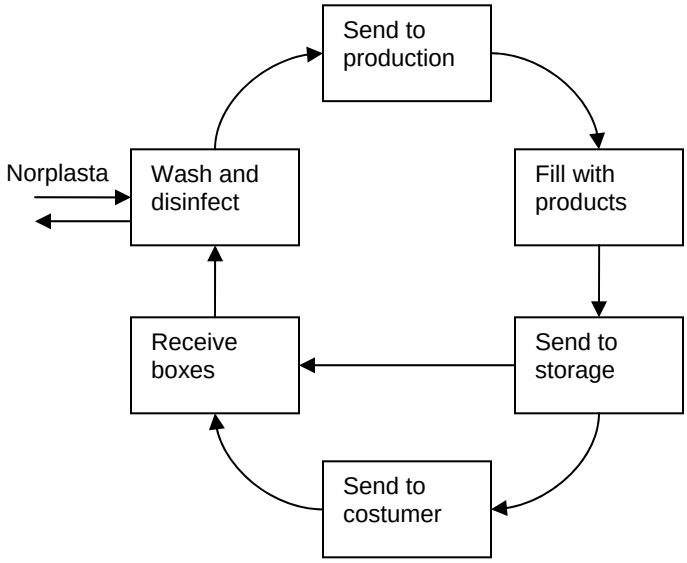


Figure 25: Gildekassen life cycle processes

Processes relevant to warehouse management

Gildekassen is the product being followed through the business cases, and as it is so the process choice needs to be relevant for both warehouse management and Gildekassen. The refinement process of different products is unique, but the use of Gildekassen is similar. Figure 24 above shows the main production chain of Gilde, but Gildekassen isn't part of the entire chain, but is used in both internal and external transport. Relevant internal processes is Slaughtering, Cut down and Refinement/Production. An external process where Gildekassen is used is Deliver. This is processes where Gildekassen enters the value chain and is an integrated part of processes. Between these processes the boxes are stored and warehouse management is an issue in all processes.

In Slaughtering Gildekassen is used in transport of entrails used in further production while the rest of the animal's body needs more treatment. In Cut down the box is used when parts of the animal's body, e.g. rind, is removed from the body, and when parts of the animal's body is finished being cut into producible pieces. Large amounts of boxes are used in Cut down since the meat and raw materials now is stored until further production is scheduled. Refinement and Production also requires huge amount of boxes. Here Gildekassen is used for transportation of all finished and packed products into storage where they remain until transport to one of Gilde's product expeditions

(Purchase) or directly to customers. All pieces are vacuum packed in plastic before put into the boxes, both finished and unfinished products.

When compared to SCOR it is easier to use Gildekassen's life cycle:

- Wash and disinfect
- Fill with products

} Source (SCOR)

- Send to customer

} Deliver (SCOR)

In some of the life cycle processes there are included one or more value chain processes to obtain a complete picture of how work and box flow is done in the business. In Fill with products process 3, 4 and 5 from the value chain are included, and in Send to customer process 7 and 8 from the value chain are relevant. These processes have been evaluated when looking at the relevant life cycle process and information from these processes has been included in this business case description.

7.2.2 Data Flow Diagrams

As with Norplasta dataflow diagrams (DFDs) are described in appendix C and the first model created is a context diagram. This show Gilde's external entities and data flow between these and Gilde's warehouse management. The warehouse management information system is modeled as one process. Figure 26 below shows the context diagram of Gilde.

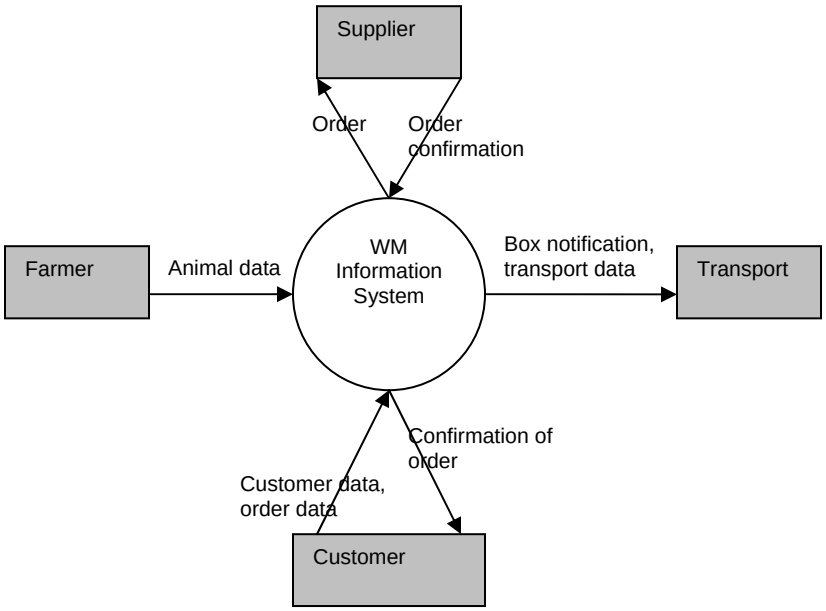


Figure 26: DFD context diagram of Gilde

This context diagram has four external entities; Transport, Customer, Farmer and Supplier, in this case Norplasta. Farmers grow and deliver animals to Gilde who prepare products of them. Other suppliers deliver all other resources necessary to complete the manufacture process, like packing and spices. Transport delivers products from Gilde's facilities to the customer, who orders products from Gilde. Transport also takes responsibility of returning boxes from customers and back to Gilde.

Gilde's DFD level 0 is shown in figure 27 below. This is the first model showing more constructive information as top level processes together with its relevant external entities and data stores. Process numbers in this model is not consistent with any other numbering used earlier. It is introduced to ease the understanding of how processes relate to each other and identify decomposed processes during business analysis.

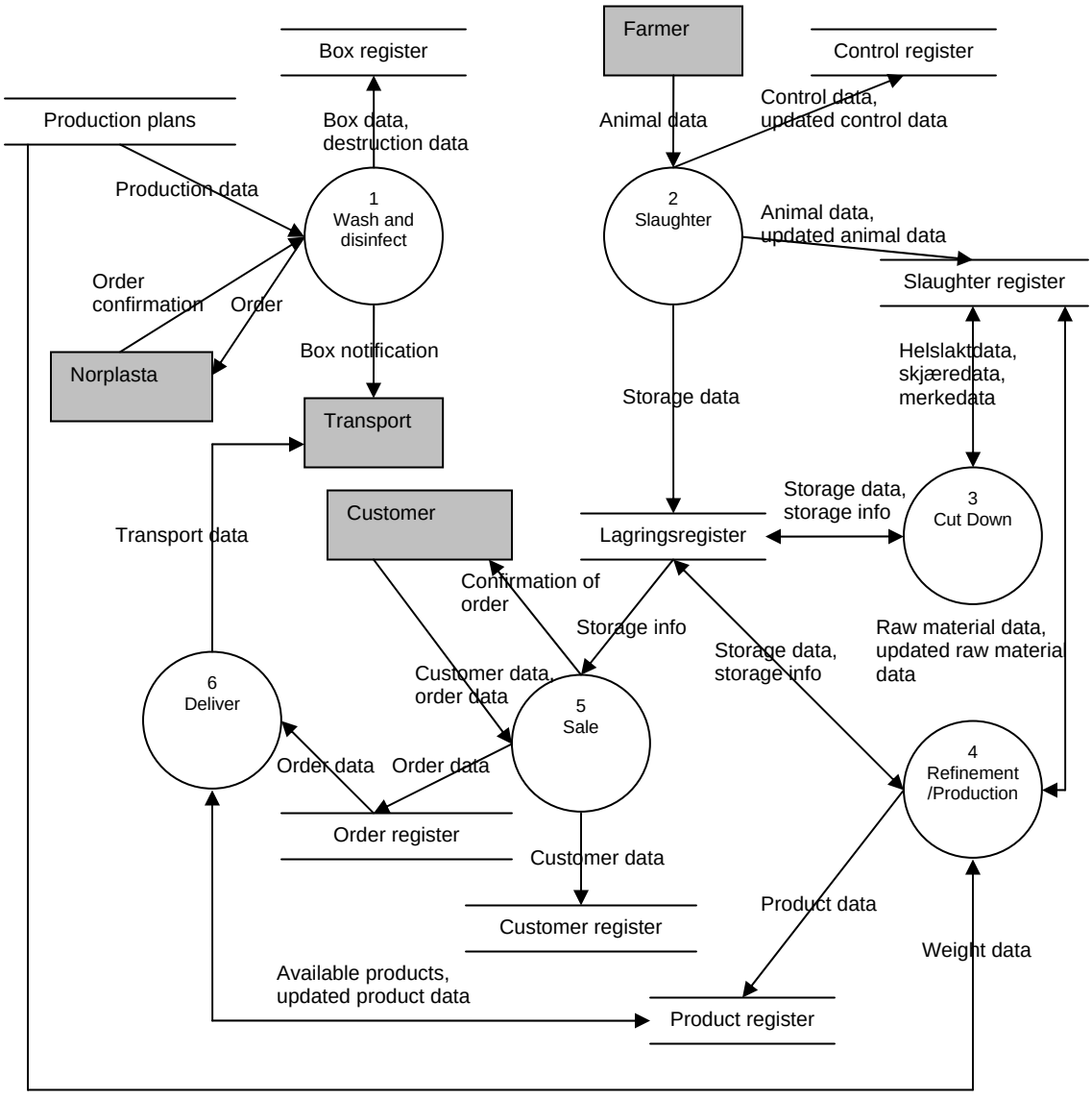


Figure 27: DFD Level 0 of Gilde

The project identifies six main processes in Norplasta's warehouse management:

1. Wash and disinfect
2. Slaughter
3. Cut Down
4. Refinement/Production
5. Sale
6. Deliver

As in Norplasta's case Gilde's processes have been decomposed to DFD Level 1 and verified by internal contact persons, but are not included in the report for confidential considerations. Data elements and information in each process are described further the following section.

7.2.3 Data Elements and Relevant SCOR Processes

Gilde is organized as internal departments "selling" and "buying" products from each other. Each department stores products and register storage data collected by the next department when treating products in its operation.

Today Gilde has a highly developed system for tracing products back to its original animal or livestock. All these connections are stored in Gilde's business application and may as well be connected to EPC numbers. One box may contain products from many different animals slaughtered several different days, but all finished products produced one day have one certain batch number for each product type. Animals entering the Slaughter-process have individual animal numbers or a live stock number. After slaughtering each carcass gets a carcass number. After the cutting process animal parts used in production are transported in boxes, some in Gildekassen. These products have a batch number for the product type and for each day. When Refinement/Production is completed the finished products have a new production batch number for each day each product has been produced.

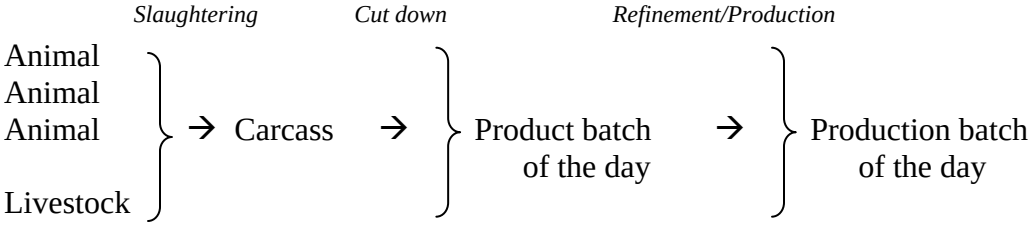


Figure 28: Relations between tagging data in Gilde

Internal data is stored electronically in Gilde's ERP system. In addition to the ERP system, they have a custom build planning application. Data is mostly registered or updated manually, and fetched by workers when needed. "Wash and disinfect" and some packing processes are highly automated, but most processes are not. When data is registered it stays in electronic format, only consignment note and packing note are in paper format. Only two kinds of plans are made manually. Production plans are done

manually, but a suggestion is generated in the ERP system based on prognoses and orders. Most transport of products is regular procedures, but some internal transport between Gilde's facilities are based on received orders and created manually.

Wash and disinfect

Sending boxes to production is an automated process with assembly lines directly from the washing machine to every packing machine. Pallets with 100 boxes on each are sent to a pre-storage room before spit up into stacks of 25 boxes. These stacks are put on the assembly line and from there they are split, washed and sent to packing machines in the production facility.

Table 31: Process 1 Gilde – Wash and disinfect

Information	Data elements and description
Box data	The number of dirty boxes
Destruction data	Number of boxes to destruction (broken, worn out)
Production data	Calculated need of boxes in production
Box notification	A notification from Gilde to transport that boxes have to be collected from customers when delivering new orders
Order	Order number, customer number, order date, number of Gildekassen, deliver date, contact person, status
Confirmation of order	*Order* + Confirmation of order

Table 32: SCOR processes in process 1 Gilde

SCOR processes
S1.1, S2.1, S3.3
S1.2, S2.2, S3.4
S1.3, S2.3, S3.5
S1.4, S2.4, S3.6

Fill with products

As mentioned there are several value chain processes involved in filling Gildekassen with products. Some products are stored internal between e.g. Slaughter and Cut down, but Fill with products is one of Gildekassen's highest consumption areas in the box's life cycle.

Slaughter

Farmers announce animals ready to be slaughtered and Gilde collects them. Animals are to put them to death and prepared for production. The carcass and its entrails used in production travels alongside each other until each part are controlled and verified. Then they are separated and packed/stored in different areas.

Table 33: Process 2 Gilde – Slaughter

Information	Data elements and description
Animal data	Number of animals, animal type, individual animal identification (cattle) or livestock (pigs), delivering farm
Control data	Cleanliness, diseases
Updated animal data	*Animal data* + amounts of animals put to death
Updated control data	*Control data* + more detailed about disease codes, etc.

Carcass and entrails data	Carcass data: original animal identification, weight, diseases in animals/livestock. Entrails data: Weight, amount of animals, animal/livestock identification
Product control data	Control of packing and labeling
Product data	Carcass and entrails data + *Product control data* + Carcass identification, and/or quantity number for entrails
Storage data	*Product data* + location, storage type, products at each storage, weight of products at each storage

Table 34: SCOR processes in process 2 Gilde

SCOR process
S1.2, S2.2, S3.4
S1.3, S2.3, S3.5
M1.3, M2.3, M3.4

Cut down

In this process unfinished products are put into Gildekassen, but also in other mean of transport. The transportation box depends on the product and products that are almost finished and do not need much treatment before finish, like fillet steak. Other parts of the animal going to be for example minced meat are transported in other bigger boxes.

Table 35: Process 3 Gilde – Cut down

Information	Data elements and description
Storage info	Storage data from process 2 (for pick up and/or receiving necessary raw material for further production)
Whole slaughter data	Carcass number, amount, animal type, inspection, disease codes, classification data (for labeling).
Cutting data	*Whole slaughter data* + products cut + pieces to sorting and/or raw material to non-direct products, pieces taken out of production
Packing data	*Cutting data* + Product number, product name, weight of each product type packed
Labeling data	*Packing data* + batch number, customer, destination
Storage data	*Labeling data* + Location, storage type, amount of each product on each storage

Table 36: SCOR processes in process 3 Gilde

SCOR process
S1.2, S2.2, S3.4
M1.3, M2.3, M3.4
M1.4, M2.4, M3.5

Refinement/Production

This is the part of value chain where products are finished, packed and sent to an expedition for further sales. Some packing lines are totally automated with packing, labeling and weighing. Information is therefore also registered automatically in the ERP system. Batch numbers are generated and connected to livestock, production and animal numbers automatically. Other packing lines are partly automated and only weighing and labeling are done automatically when the operator has verified the information. After this process boxes with finished products are sent to storages.

Table 37: Process 4 Gilde – Refinement/Production

Information	Data elements and description
Storage info	Storage data from process 3 (for pick up and/or receiving necessary raw material for further production)
Raw material data	Available raw material, raw material type, amount, batch number
Weight data	Weight needed of each raw material in production
Updated raw material data	*Raw material data* + *Production data*. Amount of raw material taken from each batch is registered
Production data	Products produced: type, amount, production date, new batch number
Packing data	Products packed; *production data* + amounts packed of each product
Product data	Products registered out from production compared to production plan (Amount produces and labeled in relation to anticipated amount); *Packing data* and batch number connected to production number
Storage data	*Pakkedata* + *Produktdata* + Lokasjon og lagringsdato

Table 38: SCOR processes in process 4 Gilde

SCOR processes
S1.2, S2.2, S3.4
M1.3, M2.3, M3.4
M1.4, M2.4, M3.5
M1.5, M2.5, M3.6
M1.6, M2.6, M3.7 and/or D1.8, D2.8, D3.8

Send to Customer

This process describes how boxes with products are sent to customers and an important part of doing this is to know what, where and to whom the products are going to. All products transported to customers are packed in boxes and Deliver is the most consuming process of Gildekassen. Customers often keep boxes for a long time period and Gilde must get transporter to call back boxes when new orders are delivered.

Sale

Customers are registered only once and orders may only be collected from registered customers. Orders are sent electronically, by phone or fax. When done electronically a confirmation of order is sent automatically, otherwise this has to be done manually.

Table 39: Process 5 Gilde– Sale

Information	Data elements and description
Customer data	Customer number, name, invoice address, deliver address, phone number, fax number, contact person, organization number
Order data	Order number, customer number, order date, product numbers, amounts, deliver date, status
Product data	Amounts of each product ready for delivery; Product numbers, product type, amounts, storage number
Confirmation of order	Confirmation of order to the customer; *Customer data* + *order data* + Information of which products can be delivered and which are in shortage

Table 40: SCOR processes in process 5 Gilde

SCOR processes
D1.2, D2.2
D1.3, D2.3

Deliver

This process is done by expeditions all over the country, but is done similar at every facility. One product is picked and controlled by the operator before moving to the next product. One product may be finished prized, or the operator weighs it when picking it. When all products have been picked from all different storages it is gathered and labeled. The order is now ready to be sent. Transportations are collaborated with other companies, like Tine[15], and mostly done regularly at every hour through the day along preplanned routes.

Table 41: Process 6 Gilde – Deliver

Information	Data elements and description
Storage info	Storage data from process 4 (for pick up and/or receiving necessary products from production)
Order data	Order number, customer number, order date, product numbers, amounts, deliver date, order status
Customer data	Customer number, name, invoice address, deliver address, phone number, fax number, contact person
Product data	Products picked to be sent. Product numbers, product types, production date, use-by date
Available products	Which products on each storage + *Product data*
Updated product data	*Product data* + which products taken from each storage and amounts
Labeling data	*Product data* + address, customer, delivery route, number of boxes
Updated order data	*Order data* + Order updated to "sent" and status is changed to "ready for invoicing".
Transport data	Transport needs estimated by orders to be sent
Confirmation of order	*Order data* + confirmation of order

Table 42: SCOR processes in process 6 Gilde

SCOR process
D1.9, D2.9, D3.9
D1.10, D2.10, D3.10
D1.11, D2.11, D3.11
D1.12 , D2.12, D3.12

ER diagram

Chapter 6, figure 14, is an ER diagram containing a general view of data in warehouse management. Figure 29 below show a similar diagram with data specific for Gilde. The entities Product, Transport, Storage, Supplier, Customer and Order are similar in Gilde's diagram and the general view. In addition Gilde's diagram has Gildekassen, Production, Animal and Farmer. This model show data only relevant to warehouse management and show data found in the business case analysis. A compete data model would be much more complex and out of project scope.

15 TINE BA is Norway's leading supplier of milk and dairy products.

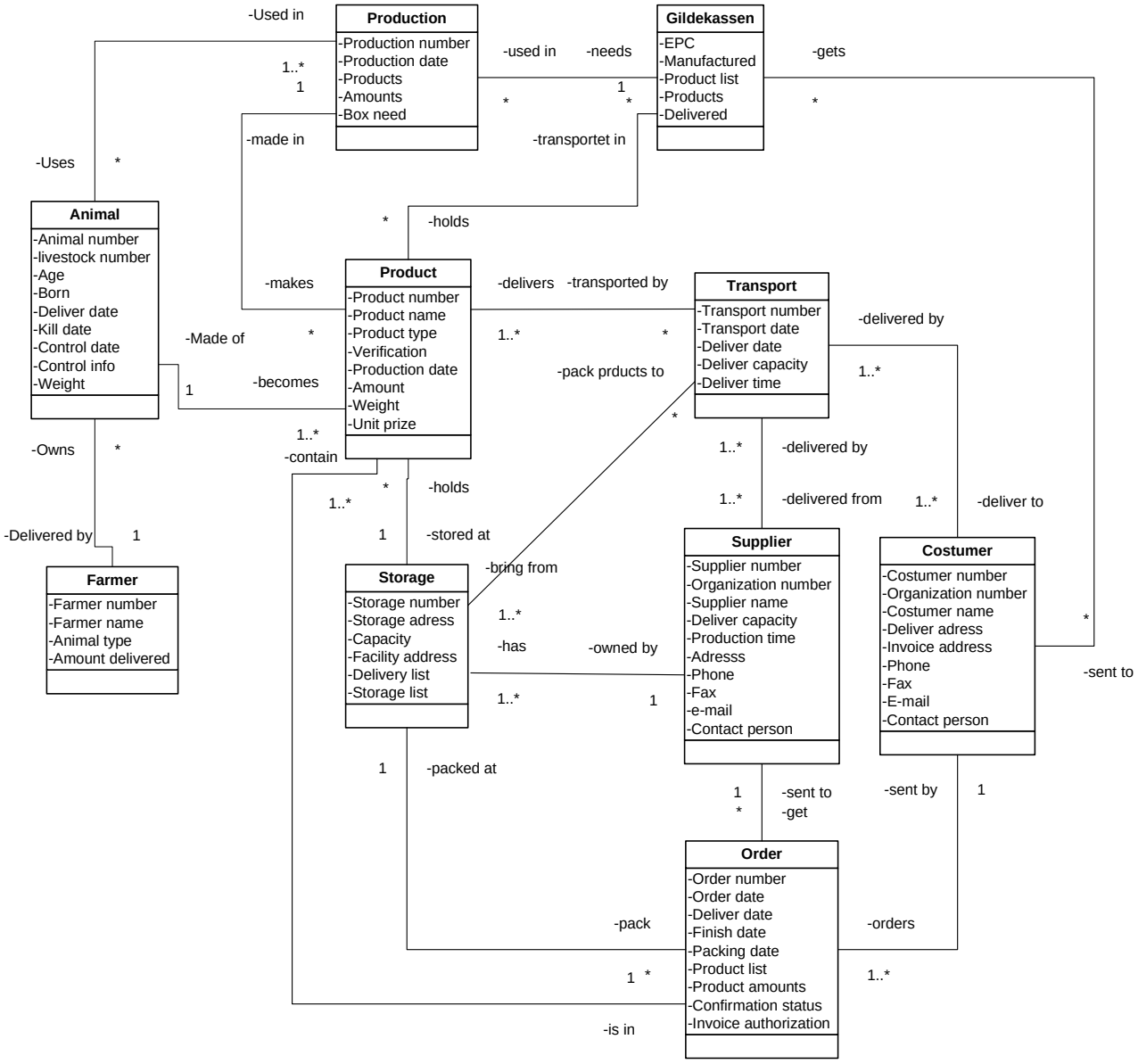


Figure 29: ER diagram – View of data in Gilde's warehouse management

7.2.4 Processes Distinguishing

From Gilde the project has identified three management processes from SCOR:

1. S1.1, S2.1, S3.3 – Schedule Product Deliveries
2. D1.2, D2.2 – Receive, (Configure,) Enter and Validate Order
3. D1.3, D2.3 – Reserve Inventory & Determine Delivery Date

These processes are directly deduced by analyzing the business DFD 1 diagrams. Because of the focus on Gildekassen processes Make are presented here, but not included in further evaluations. These processes are not relevant to warehouse management, but included to present a complete picture of Gildekassen's flow in Gilde:

- M1.3, M2.3, M3.4 - Produce and Test
- M1.4, M2.4, M3.5 – Package
- M1.5, M2.5, M3.6 - Stage Product
- M1.6, M2.6, M3.7 - Release Product to Deliver

As with Norplasta Gilde also have severe planning processes not covered in detail in this analysis, but are important processes in warehouse management and logistics. Physical processes are also important to logistics and Gilde's physical processes identified through SCOR are:

1. S1.2, S2.2, S3.4 – Receive product
2. S1.3, S2.3, S3.5 – Verify product
3. S1.4, S2.4, S3.6 – Transfer product
4. D1.8, D2.8, D3.8 - Receive Product from Source or Make
5. D1.9, D2.9, D3.9 – Pick Product
6. D1.10, D2.10, D3.10 – Pack Product
7. D1.11, D2.11, D3.11 – Load Product and Generate Shipping Docs
8. D1.12, D2.12, D3.12 – Ship Products

7.3 NorgesGruppen

NorgesGruppen is Norway's largest trading enterprise. The group's core business is grocery retailing and wholesaling. The enterprise was founded in December 1994 as a cooperative organization for a number of individual players in grocery retailing and wholesaling. The goal was to strengthen existing collaboration between these individual players. It was also important to create a common front for positioning in a market affected by a steady trend towards fewer and larger players, with growing integration between retailing and wholesaling [NORGESGRUPPEN1, NORGESGRUPPEN 2].

The company's vision is:

NorgesGruppen will improve your daily life.

The company's objective is to offer quality items at competitive prices, in addition to helping the customers save time.

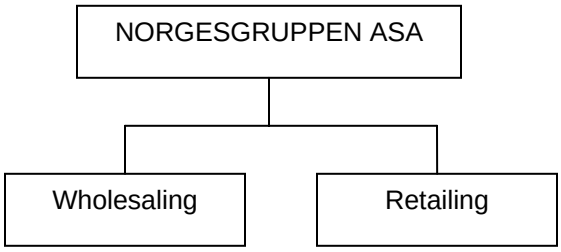


Figure 30: Resume of NorgesGruppen's organization

Wholesaling
The wholesaling business delivers to the grocery, kiosk and convenience, catering and offshore markets. This business area is responsible for the total flow of goods and information in the group. This part of NorgesGruppen is known as ASKO and STORCASH.

Wholesale has different product flows. Some products are distributed directly from supplier to retailers, but most products are wholesale distributed. NorgesGruppen also offers NorgesGruppen-labeled products, products imported and produced by the company itself. Brand name of these products, e.g. First Price and Eldorado, are commonly known and a part of NorgesGruppen's usual selection. Gilde products and Gildekassen are wholesale distributed following the green flow in figure 31.

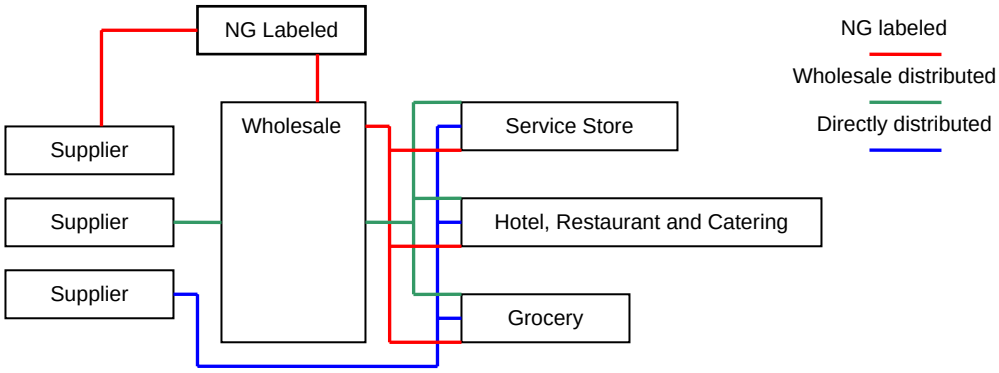


Figure 31: Product flow in NorgesGruppen's Wholesaling

Retailing and Kiosks

This grocery business embraces three nationwide chain concepts as well as a corner shop concept and a regional hypermarket concept. MENY is the chain service centre for large supermarkets, SPAR for the supermarket segment and KIWI for the discount sector. In addition, there is the Joker corner shop concept and the Ultra chain, a regional hypermarket concept. NorgesGruppen also cooperates closely with several independent regional chains and shops. This business consists of the MIX kiosk chain, with 813 retailer-owned kiosks and convenience stores.

Figure 32: Retailers in NorgesGruppen

7.3.1 Process Overview

In both wholesale and retailing there are interesting and relevant areas of warehouse management and logistics. Wholesaling is all about warehouse management and logistics since this is their core business area. Retailing is in this case the wholesale section's customers. When presenting the relationship between wholesale and retail in NorgesGruppen it will look like figure 33.

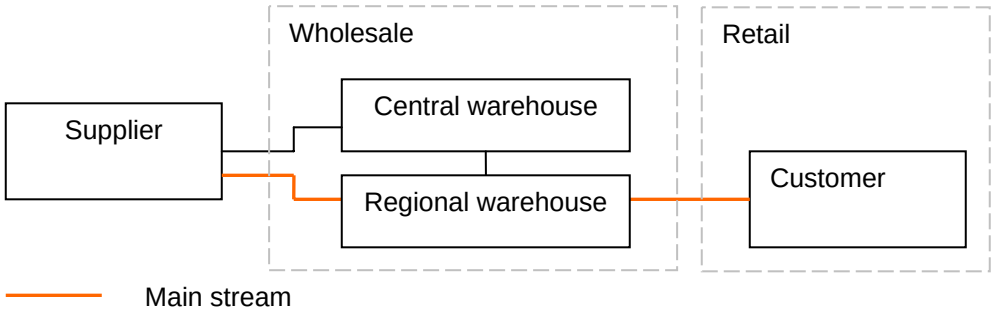


Figure 33: Product flow in wholesale and retail in NorgesGruppen

Both wholesale and retailers have separate ordering of products and separate storage facilities, and they have different internal processes in both logistics and management. Both value chains shown in figure 34.

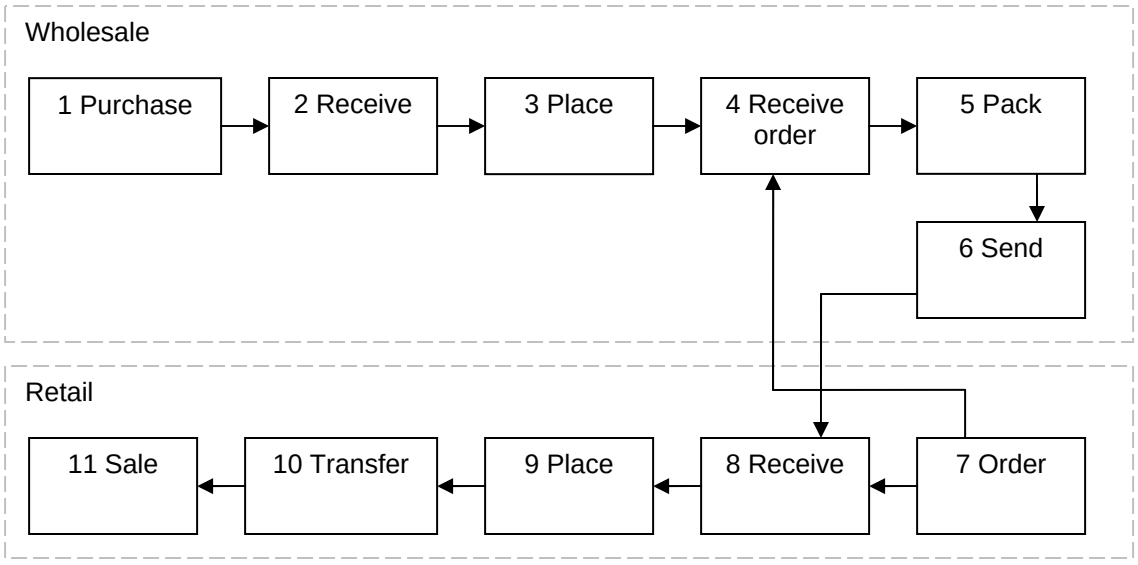


Figure 34: Processes in NorgesGruppen's value chain

As described almost every part of NorgesGruppen's operation is related to warehouse management and therefore also most processes are included in the evaluation. Process 10 and 11 are possibly not relevant because most pallets are broken up and goods are placed on shelves. Most goods from Gilde are stored in the same Gildekassen as they where transported in and remain there until placed in the shop. Therefore process 10 is relevant in this project but process 11 is not. Relevant processes are summarized below:

Wholesale

1. Purchase
2. Receive
3. Place

} Source (SCOR)

4. Receive order
5. Pack
6. Send

} Deliver (SCOR

Retail

7. Order
8. Receive
9. Place
10. Transfer

} Source (SCOR)

7.3.2 Data Flow Diagrams

A context diagram showing external entities and their communication lines to NorgesGruppen's warehouse management information system is shown in figure 35. Different from earlier context diagrams this has to entities marked with dotted lines, Wholesale and Retail. This is because the two entities are not real external entities, but a part of NorgesGruppen's internal activity. On the other hand, Retail is an external entity to wholesale and wholesale is an external entity to Retail. This relationship is illustrated by including them in the diagram like this. Real external entities are Supplier and Transport. Retailer's customers are not included while they never come in contact with Gildekassen in single stores.

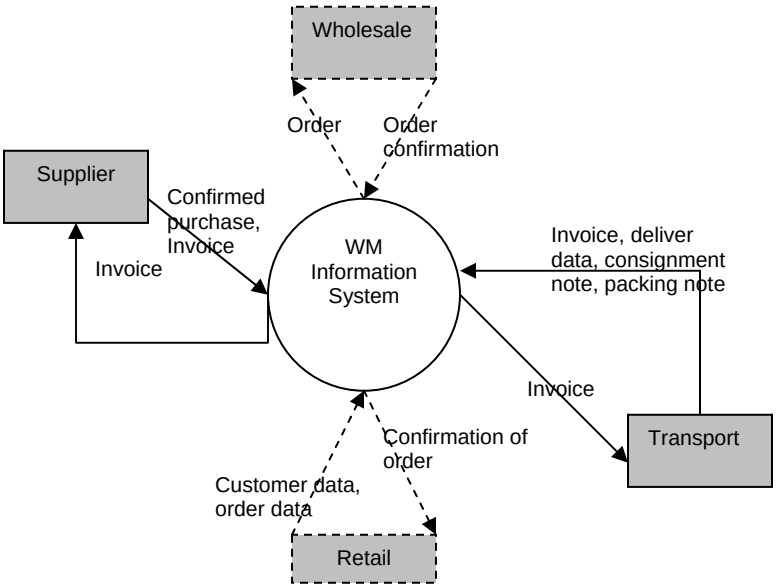


Figure 35: DFD context diagram of NorgesGruppen

As seen in the context diagram there are mostly orders, confirmation of orders and invoices traveling between the entities. Gilde is one of the suppliers in NorgesGruppen's warehouse management, delivering products to Wholesale who deliver them further to Retail. DFD level 0 in figure 36 show a more detailed picture of data flow between relevant processes and different data registers.

The project identified 10 processes from NorgesGruppen's value chain to be relevant to both warehouse management and Gildekassen. The numbering used in the value chain is used further in the DFD level 0 diagram. All processes have been decomposed further into DFD level 1 diagrams and detailed data elements found are described in the next section.

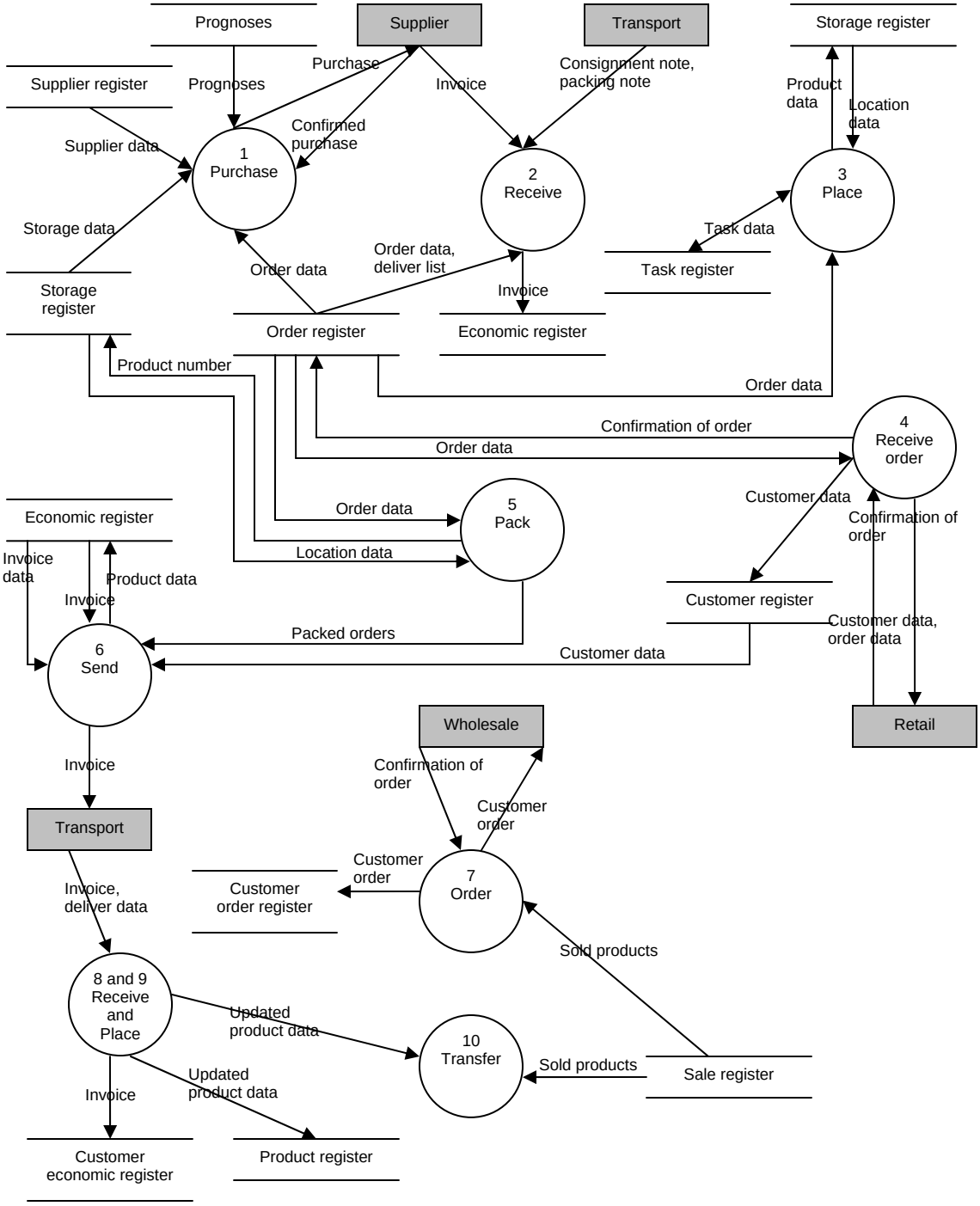


Figure 36: DFD level 0 of NorgesGruppen

7.3.3 Data Elements and Relevant SCOR Processes

NorgesGruppen inform that all information and data elements are stored electronically in their internal ERP system. Employees use paper and office tools like MS Excel when working with information, but in the end the result is always registered in the system.

There is a huge amount of data in business application, but only data relevant to Gildekassen and warehouse management are included in the representations below.

Purchase

Different regional storages purchase goods individually. Purchase is done by purchasers based on volume in stock, registered sale and future forecasts of seasons, campaign and other variations. The business system creates purchase proposal and purchasers modify and approve them. Everything is done electronically.

Table 43: Process 1 NorgesGruppen – Purchase

Information	Data elements and description
Order data	Order number, customer number, order date, products (product number, product name, product type) amounts, deliver date, status
Prognoses	Prognoses data (automatic calculated based on control factors registered by humans, e.g. seasons and campaign)
Storage data	Products in storage: product number, product type, product name, supplier number, deliver capacity, deliver time
Supplier data	Information about suppliers and products they deliver: Supplier number, organization number, address, phone number, fax number, e-mail, contact person, product number, product names, prize
Purchase data	*Order data + Prognoses + Storage data + Supplier data*
Purchase proposal	Supplier, products ordered, amounts, product prize, total prize, deliver time and date
Corrected purchase proposal	A corrected *Purchase proposal* (Same information, only corrected for errors or mistakes)
Purchase order	A *Purchase proposal* sent to current supplier
Confirmation of Purchase order	Confirmation from the supplier. Same information as Purchase Order + confirmation of that the order is possible to deliver in the terms given by NorgesGruppen

Table 44: SCOR processes in process 1 NorgesGruppen

SCOR processes
S1.1, S2.1 and S3.3

Receive (Wholesale)

Received goods are registered with handheld bar code readers when delivered in the arrival dock. Products are registered on pallet level, almost never on case or item level. Most orders delivered have an electronic Advanced Shipping Note (ASN), but in some cases also packing note in paper format is used. When arrived pallets are labeled with product number, name and description. The inventory is updated automatically using ASN when fork lifts move them to their location. All boxes from Gilde, Gildekassen, are labeled with receiving customer and destination. The ASN tells what products one Gildekassen contain. If this is not correct the receiving operator must override ASN information

Table 45: Process 2 NorgesGruppen– Receive (Wholesale)

Information	Data elements and description
Deliver list	Overview of products ordered to each day and from which supplier (to prepare storage to product arrival)
Deliver data	Arrived products, registered with ASN: Product numbers, product types, product names, amounts, supplier numbers, transporter, transport number
Consignment note	A note describing sender, receiver, and a list of contents in the delivered order. Customer, customer number, product numbers, product names, amounts. Usually ASN.
Packing note	A notification sticked to the product case or pallet. Receiver, destination, product number, product name, product type,
Updated deliver data	Corrected *Deliver data* compared to *Consignment note*, control of packing and transport
Received order	Orders received at NorgesGruppen; Order number, product numbers, product names, product types, amounts, date delivered
Invoice	Orders ostensible sent from supplier and received at NorgesGruppen, *Received order* + prize (total and unit prize), organization number, contact information, pay date

Table 46: SCOR processes in process 2 NorgesGruppen

SCOR processes
S1.2, S2.2, S3.4
S1.3, S2.3, S3.5
S1.5, S2.5, S3.7

Place (Wholesale)

The business application automatically finds a suitable location for the received products, and creates transport assignment to be performed by fork lifts. The assignments are shared automatically between fork lifts. Pallets are picked up in the arrival dock and moved to the assigned location. Status is updated when assignments are complete.

Table 47: Process 3 NorgesGruppen– Place (Wholesale)

Information	Data elements and description
Order data	Delivered orders. Order number, customer number, order date, products (product number, product name, product type) amounts, deliver date, status
Location data	An automatic generated location for where the received products are to be stored. (not one regular location, floating position)
Assignment data	Automatic generated plan for fork lift assignment and who should move which order to which location: *Order data* + *Location data* + Fork lift ID
Product data	Which products are moved to what location by which fork lift at what time, confirmation of the location generated or update location of changed from the original plan: *Order data* + *Assignment data* + confirmed move

Table 48: SCOR processes in process 3 NorgesGruppen

SCOR processes
S1.4, S2.4, S3.6

Receive order (Wholesale)
Customers may send orders electronic by using Internet, a hand terminal and automatic orders calculated by using POS data, or manually by phone or fax. Customers can choose to receive a confirmation and if they do NorgesGruppen send this immediately after receiving the order. This is done electronically. Before the confirmation is sent products are reserved to ensure delivery at a certain time.

ASKO uses regular transport routs and deliver time and the customers know the deadline for sending orders to receive goods at a certain day and time. The routes are created automatically based on a route template and calendar in the order system.

Table 49: Process 4 NorgesGruppen– Place (Wholesale)

Information	Data elements and description
Customer data	Customer number, customer name, invoice address, deliver address, phone number, fax number, contact person,
Order data	Order number, customer number, order date, products (product number, product name, product type) amounts, deliver date, status
Reservation data	Product numbers, product names, amounts, deliver date, amount in storage
Confirmation of order	Confirmation to customer. *Customer data + Order data + Reservation data*

Table 50: SCOR processes in process 4 NorgesGruppen

SCOR processes
D1.2, D2.2
D1.3, D2.3

Pack
Orders are released to packing a certain time before planned deliver. This is continually done by workers constantly getting new orders to pick and pack. When an order is picked it is packed in plastic and placed at exit dock to be labeled with a carrier label. A picked order is placed together with other transit orders from other suppliers.

Table 51: Process 5 NorgesGruppen– Pack

Information	Data elements and description
Order data	Order number, customer number, order date, products (product number, product name, product type) amounts, deliver date, status, combination with transit products
Product number	Products that are to be picked and packed
Location data	The products location
Packed orders	Orders/products ready for sending

Table 52: SCOR processes in process 5 NorgesGruppen

SCOR processes
D1.9 , D2.9, D3.9
D1.10, D2.10, D3.10

Send

All product carriers (Orders) are scanned when loaded on transport, and an invoice are printed. This is printed when loading an order has finished and this is the only document given to retailers when delivering orders.

Table 53: Process 6 NorgesGruppen– Send

Information	Data elements and description
Packed orders	Orders/products ready for sending, (from process 5)
Product data	Product numbers, product types, product names, amounts, customer number, deliver address
Customer data	Customer number, customer name, invoice address, deliver address, phone number, fax number, contact person,
Invoice data	*Product data + Customer data*
Invoice	Same as Invoice data but now a finished generated invoice

Table 54: SCOR processes in process 6 NorgesGruppen

SCOR processes
D1.11, D2.11, D3.11
D1.12, D2.12, D3.12
D1.15, D2.15, D3.15

Order (retail)

Most retailers use a hand held terminal to scan bar codes on shelves where there are shortage of products and register the wanted amount. This terminal must be connected to a computer and the order is then automatically sent to the regional storage who delivers to this particular customer. One retailer, KIWI, uses automatic product supplementing, a solution called “NG-flyt”. This solution creates order suggestion based on data in the retailers POS system, prognoses for future periods, registered campaigns and manual input. The orders may be adjusted manually by managers at the store before sending.

Table 55: Process 7 NorgesGruppen– Order (Retail)

Information	Data elements and description
Shortage/sale	Product numbers, product names, amounts short/sold
Customer order	Product numbers, product names, amounts, customer number, order time
Confirmation	Confirmation of which products are delivered to what time. May contain information of what not possible to deliver

Table 56: SCOR processes in process 7 NorgesGruppen

SCOR processes
D4.1
D1.2 D2.2

Receive and Place (Retail)

Stores receive products and invoice when the transport arrives. Verification of goods are done manually when unpacking and placing products at storage.

Table 57: Process 8 and 9 NorgesGruppen – Receive and Place (Retail)

Information	Data elements and description
Deliver data	What order(s) are delivered: Order number, customer number, order date, products (product number, product name, product type) amounts, supplier, transporter, deliver date,
Invoice	Orders ostensible sent from supplier; Product number, product name, product type, amounts, supplier, deliver date,, prize (total and unit prize), organization number, contact information, pay date
Product data	Products delivered; Product numbers, product types, product names, amounts, supplier
Updated product data	*Product data* corrected by combining order sent and order received, check of transport and packing

Table 58: SCOR processes in process 8 and 9 NorgesGruppen

SCOR processes
D4.2

Transfer

At this time most pallets are unpacked an RFID tagging ended, but Gildekassen are still an issue as products are stored in these cases until they are put into shop shelves. This process is therefore shortly described.

Table 59: Process 10 NorgesGruppen- Transfer

Information	Data elements and description
Updated product data	Information of products received (From process 8 and 9)
Sold products	Products sold/of shortage. Product numbers, product names, amounts, refill need in shelves

Table 60: SCOR processes in process 10 NorgesGruppen

SCOR processes
D4.3

ER diagram

This specific ER diagram is similar to the general view in figure 14, chapter 6.
The entities Product, Supplier, Customer, Storage, Order and Transport are still present, but supplier has changed place and Wholesaler and Retailer has entered together with Purchase and Prognoses. Where supplier used to be there is now Wholesaler. Where there used to be Customer there is now Retailer, but this does not mean that retailers of NorgesGruppen have no customers. The level of tagging relevant in the project is pallet or case, and end users of NorgesGruppen's products are not in connection with either. They are therefore not included in the diagram. Prognoses and Purchase is necessary for internal buyers to gather products that retailers want, and they are sent to suppliers ho deliver products to NorgesGruppen.

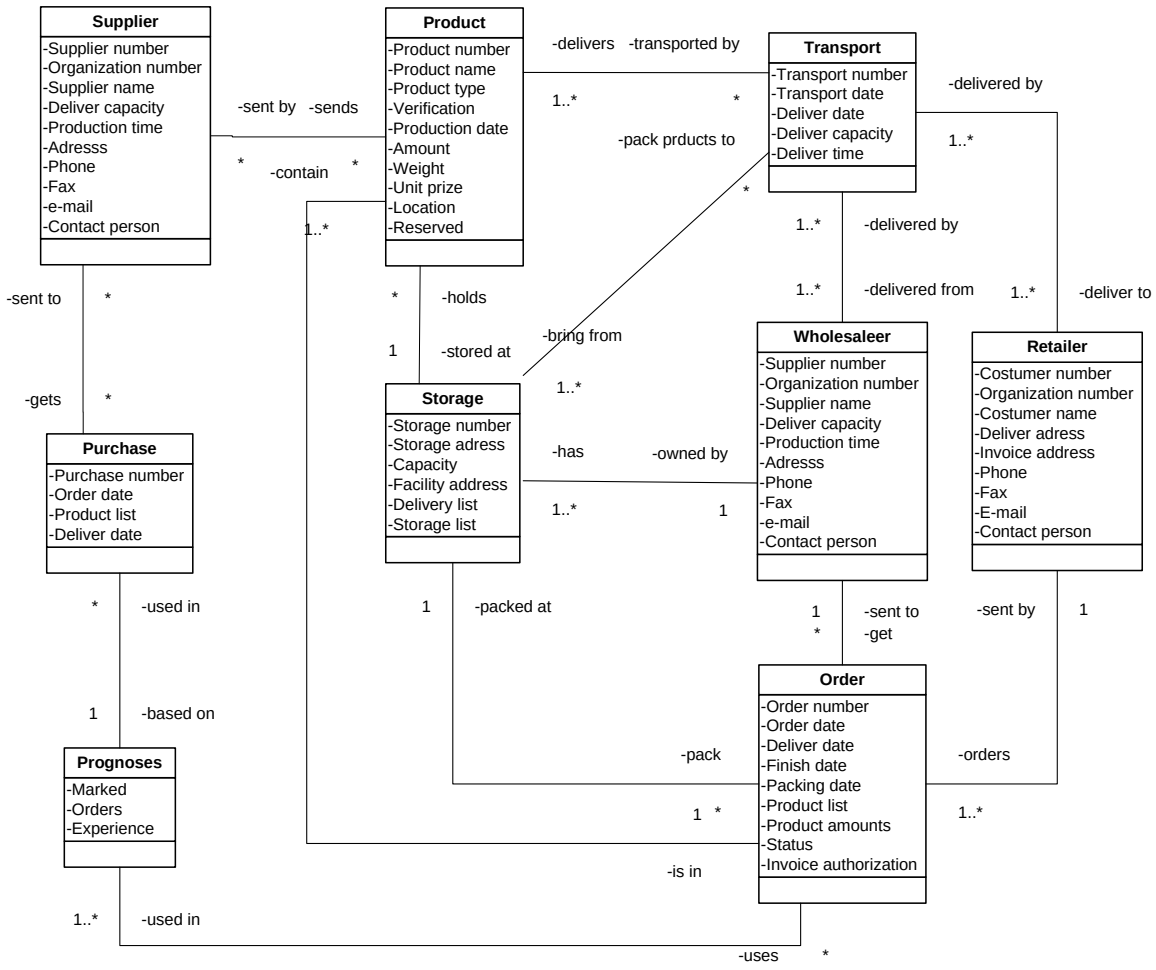


Figure 37: ER diagram – View of data in NorgesGruppen's warehouse management

7.3.4 Processes Distinguishing

NorgesGruppen has six management processes described by SCOR's processes Source and Deliver and are deduced from the business' DFD 1 diagrams:

1. S1.1, S2.1, S3.3 – Schedule Product Deliveries
2. S1.5, S2.5, S3.7 – Authorize Supplier payment
3. D1.2, D2.2 – Receive, (Configure,) Enter and Validate Order
4. D1.3, D2.3 – Reserve Inventory & Determine Delivery Date
5. D1.15, D2.15, D3.15 – Invoice
6. D4.1 – Generate Stocking Schedule

In addition logistics are about movement of physical products and are probably the largest task in this area. Physical processes found in relation to SCOR are:

1. S1.2, S2.2, S3.4 – Receive product
2. S1.3, S2.3, S3.5 – Verify product

3. S1.4, S2.4, S3.6 – Transfer product
4. D1.9, D2.9, D3.9 – Pick Product
5. D1.10, D2.10, D3.10 – Pack Product
6. D1.11, D2.11, D3.11 – Load Product and Generate Shipping Docs
7. D1.12, D2.12, D3.12 – Ship Products
8. D4.2 – Receive Product at the Store
9. D4.3 – Pick Product from Back Room

There are also many planning processes necessary to perform processes from both management and physical movement of products. These are not covered in detail here, but will be included in the solution evaluation.

8 Solutions

Each business has been analyzed according to data and information in processes relevant to warehouse management and similar SCOR processes are connected to each business process. By evaluating challenges identified by the current business and goal accomplishment in the relevant SCOR processes in appendix D, possible RFID solutions have been found. Description of how these solutions may be implemented in each business is described in this chapter, and changes in data and information is evaluated in the next. All solutions may be implemented with different architectures. The project has identified three different architectural views. These are presented first, but no choice of architecture is done as this is not a part of the project focus.

When evaluating solutions for each business the project has used both pallet tagging and case tagging (Gildekassen). The tag's EPC number is the main connection to information for all parts in chain, but is not necessarily used in every step. The case level tag is assumed to be placed in/on boxes during production at Norplasta and activated when Norplasta or Gilde find this advantageous. Pallet tags are placed and activated when a pallet is packed and ready for storing.

8.1 Architectural Overview

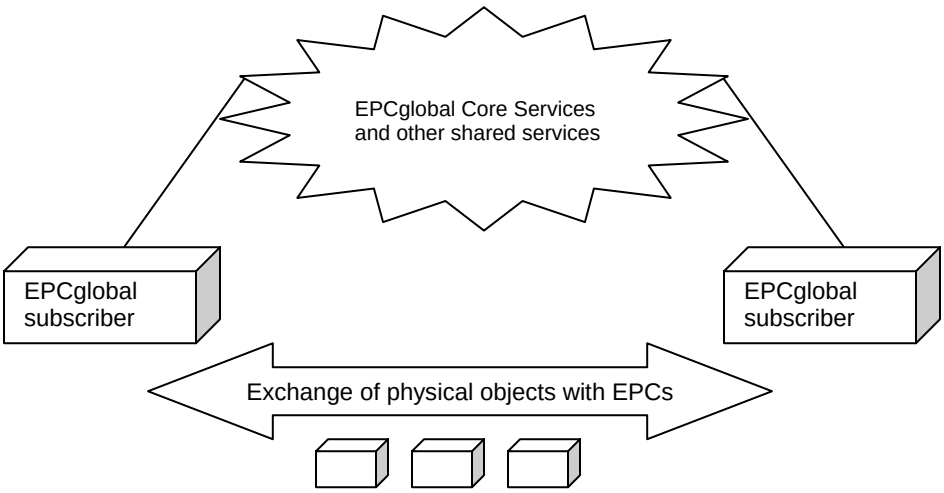
Through the work of writing this report the project discovered three possible architectures, two more realistic than the last. The architectures have a short introduction to give an understanding of how the choice of architecture may impact how information flows. No choice or advice of architecture is made as this is not a part of the project. An architectural choice requires a deeper understanding of several technical aspects not covered in this report.

8.1.1 EPCglobal Architecture Framework

As described earlier the EPC does not contain any explicit information, but links to a system on the Internet. This connection provides detailed information about items everywhere in the supply chain, without storing information inside the tag. This solution is known as EPC Network or EPCglobal Architecture Framework [EPCGLOBAL].

The Framework consists of EPCglobal core services and other shared services offered by the framework, together with exchange of data between EPCglobal subscribers. The subscribers are different companies using EPC when exchanging physical objects, see figure 38.

Information from each EPCglobal subscriber may be uploaded to EPCIS (Electronic Product Code Information Service) which stores, hosts and provide access to product information enabled by RFID. Collaborating subscribers may then collect information from this service and use it to make the internal value chain more efficient, and consequently making the entire supply chain more efficient.



Source: [EPCGLOBAL]

Figure 38: Architecture framework overview

8.1.2 Communicating ERP Systems

Without a framework as presented above the different internal ERP systems may communicate directly through the Internet. According to Jon Atle Gulla an ERP system is "a packaged application that supports and automates business processes and manages business data" [GULLA]. ERP usually has support for manufacturing and logistics, sales and distribution, human resources and financial accounting. The two former are defined by the report to be a part of warehouse management.

With continuous data feed from RFID systems several functions has the potential of further automating work processes. With data from other RFID systems the potential is even more notable. To do this the system needs communication channels to business partners ERP system, who keeps their RFID data. An illustration of how this is connected is shown in figure 39.

The components needed in such a system are two or more communicating ERP systems. Most likely containing a special module for handling RFID data, databases to contain data while not in use, and a RFID system at each site to read, collect, filter and store data from physical objects moving between businesses.

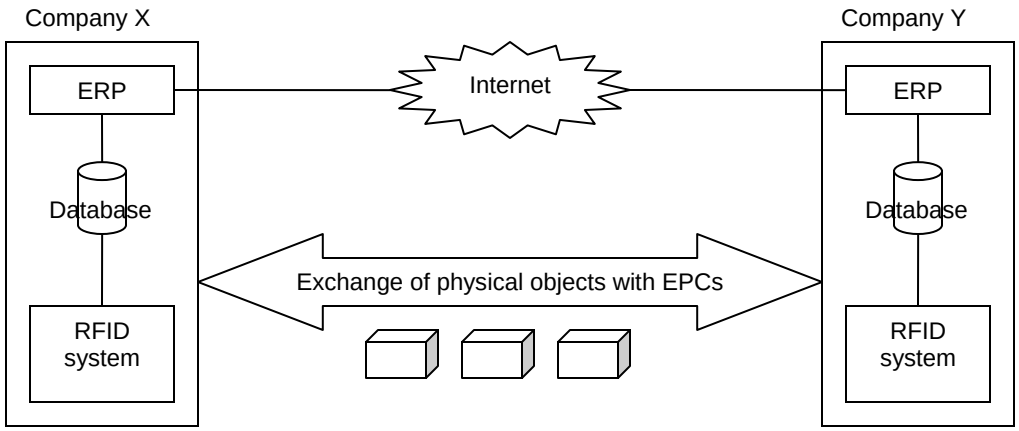


Figure 39: Exchange of RFID data between ERP systems

8.1.3 Information Stored in Tags

The last architecture identified by the project is simply storing all information inside the tag together with the EPC. No communication is required apart from reading the tag. Data collected at each company must be filtered by each internal RFID system and stored in the internal database. When new information is created data have to be stored in the tag before sending the item to next part in chain. This solution has high requirements to tag size, read rate and data updates in the tag.

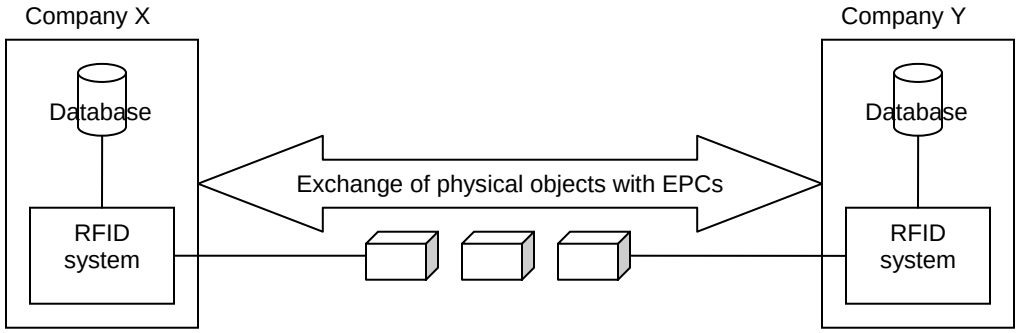


Figure 40: Exchange of RFID data by reading tags

8.2 RFID solutions in Norplasta

Norplasta has six processes relevant to warehouse management:

1. Purchase raw material
2. Receive and store raw material
3. Send raw material to production
4. Receive raw materials from production
5. Order products
6. Deliver products

Norplasta has an ERP system doing many of its tasks related to information storing and flow, but there are some elements of manual work and difficult forecasts. One of Norplasta's main problems concerning Gildekassen is that there are often uncertain orders from Gilde. When Gilde orders new boxes the amount is considerable large and a miscalculated production plan may cost Norplasta both work hours and money.

Process 1, 2, 3 and 4 – Purchase raw material, receive and store raw material, Send raw material to production and Receive raw material from production.
These are difficult processes to evaluate because of the raw materials nature. As described most raw material received by Norplasta are materials with high granularity, like plastic raw material or color substances, and impossible to tag. The raw material arrives in tank trucks and is stored in silos. From here it's transported by automatic pipe systems to the production hall and production machines.

One possible solution is to tag the transporting tank trucks. One truck or tank may be tagged with an ID, possibly EPC or an EPC connected to the truck or tank ID, the raw material loaded, the amount and supplier information. When the truck arrives at Norplasta's production site it must drive through a portal reading the trucks tag information and sends this to Norplasta's ERP system. The trucks cargo is automatically registered in the ERP system and can be used to automatically calculating ordering of new resources/raw materials to comply with future production plans. This solution may be used for every resource not possible to tag, but Norplasta also get tag-able products like packaging. This arrives as pallets and may be tagged directly. These have to be unloaded and moved through a portal in the storage door to be registered. From this point forward the ERP system can use this information in the same way as with raw material.

In process 3 and 4 plastic raw material and color substance is attended to by automatic pipe systems transporting it to and from the production facility. There isn't found any solutions with RFID that may give these processes any improvements. When it comes to pallets with resources like packing material, these may be attended to by the ERP system. The pallets are read and registered at arrival and the number of pallets containing each resource is known to the system. When a raw material needs to be sent to production a pallet is moved from storage through a portal where its identifications are collected and the system notified. It is the same when returning material from production.

One problem identified is that pallet packaging of tagged resources may be broken when arrived or when returning from the production and the RFID tag may be lost. Another problem may be that returning pallets has a different amount of resource after production. This may be calculated by the system, but may be an advanced process. It is possible that this is an inexpedient tagging solution.

Process 5 – Order products

Gilde do not have an exact number of boxes in use and it is difficult for them to know exactly how many new boxes they need at a certain time. If Gildekassen is equipped with tags and Gilde has a system for counting the number of boxes in its facilities, Norplasta could get information of this electronically and in real-time.

Orders from Gilde are today sent manually and randomly by administrative personnel. As discussed earlier in the report manual work may lead to more mistakes in information flow than automatic executing. If the RFID systems communicate with the ERP system the box requirements data may be sent automatically and be confirmed automatically at Norplasta as well. It may be sent regularly, e.g. every day or every week, or when the bow requirements reach a certain level. This information may be used by Norplasta's ERP system to create accurate production plans based on real time demand at Gilde's facilities.

Process 6 – Deliver products

When orders are received and the right products and amounts have been manufactured it is time to send it to the customer. Products are placed in the storage room while waiting for the rest of the order to finish, and when all products in an order have reached the storage they are combined and packed for further transportation. The context of the evaluation says that Gildekassen are tagged in production and tags may be activated whenever Gilde and/or Norplasta find this advantageous.

If box tags are not activated the pallet containing the boxes may be packed, tagged and activated as a whole. To be registered the pallet needs to be transported through a portal when leaving production or storage. Now the ERP system may get information and mark the correct order as finished or loaded at a certain date. One pallet usually consists of a predefined number of cases and the system would know how many cases that have been loaded at a certain time. If the number of cases is not consistent with the predefined number this needs to be registered manually and connected to the pallet's EPC number. The system will now still have the precise number of cases. The system would know when all products in one orders has finished loading and then be able to automatically send a Consignment note to the customer. If the transport carries a PDA with wireless internet communication a consignment note may also be downloaded to this machine, and a consignment note in paper format will not be necessary. The same solution may be used at other transport documents like export papers.

If tags are activated at Norplasta before loading, the exact number of boxes may be counted as they are transported through a portal. No predefined amount needs to be registered and tags on pallet level may be leaved out. The rest of the solution is similar to pallet level tagging, but now the precise number of boxes is counted every time. It is also possible to use both pallet and case tagging to connect which box is loaded on which pallet. This may be an advantage if boxes “disappear” during transportation or storage. The rest of the solutions include both possibilities.

When finished boxes have been loaded on a pallet in the production hall it may automatically be packed and tagged with RFID. This tag contains an EPC number connected to a specific order number and is therefore also connected to a specific customer. This connection may be done automatically if the packing/tagging machine knows what is being packed. Some of the process may be easily done by an operator choosing what product is being packed and the system does the rest of the information connections. The system now knows how many boxes are transported to the storage room and how many that is missing to finish an order. When orders are finished packed and tagged the system can order transport automatically.

When transport date has arrived the system knows what orders to send and what pallets are connected to each order. When an operator is picking pallets a reader in the fork lift may tell if this is one of the correct pallets in an order, show how many pallets are left to load and which EPC number they have. Finding pallets in Norplasta’s storage area is not a huge problem, but if the system says that a certain number of pallets in an exact order are in the storage room, the operator knows if the order is finished loaded. They also know what exact pallets that are connected to each order and customer when loading them on transport. When customers receive the order they can now use the RFID to confirm that it has arrived and if there is any items missing. This verification is easy if case level tags are activated before sending. If not the storage workers at the customer must check whether the pallets contain the correct amounts. Pallets usually do not disappear and its EPC will only be used to verify that all pallets in the order has arrived the correct customer.

Verification may be sent automatically between to communicating systems, and when verification is registered at Norplasta invoices may be sent. This process will be done faster than today’s more manual processes and claim less use of paper.

8.3 RFID Solutions in Gilde

Gilde has six processes relevant to warehouse management:

1. Wash and disinfect
2. Slaughter
3. Cut down
4. Refinement/Production
5. Sale
6. Deliver

Processes in Gilde relevant to Gildekassen and warehouse management are different than other businesses in this report. Gilde is the main user of Gildekassen and to get a complete picture of Gildekassen's flow and management processes relevant to it, processes from production has been found advantageous to include. The description of box flow is based on Gildekassen's life cycle, shown in figure 25, and a selection of processes from Gilde's value chain shown in figure 24.

Gilde identifies several challenges connected to Gildekassen:

- Exact number of boxes not known
- Where boxes are at a certain time is not known
- Unstable ordering procedures
- Document washing of each box

Process 1 – Wash and disinfect

Wash and disinfect is an important process when it comes to estimating the future box inventory. This process is responsible for delivering boxes to production which is planned several days, weeks and in some cases even months ahead. The number of boxes in circulation at Gilde and Gilde's customer are unknown. Workers in this process counts boxes and call for box return when needed. Gilde also has a sharing policy that should secure that boxes are transferred between productions sites when variations of box need differ at each site. One problem is that boxes are stored to cover variations in seasons. Sites may not want to share its stored boxes in fear of not covering their own demand in these periods. Box amount information is transferred by phone and easy to change manually. When no one wants to share its boxes the asking facility is forced to order new boxes from Norplasta, even if Gilde in its entirety have enough boxes to cover the need.

As described in the introduction to this section boxes are tagged with RFID at Norplasta. If arriving boxes are not activated it is done when entering Gilde's facility. Boxes are sent to a storage room before washing. The entrance may be equipped with readers and count the number of boxes waiting to be washed, including boxes from both Norplasta and production/transport. After washing the boxes are sent to production or to a buffer zone where they are stored until variations require them to be put into circulation. This storage may also have readers that count the number of boxes stored. To gain a complete picture of how many boxes there are in storage, buffer zone and production boxes may also be counted when leaving washing and entering production. This counting may be performed

at each facility and information may be exchanged electronically between production sites. This information is not possible to change manually, “hiding” boxes from sharing can not be done and unnecessary ordering of boxes may be reduced. By using wireless communication the system will also be able to tell transports to collect boxes when delivering goods to customers.

Information from all facilities may be combined to create a jointly box order and sent electronically by automated processes in Gilde’s business application. This order may be completely automated and based on box accounting, future production plans, forecasts and known variations factors adjusted by humans.

Solutions not addressing any of Gilde’s identified challenges are also relevant, like registering and verification of orders received at Norplasta. When an order is delivered the boxes or pallets with boxes may be tagged with RFID. Both levels of tagging may contribute to automatic registering received orders, and verify this by comparing with amounts in orders sent. If boxes are tagged it is also possible to verify the number of received boxes automatically and establish an automatic invoice authorization.

Gildekassen may be followed through every step of the washing process. When boxes are received, washed, buffered or sent to production, readers may “see” each box and collect their location. When doing this it is possible to count how many times a box has been washed and been circulated. If wanted it is possible to set a “lifetime” to each box and get notifications when they are supposed to be removed from circulation. Boxes removed may be registered by readers at an area for boxes to be destructed or done manually by the operator removing them. This is easies done by handheld readers or a special “reading station” in the facility, which terminate the tag or set the tag status as terminated. If a box like this enters circulation after this termination an alarm will notify workers to remove the box.

Process 2, 3 and 4 – Slaughter, Cut down and Refinement/Production

The processes Slaughter, Cut down and Refinement/Production have similar use of Gildekassen. The solutions here are also similar and therefore described together. These three processes are the content in process Fill with products in Gildekassen’s life cycle, see figure 25. The main concern in this part of cycle is where boxes are, and what they contain. Solutions described in process 1 register boxes as they enter production and transported to packing areas on automatic transport lines. In addition to packing Gildekassen is used in manual transport and storing of unfinished products. Each work area may have a reader in entrances to register which boxes are at each department. The amounts of in-registered and out-registered boxes may be counted and stored electronically for managers to see internal box movement.

When products are packaged and put in boxes it is possible to register the content in relation to box EPC. Packing lines in Slaughter and Cut down are manual processes and creating relations between EPC and content may be cost and time consuming. When

transporting items the content may vary a lot because there are many parts of one animal, and tagging each box with what part of the animal it contains is not advantageous.

When packing finished goods one packing line always pack one product at the time. This is done automatically or by an operator depending on the product type and packing line. After packing a box it is weighted, registered and labeled by a machine or operator. This process may easily be extended to update RFID data. The EPC will be connected to data of products in this specific box. The business application may have a predefined amount of a certain product in one box. By using this amount the application will know how many products are finished and ready for delivering. If the number of items does not mach the predefined number it is possible override it registers the right amount and connects this to the EPC. From here the box and its connected data may be seen through readings done when moving the box around in internal areas.

Process 5 - Sale

This process can not be changed by an internal RFID system, but if the customers also use RFID product data communication may increase and improve the sale process. If Gilde's customers have RFID in their storages an automatic order may be sent to Gilde when the product amounts reaches a certain predefined level. The business application may automatically return a confirmation of order. It may also reserve inventory directly by using EPC numbers and the products amounts information.

Other indirectly improvements of the process may be customer service. Sellers may have complete inventory lists when receiving a phone inquiry containing inventory questions, and easily answer questions connected to this. A RFID system connected to a sensor system supervising the products quality would also increase the customer service since Gilde always will know under what conditions their products has been stored.

Process 6 - Deliver

When picking an order the operator takes products from different boxes and batches and collects them in new boxes that contain one specific customer order. Information of how many products taken from each bath to complete one order are registered in systems today, but this connection may also be done by box EPC. One tag may connect to this data and tell which order contains which boxes, the boxes content and which customer. Compared to today's solution this will be a higher granularity of tracing since connections today use order numbers. When boxes are packed they are put together and placed on pallets that may also be tagged. Tagging of pallets may not be advantageous while there is no real reason to do this when Gildekassen is tagged. Combined orders are labeled manually, but with EPC connected to the necessary order and customer information the physical label is redundant. Still it may be advantageous to workers not able to read the tag.

The business application knows what orders to send each day, and with EPC it also know what specific boxes to send. Most orders are pre-packed on pallets and workers loading

orders only need these. In some cases one order is collected in few boxes and pallets are not needed. As described in other business cases also Gilde uses fork lifts to transport pallets in the storage room. A reader attached to this may tell if one pallet is one of the correct pallets in an order, show how many pallets are left to load and which EPC number they have. Finding pallets or boxes is not known to be a problem at Gilde, but a RFID system may notify if there are pallets left to be loaded and the operator will know if there are pallets left in the storage room. Through the business application the operator will know what exact pallets or boxes are connected to each order and customer when to load them on transport.

Boxes are read while loaded on transport and an automatic packing and/or consignment note may be created in the cargo door. When loading finishes a worker are able to print the exact number of boxes loaded, which boxes and what they contain. The packing/consignment note may be completely electronic and downloaded to the transport PDA, if this is in use.

When customers receive the order they can now use the RFID to confirm that an order has arrived and if there is any items missing. The invoice can be created and sent the minute the customer automatically verifies the received order. Invoices may be sent automatically in paper format and/or in electronic format. This process will be done faster than todays more manual process and claim less paper if this is wanted by the business. Automatic verification in a RFID system involves checking that the right products and/or orders has arrived the correct customer. Gilde will know which customer received which boxes and calculate how many are returned or still in the possession of customers. This solution can contribute to sustain box accounting and give accurate box inventory when ordering new boxes from the supplier.

When implementing these solutions the project finds changes few changes in data, but many processes are automated and the data are registered more often.

8.4 RFID solutions in NorgesGruppen

NorgesGruppen has 10 processes relevant to warehouse management:

Wholesale	Retail
1. Purchase	7. Order
2. Receive	8. Receive
3. Place	9. Place
4. Receive order	10. Transfer
5. Pack	
6. Send	

These processes have been connected to different SCOR processes and provide different solutions. Some processes are similar in wholesale and retail and have similar solutions. There are some processes where RFID solutions do not provide any noticeable improvements. NorgesGruppen have many well-developed systems dealing with many challenges usually addressed by RFID, but the project found several areas where the technology may be implemented to gain improvements in processes.

NorgesGruppen do not identify any severe problems handling Gildekassen. One issue though of is that suppliers use many different ordering techniques, like Internet, NG-flyt[16] and fax. Another issue is that suppliers use different levels of ASN and NorgesGruppen therefore has to accept and handle all levels of electronic shipping note.

Process 1 - Purchase

As mentioned purchase is based on volume in stock, registered sales, future forecasts, seasons, campaign and other variations. A purchase proposal is created in the business system and verified by purchasers. Volume in stock is one part of the processes where RFID can contribute. With readers in the storage room, or in the entrance of storages, it is possible to keep an accurate accounting of Gildekassen in storage. If box content is registered before transport to NorgesGruppen information will be available and heighten the granularity of data even more. Today's solution uses ASN and products are actually registered on item level in relation to a box.

Process 2 – Receive (Wholesale)

NorgesGruppen uses handheld barcode readers when registering their arriving products. With readers in the docking entrance all boxes, or pallets, are registered simultaneously as they are unloaded. As products are registered a verification of amounts may be done compared to what is ordered. Order numbers may be transferred in the registration process and if verification succeeds an automatic authorization of supplier payment may be established. If suppliers, in this case Gilde, register when an order is loaded and transport initiated, NorgesGruppen's deliver list may be updated with this information.

[16] Solutions create order suggestion based on data in the retailers POS system. This is described in NorgesGruppen's business description, chapter 7.

As described earlier Gilde's products are transit products, and customer orders sent from NorgesGruppen is finished packed at arrival. Pallet tagging is the most used level in NorgesGruppen, but Gildekassen is labeled with customer and destination in addition to ASN connecting box content to one box. Labels must be read manually when boxes are grouped with the rest of the customer order. A label is not necessary when using RFID tagging. Boxes do not have a unique identity in the ASN, but this is possible with RFID. With unique identities on boxes they may be traced through NorgesGruppen's entire facility.

Process 3 – Place (Wholesale)
Different rooms/areas in NorgesGruppen's facilities may have readers in entrances and/or exits. Doing so tagged units are tracked in every step of the movement. Fork lifts or drivers may be tagged and the solution makes it possible to automatically know for certain who moved what unit. The company will always now where each unit are when they where moved and by who. Tracing products in facilities will also give information of how long units are in each area, and sensors in areas may supervise the environment where products are placed. Tags may have information of how an optimal environment should be for the tagged product, and business systems may alert if this is not followed. If a unit is placed in the wrong storage workers will know, maybe even in the same second as moving the unit into a storage.

Process 4 – Receive order (Wholesale)
This process does not have many direct changes with RFID, but there are still several aspects that may improve the execution of it. Orders are received from retailers in many different formats. If all retailers have RFID-monitored storages with readers and tagged products, all orderings may be done automatically and in unified format. Reservation and confirmation of order may be sent as usual. Reservations of products may be done by using box EPC, not only based on how many products the business system has registered in storage

Process 5 - Pack
In this process products are picked and packed. Picking is done by workers in fork lifts. There is not found any direct solutions that improve the existing process. Auto-generated pick lists already exist, but it may use box EPC instead of pallet numbers. Finding the products may be done by handheld readers, but with a registered location this is not necessary. After picking orders are packed in plastic. The packing process is manual and should easily be automated by a packing machine. In this process the order/pallets may be tagged and activated by the same machine. The activation may register an order as ready to be loaded on transport, and simultaneously verify that all the correct boxes are in that particular order.

Process 6 - Send
When orders are ready for sending they are placed at the exit dock. When products are loaded they are scanned by operators using handheld barcode scanners. This task may be completely removed and replaced by an automatic process registering products and orders as they are moved through the exit dock. The earlier scanning process was used to verify an order packed and generate invoice. When using RFID the order may be verified before entering this process and invoices may still be generated based on RFID data. The boxes are identified in NorgesGruppen's facility for the last time, until customers choose to return them to NorgesGruppen or Gilde.

Process 7 – Order (Retail)
As with purchase this process may be automated completely by using RFID in storage areas, but in this case it has to be done at customers. This process is connected to process 4 in wholesaling and solutions are described hare and in process 1.

Process 8 and 9 – Receive and Place (Retail)
These processes, Receive and Place, mostly have the same solutions as process 2 and 3, Receive and Place in Wholesale. Products are registered and verified when arriving in the back room. They may be registered at different locations in the storage if this has several rooms/areas and each has an individual reader. The inventory list is updated automatic based in this, and employees now have no chance in missing any products they may be looking for. Employees may check the system and if it says that a box of something is in storage, it is. When products are verified invoice authorization may be invoked and payment may be done.

Process 10 - Transfer
This process is unusual since most pallets and cases are unpacked before this point of value chain, but Gildekassen transport products all the way to the shop floor. Here products are put in shelves and Gildekassen is left empty in return piles in back rooms. It is possible to track products until this point, but after this point the EPC no longer connects to transported products. The connection must be dissolved and put into product history. This may be done by placing cases in a certain dissolve area in the back room, or done by readers when loading returning boxes in transport.

The METRO Group business cases mentioned earlier in the report [COLLINS2] uses smart shelved to ease the refilling process. This is not relevant at pallet or case level, but as seen Gildekassen are still in use at this point. The shelves in the business case uses EPC in item level and are therefore not included as a solution, though it may bring many advantages to a stores management.

8.5 Common Solutions and Summary

This chapter has presented an architectural overview and possible solutions in warehouse management for the three business cases. Solutions have differences and similarities that may affect data collection and information communicated between businesses. Some solutions are unique for one business and others are found in all three businesses. This section gives an overview and compares solutions of all three business cases to find these differences and similarities.

8.5.1 Differences

All business cases have solutions that may register products and verify product amounts as it arrives at the business, except Norplasta who also receive raw material not possible to tag. This solution in process 1,2,3 and 4 in Norplasta's solutions description show that it is possible to collect information from transporting trucks, not only arriving pallets, and still gain same data as with product tagging.

NorgesGruppen is the only business mentioning invoice generation. They send an invoice together with orders when transport to their retailers, an invoice possible to generate automatically by reading products as they are loaded onto trucks. This solution assumes box EPC to be connected to box content and use this information when generating the invoice.

Gilde has Receive Product from Source or Make as one of their processes. This is mentioned because of the nature of Gildekassen's life cycle and not mentioned in Norplasta, which also is a production business where this is relevant. The reason why the process is not included is that the tag may not be activated. If tags are activated before entering the storage area of Norplasta the process are similar to Gilde's. If not it is will not be possible to perform. The RFID solutions in this process are similar to receiving products from supplier. Boxes are registered as they are transported into the storage for finished products, and the system will know what is possible to reserve and transport.

NorgesGruppen is the only business directly handling retail products. Products from Gilde are transported in Gildekassen and are therefore relevant to the project. Retailers may generate automatic orders similar to NorgesGruppen wholesale and Gilde by monitoring storage area or back rooms. Products may also be registered and verified at retailers similar to when receiving products at production businesses. It is also possible to register when a product has been picked from the backroom and are leaving for the shop floor.

8.5.2 Common Solutions

All business cases have solutions for handle automatic registering of products as they arrive and verify that the correct amount is present, assuming that the supplier tag orders before transport. This collected data may be compared to orders sent from the business and automatically authorize supplier payment. Only Norplasta and NorgesGruppen

mention payment authorization as a part of their sourcing process, but Gilde may easily introduce this when using RFID.

Norplasta, Gilde and NorgesGruppen wholesale may benefit from automatic ordering systems at their customers storage. Box/product requirements may be collected by reading the amounts of boxes, possibly connecting EPC numbers to box content, and compare this to manual controlled factors like seasons, variations and so on. It may also be automatically compared to data in the business system like orders and campaign. All these factors placed together with read data can create automatic orders and send them electronically to suppliers. This system is relevant for NorgesGruppen retail, NorgesGruppen wholesale, Gilde and Norplasta, but raw material used in production at Norplasta is not possible to tag and may cause difficulties to an automatic order system. Other products like packing are possible to order automatically.

When moving boxes around in storages or other business facilities readers may register and track where boxes are. If relevant this tracking data may be combined with sensor data and information other than location is available to the business.

All three businesses have solutions for direct product reservation based on box EPC. At Norplasta this may seem unnecessary since all Gildekassen is going to Gilde, but different Gilde facilities may order different amounts and have different deliver addresses. This reservation mechanism will easily show workers which pallets of boxes are going where.

All three businesses have pick, pack, load and generate shipping documents as processes in their warehouse management. Picking may be done by using EPC to find the correct reserved box, or in larges storages it may be used to find the correct pallet faster. The packing process do not necessarily have a direct solution, but this may be a perfect time and place of activating or registering/reading data simultaneously to packing. This assumes the packing process to be mechanical and not manual when the latter will create a more time consuming process with more tasks. When loading products registering may take place and data are used to create accurate shipping docs automatically. This data may also be used to verify orders to be sent and invoice making. At Norplasta this may be a less improvement if box tags are not activated before sending, but still feasible.

8.5.3 Summary

As seen most solutions are similar but as described during each business evaluation the internal implantation may be different. NorgesGruppen stand out from the other two cases because of its retailing, but also here the solutions are the same as before. Some processes are mentioned only once or twice, but are still relevant for all companies because the processes must exist in to make the business function. Norplasta has one solution with tagged transport trucks. This is not highly relevant to Gildekassen, but still an important part of manufacturing the box, and an interesting twist to register supplies not possible to tag.

9 Evaluation of Solutions

Introducing solutions described in the previous chapter will impact the businesses data and information in several ways. Management and logistics may have to change its processes and communication between business partners will change from today's communication solutions. This chapter will take a deeper look into specific changes that may occur by focusing on the research questions presented in chapter 5. Individual evaluations are included under each business, but aspects relevant to all business are gathered in a general evaluation.

Evaluation of changes in data and information are done based on how the project believes the data to be affected by the described solutions. These assumptions are based on a thorough literature study of business cases from all over the world, but mostly done by using knowledge of data structures in information systems. This extraction method has been chosen because there is little research done in the area of logical data changes with RFID in business cases. The evaluation of changes in management and physical processes uses processes from SCOR relevant for the business, presented in the current business case. Changes are found by checking solution description against these processes and the summary of this is found here in the evaluation. Positive and negative issues found in solutions during the evaluation are presented in the end of each section. Changes in information are marked by italic writing.

9.1 Evaluation of RFID in Norplasta

9.1.1 Changes in Data and Information

Most of the solutions in Norplasta will not change many data elements or information sent, but it will be sent or received more often and many of the processes will be substantially automated. Some processes will not require any manual handling of data and some processes only need verification before continuing the automated process.

Table 61: Information changes in process 1 Norplasta – Purchase raw material

Information	Data elements and description
Order data	*Unchanged, but may be automated*
Prognoses	*Unchanged, but may become more accurate if customers use RFID and transfer order data regularly.*
Requirement data	Unchanged
Product data	Not relevant for established suppliers, products only registered once
Supplier data	Not relevant for an established suppliers, only registered once
Purchase proposal	*Unchanged, but automated and done by the ERP system based on registered received resources.*
Corrected purchase proposal	*Manually corrected Purchase proposal not necessary, but may be practical if e.g. production plans change or similar incidents happen.*
Purchase order	*Unchanged, but may be automatic sent electronically or in paper format (or both) by the ERP system*

Confirmation of Purchase order	Unchanged, depends on the suppliers system.
Confirmation	Unchanged

Table 62: Information changes in process 2 Norplasta – Receive and store raw material

Information	Data elements and description
Delivery list	Unchanged
Deliver data	Unchanged
Consignment note	*With the described solution this information will be in both unchanged paper format and new electronic format. The electronic data is found when reading the tag and used to register received goods. The paper format isn't necessary but may be practical for storage workers receiving the cargo.*
Packing note	*With the described solution this information will be in both unchanged paper format and new electronic format. The electronic data is found when reading the tag and used to register received goods. Marking the received resources is practical for storage workers receiving the cargo.*
Updated Deliver data	*This process is likely to be partly automated. It is not necessary to control the received goods against Consignment note, but controlling packaging and transport must still be done manually. Still, this is less time consuming and a superficial inspection done simultaneously as the resources are unloaded and transported to storage.*
Transported products	*This information will be automatically registered. No paper documents or manual intervening necessary.*
Placed products	*Unchanged, unless the storage has readers as well. Then local location may be stored automatically when moving resources.*
Received products	*May be done in earlier processes*
Received invoice	*Same data, but invoices may automatically be authorized for payment when a certain order and its products have been registered.*

Table 63: Information changes in process 3 Norplasta – Send raw material to production

Information	Data elements and description
Production data	Unchanged
Specified production data (production card)	Unchanged
Raw material available	*Unchanged, but automatically updated when tag-able products are moved from storage.*
Necessary raw materials	Unchanged

Table 64: Information changes in process 4 Norplasta – Receive raw materials from production

Information	Data elements and description
Unused raw material	*Unchanged, but automatically updated if RFID tag intact on pallet and the amount problems are solved*

Table 65: Information changes in process 5 Norplasta – Order products

Information	Data elements and description
Customer data	Not relevant for an established customer, only registered once
Box requirement data	*Box requirements (amounts) calculated by internal Gilde systems (The amounts may be calculated using data as boxes in facility, estimated boxes at customers, forecasted return of boxes and future production)*
Production data	*Same data, but creating production plans based on box requirements data*
Confirmation	Unchanged

Table 66: Information changes in process 6 Norplasta – Deliver products

Information	Data elements and description
Order data	Unchanged, delivered by the ERP system
Transport order	Unchanged, calculated by the ERP system based on orders and their estimated deliver dates.
Transport data	Unchanged, collected manually and calculated/attended to by the ERP system
Cargo data	*Unchanged, but highly automated.*
Invoice	*Unchanged, but highly automated*
Customer data	Unchanged, attended to by the ERP system
Export data	*Unchanged, but automated*

9.1.2 Changes in Management Processes

Management processes identified from SCOR is:

1. S1.1, S2.1, S3.3 – Schedule Product Deliveries
2. S1.5, S2.5, S3.7 – Authorize Supplier payment
3. D1.2, D2.2 – Receive, (Configure,) Enter and Validate Order
4. D1.3, D2.3 – Reserve Inventory & Determine Delivery Date

Point 1 may be partly automated. A business system connected to a RFID system can monitor the in and out registering of products in the resource storage. By monitoring pallets/cases directly, or by registering trucks delivering goods and what is used in production using the production plan, the systems are able to calculate orders. If the system has some manually set factors like variations and seasons and uses order data directly from the system, this process is mostly automated. Norplasta may choose to send orders directly or manually verify the order before sending it.

Authorizing supplier payment may be completely automated if verification of orders is only based on amounts. If other factors like packaging or transport have to be verified before authorizing it may be done manually the instant the resource arrives by using a touch screen in the arrival dock or by using PDAs.

Receiving and entering orders may also be automated by customers monitoring their storages and use the same automated ordering technique as described. Verifying may also be done based on directly reservation of products, if this is in storage, and not done manually because of the large amount of factors to evaluate during production planning. Determining delivery date will also be a part of this manual process if products are not

available. When available this may automatically be verified as sent on nest available transport. Transports are not regularly and must be done manually, but a notification of reserved space on a transport may be sent to the administrative personnel.

9.1.3 Changes in Physical Processes

From SCOR Norplasta have seven physical processes:

1. S1.2, S2.2, S3.4 – Receive product
2. S1.3, S2.3, S3.5 – Verify product
3. S1.4, S2.4, S3.6 – Transfer product
4. D1.9, D2.9, D3.9 – Pick Product
5. D1.10, D2.10, D3.10 – Pack Product
6. D1.11, D2.11, D3.11 – Load Product and Generate Shipping Docs
7. D1.12, D2.12, D3.12 – Ship Products

Receiving products will still be a completely physical process without any changes, but registering them in the system may be done automatically using RFID. Workers only have to transport goods through an ”intelligent dock” with RFID readers registering RFID tags. Verifying amounts is done simultaneously as unloading products and may be a completely automated process. Verifying other factors will still be manual.

In point 3 products are transferred from arrival area and to its respective storage location. Tagged products may be registered in different areas by bringing them through RFID portal and get more accurate location then if workers should remember these themselves.

Picking products are not a difficult process at Norplasta, but the business system may give information to workers about which pallets to pick to complete a certain order. The picking process itself will still be physical but workers get more information when performing the process. The packing process is not changed in any other way then entire pallets may be tagged and activated if wanted.

Loading and generating shipping documents may be partly automated. The loading process is physical and does not change, but generating shipping docs may be done automatically when loading products. The solution describes it as readers collecting product data when products are loaded and using the connection between EPC and content information to automatically generate the information in these documents. Now this may be printed on paper, sent to the customer electronically and/or downloaded to the transporters PDA.

Ship product will not change with any of the mentioned solutions.

9.1.4 Evaluation of Described Solutions

Evaluation of solutions in process 1 to 4 – Purchase raw materials, Receive and store raw material, Send raw material to production and Receive raw material from production
The problem of products not possible to tag is in reality a small problem because carriers or transport may be tagged instead. In Norplasta's case there are raw materials where there are no carriers to tag so the only solution is tagging transporting trucks. This may on the other hand cause a problem. Tagging trucks, or to be more correct containers, has been done in a business case in China [GAMBON], but this may not be realistic here in Norway. To get a complete solution with tagged trucks all trucks in Norway have to be tagged. It is common to hire truck companies to transport materials and products between geographic distinct places and these trucks are used at more then one customer. It is also possible that one business hires trucks from several truck companies. The project realizes that this is a very complicated solution, though not impossible. It requires thorough planning, maturity of solutions and positive engagement from truck companies.

One problem identified in process 3 and 4 is that pallet packaging often gets broken or removed when arriving or returning from the production. These causes the RFID tag to be lost. Another problem may be that returning pallets has a different amount of resource after production. This may be calculated by the system, but may be an advanced process. It is possible that this is an inexpedient tagging solution. The project finds it difficult using RFID tags on resources used in production. The nature of Norplasta's resources, granularity or not, makes it impractical and technical unfeasible. Information may be lost trying to tag products when the tag is lost and it is not found that this tagging will improve the ordering process further. If resources possible to tag are tagged until it reaches the production hall, this is all the information the business system needs to update its automatic order system.

Evaluation of solutions in process 5 – Order products
This process is only possible to improve if Gilde implement RFID in their production. Tracking and counting boxes inside Gilde may contribute to automatic ordering system and orders may be sent more often and on a regular basis. Compared with today's manual ordering routines it is likely that Norplasta would be able to create more accurate long term production plans, and meet Gilde's demand more precisely. Gilde wouldn't have to order anything from Norplasta and boxes would show up whenever and wherever needed. This change in process execution would change information flow, from order data to purely box requirements.

Evaluation of solutions in process 6 – Deliver products
This is the process where most process changes are found, and many of them imply the tag to be activated before leaving the production hall. With activated tags finished orders stored may be confirmed as ready to be sent, pallets do not need to be tagged further at Norplasta before transport and a specified inventory list for each transport is created. The former is most likely not necessary since the storage area of Norplasta do not require any complicated management. Updating production plans, marked with which products

are finished, are advantageous and may be done based on RFID. This is a task performed by Norplasta today and not dependent by RFID. Tagging pallets with Gildekassen is not necessary if box tags are activated, but must be done if activation is excluded. Both are easy processes possible to perform when pallets of boxes are leaving the production hall. Electronic consignment note may replace today's manual paper system. The system register products loaded, verify them against the order from that specific customer (One box/pallet may be directly connected to both order number and customer number), and send it to transport PDA and customer, who receives it several hours before products arrive. By electronic registering and verifying of received products at the customer an invoice may be generated automate and sent electronically to the customer. All this contributes to removing several time consuming manual processes and collects data automatically without human interaction.

9.1.5 Summary

Norplasta feels it lacks certain and reliable orders from Gilde. This information is possible to establish automatically if receiving electronic real-time orders from Gilde. This solution and other described in Norplasta do create severe changes in data. The number of data transmissions between Norplasta and Gilde increases with real-time demand collected from Gilde's storages.

Norplasta has four identified management processes found using SCOR. Resource order proposal may be created automatically and if wanted manually verified before sending it electronically. Authorization of supplier payment may be completely automated if verification of orders is only based on amounts. Receive, enter and validating orders may also be automated if customers use RFID monitored storages. These orders are in real-time, data consistency between businesses is high and verification may be done automatically or manually. Reserving inventory is possible to do automatically if using direct EPC connections to orders. Determining delivery date may also be automated, but seems to be a complicated process as deliveries are not regularly and large orders must usually be sent to the production planning before this date may be set.

At Norplasta there is found changes in six of Norplasta's seven physical processes. Receiving products are partly improved by automatic product registering and verifying. Transferring products are not directly changed, but product location is a new data element used to track products when transferred. Picking and packing products may be improved by using EPC to see which pallets are in each order and if all elements in an order are found. In addition data about customer and deliver address are available through EPC. Loading products are not changed, but registering loaded products may be done automatically during loading. Based on this consignment note and packing note may be created and sent electronically to the customer. All though this is a physical process it is also possible to see this as a managerial part. Based on this management is improved further by solutions in physical processes. Shipping products are not impacted by any described solution as it is not a part of the business case.

9.2 Evaluation of RFID in Gilde

9.2.1 Changes in Data and Information

As with Norplasta RFID solutions in Gilde will not make great impact on specific data elements, however two elements will change. Process 1 handles ordering of new boxes fro Norplasta and here orders have become box requirements. In process 5 order data will become product requirements data, automatically communicated between Gilde's customers and the internal business system. The frequency of data collection and automation of processes based on collected data will contribute in considerable changes in how processes are performed. It is also considered information possible to share with Norplasta, like box requirements deduced from the amounts of boxes in Gilde's internal facility.

Table 67: Information changes in process 1 Gilde – Wash and disinfect

Information	Data elements and description
Box data	*Unchanged, but this data may now be collected several places, not only in storage of unclean boxes. Box data may be collected at storage, washing, buffer and when leaving for production. Automatically collected and the complete amounts may be shared with other facilities.*
Destruction data	*Unchanged, but may be automated*
Production data	Unchanged
Box notification	*Unchanged, but may be automated and electronically*
Box requirement	*Box data evaluated and analyzed by the business application, automatically sent to Norplasta*
Confirmation of order	*Unchanged, but may be automated*

Table 68: Information changes in process 2 Gilde - Slaughter

Information	Data elements and description
Animal data	Unchanged and not relevant to Gildekassen
Control data	Unchanged and not relevant to Gildekassen
Updated animal data	Unchanged and not relevant to Gildekassen
Updated control data	Unchanged
Carcass and entrails data	*Carcass data: Unchanged* *Entrails data: Unchanged, but data may be connected to box EPC*
Product control data	*Unchanged, but data may be connected to box EPC*
Product data	*Unchanged, but data may be connected to box EPC*
Storage data	*Unchanged, but data may be connected to box EPC and location may be updated automatically by readers*

Table 69: Information changes in process 3 Gilde – Cut down

Information	Data elements and description
Storage info	Unchanged. Storage data from process 2
Whole slaughter data	Unchanged
Cutting data	Unchanged
Packing data	Unchanged
Labeling data	*Same as before, but data about products transported in Gildekassen may be connected to an EPC. This is also most likely the process where the tag is attached.*
Storage data	*Unchanged, but may be automatically collected*

Table 70: Information changes in process 4 Gilde – Refinement/Production

Information	Data elements and description
Storage info	Unchanged. Storage data from process 3
Raw material data	*Unchanged, but some products may be tagged with RFID*
Weight data	Unchanged, calculated by the business application
Updated raw material data	Unchanged
Production data	Unchanged
Packing data	*Same as before, but data about products transported in Gildekassen may be connected to an EPC. This is also most likely the process where the tag is attached.*
Product data	Unchanged
Storage data	*Unchanged, but data may be connected to box EPC and location may be updated automatically by readers*

Table 71: Information changes in process 5 Gilde - Sale

Information	Data elements and description
Customer data	Unchanged and not relevant, only registered once for each customer
Product requirements data and Product data	*Same as the earlier process Order data and Product data, but now a highly automated ordering process containing product needs collected by the RFID system. Reservations may be done directly by using EPC Processes more accurate and performed by the RFID system in collaboration with business application.*
Confirmation of order	Unchanged

Table 72: Information changes in process 6 Gilde - Deliver

Information	Data elements and description
Storage info	Unchanged. Storage data from process 4
Order data	*Unchanged, but highly automated*
Customer data	Unchanged and not relevant, only registered once for each customer
Product data	*Unchanged, but products may be connected to a box EPC instead of order number alone and gain higher granularity in product tracing*
Available products	Unchanged
Updated product data	*As with Product data this may be connected to box EPC and gain higher granularity in tracing*
Labeling data	*Unchanged, but visible tagging not necessary if RFID EPC has an information connection to relevant data. Automating possible*
Updated order data	*Unchanged, but highly automated*
Transport data	Unchanged

9.2.2 Changes in Management Processes

From SCOR Gilde has the following management processes:

1. S1.1, S2.1, S3.3 – Schedule Product Deliveries
2. D1.2, D2.2 – Receive, (Configure,) Enter and Validate Order
3. D1.3, D2.3 – Reserve Inventory & Determine Delivery Date

Management process 1 may be completely automated and the manual process of counting and/or checking the stock of boxes is removed. By reading the boxes several times during

circulation in its life circle the accuracy of boxes is believed to be more accurate. This is also believed to be the background of more automatically evaluation process where future box orders are planned.

Receiving and entering orders may be automated by customers monitoring their storages. Verifying may also be done based on directly reservation of products at each expedition, or expeditions may do this manually when products are not in storage. Probably will also determining delivery date be a part of a manual process if products are not available. When available this may automatically be verified and sent on nest available transport. Transports are regularly and bring the orders that are ready.

9.2.3 Changes in Physical Processes

Gilde has eight physical processes identified in SCOR:

1. S1.2, S2.2, S3.4 – Receive product
2. S1.3, S2.3, S3.5 – Verify product
3. S1.4, S2.4, S3.6 – Transfer product
4. D1.8, D2.8, D3.8 - Receive Product from Source or Make
5. D1.9, D2.9, D3.9 – Pick Product
6. D1.10, D2.10, D3.10 – Pack Product
7. D1.11, D2.11, D3.11 – Load Product and Generate Shipping Docs
8. D1.12, D2.12, D3.12 – Ship Products

Point 1 and 2 are similar to Norplasta and receiving products are a physical process without any changes. Registering products may be done automatically using RFID. By transporting goods, in this case Gildekassen, through a portal of readers the boxes EPC are registered. Verifying amounts is done simultaneously as receiving and may be a completely automated process. Verifying other factors will still be manual.
Point 3 has a process that does not change in a physical manner, but data is now collected electronically and automatic by the RFID system. It is also possible to track and find one specific box, a task not possible with today's system. This data may be used to management decisions.

Receiving products from Source or Make have the same solutions as point 1 and 2. Products may be registered as they arrived and verified in amounts. In this process it is also possible to see the content of boxes, if it is registered during packing of products.

Boxes are tagged with EPC and if an order contains boxes filled with one product type it can reserve a certain EPC number. Otherwise operators must pick products from different boxes and collect them in one box meant for one order and customer. The picking process is not automated in any way, but operators may get information of which boxes or pallets to pick. The packing process does not change physically, but operators should register which and how many products are packed in a certain box by connecting it to the box EPC.

Similar to Norplasta loading and generating shipping documents may be partly automated. Generating shipping docs may be done automatically by registering boxes during loading. Readers collect EPCs when boxes are loaded, and by using the connection between EPC and content information shipping documents may be automatically generated. It can be printed on paper, sent to the customer electronically and/or downloaded to the transporters PDA.

Point 8 does not change with any of the described solutions.

9.2.4 Evaluation of Described Solutions

Evaluation of solutions in process 1 – Wash and disinfect
Solutions described in this process deal with most of the challenges identified by Gilde. Keeping track of box accounting is automatically done by counting boxes arriving and leaving the washing area. This information combined with box accounting in other areas creates background for automatic order generation, and may even send orders to Norplasta. The last task is possibly not a realistic to automate today. Business managers want to get the last say in processes concerning money, and until it is proved that RFID systems are to be trusted this process probably remains manual. Order proposals may be generated, but verifying it and sending it are done manually, though electronically as it is today.

Sharing information in internal systems are one positive effect of the electronic data of box accounting. One common supervisor may use this data to distribute boxes from and to facilities to deal with variations in regions, and not leave this to local administrators. An impartial employer will easily distribute boxes without concerns of local wishes of hoarding. This causes less unnecessary orders of boxes, less empty time for each box, quicker box turnover and possibly emancipation of capital earmarked to box purchases. Box requirements from all facilities may be combined if wanted, but the project do not recognize this as either positive or negative, but it may possibly cause less administrative work at each facility.

Registering boxes as unfit for use in production may be a process hard to deal with. Removing boxes from its life cycle may happen at any point, and a routine for registering removed boxes should therefore also optimally be done at every point. This causes unnecessary costs and tasks, and a concrete routine for registering removed boxes should be made at one point in life cycle. Possibly the best point is washing as this is the main area of box accounting.

Evaluation of solutions in process 2, 3 and 4 – Slaughter, Cut down and Refinement/Production
Two main solutions are mentioned here, tracking boxes and content registering. Tracking is as described possible to install and readers only has to be adapted to wanted reading points. Content registering on the other hand is probably a combined manual and automatic process. Fully automated packing lines may also have a fully automated content registering. This should not be a problem to install as the packing line already register weight and products finished in the ERP system. One additional process in the computer system is to register this connected to the EPC. It probably should register parcels as well to complete the content data. In partly or completely manual packing lines this process may be reconstructed for operators. Operators already verify weight and product data for the ERP system, and the system may also here register content to EPCs after verifying it.

When using RFID the potential of sharing data is much higher. In processes where food products are transported and/or kept in Gildekassen food safety may be highly relevant. Boxes stored may be communicating with sensor systems or have an internal sensor in the tag, and collect environmental factors like temperature and humidity that's important to secure food quality. This is mostly relevant at places where the food products stay over a certain time, like storage areas with cooling or freezing.

Evaluation of solutions in process 5 - Sale
This process has no direct solutions, but the sale process may improve by customers using RFID systems. The time of order handling decrease and the quality of customer service increase. Answering questions about product inventory and food safety may be supported by concrete data and Gilde's trustworthiness is maintained.

Evaluation of solutions in process 6 - Deliver
When sending orders several solutions influence the process. Identifying pallets may be done using handheld readers, but pallets are probably also labeled to ease the work for operators without handheld readers. It is debatable if pallet tagging is necessary when Gildekassen is tagged and the pallets are labeled, and pallet tagging is probably superfluous.

When orders are sent they are registered and shipping docs printed or sent electronically to transport and/or customer. Orders to be sent may be verified against orders in the computer system, the information communication between Gilde and its customers speed up, customers become attentive to orders in its way, verification at customers may partly be done automatically comparing it to this electronic data and invoice may be done earlier. Time consumption decreases and several tasks are removed from manual work.

9.2.5 Summary
Gilde see the same challenge as Norplasta. In addition they need to know exactly how many boxes they possess and how many there are at customers. In time Gilde also needs to document box washing routines, an issue possible to solve with RFID. By counting

boxes at elected areas the accounting of boxes are solved. One of the areas might be the washing area, and this process will be documented each time a box is washed. If customers of Gilde, like NorgesGruppen, register boxes when arrived they will also account for external boxes. This would also increase the data flow between the businesses. Data may be collected electronically instead of in paper, data may be sent more often and data collecting is automated.

Gilde has many of the same management processes. Scheduling product deliveries may be automated by monitoring box accounts in the internal facility. Using this data in combination with other factors an order may be generated and sent to Norplasta, with or without manual verification. Receiving, entering and validating order has the same solution as described in Norplasta, and it is the same with reserving inventory. Determining delivery dates are easier with Gilde than with Norplasta. Gilde has regular transports and customers have fixed ordering times to reach each transport. If products are finished and stored at expeditions, then products may be reserved a delivery dated be calculated automatically using products location data and known transport routines.

Gilde has the similar solutions as Norplasta and the impact on physical processes is therefore similar. Receiving, verifying and transferring products are partly automated. Receive product from source and make is on process different from Norplasta, but also this process has the same solution as registering incoming products. Picking, packing, loading and generation of shipping docs are similar. Shipping products is not a part of the business case.

9.3 Evaluation of RFID in NorgesGruppen

9.3.1 Changes in Data and Information

As with data changes in the two previous the project mostly find automated processes and unchanged data elements. However, there are some changes relevant to mention. Corrected purchase proposal in process 1 is not necessary when doing readings regularly and are therefore possible to remove. Process 2's deliver list gets additional data from Gilde's deliver system, and consignment and packing note are done electronically and may be sent between two communicating business systems. Order data in process 4 becomes product requirements data when implementing RFID.

Table 73: Information changes in process 1 NorgesGruppen - Purchase

Information	Data elements and description
Order data	*Unchanged, but may be sent more often*
Prognoses	Unchanged
Storage data	*Unchanged, but gains more precise product inventory when readings are done more often*
Supplier data	Unchanged
Purchase data	*Unchanged but have same changes as Order data and Storage data*
Purchase proposal	*Unchanged, but may be created more often when using RFID. In some cases this process may be skipped and done automatically by the RFID and business system*

Corrected purchase proposal	*Parts using RFID may skip these processes. When readings are done more often it is more certain that these data are correct.*
Purchase order	*Unchanged, but may be done automatically*
Confirmation of Purchase order	Unchanged

Table 74: Information changes in process 2 NorgesGruppen - Receive

Information	Data elements and description
Deliver list	*Data from Gilde may be implemented in addition to the original data*
Deliver data	*Unchanged data elements, but automatically done by using RFID*
Consignment note	*Automated and done electronic*
Packing note	*Not necessary when using RFID, but may be disadvantageous to remove completely. In case it is kept data is unchanged*
Updated deliver data	*Unchanged, but parts of process is highly automated*
Received order	*Unchanged, but highly automated*
Invoice	*Unchanged, but parts may be highly automated*

Table 75: Information changes in process 3 NorgesGruppen – Place (Wholesale)

Information	Data elements and description
Order data	Unchanged
Location data	unchanged
Assignment data	Unchanged
Product data	*Same data as before, but collected in an automatic way. In addition data about the environment may be included here.*

Table 76: Information changes in process 4 NorgesGruppen – Receive order (Wholesale)

Information	Data elements and description
Customer data	Unchanged and not relevant, only registered once for each customer
Product requirements data	*A highly automated ordering process containing product needs collected by the RFID systems, instead of Order data.*
Reservation data	*Same data, but box EPC in addition*
Confirmation of order	Unchanged

Table 77: Information changes in process 5 NorgesGruppen - Pack

Information	Data elements and description
Order data	*Unchanged, but box EPC come in addition*
Product number	*Unchanged, but also include box EPC*
Location data	Unchanged
Packed orders	*Unchanged, bur automatic registered during packing*

Table 78: Information changes in process 6 NorgesGruppen - Send

Information	Data elements and description
Packed orders	*Unchanged, but connected to EPC*
Product data	*Unchanged, but highly automated an connected to EPC*
Customer data	Unchanged
Invoice data	*Unchanged, but highly automated*
Invoice	Unchanged

Table 79: Information changes in process 7 NorgesGruppen – Order (Retail)

Information	Data elements and description
Shortage/sale	Unchanged
Product requirements data	*A highly automated ordering process containing product needs collected by the RFID systems, instead of Customer order.*
Confirmation	Unchanged

Table 80: Information changes in process 8 and 9 NorgesGruppen – receive and Place (Retail)

Information	Data elements and description
Deliver data	*Unchanged, but highly automated*
Invoice	*Unchanged, but automated authorization and product verification*
Product data	*Unchanged, but automatic registered*
Updated product data	*Unchanged, but parts are automated. Not check of transport and packing*

Table 81: Information changes in process 10 NorgesGruppen - Transfer

Information	Data elements and description
Updated product data	*Unchanged, but parts are automated. Not check of transport and packing (From process 8 and 9)*
Sold products	Unchanged and not relevant for pallet and case

9.3.2 Changes in Management Processes

The project identifies six management processes from SCOR:

1. S1.1, S2.1, S3.3 – Schedule Product Deliveries
2. S1.5, S2.5, S3.7 – Authorize Supplier payment
3. D1.2, D2.2 – Receive, (Configure,) Enter and Validate Order
4. D1.3, D2.3 – Reserve Inventory & Determine Delivery Date
5. D1.15, D2.15, D3.15 – Invoice
6. D4.1 – Generate Stocking Schedule

In point 1 a business system connected to a RFID system can monitor the in and out registering of products in the resource storage. By monitoring Gildekassen directly the system are able to calculate orders. If the system has some manually set factors like variations and seasons and uses customer order data from the system, this process is mostly automated. The order may be sent directly or manually verified before sending it.

If authorization of supplier payment is only based on amount it may be completely automated. Other factors like packaging or transport have to be done manually and

registered manually if included in the authorization. This may be done by e.g. using a touch screen in the arrival dock or by using PDAs.

As described in point 1 receiving and entering orders may also be automated by retailers monitoring their storages, and use the same automated ordering technique. Verifying may also be done based on directly reservation of box EPC. Determining delivery date will also be a part of this manual process if products are not available. When available it may automatically be verified as to be sent on nest available transport. Notification of reserved space on a transport may be sent to the system, and used in the manual transport planning.

As mentioned in the solution summary NorgesGruppen is the only business mentioning invoice generation. They send an invoice together with orders when transport to their retailers, an invoice possible to generate automatically by reading products as they are loaded onto trucks. The manual registering with handheld barcode readers are unnecessary. The invoice may not even be in paper format bun only sent directly the receiving retailer. The process is shortened and less manual tasks are required.

Point 6 is similar to pint 1 and is also described in point 3. When ordering products retailers use a handheld barcode scanner, manually registering every product to be ordered. Notice that a process like this may be extremely time consuming at large retailers and a RFID solution will provide huge efficiency improvements to the ordering process.

9.3.3 Changes in Physical Processes

Physical processes from SCOR found in NorgesGruppen is:

1. S1.2, S2.2, S3.4 – Receive product
2. S1.3, S2.3, S3.5 – Verify product
3. S1.4, S2.4, S3.6 – Transfer product
4. D1.9, D2.9, D3.9 – Pick Product
5. D1.10, D2.10, D3.10 – Pack Product
6. D1.11, D2.11, D3.11 – Load Product and Generate Shipping Docs
7. D1.12, D2.12, D3.12 – Ship Products
8. D4.2 – Receive Product at the Store
9. D4.3 – Pick Product from Back Room

NorgesGruppen register pallets at arrival by using handheld barcode readers. Registering receiving boxes can be done automatically using RFID, but the receiving itself will still be a completely physical process without any changes. At arrival products are transported close to RFID readers registering box EPC in the system. Verifying amounts is done simultaneously as unloading products and may be a completely automated process, but verifying other factors will still be manual.

Gildekassen may be registered in different areas by bringing them through RFID portals and gets a more accurate location then if workers should remember these themselves.

Picking products are a procedural routine at NorgesGruppen, but business systems at both wholesale and retail may give information of which boxes to pick to complete a certain order or to refill a certain shelve. The picking process itself will still be physical but workers get more information when performing the process. The packing process may become automated and both packing and tagging of pallets can be done here if wanted. The automated packing may also be a good place to read and register an order and its products to be ready for transport.

Loading and generating shipping documents may be partly automated. NorgesGruppen only uses invoices between wholesale and retailers. The loading process is physical and does not change, but generating invoice may be done automatically when loading products. Readers are collecting product data when products are loaded and using the connection between EPC and content information to automatically generate the information in these documents. In addition the EPC also needs to be connected to an order and customer number. Now this may be printed on paper, sent to the customer electronically and/or downloaded to the transporters PDA.

Shipping products do not change

Point 8 have the same solutions as described in point 1 and changes may be found here.

In point 9 the picking process do not change, but a box may be registers as removed from the back room by using RFID readers in the door. This may update the inventory list used by the ordering system.

9.3.4 Evaluation of Described Solutions

Evaluation of solutions in process 1 – Purchase
The purchase process may be partly automated by using storage monitoring as tool to generate orders. Orders may be sent to supplier based on factors set by humans, like seasons etc. To implement this as a completely automated process may be difficult. The technology is new in Norwegian businesses and its reliability has not been proven in Norwegian conditions. Managers would rather not loose the control of issues influencing business economics.

Using this solution orders may be sent to suppliers more often because real time inventory is collected regularly. If retail orders are automated with RFID the process will speed up even more. NorgesGruppen uses ASN and it is debatable that RFID actually will improve the process further since NorgesGruppen's already deal with several issues RFID are believed to improve. One argument of using RFID here is that tags may be read several times during the stay at wholesales storage, and not only during arrival. Environmental conditions may be supervised and orders generated.

Evaluation of solutions in process 2 – Receive (Wholesale)
With RFID registering and verifying may be automated and operators may not be necessary. Payments may also be automatic based on this information, though possibly not wanted by the business.

Information of delivers from suppliers is not in real time, but longtime forecasts of deliver dates are not necessary when planning the receiving process based on RFID information. Information become more accurate in time when registered during loading on truck and NorgesGruppen receives a notification when products leave Gilde.

A label on Gildekassen is not necessary when using RFID tagging, but it is possible that removing it will make the grouping process more time consuming because workers need to see the information when performing the task. Handheld tag readers will possibly increase the amount of time used on each pallet or box.

Evaluation of solutions in process 3 – Place (Wholesale)
When using the described solution no manual assignment verification is necessary. The system will always know where each unit are, when they where moved and by who by updating the information as workers drive through RFID portals. Automatic updating gives the worker more time for placing instead of information updating. The company may also use this information to make the placing process more efficient in the planning level.

Evaluation of solutions in process 4 – Receive order (Wholesale)
Here only one solution is described; uniform ordering from retailers based on RFID monitored storages. NorgesGruppen would only have to handle on kind of order data, it may be automated in reservation and even further orderings from NorgesGruppen's suppliers. This causes for less complex order handling, it is possible to create completely automated process, time consumption decrease and customer service may increase.

Evaluation of solutions in process 5 - Pack
It is not found any striking arguments for RFID to improve NorgesGruppen's pick and pack process. They already have pick lists with product locations, but packing is manual. This can be done by a packing machine, which also would be a perfect place for tag readings and information registration. It is also possible to tag pallets during packing, but Gildekassen already have tagging. It in not necessary to tag them further, but it may be advantageous to connect boxes to the rest of the order by using the EPC and order number. Visible labeling is not necessary using RFID in this process.

Evaluation of solutions in process 6 - Send
This is one of the processes where most process changes are found. Electronic invoices may replace today's manual paper system. The system register products loaded, verify them against the order from one specific retailer. This information may also be sent it to transport PDA or retailer, who receives it several hours before products arrive. By electronic registering and verifying of received products at the retailer the payment may be authorized and performed automatically, if wanted by the retailer. All this contributes

to removing several time consuming manual processes and collects data automatically without human interaction. Electronic data is quicker than paper system and automatic performance of tasks removed human delays and errors. If management will keep some control of the process all data and tasks may be generated and verified by administrative personnel.

Evaluation of solutions in process 7 – Order (Retail)
This evaluation is a combination of process 1 and 4, an equal when it comes to both wholesale and retail. Unnecessary orders may be avoided and an accurate inventory list is available. Time used for finding products to order is eliminated and workers may spend more time in customer service than planning deliveries.

Evaluation of solutions in process 8 and 9 – Receive and Place (Retail)
As described process 8 and 9 have similar solutions as process 2 and 3, Receive and Place in Wholesale. Inventory lists may be updated automatic when products arrive, and it is not possible for workers to "miss" any products in the storage room. If the inventory list says it is there they can be sure to find it there. Automatic authorization of supplier payment may be implemented if wanted, and may also remove one task not necessary to handle manually.

Evaluation of solutions in process 10 - Transfer
Also here the solution has been described before, and so has the changes. This is a part of a transferring process, moving products from the back room to the shop floor. When doing this the inventory list is updated and maintain data used when generating orders. Tracking of products is possible up to this point.

9.3.5 Summary

NorgesGruppen could not see any information lack in their warehouse routines, but they did mention inconsistent order formats from retailers as something to improve. This is also possible with RFID, though comprehensive. Orders may be automatically collected at both wholesale storages and at retail storages.

All management processes found in NorgesGruppen's warehouse management has been described above. Schedule product deliveries, authorizing supplier payment, receive, enter and validate orders and reserving inventory and determine delivery dates. As most solutions are similar also the impact of management processes are similar. They may be partly or completely automated, and information may be shared between business partners electronically. Management processes distinct for NorgesGruppen's retail are invoice and generating stock schedule. The latter has the same solution as scheduling product delivers. Invoicing is done when loading product on transport and is generated from loaded products, a process than may be complete automated if using RFID.

NorgesGruppen also has similar processes as both Norplasta and Gilde. Receiving, verifying, transferring, picking, packing, loading, generating shipping documents and shipping all have the same impact on physical processes. Two processes not discussed

earlier are receiving product at the store and picking products from the back room. The former has the same solution and impacts as the regular receiving process and products are automatically registered when unloaded. Pick product from the back room improved by electronically available stock lists used to find if there is any products left in the back room. This saves time because workers do not have to look for products since the list are updated when products arrive or leave the back room. The product is registered when it is taken out to the shop floor.

9.4 General evaluation

All warehouse management processes found in all three business cases are impacted by implementing RFID. There are some data elements changed, like order data changed into box or product requirements or new data elements as location. Mostly the processes are impacted by automation of management processes.

Summarized from all three businesses the process changes are:

- Automatic updating inventory lists
    - Registering in and out going products
    - Verifying products
    - Counting products/boxes in facilities
- Automatic authorization of supplier payment
- Automatic generation of invoice, consignment note or packing note
- Generating orders
- Automatic updating production plans based on automatic order data
- Unified orders from multiple customers
- Reservation of orders based on EPC
- Pick lists based on EPC
- Tagging pallets during packing
- Automatic transport orders/planning based on automatic order data, registered finished products and automatic reservations

Possibilities and challenges with the changes are presented and evaluated in this section and it is found that there are many possibilities but also obstacles to face before the solutions may be realized.

9.4.1 Possibilities

During the evaluation many possibilities has appeared, and this section is not going to repeat them all. Instead it gives an overview of aspects relevant to management and logistics found during the evaluation.

Improved planning processes

The least recognized process changes are those formed in enabling processes. When using the list of changes above and the list of management processes in chapter 7, the following enabling processes are impacted:

- ES3 – Maintain Sourcing Data

- ES4 – Manage Product Inventory
- ES6 – Managing Incoming product
- ED3 – Manage Deliver Information
- ED4 – Manage Finished Product inventories
- ED6 – Manage Transportation
- ED7 – Manage Product Life Cycle

In addition to these processes not mentioned in the individual evaluations also planning is an important part of warehouse management and logistic. Many planning processes are found to be partly automated. The transportation planning may be updated by using concrete order data like products shape and size, product amounts, estimated deliver dates and so on. Storage planning may be done using the same data as transport planning, maybe in combination with production planning or inventory planning. When looking at SCOR's planning process the described solutions are found to give improvements in sourcing planning, production planning and deliver planning. Three processes from each of these areas are impacted:

- P2.1 – Identify Prioritize, & Aggregate Requirements
- P2.2 – Identify, Assess, & Aggregate Resources
- P2.3 – Balance Resources with Requirements

The solutions and changes are already described several times and not repeated here.

Communication and data sharing

Communication information between business partners may be an issue and requires strong relations between the collaborating partners. EPCglobal Architectural Framework provides well tested communication solutions and is in many cases a self-evident choice of communication standards. By using this framework information may flow safe and easily between not only partners in the described, but all businesses subscribed to this solution. There is no need for direct communication between businesses systems, which heighten information safety, and no internal research is necessary

Automation

There are found huge possibilities in automated data collection and information flow in this project. Data collection is automated by using tags and readers sending data to a business application sorting and analyzing data of value and discarding unimportant data. Data may automatically be shared in the framework from EPCglobal and systems may collect data needed in their internal systems. Both automated collection and sharing saves businesses from several manual tasks and executes them with less time consumption.

Flexibility

Product data is attended to by the tags and is easily accessible at any point in chain. This leads to information that may give severe decision support in marked strategic choices for each product. A business can do decisions quicker based on better grounds, and appear more dynamic and flexible. The collected information also give competitive advantages in logistics and service. Products may be monitored through the entire supply chain and product quality secured.

9.4.2 Challenges

Many challenges have been presented earlier in the description of RFID in chapter 3. This section revises issues most important to management and logistics.

Undeveloped business applications

Many changes and related solutions require business applications able to handle RFID data. Data needs to be collected, analyzed and made available for businesses. More and more suppliers of enterprise solutions are implementing RFID support in their systems, but this is not a common part of Norwegian business systems. There is a lot of research and testing to do before RFID becomes an integrated part of Norwegian businesses' information technology.

Acceptance

Making managers to not get directly involved in the processes and only see the results over time may be a hard convincing process. People may feel they loose control, but this is a usual problem in most system implementations. By using known techniques for process changes and employee training this is a challenge easy to possible to deal with. A part of employees acceptance phase is converting them to a complete paperless information system. This may be hard for people who are used to work whit physical artifacts transferred by hand.

Technical

RFID solutions are not optimally tested and may still give data errors. Implementing a solution requires thoroughly testing of tags, readers, middleware and business system in a real implementation environment. Businesses must be prepared to use time and resources because this is the only way of getting a completely well-stated choice of implementation.

Security

Information sharing implies higher security than with purely internal data. Data traveling over large distances has higher probability of being catched by unauthorized persons. Solutions with EPCglobal's framework have in-built solutions, but solution with communicating ERP systems or single tag reading requires much research on information transfer security. Businesses must pay attention to this subject when choosing implementation method.

10 Conclusion

This report has been investigating and trying to find answers to three research questions established from the project goal and theory and terminology. Investigation included project scope narrowing, business analysis, solutions description and evaluation of three Norwegian businesses; Norplasta, Gilde and NorgesGruppen. The project scope chosen was warehouse management, restricted by Gildekassen as product to follow through the business case. Summarized the research questions are:

1. How will RFID increase the information flow in business processes?
2. How will management processes be impacted by implementing RFID?
3. How will RFID simplify warehouse logistics?

All processes are mapped to the process reference model SCOR to distinguish between management and physical processes. Question one has been answered by detailed process analysis and data extraction by using the modeling techniques Activity diagram, DFD and ER model. Information and data elements are presented in tables through the business analyses, and further evaluated when business specific solutions where described. Question two and three are answered by doing a thorough evaluation of how described solutions impact management and physical processes. The complete evaluation may be found in chapter ten.

Question 1
When looking at challenges mentioned by the businesses it is clearly that order and registering procedures are a common area where improvements are wanted. Registering orders and arrived/sent products automatically are therefore common solutions. All described solutions create changes in both data elements and data collection. Summarized the data extensions are: exact product accountings (box amounts), product location data, direct reservation data, order - product connections and environmental data. Automatic collection of electronic data may be done during loading and unloading products (consignment note, packing note and invoice), transferring through different areas and in storage areas.

From this data it is possible to deduce other information. This may be e.g. boxes flow area, flow time and environmental conditions. The utilization of sensor information is not high. The research on RFID and sensors in Norway has not come far, and it is possible that this is an area not yet reach in the development process. The focus on Gildekassen and tagging in pallet/case level made it irrelevant to include more sensor data in the solutions and evaluation.

Question 2
Here it is found that every management process may be automated in some degree. Most of the data in the processes may be collected and transferred electronically internal and between business partners. Every solution is seen as a process improvement as it consequently requires less manual tasks and human data collection. This leads to fewer

errors and more frequent data collections within the same time and cost limit. The conclusion does not discuss the practical implementation issues, but in some cases this is a relevant challenge. E.g. the number of retailers at NorgesGruppen is severe and the optimal improvement may not be reached until all retailers implement RFID in their storages. The general conclusion is that management processes are highly automated and efficiency increased.

Question 3
Logistics include all processes evaluated in this report. Processes relevant to logistics have been found using the chosen definition of logistics and the evaluation of how this is pursuant to SCOR, see appendix D. It is already found that all management processes is impacted by RFID and improvements are possible by automating electronic data collection and transfer. The remaining processes are physical processes where material products are transferred and stored

As seen in chapter ten also most physical processes are changed. Shipping products have not been evaluated as it has no solutions in any of the internal supply chains, but it is possible to monitor this process by instilling readers in every transport. Further it is seen that the rest of the processes are improved by automatic registering of products; where they are, where they are going and how different boxes connects to each other. Several manual registering processes may consequently be removed. The paper based consignment and packing note (and invoice at NorgesGruppen) may be eliminated as data may be transferred electronically to both driver and customer. Based on this and earlier conclusions it is possible to say that RFID do simplify logistics.

Goal achievement
The project has answered the research questions, and the goal is achieved.
Supportive goal one, “Present how RFID technology may increase the amount of electronic data”, has been achieved through chapter three and answering research question one. Supportive goal two, “Find management processes where automating are realistic and advantageous”, has been found by answering research question two. Supportive goal three and four, “Find information advantageous to share between business partners” and “Find strategic areas in chain to implement surveillance/track and trace”, has been done by investigating solutions in the logistics area warehouse management and partly by answering research question one. By this the main goal, *Investigate how RFID contributes to improve management and supply chain*, has been reached.

10.1 Project problems

SCOR inadequate
During the analyses the project discovered that SCOR is inadequate for some of the business processes found. This emerged during the description of Norplasta and probably results in missing information in the evaluation. The project has tried to find processes covering the information hole, but parts of the evaluation are probably insufficient.

Confidentiality
During the information extraction from businesses the issue of confidentiality came up. Some businesses have information not reachable for this project and value chain descriptions may be deficient. On the other hand businesses approved the case description to be as correct as possible without the confidential information and the project must presume the information to be correct.

Method criticism
Business analyses must consider human errors in both data collection and data modeling. Data collection is done by interviews, observations and document revisions. The two former methods include many human factors and no absolute knowledge. The project tries to reduce this source of error by combining them with document revisions which introduce more concrete information and knowledge in each business. Solutions are based on business cases found in magazines known in the area of RFID, but some of the cases are written for commercial purposes. This often results in exaggerated results and possibilities without stating the real challenges. The cases are also from RFID leading countries and some solutions may turn out to be unrealistic in Norway.

10.2 Further work

The businesses need to state if the described solutions and advantages are something they want to implement in their business. They should do a thorough evaluation of described solutions and find those most likely to give most benefits and profit. Technological components must be chosen and tested thoroughly in a realistic environment. They need to establish business partners using RFID and create concrete communication channels and agree on data and information sharing.

This report shows that the area needs comprehensive research to be fully understood. A natural extension of this master thesis is to perform a similar study on several supply chains and state proposals of best-practice implementations areas. Other projects should implement the technology in a real test environment and seek to confirm or invalidate the assertions given in this report. Questions to be answered in later projects may be:

- Which data is necessary to share to gain a competitive and efficient supply chain?
- What changes do RFID create in the business partner communication?
- What exact process changes arises when implementing RFID?
- Do RFID implementations result in less employee needs?
- How is logistics factors influenced by RFID (Lead time etc)?
- How do business systems (ERP etc) support RFID and is it compliant with Norwegian needs?

11 References

[AMBLER] Scott W. Ambler, *A UML Profile for Data Modeling*, Agile Data, http://www.agiledata.org/essays/umlDataModelingProfile.html, 13.06.2007

[ANGELES] Rebecca Angeles, *RFDI Technologies: Supply-Chain Applications and Implementation issues*, Information System Management, Winter 2005

[BACHELDOR] Beth Bacheldor, *Oil Refineries to Test Sensor Tags*, RFID Journal, January 2007

[BANKEN_AARLAND2003] Kjell Banken og Rolf Aarland, *Logistikk, ledelse og marked*, 2003, 2. utgave, Fagbokforlaget Vigmostad & Bjørke AS

[BITKOM] BITKOM RFID Project Group, *RFID White Paper – Technology, Systems, and Applications*, December 2005, BITKOM German Association for Information Technology, Telecommunications and New Media, RFID journal, November 2006

[CHEN] Peter Pin-Shan Chen, The Entity-Relationship Model-Toward a Unified View of Data, ACM Transactions on Database Systems, Volume 1 , Issue 1, Page 9 – 36, 1976

[CHOPRA_MEINDL2007] Sunil Chopra and Peter Meindl, *Supply Chain Management, Strategy, Planning, & Operation*, Third Edition, 2007, Pearson Prentice Hall

[COLLINS1] Jonathan Collins, *University Takes a Fresh Approach to RFID*, RFID Journal, August 2005

[COLLINS2] Jonathan Collins, *METRO is Back on Track*, RFID Journal, 2006, http://www.rfidjournal.com/magazine/article/2762, 21.03.2007

[COLLINS3] Jonathan Collins, *RFID's Impact at Wal-Mart Greater Than Expected*, RFID Journal, May 2006

[COLLINS4] Jonathan Collins, *Hampton Unlocks ROI from RFID*, RFID Journal, April 2005

[CSCMP] Council of Supply Chain Management Professionals (CSCMP), *Supply Chain Management/Logistics Management Definitions*, 2007, http://www.cscmp.org/Website/AboutCSCMP/Definitions/Definitions.asp, 14.02.2007

[DEMARCO] Tom DeMarco, *Structured Analysis and System Specification*, 1979, Prentice Hall

[EPCGLOBAL] 10 authors from different related organizations, *The EPCglobal Architecture Framework, EPCglobal Final Version of 1 July 2005*, EPCglobal,

01.07.2005, http://www.epcglobalinc.org/standards/Final-epcglobal-arch-20050701.pdf, 23.04.2007

[FORCINIO] Hallie Forcinio, *The business Value of RFID*, Microsoft, January 2006, http://download.microsoft.com/download/e/2/b/e2b4227d-54a9-4c09-82b8-892f98d73b51/BusinessValueBizTalkRFID.doc, 18.06.2007

[FOWLER2005] Martin Fowler, *UML Distilled, Third Edition, A Brief Guide to the Standard Object Modeling Language*, 2005, Pearson Education Inc.

[GAMBON] Jill Gambon, RFID *Contains Solution to Chinese Shipping Problems*, RFID journal, November 2006

[GJØNNES] Knut Gjønnes, Project engineer, meeting at Gjønnes' office at Gilde's production site in Trondheim Mai 22, 2007 and 5. June 6, 2007.

[GULLA] Jon Atle Gulla, *Introduction to Enterprise Systems*, Version 1.0, 14.04.2004, Department of Computer and Information Science(IDI), Norwegian University of Science and Technology (NTNU)

[HAWRYSZKIEWYCZ] Igor Hawryszkiewycz, *Introduction to Systems Analysis & Design*, 5th edition, 2001, Pearson Education Australia, Prentice hall

[HEINRICH2005] Claus Heinrich, *RFID and Beyond, Growing your business Through Real World Awareness*, 2005, Wiley Publishing. Inc.

[INTERMEC] Intermec Technologies Corporation, *Example of tag and reader shapes*, http://www.intermec.com/products/rfid/index.aspx, 18.06.2007

[KOTLER2003] Philip Kotler, *Markedsføringsledelse*, 2004, Gyldendal Norsk Forlag AS, 2nd edition. Original title: Marketing management, Pearson Education, Inc, 2003, Prentice Hall

[LAHIRI2006] Sandip Lahiri, *RFID Sourcebook*, 2006, Pearson plc, IBM Press

[LANDT] Jeremy Landt, *The history of RFID*, Potentials, IEEE, Volume: 24, Issue: 4, 2005

[LEWIS] Steve Lewis, *A basic introduction to RFID technology and its use in the supply chain*, Laran RFID, April 2005, RFID journal, August 2006

[NORGESGRUPPEN1] NorgesGruppen, *Årsrapport 2006, NorgesGruppen*, http://www.norgesgruppen.no/norgesgruppen/multimedia/archive/00004/_rsrapport_NorgesGrup_4615a.pdf, 18.06.2007

[NORGESGRUPPEN2] NorgesGruppen, *NORGESGRUPPEN – Norway's largest food retailer*, An English information brochure, http://www.norgesgruppen.no/norgesgruppen/multimedia/archive/00002/NG__english_brochure_2706a.pdf, 18.06.2007
[NORPLASTA] Rolf Solberg, *Kvalitets og Miljøhåndbok- Systemdel, Dok.nr.: 00.001*, 06.01.2006

[NORTURA1] Nortura, *Årsmelding 2006*, http://www.nortura.no/getfile.php/Gilde.no/Bildearkiv/%20Om%20oss%20-%20nye/Filer/Nortura_Arsmelding_2006_hele.pdf, 11.05.2007

[NORTURA2] Nortura, *"Going for Nortura"*, 04.06.2007, internal English PowerPoint presentation of the company

[ROBERTI] Mark Roberti, *Case Study: Wal-Mart's Race for RFID*, eWEEK, September 2005

[ROBERTI2] Mark Roberti, *Wal-Mart Tackles Out-of-Stocks*, RFID Journal, March/April 2005

[ROBERTI3] Mark Roberti, *EPC Reduces Out-Of-Stock at Wal-Mart*, RFID Journal, October 2005

[SCC] Supply-Chain Council, http://www.supply-chain.org, 24.10.06

[SCOR1] Supply-chain council (SCC), *SCOR Quick Reference, Supply-chain Reference-model*, Version 8.0, http://www.supply-chain.org/galleries/default-file/SCOR%208%200%20Reference%20Guide.pdf, 18.06.2007

[SCOR2] Supply-chain council (SCC), *Supply-Chain Operations Reference-model, SCOR Overview*, Version 8.0, http://www.supply-chain.org/galleries/default-file/SCOR%2080%20Overview%20Booklet2.pdf , 18.06.2007

[SHEPARD2005] Steven Shepard, *RFID, Radio Frequency Identification*, 2005, The McGraw-Hill Companies, Inc.

[SIMCHI-LEVI] David Simchi-Levi, *The impact of RFID in Supply Chain Efficiency*, published in [HEINRICH2005], pp. 209 – 220,

[SIMCHI-LEVI_KAMINSKY2003] David Simchi-Levi and Philip Kaminsky, *Designing & Managing the Supply Chain, Concepts, strategies & case studies*, 2003, McGraw-Hill/Irvin

[SINTEF] Ukjent, *RFID og Sensorer*, SINTEF, 23. August 2006, http://www.sintef.no/content/page1____7947.aspx, 18.06.2007

[UTI] ITU, *The Internet of Things, ITU Internet Reports2005, Executive Summary*, International Telecommunication Union (ITU), Geneva, 2005, http://www.itu.int/osg/spu/publications/internetofthings/InternetofThings_summary.pdf, 15.06.2007
[WALMART] Unknown, http://walmartstores.com and http://www.walmart.com/, 18.06.2007

[WESSEL] Rhea Wessel, *Nordic Researchers Aim for Multiprotocol Multisensor RFID Tag*, RFID journal, January 2007

[WOLFRAM] Dr. Gerd Wolfram, *Supply Chain Success: The METRO Story*, MGI METRO Group, Presentation at RFID Journal Live Europe, October 2005, http://www.rfidjournallive.com/files/main/Tues_0845_Wolfram.pdf, 18.06.2007

[YIN2003] Robert K. Yin, *Case Study, Research, Design and Methods*, 3rd edition, 2003, Sage Publications, Inc.

A List of Figures

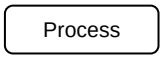
B List of Tables

C Symbol descriptions

Activity diagram

An activity diagram shows the different processes in a certain task, and how these are performed according to each other. Martin Fowler states in his book [FOWLER2005] that "Activity diagrams are a technique to describe procedural logic, business process, and work flow". The technique is widely known in computer engineering and a part of the Unified Modeling Language (UML). UML is a family of graphical notations used when describing and designing software systems. The project uses this modeling technique, among others described later, to decompose and analyze Supply chain processes described by the business cases.


Start of activity flow

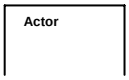


Activity


Activity flow


Choice/select

[Text] Flow description (usually used at choice)



Swimlane, to distinguish between different actors of activities

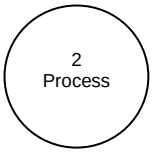
Fork/join, activities that must be synchronized before performing next activity after join


End of activity flow

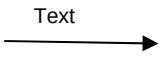
Data flow diagram

A dataflow diagram (DFD) is a graphical representation of the data flow through an information system. [DEMARCO] This is done to analyze and visualize what data flows where, and which external entities are included in the system. As this may be a complex and difficult process the data flow is modeled in different levels. The first model created is usually a context diagram. This only show external entities and data flow, together with the information system as one process. The first model showing more constructive information is a DFD level 0 diagram. This model show the top level processes, together with its relevant external entities and data stores. The next level, DFD level 1, decomposes each and every process from the level 0 diagram. The processes may be decomposed to DFD level 2 or further, depending on the necessity to look at them more closely. A DFD may be done in a logical view or a physical view. Logical the DFD show how the business operates and the activities included in operation. It does not distinguish between manual or digital storage of data. A physical DFD show how the computer information system is. It shows applications and procedures, distinguishes between files, databases and manual storing systems and temporary storage in computer systems. A symbol description is shown below.

This report uses logical DFD to describe the business cases operation.



Process *(Numbered to easier distinguish different processes. Lower level processes get lower level numbers, e.g. 2.1 and 2.2)*



Data flow with data description *(Directional)*

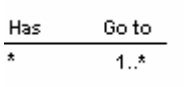
Data register

External entity

ER diagram

An ER diagram describes Entities and Relations between them [CHEN]. Each entity has data relevant to it and communicates this to other entities. This is commonly used in database design and easily translated to relation databases. The model symbols used in the report is a version of UML class diagram without methods and relation connections with multiplicity. It is similar to Scott Amblers logical data model in his UML profile for data modeling [AMBLER], but is also partly found in Martin Fowlers domain diagram in UML Distilled [FOWLER]. The model is used in this project to easily show single date elements, what entity they belong to and where it may be communicated.

Entity with name and data



Relation with description and multiplicity

D Logistics and RFID in SCOR

As described in the report the main goal is to investigate how RFID contributes to improve management and supply chain. This document summarizes which parts of SCOR are relevant to the chosen definition and finds RFID solutions that may contribute to reach the project goal.

Logistics in SCOR

SCOR is a tool for supply chain management and include logistics in its processes, but as seen in the chosen definition logistics is only a part of supply chain management. SCOR seem to be highly based on logistics and contain several aspects of the area. It is therefore necessary to find what parts of SCOR are relevant to the chosen definition of logistics. When evaluating the description of SCOR it is found that all five main processes are more or less involved in logistics. Those parts not relevant mostly concern business rules, capital assets and regulatory requirements and compliance. The definition of logistics given earlier in the report guides the evaluation of which parts of SCOR is included in the project scope:

Logistics Management is the part of Supply Chain Management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet the customers requirements.

This part of the report will further compare the description of every top and second level processes to this definition and describe which parts of SCOR is relevant for the project.

Plan

Plan is described to:

1. Balance resources with requirements and establish/communicate plans for the whole supply chain, including Return, and the execution processes of Source, Make, and Deliver.
2. Management of business rules, supply chain performance, data collection, inventory, capital assets, transportation, planning configuration, and regulatory requirements and compliance.
3. Align the supply chain unit plan with the financial plan.

Point one and two of this process description is clearly in the project scope. Here the entire supply chain is planned before execution and logistics is a big part of these plans. In point one logistics is involved in transportation of the physical resources and is therefore a factor in balancing them with the requirements.

In point two logistics is not part of management of business rules and capital assets, even though it is important in logistics. Regulatory requirements and compliance is important in those parts impacting logistics, but mostly not relevant. The rest of point two is logistics relevant.

Point three is not a part of logistics, but logistics must be performed in the most efficient and effective way possible, and therefore may impact the financial plan.

Source

> Source is described to:
>
> 1. Schedule deliveries; receive, verify, and transfer product; and authorize supplier payments.
> 2. Identify and select supply sources when not predetermined, as for engineer-to-order product.
> 3. Manage business rules, assess supplier performance, and maintain data.
> 4. Manage inventory, capital assets, incoming product, supplier network, import/export requirements, and supplier agreements.

Point one is clearly included in logistics, even though authorization is not implicitly a part of the definition. Receiving goods is relevant to logistics and this must be performed to authorize payment.

Identifying and selecting supply sources is not directly a part of logistics, but knowing where the products are at any time is one of the main tasks of a logistics system.

In point three assessing supplier performance is important in making efficient and effective flow of goods, and is therefore part of logistics. Maintaining data is relevant to logistics in cases where data and information is relevant to logistics processes.

Point four is relevant to logistics, but capital assets are not directly relevant except where optimizing logistics processes impact the task.

Make

Make is described to:

- Schedule production activities, issue product, produce and test, package, stage product, and release product to deliver.
- Finalize engineering for engineer-to-order product.
- Manage rules, performance, data, in-process products (WIP), equipment and facilities, transportation, production network, and regulatory compliance for production.

Schedule production activities is part of the logistics when it comes to making resources available, and the same is for produce and test. In addition, tracking items is a logistics task important here. Package, stage product and release product to deliver are all logistics processes. Issue product[17] on the other hand is not found to be of much relevance since there is no physical logistics necessary, although this information also needs transferring to the right part of the value chain.

The second point is not part of any logistics process, but like in the first point making resources available is an important logistic task.

In the last point most tasks are included in logistics, but managing rules, data and regulatory compliance will also contain parts not relevant for logistics.

Deliver

Deliver is described to:

- All order management steps from processing customer inquiries and quotes to routing shipments and selecting carriers.
- Warehouse management from receiving and picking product to load and ship product.
- Receive and verify product at customer site and install, if necessary.
- Invoicing customer.
- Manage Deliver business rules, performance, information, finished product inventories, capital assets, transportation, product life cycle, and import/export requirements.

Deliver has five points. The first point is clearly part of logistics, even though some parts are administrative processes not directly included in the definition.

[17] Releasing product specifications to production

The second point, warehouse management, is definitely a part of logistics since controlling this is the core task in many logistics systems.

All tasks in point three are included in logistics, but installation of products is discussed to be an internal process not affected by the definition. Still, it can provide important information of products to other parts of the supply chain and therefore be relevant for logistics in these parts.

Invoicing customers is not a logistics process, but information from the logistics system is used in the process. Managing rules will also contain parts not relevant for logistics.

In the last point managing capital assets is not a part of the definition of logistics, but as mentioned earlier, optimizing logistics processes may impact the task.

Return

Return is described to:

- All Return Defective Product steps from source – identify product condition, disposition product, request product return authorization, schedule product shipment, and return defective product – and deliver – authorized product return, schedule return receipt, receive product, and transfer defective product.
- All Return Maintenance, Repair, and Overhaul product steps from source – identify product condition, disposition product, request product return authorization, schedule product shipment, and return MRO product – and deliver – authorize product return, schedule return receipt, receive product, and transfer MRO product.
- All Return Excess Product steps from source – identify product condition, disposition product, request product return authorization, schedule product shipment, and return excess product – and deliver – authorize product return, schedule return receipt, receive product, and transfer excess product.
- Manage Return business rules, performance, data collection, return inventory, capital assets, transportation, network configuration, and regulatory requirements and compliance.

Return has four points, but the three first is similar and are evaluated together. Identify product condition, disposition product and request product return authorization are not part of the logistics definition, but information from these processes is important to initiate the logistics relevant processes. Schedule product shipment, and return product – and deliver. This is processes relevant to Source return. Authorizing return of products in Deliver return is not relevant to the logistics definition. Schedule return receipt, receive product and transfer defective product are logistics processes.

The last point is similar to points evaluated earlier. Capital assets are not directly a part of the definition of logistics, but the rest of the tasks are relevant for logistics.

Goal Accomplishment with RFID in SCOR

The basis for this evaluation is earlier described characteristics of RFID and many different business cases, the most essential presented earlier in the report [BACHELDOR, COLLINS1, COLLINS2, COLLINS3, COLLENS4, GAMBON, ROBERTI1, ROBERTI2, ROBERTI3, WOLFRAM]. The evaluations do not differ between passive and active tags, or any other technical or economical constraints and solutions are in a general view. The representations through the document present each third level process in SCOR and RFID solutions that may contribute to accomplish; *Improved management* or *Track and Trace*. Data captured by the solutions are electronic and sent to a business system preparing the data for further use.

Processes not relevant to the project scope, or where no solutions are found, are marked white. When a process has a solution and is relevant to the project it is evaluated and marked gray. In the last section the results of the evaluation are summarized.

Plan

Plan is about planning the rest of the processes, and the value chain in its entirety. Plan is an indistinct term, but when using the definition of aggregate planning presented by Chopra and Meindl in [CHOPRA_MEINDL2007] the term gets more definite: “Aggregate planning is a process by which a company determines ideal levels of capacity, production, subcontracting, inventory, stock outs, and even pricing over a specified time horizon. The goal of aggregate planning is to satisfy demand while maximizing profit”. By implementing an RFID system a business can support planning several of these aspects. When the actual system is introduced RFID offers much information through data collected and analyzed by business applications. The information gathered is important for businesses to make a correct forecast and calculation in production. To meet demands in the marked the forecasts needs to be as close to the real world as possible. Information from RFID systems is closer to the real world than any information earlier collected. E.g. business applications gathering RFID data may be set to inform demand at every hour or more often, and the data may be gathered from storage room in beforehand instead of sales data from cash registers.

It is possible to use information like this in every plan processes. Plan does not have any direct solutions of its own, but uses information from solutions in the rest of the processes. These will be described further when evaluation each process. The table below presents all lower level processes in Plan. Establishing and communicating plans (line four in the table) are not impacted by RFID systems. The rest of the processes are relevant to solutions a RFID system offer. They may be automated partly or entirely, made more efficient or the amount of work may be reduced (the process is automated or removed).

Lower level processes in Plan

	P1 – Plan Supply Chain	P2 – Plan Source	P3 – Plan Make	P4 – Plan Deliver	P5 – Plan Return
1	**P1.1** – Identify Prioritize, & Aggregate Supply-Chain Requirements	**P2.1** - Identify Prioritize, & Aggregate Product Requirements	**P3.1** - Identify Prioritize, & Aggregate production Requirements	**P4.1** - Identify Prioritize, & Aggregate Delivery Requirements	**P5.1** - Identify Prioritize, & Aggregate Return Requirements
2	**P1.2** – Identify, Assess, & Aggregate Supply-Chain Resources	**P2.2** - Identify, Assess, & Aggregate Product Resources	**P3.2** - Identify, Assess, & Aggregate Production Resources	**P4.2** - Identify, Assess, & Aggregate Delivery Resources	**P5.2** - Identify, Assess, & Aggregate Return Resources
3	**P1.3** – Balance Supply-Chain Resources with Supply-Chain Requirements	**P2.3** - Balance Product Resources with Product Requirements	**P3.3** - Balance Production Resources with Production Requirements	**P4.3** - Balance Delivery Resources with Delivery Requirements	**P5.3** - Balance Return Resources with Return Requirements
4	**P1.4** – Establish & Communicate Supply-Chain Plans	**P2.4** - Establish & Communicate Sourcing Plans	**P3.4** - Establish & Communicate Production Plans	**P4.4** - Establish & Communicate Delivery Plans	**P5.4** - Establish & Communicate Return Plans

Enable Plan

The report establishes an understanding of which parts of SCOR that is included in the project. When considering Enable Plan it is found that EP1, EP5 and EP9 are not in the project scope. EP7 and EP8 have no solutions found that may accomplish any of the aspects listed in the introduction. The processes are listed in the table below.

Processes in Enable plan

Enable Plan
EP1 – Manage Business Rules for Plan Processes
EP2 – Manage Performance of Supply Chain
EP3 – Manage Plan Data Collection
EP4 – Manage integrated Supply Chain Inventory
EP5 – Manage Integrated Supply Chain Capital Assets
EP6 - Manage Integrated Supply chain Transportation
EP7 – Manage Planning Configuration
EP8 - Manage Plan Regulatory Requirements & Compliance
EP9 - Align Supply Chain Unit Plan with Financial Plan

Source

Processes in Source include purchasing materials and recourses not possible to obtain by the company itself. RFID tagging in these processes will make it easier to manage ordering and receiving/verifying of products. The solutions described below imply the pallets or cases to be tagged at the supplier before shipping. Tagging goods in the entire supply chain is a condition for gaining benefits in all parts of the chain. Information needs to be collected through every part of supply chain to get a whole picture of the product life cycle, and it is up to collaborating partners to agree on information exchange.

S1 – Source Stocked Product, S2 – Source Make-to-Order Product and S3 – Source Engineer-to-Order Product

Process S1 and S2 are approximately identical. The difference is that ordered products is either pre-produced and stocked, or produced at inquiry. The ordering and delivery of products are identical and therefore described together. S3 has the same processes as S1 and S2, but the first two third level processes make S3 stand out. The two processes are:

- S3.1 – Identify Sources of Supply
- S3.2 – Select Final Supplier(s) and Negotiate

These processes are important logistics processes since capacity and quality of the supplier are important for the internal business processes, but are not relevant when it comes to implementing RFID. A requirement to suppliers may be RFID compliance to create a more efficient supply chain. The rest of S3 is described together with S1 and S2.

S3 is a process where products often are "one-of-a-kind". Tagging these products is not necessarily realistic, but valuable goods will get increased tracking possibilities and owner and product information may be tagged to the product.

Process		**Solution**	**Goal accomplishment**
S1.1, S2.1 and S3.3	**Schedule Product deliveries**	Automatic ordering from monitored storage rooms	*Improved management*[18]; Less manual work, faster order sending, real demand
S1.2, S2.2 and S3.4	**Receive Product**	Automatic registering of received goods at storage rooms	*Improved management*; More accurate inventory lists, quick updates *Track and Trace*; Location electronically available
S1.3, S2.3 and S3.5	**Verify Product**	Automatic verifying of received goods against an order sent	*Improved management*; Exact number of goods registered, quicker verification
S1.4, S2.4 and S3.6	**Transfer product**	Automatic registering of goods at different sites	*Track and Trace*; Location electronically available, no searching for goods
S1.5, S2.5 and S3.7	**Authorize Supplier payment**	When products are verified the payment may be automatically authorized	*Improved management*; Quicker processes, less invoice disputes

Enable source

ES5 is not a part of the project scope and not evaluated. ES1 is part of project scope but no direct solution is found. The process may use results from monitoring other processes and get important information. ES8 and ES9 are in project scope since the processes are included in the definition of logistics, but there are not found that a RFID system can give any solutions that result in accomplishing the project goal. Still, it is important that RFID is taken into consideration when managing all processes.

Sourcing Data in ES3 is defined as data about the supplier and its products. This also includes deliver capacity and product amounts and is therefore relevant.

[18] Improved management also includes improved supply chain

Process		Solution	Goal accomplishment
ES1	**Managing Sourcing Business Rules**		*No solution found*
ES2	**Assess Supplier Performance**	RFID in value chains helps supervising the performance of suppliers and ease the choice of business partners	*Improved management;* Faster and easier data collection when assessing performance
ES3	**Maintain Sourcing Data**	RFID collects data from pallets and cases and maintain location, amount, and product condition	*Track and trace;* Location electronically available, *Improved management;* The amount counted is more reliable, no searching for goods, more information available, product state monitored and automatically communicated when possible
ES4	**Manage Product Inventory**	The specific products and its amount registered is available and may trigger automatic ordering systems	*Improved management*; Less manual work, quicker processes, more electronic information
ES5	**Managing Capital assets**		*Not in project scope*
ES6	**Manage Incoming Product**	See S1.2 and S1.3 (In some cases also S1.4)	
ES7	**Manage Supplier Network**	Automatic monitoring of products in the network	*Track and trace;* Products monitored in supply chain, no searching of goods, connected businesses share information
ES8	**Manage Import/Export Requirements**		*No solution found*
ES9	**Manage supplier Agreements**		*No solution found*

Make

Make describes activities necessary to produce items and make them ready for deliver. Make identifies three different strategies for production.

M1 – Make-to-Stock, M2 – Make-to-Order and M3 – Engineer-to-order

Make-to-stock, process M1, is the daily production done to contain a certain amount of products in storage. Make-to-order, M2, is about creating finished products according to a specific order. With the first strategy it is possible to automatically create production

plans when the amount in storage reaches a certain level. In Make-to-order the business needs one or more orders to create a plan like this. Engineer-to-order, M3, is closely related to the two former processes, but the product needs to be developed according to costumer specification before production. M3 has one lower level process that stands out from M1 and M2 and this process has no impact on the goal accomplishment. The lower level process is named M3.1 – Finalize Engineering, and not included in the presentation below. Remaining processes are equal and described together.

The process Issue Product, M1.2, M2.2 and M3.3, is defined to be releasing of product specification to production. This is not found to be a part of project scope and not described further here.

Process		Solution	Goal accomplishment
M1.1, M2.1 and M3.2	**Schedule Production Activities**	Automatic determine what and how much that needs to be produced	*Improved management*; Faster production and smaller production quantity
M1.2, M2.2 and M3.3	**Issue Product**		*Not in project scope*
M1.3, M2.3 and M3.4	**Produce and Test**	Resources needed in production may be monitored. Condition of resources/products automatic communicated	*Improved management*; Amount of resources used monitored, automatic ordering, finished products registered Product condition monitored
M1.4, M2.4 and M3.5	**Package**	Finished products are tagged and than possible to trace	*Track and Trace*; Location electronically available, *Improved management*; No searching for goods, exact number of goods registered, production plans automatically updated, product condition monitored and automatically communicated when possible
M1.5, M2.5 and M3.6	**Stage Product**	Automatic updating where products are and the products condition before sending	*Track and Trace;* Location electronically available, product condition monitored
M1.6, M2.6 and M3.7	**Release Product to Deliver**	See M1.5	

Enable Make

This is the lower level processes needed for Make to occur. EM1, EM7 and EM8 are part of the project scope, but no solution is found to accomplish the project goal. As with ES1 EM 1 is part of project scope but no direct solution is found. The process may use results from monitoring other processes and get important information. EM5 is not in the scope when it comes to RFID tagging produced goods.

Process		Solution	Goal accomplishment
EM1	**Manage Production Rules**		*No solution found*

EM2	**Manage Production Performance**	Automatic updating inventory and resources produced and used.	*Improved management*; Amount of resources used monitored, inventory monitored, easier/faster logistics planning
EM3	**Manage Make Information**	Automatic updating inventory and production plans	*Improved management*; Less manual work, exact number of goods registered
EM4	**Manage In-Process Products (WIP)**	See EM2 and M1.4	
EM5	**Manage Equipment and Facilities**		*Not in project scope*
EM6	**Manage Transportation**	Automatic ordering of transportation	*Improved management;* Automatic update of amount of finished products ready for transportation, automatic production plans
EM7	**Manage Production Network**		*No solution found*
EM8	**Manage Production Regulatory Compliance**		*No solution found*

Deliver

Deliver imply all activities and information necessary to get products from production site and to the costumers. This process has many similarities with Source and often includes the same solutions. The main difference is the business's role in product distribution. SCOR identifies four lower level processes, three of them described together.

D1 – Deliver stocked product, D2 – Deliver Make-to-Order and D3 – Deliver Engineer-to-order Product

These three processes are similar to each other, but D3 differ at the first four lower level processes. Of these four processes only D3.3 is a part of project scope. As mentioned earlier resource management and production plans may be created easier with RFID. The four processes not included in the presentation below are:

- D3.1 – Obtain & Respond to RFP/RFQ[19]
- D3.2 – Negotiate & Receive Contract
- D3.3 – Enter Order, Commit Resources & Launch Program
- D3.4 – Schedule Installation

Orders in the category of Make-to-order are as mentioned not necessarily joined before production. The production strategy differs from business to business and depends on which orders that needs to be produced at a certain time.

[19] RFP/RFQ - Request for Proposal/Request for Quotation

The processes D1.1 to D1.7 are activities included in order management and are mostly administrative processes. In many cases information from a RFID system may ease the execution of these processes by automate parts or the whole process. Processes D1.8 to D1.12 are by SCOR defined to be included in warehouse management. Process D1.4 is in project scope, but not directly impacted by an implemented RFID system. Consolidating orders has been done by business applications for several years and there is not found that RFID may improve this process any further. The same is for D1.6 where shipment routing usually is done effective in business applications.

Process		**Solution**	**Goal accomplishment**
D1.1 and D2.1	**Process Inquiry & Quote**	Storage rooms with RFID automatically send real time demand (orders) to production sites. Automatic validation.	*Improved management*; Faster and automatic administrative processes, faster production and smaller production quantity possible
D1.2 and D2.2	**Receive, (Configure,) Enter and Validate Order**		
D1.3 and D2.3	**Reserve Inventory & Determine Delivery Date**	Automatic production plans based on orders may reserve inventory/products if wanted. Determined Delivery date may be forecasted automatically in proportion to the production plan	*Improved management;* Faster and automatic administrative processes, faster resource assessment, more accurate delivery dates
D1.4 and D2.4	**Consolidate Orders**		*No solution found*
D1.5, D2.5 and D3.5	**Build Loads**	Automatic planning	*Track and Trace*; Location electronically available *Improved management*; Automatically planned from production plans, faster building process
D1.6, D2.6 and D3.6	**Route Shipments**		*No solution found*
D1.7, D2.7 and D3.7	**Select Carriers & Rate Shipments**	Rating shipments may be done automatically by reading tags	*Improved management*; Quicker processes, faster and easier rating

D1.8, D2.8 and D3.8	**Receive Product from Source or Make**	See S1.2 and S1.3	
D1.9, D2.9 and D3.9	**Pick Product**	Automatically generated lists of what to be picked and packed, easier/faster finding products with handheld readers	*Improved management;* Automatic list generation, more accurate inventory lists, quicker process
D1.10, D2.10 and D3.10	**Pack Product**		
D1.11,	**Load Product**	Automatically generated	*Improved management;* Less

D2.11 and D3.11	**& Generate Shipping Docs**	shipping docs (and sending if electronic sending procedure)	manual work, quicker process
D1.12, D2.12 and D3.12	**Ship Product**	Automatically monitoring of products (states, locations, transportation time etc)	*Track and Trace;* performance evaluation, location monitoring, lead time supervising, sensors supervise product state
D1.13, D2.13 and D3.13	**Receive & Verify Product by Customer**	See S1.2 and S1.3	
D1.14, D2.14 and D3.14	**Install Product**	Automatic updating inventory lists	*Improved management;* Less manual work, accurate inventory lists
D1.15, D2.15 and D3.15	**Invoice**	Automatically generate invoices according to delivered products	*Improved management*; Less invoice disputes, faster invoice processes

D4 – Deliver Retail Product

This is goods packed and adapted for retailing. Products at this level is usually not tagged with RFID, but may arrive as pallets or cases (depends on store and/pr product type). At process D4.3 the pallet is dissolved and processes from this point is not relevant to pallet or case tagging.

Process		**Solution**	**Goal accomplishment**
D4.1	**Generate Stocking Schedule**	See S1.1	
D4.2	**Receive Product at the Store**	See S1.2 and S1.3	
D4.3	**Pick product from the backroom**	See D1.9	
D4.4	**Stock Shelf**		*Not in project scope*
D4.5	**Fill Shopping Cart**		*Not in project scope*
D4.6	**Checkout**		*Not in project scope*
D4.7	**Deliver and/or install**		*Not in project scope*

Enable Deliver

As with Enable Source process five in Enable Deliver, ED5, is not part of the project scope and therefore not described further. ED1 and ED8 is a part of the project scope since the processes are included in the definition of logistics, but no solution that result in accomplishing the project goal further is found. As with ES1 and EM1 ED1 have no direct solution, but the process may use results from other processes to get relevant and important information.

In ED3 the report defines Deliver Information as data about the costumer and the ordered product(s). This also includes the amount of products and is relevant.

Process		Solution	Goal accomplishment
ED1	**Manage Deliver Business rules**		*No solution found*
ED2	**Assess Delivery Performance**	RFID in a value chain helps supervising the performance and automatically calculate best-practice delivery	*Improved management;* Faster and easier data collection when assessing performance, quicker conclusions
ED3	**Manage Deliver Information**	See ES3	
ED4	**Manage Finished Product Inventories**	The specific products read, and the amount registered at the costumer may trigger automatic delivery systems	*Improved management;* Less manual work, inventory monitored, easier/faster logistics planning, production plans automatically updated
ED5	**Manage Deliver Capital Assets**		*Not in project scope*
ED6	**Manage Transportation**	The products read and the amount registered in storage may trigger automatic transportation appointment	*Improved management,* Less manual work, easier/faster logistics planning, quicker processes accomplishment
ED7	**Manage Product Life cycle**	Automatic updating products condition and location	*Track and Trace;* Monitoring products, monitoring product conditions
ED8	**Manage Import/Export Requirements**		*No solution found*

Return

This process is invoked when a product for some reason needs to be returned to supplier or production. SCOR identifies three main reasons for Return; the product is defect, needs maintenance or is an excess product. For each of these there is a process from either Source or Deliver. These will be described together.

One of the challenges in Return is the tags lifetime. The product may be at the costumers for several years before Return is invoked. Tags may have been damaged or become incompatible. The considerations below assume the tags to be “alive” and compatible at return time.

SR1 – Source Return Defective Product, SR2 – Source Return MRO[20] Product and SR3 – Source Excess Product

There are several lover level processes in this part of Return that are not included in the project scope. Two processes are included and both evaluated below.

[20] MRO – Maintenance, Repair and Overhaul (or Operations)

Process		Solution	Goal accomplishment
SR1.1, SR2.1 and SR3.1	**Identify Product Condition**		*Not in project scope*
SR1.2, SR2.2 and SR3.2	**Disposition Product**		*Not in project scope*
SR1.3, SR2.3 and SR3.3	**Request Return Authorization**		*Not in project scope*
SR1.4, SR2.4 and SR3.4	**Schedule Shipment**	See D1.7, D1.11 and D1.12	
SR1.5, SR2.5 and SR3.5	**Return Product**	See D1.7, D1.11 and D1.12	

DR1 – Deliver Return Defective Product, DR2 – Deliver Return MRO Product and DR3 – Deliver Return Excess Product

Authorization is not defined in the project scope and not evaluated. The rest of the lower level processes has been described earlier.

Process		Solution	Goal accomplishment
DR1.1, DR2.1 and DR3.1	**Authorize Product Return**		*Not in project scope*
DR1.2, DR2.2 and DR3.2	**Schedule Return Receipt**	See D1.11	
DR1.3, DR2.3 and DR3.3	**Receive Product (includes verify)**	See S1.2 and S1.3	
DR1.4, DR2.4 and DR3.4	**Transfer Product**	See S1.4	

Enable Return

ER5 is not in the project scope as with every other process including capital assets. ER1 and ER8 have no solution to get closer to the project goal. ED1 have no direct solution, but the process may use results from other processes to get relevant and important information. Most of the other processes have been described before.

Process		Solution	Goal accomplishment
ER1	**Manage Business Rules for Return Processes**		*No solution found*
ER2	**Manage Performance of Return Processes**	RFID in a value chain helps supervising the performance and automatically calculate best-practice return	*Improved management;* Faster and easier data collection when assessing performance
ER3	**Manage Return Data Collection**	See ES3	
ER4	**Manage Return Inventory**	See ED4	
ER5	**Manage Return Capital Assets**		*Not in project scope*
ER6	**Manage Return Transportation**	See ED6	

ER7	**Manage Return Network Configuration**	See ES7	
ER8	**Manage Return Regulatory Requirements & Compliance**		*No solution found*

Summary

It is found that several parts of SCOR may hold RFID solutions, or solutions influence the efficiency of processes, to gain the project goal. All second level processes are included in goal accomplishment, but several third level processes are out of project scope or have no relevant solution.

Plan is definitely a process that may improve according to this goal. As mentioned earlier there is not found any direct RFID solution in this area, but the process pulls RFID data and information from other processes. It is believed that RFID data may improve both quality and quantity of information and create a more powerful decision base in the planning process. Decisions may be done based on information closer to real time and fewer long term forecasts are needed, and the process has big potentials with RFID.

Almost every evaluated process in Source has solutions to gain *Improved management*. In addition *Track and trace* is mentioned in some of the lower level processes. These aspects are relevant for management improvements and will contribute to gain the project goal. This means that the entire process can change with RFID, and execute in a way that implies improved management and supply chain. Solutions may be monitoring amounts of products and automatic resource ordering, or registering and verifying received products. This alone would eliminate several manual and time consuming processes.

Most evaluated processes in Make have solutions to gain *Improved management*, except one only have solutions for *Track and trace*. Process management will be easier when it comes to monitoring resources used and products produced. This information may trigger several automatic functions in the business application, e.g. automatic updating production plans or order new delivery of resources.

Deliver have four processes where three of them concentrate on delivering products to distribution and one on retail products. *Improved management* is found in almost every process, but there are several processes where no solution is found for any of the aspects. Two lower level processes have solutions for *Track and Trace*. There is found many similarities to Source and improved management is mainly possible through monitoring the product amounts, combined with order information from business applications. Solutions may be automatic ordering of transportation or generating product pick lists.

Return mostly has the same solutions as described in other processes, or lower level processes are not defined to be in the project scope. Return processes relevant to Source mostly have the same solutions as Deliver. Deliver relevant Return processes are

compared to solutions at Source. Automatic generation of shipping documents or *Track and trace* of products during shipping are amongst solutions that may contribute to improved management.