Master's degree thesis

LOG950 Logistics

Internet-of-things(IOT) - Technologies Enabling Efficient Inbound and Outbound Logistics in Engineer-To-Order (ETO) Manufacturing Companies

Sowmya Thota

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Abstract

This paper presents research based on the engineer-to-order (ETO) companies Brunvoll and Kleven whom manufacture of thrusters and Ships respectively for the global market. The unique properties of engineer-to-order companies and the globalization trend cause a need to look at how such companies handle information and material flow. E.g. the engineer-to-order production approach is characterized by an inherent innovative construction process in which many details are becoming known as the ship is built. These details are not known upon the receipt of a customer order. Thus, specifying the exact documentation of the product is not possible at the time of ordering. This engineer-to-order process propagates to some of the major suppliers, like the supplier of thruster since the order for a thruster is sent early in the engineering process. Consequently, the thruster company receives the order before all details known. Changes during thruster production are common. This pose special challenges:

- *Documentation of details:* detailed engineering drawings are not completed until the product is completed. Thus, a challenge is to handle the information flow associated with the order flow. Since, the delivery of an order contains many more details than specified in the purchase order, standard 3-way match(consolidation) of the order is not possible i.e. ensuring that you get what you ordered, and that you pay of what you ordered cannot be handled in a standard way.
- *Inbound delivery:* inbound delivery of the thruster components pose logistical challenges upon delivery. The components are placed on storage locations of the shipyard in an arbitrary settings, since the identification of components are according to the thruster manufacturer, the shipyard does not know exactly what components received are, and thus where to store them in a logical manner.
- *Picking:* the picking and montage of components pose further challenges since the detailed engineering drawings of the shipyard does not matched with the component specifications in the detailed engineering drawings of the thruster.

The objective of this paper is to identify the present situation of information flow and material flow, in the internal and external supply-chain network of the companies and to provide necessary suggestions for improvement towards the vision of an extended supply network. The intent of this thesis is to define the present situation and propose way to handle the challenges.

The major challenge in this thesis is the missing synchronization between the components received and engineering drawings of the thruster. A proposed integration of Internet-of-things (IOT) and Logistics have the potential to provide control of the present problems to improve information flow and material flow efficiency.

In the course of transforming a value chain into a smart system, I use Value Stream Mapping (VSM) and Data Flow Diagrams (DFD), GS1 Standards, Radio Frequency Identification (RFID) and Global Data Synchronization Networks (GDSN) to map and understand the

information flow and material flow in AS-IS situation and meet the planned demand of the customer without delays in the future like TO-BE situation.

The paper focuses on classifying the current Identification of Products from the process and increase the performance of the dynamic production planning system across the value chain by focusing on RFID and GDSN on the way to increase the horizontal coordination in the supply chain. Visual charts and delivery performance are studied further in this thesis.

The results of the case analysis clearly explain that the global standards for identification of products is a basic support system for the supply chain visibility. Redesigning the supply chain network with global standards and RFID adoption in the supply chain could improve the traceability of the product. Moreover, the level of degree of adaptation of global standards, demonstrates the opportunity of achieving strategic benefits of improving traceability.

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1. Introduction

In this global world, the competition between the firms is extensively increasing and the expansion to globalization creates various challenges for handling the supply-chain. In modern trend, increase in the outsourcing appearances a multi-tiered global supply chain that integrates multiple firms and networks. Moreover, managing the uncertainty and complexity among the global supply chain is very difficult, companies are motivated to stay competitive in a dynamic and global environment. This can be possible only by communication, and cooperation between the actors in the supply chain. However, the main aim of any organization is to provide value to the customer interest and focus on continuous improvement and further development of the products and services. Value is certain forms of characteristics, not substantive quantities. To create value is not to create products, but products with certain characteristics and qualities (Salvatierra-Garrido and Pasquire 2011).

The increase in global sourcing of production creates various challenges in manufacturing companies. To face these challenges, companies need to focus on creating a knowledge base innovation and definite value chain and manufacturing network with a global supplier base. In 2015, the Manufacturing Network 4.0 project started. Several manufacturing companies are involved in this project to contribute with competence within production strategy, logistics and material flow. Brunvoll and Kleven are engineer-to-order companies, they are part of this project. These companies, just started their journey towards the Internet-of-things. The engineer-to-order manufacturing process is different compared to make to stock and make to order production process. The ability to handle customer request and innovative solutions are the inherent property of ETO manufacturers which gives them a business advantage over make-to-order (MTO) companies. The ETO production process is more flexible and mainly depends on dynamic production. This pose some unique challenges for the production planning and execution of ETO companies.

This paper is about the theoretical knowledge of integrating Internet-of-things (IOT) and Logistics stimulating case study research. Fundamentally, the thesis is focused on understanding the existing stage of company's information flow and production process in ETO companies to simply identify and suggest the improvements to reach the ultimate goal of extended supply chain networks.

This brings a question how the production process and information flow is observed in internal and external supply chain networks, is there any improvements to be obtained and where can the case companies flinch to look for improvements. This thesis is mainly focused to seek the answers for these questions and facilitate it further.

1.1. Background For Research Problem

The Norway is most popular for oil and gas industry. Their primary focus is on oil industry. However, Norway has not taken any initiative or organizations that exclusively focus on development or promotion of digitalization and automation within the manufacturing industry. The Norwegian government supports digitalization and automation in manufacturing through a broader cluster initiatives (N.C. 2015). Therefore, the ikuben is one of the broad cluster initiatives in Norway; they were inspired by a German company in industry 4.0 and in 2015 ikuben launched a research project Manufacturing Network 4.0, in collaboration with Norwegian University of Science and Technology, Molde University College and other institutions and manufacturing companies.

The goal of Manufacturing Network 4.0 project is to create a knowledge platform between the research and the industry that enables Norwegian manufacturers to expand their Industry 4.0 concept from the factory level to the integration of global manufacturing networks. The Industry 4.0 is next generation technologies that could apply in production and manufacturing companies. It refers to a future developmental stage in organization and management of the entire value chain process involved in manufacturing industry and raises the industrial production to new levels. It develops an interactive relationship between objects, machinery and people, which enable production system to act faster, work more efficiently and deliver high quality (Breil-Hansen 2015).

The industry 4.0 vision is "Internet-of-things", it is the ubiquitous connection of people, things and machines. This would create a seamless link between the virtual world and the physical object within the real world(Koch et al. 2014). Industry 4.0 contains the use of developments in communication and information technology to increase the degree of automation and digitization of production, manufacturing and industrial process. The goal is to manage the entire value chain process, by improving efficiencies in the production process and coming up with products and services that are of highly in quality and become a smart factory , smart manufacturing systems and factory of future are intended(Anastasia 2015). The foundation step for industry 4.0 is digitization and increased integration of vertical and horizontal value chains(Koch et al. 2014).

Digitization:

Digitization of the product is the key to sustainable future success. Products that are primarily mechanical today will be enriched by digital solutions and connectivity. Moreover, the direct incorporation of digital intelligence into the product itself, can also increase the internet based services related to the product(Koch et al. 2014). The first step on the way to digitalization is giving all things a name.

As the authors (Koch et al. 2014) explained in a paper that, the three pragmatic steps for the application of digital concepts for the value chains.

i. *Give all things a name:* Give all products and production material a clear identification (ID) with a unique name. Digitizing and connecting products and the value chain can only be made possible on the basis of clear identification. Data can be collected and a complete digital internal description of products and product components may then be presented. This endorses efficient inventory and supply chain management.

ii. *Measure, measure, measure*

Measure all process and sensor data along the entire value chain in order to track the current state of product's and production material. Install sensors at multiple measuring points along production and on the products if they are not available already in order to get a comprehensive view. The availability of measuring data allows companies to improve processing times, increase the products quality and decrease process costs.

iii. *Connect and analyse*

Connect the identified products with their digital specification. Connect the different sources of data and create necessary communication and IT infrastructure in order to achieve connectivity and to be able combine and analyse data. This will allow you to define measure to increase efficiency and optimise quality for value chain.

Integration of Vertical and Horizontal supply chain:

Vertical integration of Smart production systems: The companies those working under Industry4.0 concept they should not work on a standalone concept they always should work in a network of smart factories, smart products and other smart production systems (Anastasia 2015). Digitization in the vertical value chain, is connected with securing a reliable flow of information and data from sales through manufacturing and logistics as shown in Figure1. The vertical integration improves the quality and reduce the cost of manufacturing operations.

In vertical integration, resources and products are networked and materials and parts can be located anywhere and at any time. This process also enables wear and tear on materials to be monitored more effectively and reduce the waste(Schlaepfer and Koch 2014).

Similarly, networking and integration also involve the smart logistics and marketing services of an organization, as well as smart services, since production is customized in such a way that it is individualized and targeted specifically to customers(Anastasia 2015) .

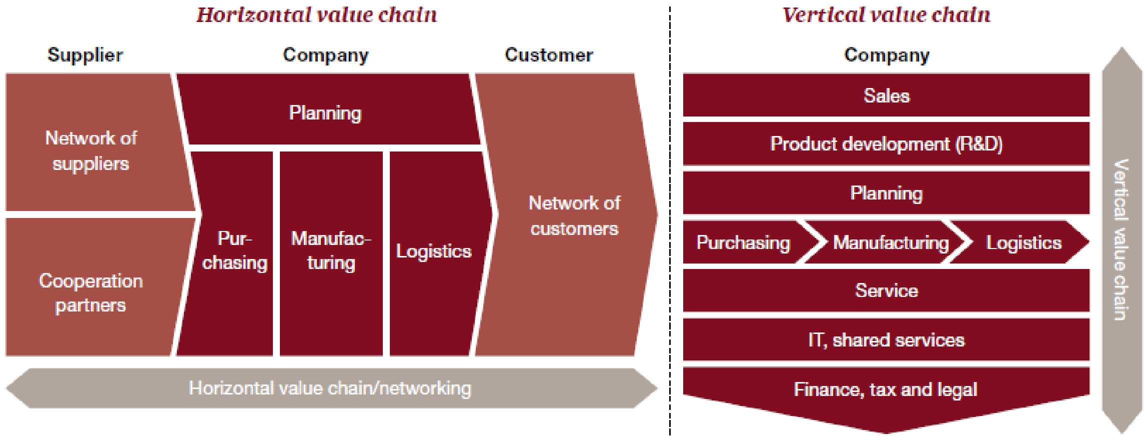


Figure 1Horizantal and Vertical Value Chain(Koch et al. 2014)

- *Horizontal integration through global value chain networks:* The new value creating networks from business relations to customer. Thus, similar to the networked production systems, including the upstream suppliers and encompasses integration of all the departments from inbound logistics through warehousing, production, marketing and sales to outbound logistics and downstream services see Figure 1. The digitization of the horizontal value chain integration optimizes the flow of information and goods from their own company to the supplier and back(Koch et al. 2014). The history of any part or product is logged and can be accessed at any time, ensuring constant traceability i.e. product memory. By this it creates a dynamically handled customer specifications in real time at all stages of value chain (Schlaepfer and Koch 2014).

  This type of horizontal integration can develop a new business models for customers and business partners. This also shows a new ways for coordination in the entire value chain among partners.

Manu Net 4.0 particularly contributes through competence within production strategy, logistics and material flow, and ICT (Internet and Communication Technology) solutions for control of flow of material and resources, including supplier relation management, economy and business models. The main unit of study in this thesis is a case study on two leading manufacturing companies in Norway i.e. Brunvoll and Kleven.

1.2. Engineer-To-Order (ETO) Companies

1.2.1. Brunvoll

The Brunvoll is a world-leading supplier for thruster systems; they delivered 8000thrusters for more than 5000 vessels. In 1912, the Brunvoll brothers Andreas established the company named Brunvoll, made its entry to provide the thruster system for vessels. In 1918, the company moved to Molde, and Artur Brunvoll joined his brother. During the early stages, the company manufactured low-pressure diesel engines and controllable pitch propellers for fishing vessels. Brunvoll is a single-source supplier and took full responsibility for whole thruster system, and each system can be optimized to meet the needs of individual vessels and operations. They provide fully integrated thruster solutions complete with drive motors, hydraulic power units, control system alarms and monitoring system. They also provide a service and support for the lifetime of the thruster system, and their value chain is shown in figure1 (Brunvoll 2015)

Brunvoll’s main goal is to generate steady and healthy long-term growth and profitability in designing, manufacturing , marketing and service for a complete thruster system (Brunvoll 2015). The Brunvoll group company has revenue approximately 827.4millionNOK and net income for the year 2014 was 49.1Million NOK with 330 people working and the company is having agents though 28 different countries from Europe, Asia, Australia and America. It is a leading supplier for all advanced thruster systems for specific type of vessels.

In 2014, the Brunvoll placed a significant effort in reviewing their documented control systems to meet the ISO certification requirements. Figure 2 shows the Brunvoll value chain; they also developed continuous improvement plans in all processes and around the value chain to reduce their affluent edge. In this year, they completed 650 after sales service field jobs consisting of 50 installations, 140 commissioning jobs and 450 ordinary service jobs (Brunvoll 2014)

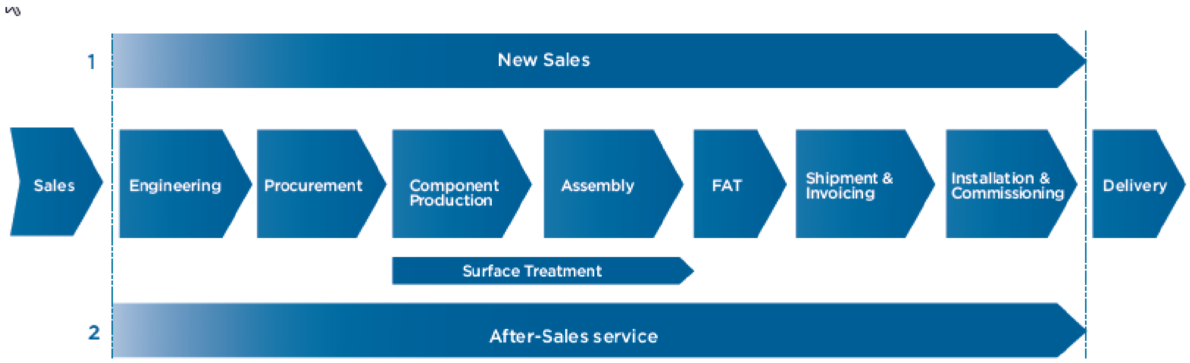


Figure 2: Brunvoll Value Chain(Brunvoll 2015)

1.2.1.1.Enabling Technologies at Brunvoll

The Brunvoll has their own Information technology department, and currently they were focusing and investing on automating their organizations. Overall Brunvoll uses an ERP – system M3 with a high integration to be other technological supporting systems. The sales department uses Lotus Notes with support to ERP system, and the production department schedules all project's information, and update processes are shown in M3 system with Inventory status etc.

The Internet-of-things at Brunvoll is in preliminary phase. Their main goal in considering this project is to use of the Internet and communication technology for integration of Value chains in engineer-to-order Manufacturing Company. At Brunvoll, the service order can be received from different service order hubs or from a mediator in relation with customers, for example direct sales via partner companies, etc. as shown in (Appendix Figure1). Moreover, their focus is to provide the solutions for various service-needs in addition to the existing product and to investigate IOT infrastructures supporting several sales and distribution channels as well as various sourcing schemes utilizing the industrial Internet. This project is included with envision of various services like engineer-to-Order Service, ETO Design-to-Order Service, ETO Manufacture-to-Order Service, After-Sales Service, and Leasing Service).

1.2.2. Kleven Maritime

Kelven Maritime AS is a Ship Building Company located at Ultensik West Coast of Norway with 768 employees with an annual profit of approximately 76.0 Million NOK. It has a strong brand reputation within the shipping industry, and the company is a leading supplier for highly specialized ships of different sizes and designs, mainly in offshore vessels, coast guard vessels, special tugs fishing vessels and other work boats(Maritime 2016). In 1915, Myklebust Verft established the Kleven and Kleven Martime AS was founded in 2000. During the past years, their history been characterized by a willingness to hard work and wish to improve working methods and results.

Kleven Maritime main goal is to satisfy the customer needs by combining the creativity and innovation with quality and service. Their mission to be an attractive supplier of specialized ships and services, participating in projects in concept phase to give ship-owners added value through innovative solutions(Maritime 2016). Their vision is to be a preferred partner in defined areas.

Kleven Maritime owns two yards, Kleven verft AS and Myklebus Verft AS, located in Norway. The company also provides a high-level knowledge based innovation, openness in relation to experience and targets, honesty, a strong motivational element and pure enthusiasm. In 2014, the company delivered eight different vessels and signed 13 new contracts. The Kleven group of companies revenue is totalled 5,039.4 million NOK (Maritime 2016).

Production and Project execution:

The company is mainly focusing on increasing their capability within core activities and outsourcing their non-core activities as shown in Figure 3. Each project at Kleven Maritime targets management, control and completion according to the customer requirements. The production strategy mainly focuses on subcontracting hull, pipes, surface treatment, interior work and electrical installation. The hull is either delivered complete or in blocks transported to Kleven verft AS. The production takes place in two yards, the Kleven Verft AS, large hull blocks were assembled after completion these assembled hulls are delivered to Myklebust verft for mounting of propellers and rudders(Maritime 2016).

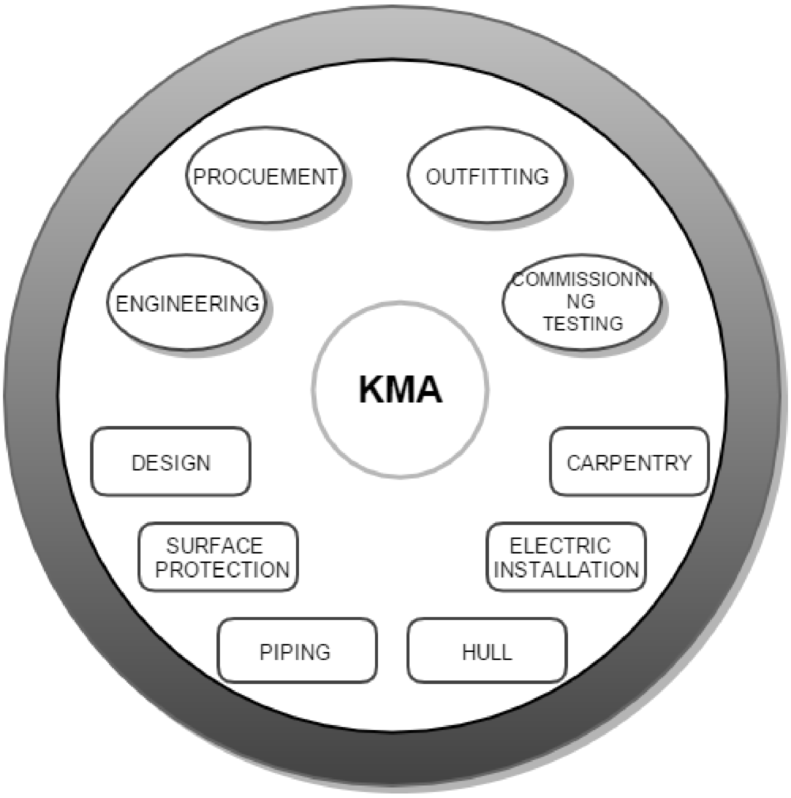


Figure 3: Kleven Business Strategy(Maritime 2016)

1.2.2.1.Enabling Technologies at Kleven

Kleven is a design, engineering, procurement and manufacturing company, mainly focusing on enforcing the technology competence. The value chain for the ship building industry is different compared to the other engineer-to-order companies. Because, the Ship building industry mainly focuses on the core part i.e. assembly, they have a large network of the supply chain as shown in Figure 4. From the interview, it revealed that they use the SFI codes for their projects, and the first step is to prepare the project documentation and design of the ship. Overall, they make use of many systems in their business processes. Moreover, they normally use file and folder system for saving the project information, ERP system for warehouse operations that entered by the operators manually, planning system, and they widely use Microsoft Excel. In the company, everything is based on the project SFI codes. When they receive the goods from the suppliers, they use the project id as main labeling system.

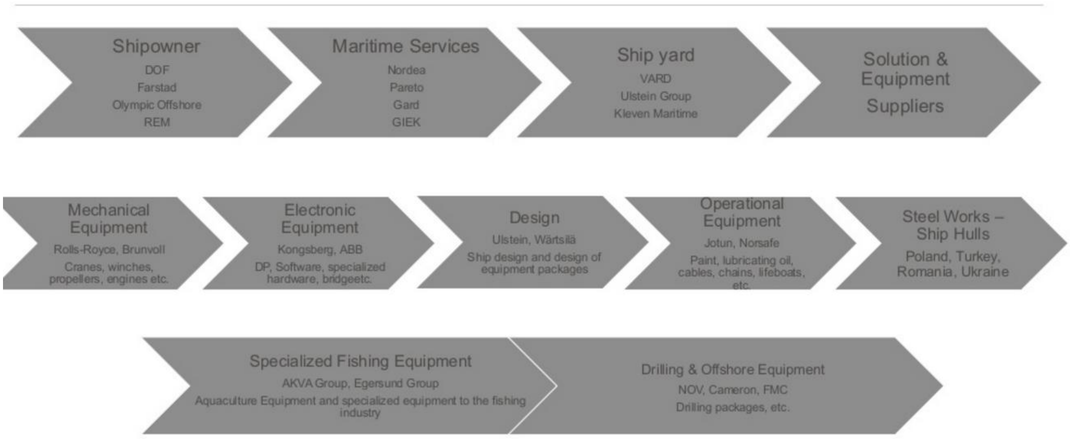


Figure 4 Norwegian Shipbuilding Value chain(OperatelGroupAS and HinaConsultingAS 2015)

The Internet-of-things at Kleven is in preliminary phase. Their focus is to identify the importance of proximity between different parts of their manufacturing network to reduce lead-time, increase efficiency, sustainability, and develop innovativeness. Furthermore, integration of their value chains using ICT was their main research area, that they were interested. In order to obtain this, they initiated a project to investigate the new design with all opportunities, consequences and effects. This project requires a holistic approach involving a number of different disciplines, and the most important is the relation between design and product functionality, method of production and logistics. A new-product design implying a more cost efficient vessels, effective production and material flow, and improved control of the entire construction process. Their main challenge is to provide ICT solutions for control of flow of materials and resources, including suppliers.

1.2.3. Product

The Brunvoll company supplies different varieties of thrusters and thruster system to the Kleven. However, keeping in mind about time and information gathering this thesis is mainly focused on a project and one thruster in that project to identify the information flow and material flow of the product. Therefore, the project number is 373; this is a off-shore vessel build at Kleven verft AS and delivered to a customer in August 2015. In this particular project, the brunvoll delivered seven different type of thruster to Kleven as shown in table1 below.

Thruster	Type	Numbers
Tunnel Thruster	FU-100-LTC-2750-2500KW	2
Retractable Azimuth Thruster	AR-80-LNC-2100-1500KW	2
Tunnel Thruster	FU-100-LTC-2450-2050KW	3

Table 1 Product description for project 373 (from PO see appendix 3)

The product FU-100-LTC-2750-2050KW belongs to a family of Tunnel thruster, and this is the product which has narrowed the study in this research. Figure 5 shows the product FU-100-LTC-2750-2050KW that use writing in this thesis. Brunvoll has a comprehensive range of tunnel thrusters with different models and different power systems as shown in appendix figure 2. The Brunvoll delivered thousands of standardized and customized tunnel thrusters for finishing, cruise, naval, merchant and offshore vessels. They are mainly focusing on developing more reliable, optimized and cost-effective systems to reduce the weight of gear box, propeller hub and tunnel- structural improvements ensure that the thruster is just rugged despite the lower weight(Brunvoll 2015).

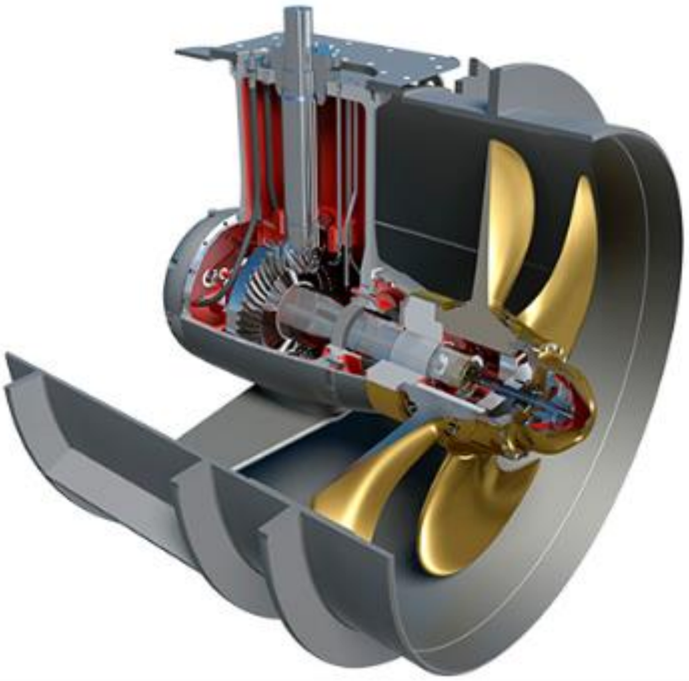


Figure 5 The Product Tunnel thruster FU 100-LTC-2750-2050KW(Brunvoll 2015)

1.2.4. . Process flow across the value chain:

Tore Roppen the Director of the supply chain at Kleven , revealed in a meeting that, when the clients or ship owners approach them, they do not have any basic information about the project. First they perform the documentation based on the customers' requirements, in this stage they do not have any information about technical requirements of the vessels. After this, they will send the requirements for request for proposal process, and some customers require specific suppliers for specific products. For example, Brunvoll as the supplier for Thruster solutions. When once Brunvoll receives the documentation of the vessel thruster system, they will perform the design of the thruster system based on the requirements specified by customers and perform documentation. Then Brunvoll sends the technical information to Kleven and the vessel owner to get granted for the production. Therefore, until this situation the Kleven do not have any particular technical information regarding the product and specifications. He also mentioned that, they receive the documentation with the product item, in that they would come know all the parts those are included and technical specifications with manual.

Ragnar Olsvik Hovind the Business controller at Brunvoll explained in a meeting that, before dispatching the goods they might send the soft copy of sales order with project id, SFI identification codes and the documentation with the technical specifications to Kleven and the vessel owner. During delivery of the goods, they will also attach the sales order receipt and documentation of the product and dispatch them to the client warehouse. He also mentioned that, they would dispatch the goods in different segments based on the production plan at Kleven. Each segment of the product combines the same procedure of information mentioned above.

1.2.4. Research Problem

Logistics management is a supply chain management module that is used to meet customer demands through the planning, control and implementation of the effective movement and storage of related information, goods and services from origin to destination. Logistics management helps companies reduce expenses and enhance customer service(Technopedia 2016).

In the present context, the engineer-to-order companies has a different production style compared to a make-to-order (MTO) and a make-to-stock (MTS) companies. Moreover, these companies invest in Millions of money in product, if the goods are missing and there is no scope of tracking systems for goods, it costs a lot of money and time for the customers. A main problem, for these companies is to handle the material flow in the inbound and outbound logistics system; the warehouse employees obtain this system manually. As we discussed in the above sections that, the Kleven uses SFI codes for identification of their products. The SFI coding system is mainly used for maritime and offshore industry worldwide. This system consists provides a highly functional division of technical and financial information. The SFI group system ties together all vessel management functions such as operations, purchasing, accounting, maintenance, quality, etc (Manchinu and McConnell 2016). From the below Figure 6, we can observe that the Brunvoll receives the Purchase order (See appendix Figure 3) from Kleven with an SFI codes, project id with delivery dates and mandatory information during delivery. Once the order conformation is finished the Brunvoll should send three sets of technical drawings to Kleven through Email. Kleven Company also mentioned briefly that while dispatching the goods the Brunvoll has to include Project id, Yard Number, and Purchase order number both on goods and list of contents and consignment note. The Klevens main problem is improper coordination between the goods received on pallets, delivered documents and drawings of the thruster with their internal technical drawings. From the personnel interview, Tore Roppen the director of supply-chain management explained that this identification of the goods related to drawings and list of components was a big problem for them. Because during the drawings and contracts, they do not know anything about the list of components, they receive this through email by an attachment in scanned PDF format before and during dispatching.

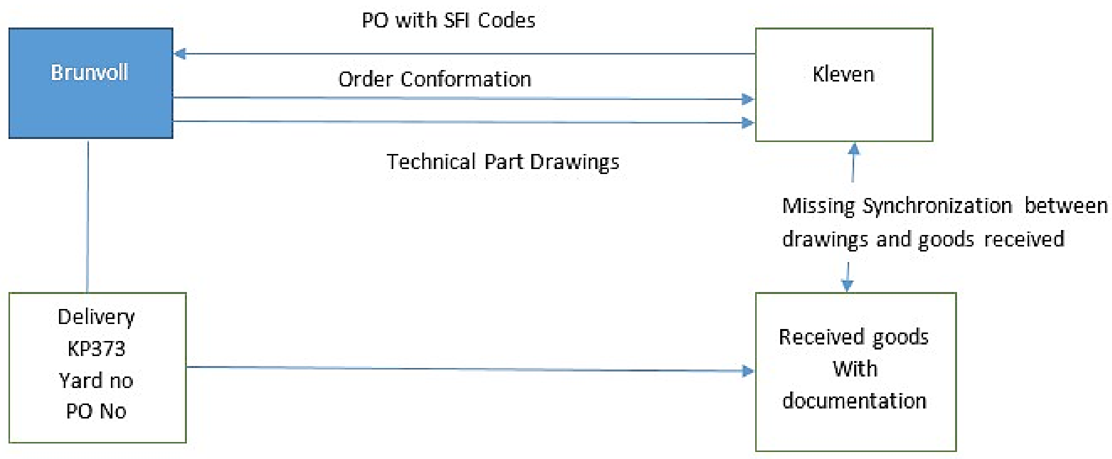


Figure 6 Overview of Problem Statement

Nowadays, the external supply-chains are moving towards external supply networks and internal supply chain of individual companies are moving towards internal supply networks. Moreover, together these trends are moving towards a combined manufacturing network supporting the dynamic and flexible manufacturing networks with main intention of horizontal integration of the value chain in which manufactures move towards service structures. However, in present the market providing different technological solutions like barcode and QR codes for material identification. This identification of the material processes done manually by the customers. By using these technologies the tracking and tracing of goods are challenging.

The identification of the products is the main intention of this paper. The digitization of products with a globally unique identification is one of the pillar for the manufacturing network vision. In the present context, the companies' uses the internal article numbers or product numbers to identify their products. However, these identification codes are not familiar with the other actors in the value chain. When the other actors in the value chain receive the material, the material consists of the supplier article number. The supplier article number could misplace the warehouse employees to identify the specific goods for particular process. Mostly, the identification issues were solved by implementing the global standardization of products, location, etc. using GS1.

1.3. Purpose and Research Question

ETO is a flexible manufacturing environment, where the customer has a greater choice to design their own products. The in-built characteristic of ETO manufacturing system is that the many details of the product and the product components are developed during the design and manufacturing process. This pose a specific challenge, which is obtaining the changes during the production process. Therefore, the whole component list known when the manufacturing of the product is finished. This creates different challenges in the supply-chain. One is how to incorporate complex products from suppliers. (Transaction costs:

internalize them: a pro in-sourcing argument: complete control is hard if suppliers are used. Complete control only if in-house. Consequences for innovation: complex ETO products needs close attention to the engineering and manufacturing/assembly process.

The objective of this research is to integrate the Logistics and information and communication system in order to enhance the supply-chain performance by tracking and shipping of goods. The central focus of the thesis is defining the first step of the digitization i.e." giving all tings a name" in the sense that this clearly shows the need for mapping the current information flow of the internal and the external supply chain of ETO companies. Having such knowledge is mandatory for making a decision on how a companies should proceed with adapting 4.0 technologies. The second and third step in digitization use to propose future work with the standardization of identification codes and show how sensor technologies like RFID can improve the trace and track technology in the value chain. The research questions are described below

a) Central Focus:

Understanding the existing state of a company's production process, internal communication and external communication in the supply chain and to improve the communication between the actors in the supply chain. I enclosed the following central focus for this dissertation.

"Identifying the present status of information flow inside the companies and between the companies for tier 1 supply-chain"

In engineer-to-order companies, the production process starts from design phase, procurement, fabrication, assembly testing and dispatch to final customer. In this process, the customers are highly involved in the design phase. The value stream map and the data flow diagrams shows the information flow and material flow of the selected companies in this dissertation.

b) Sub Research Questions:

Based on the Central Focus of this paper, I formulated secondary research questions, stated below, that are applied to the companies in order to know the information flow and production flow. The case is described in more detail in the next subsection

1. *How are products and product components currently identified in the material flow and information flow of the internal and external supply chain of an ETO company?*

2. *To what extent is standard identification schemes used in ETO information flow?*

3. *How can IOT-technologies improve the operations of ETO-manufacturers and approach the efficiency of MTS?*

1.4. Structure of the Thesis

This paper is the case study, which is based on the journal articles, conference papers, books and survey reports. The thesis is based on an ongoing project Manufacturing Network 4.0 and the data from interviews and research group, are the benefits for better understanding the case and information and communication technology in the present context.

The thesis is divided into five chapters: Chapter 1 describes a summary of the thesis and research question. Chapter 2 covers a brief background of Internet-of-things, Engineer-to-order companies and global standards, reviewing relevant literatures; Chapter 3 designates the relevant methodology to justify the real time project; Chapter 4 delivers an analysis defining the research questions; and Chapter 5 deliberates the suggestions, conclusion and limitation of the research with appropriate recommendations for future research.

2. Literature Review

This chapter provide a brief literature review of the previous research related to research questions. This chapter is divided into four sections. The first section provides a brief explanation of the Internet-of-things and its elements. The second section will provide the supporting literature for logistics and supply chain management and manufacturing strategies. The third section provides brief introduction about global standards and their importance. The last and final section, fourth section presents the implementation of the Internet-of-things in Logistics. The proposed literature is used to solve the research questions present in the section1.4.

2.1. Conceptual frame work of Internet-of-things(IOT)

Today's challenge for any organization is to remain competitive by offering better products and services with improve in quality and performance. Since, several decades Internet became a market leader and primary usage for communication. The Internet is used as a primary foundation for communication between two parties and it requires a lot of storage and data to transfer. Whereas, the concept Internet-of-things derives about the things or objects start communicating between each other. The Internet-of-things has a special characteristics of two-way communication systems i.e. communication between things-to-people and things-to-things. From the Appendix Figure4, we could observe the main idea and difference between how Internet-of-things and internet works.

According to (Vermesan and Friess 2014) *The Internet-of-things is a network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.* The Internet-of-things (IOT) is an essential and foundation path for the smarter world with global computing and networking technology. It aims to create different task easily for the users and provide an easy way of monitoring the work around us like transportation of goods etc.

As the author's (Bahga and Madisetti 2014) explained in their book, the scope of IOT is not limited to just connecting things(devices , appliances, machines)to the Internet. IOT allows these things to communicate and exchange the data among them (control and information, that could include data associated with users) while executing meaningful applications towards a common user or machine goal. Data itself does not have a meaning until it is contextualized processed into useful information.

Smart objects are nothing but tagging a consumer good with the visual and unique code. The smart objects plays a key role in IOT since, the embedded information and communication technology helps to interact with the devices. The Internet-of-things offers a solution based on information technology and communication technology by storing and exchanging the data between individuals and different groups. According to (Vermesan and Friess 2014) Internet-of-things is a concept and a paradigm that considers pervasive presence in the environment of a variety of things/objects that through wireless and wired connections and unique addressing schemes are able to interact with each other and cooperate with other things/objects to create new applications/services and reach common goals.

The author (Fleisch 2010) explained clearly in his article that , the basic difference between internet and Internet-of-things in a derived way,

a) *Hardware:* The hardware in IOT is different and serves for different purpose. They are very small, in many cases invisible, low end and low energy consumption computers. They typically feature only small fraction of functions and require a limited amount of information for sensing and storing. Whereas the internet are full-blown computers from high capacity, work stations to mobile phones that require regular access to power grids.

b) *Identification and Addressing:* In IOT the identification and addressing never ends, in most cases the Internet-based identification and addressing require too much capacity to become part of low-end smart things. Therefore, academic and industrial communities are searching for alternative technologies and standards (EPC, ucode, IPv6 etc.) to number and address the smartening physical world.

c) *Communication and Services:* The internet-based services targeted towards human beings as users. Whereas, the IOT is almost completely exclude humans from direct intervention. They are smarting things and communicate among each other and with computers on the internet a machine-to-machine way. When user need to be involved e.g. for decision-making they currently contribute via personnel computers and mobile phones.

d) On the *infrastructure level,* the IOT can be view as an extension of Internet. It is based on the technical internet building blocks such as DNS, TCP, and IO with identification and addressing schemes, last mile communication technology and an Internet gateway that matches the IOT requirements, foremost among them low energy consumption, low cost and mobility.

e) On the *application level*, IOT application never work individual, but always use internet based services. So, IOT applications might simply observed as a special set of Internet applications.

The Internet-of-things aims to enable the things those connect in the network anytime, anywhere with anyone ideally using the service. They act as a bridge between the Internet and physical world and reduce the transaction cost between real and virtual world. The objects with unique identity connected in the network make themselves recognizable. The IOT technologies opens a new business process models for Logistics and manufacturing companies and make the exciting models highly efficient and more profitable.

2.1.1. History of Internet-of-things(IOT)

The Internet-of-things is not a new concept to the world. It has been in operation since long time. It relates to the family of computer science and electronics and communication technology. It has taken a new model that combines the objects and connecting them remotely and sharing the data. This concept provides a connection between the real world and the virtual world.

In 1990 the first things was born known as *Internet Toaster* by John Romkey and Simson Hackett in their first connected Toaster device powered by the Internet. After ten years later in 1999, after the thing toaster connected to the internet, the Kevin Ashton coined the term Internet-of-things. Later in the same year, Dr Andy Stanford-clark of IBM, and Arln Nipper of Arcom introduced the first Machine-to-Machine Protocol for connected devices (Oweis et al. 2016).

However, it has been more than 15 years the coinage of the term Internet-of-things, in this time period there are more than 15 billion devices connected worldwide. The main goal and vision of IOT says that they should connect 50billion devices by 2020.

If we observe form, the past fifteen years history of IOT, the concept Internet-of-things was introduce to identify the products and goods with a unique code and data transmission between the things.

2.1.2. Characteristics of Internet-of-things

Internet of thigs have wide variety of characteristics. The summary of the characteristics was explained by (Bahga and Madisetti 2014) in their book.

1. *Dynamic and Self-Adapting:* IOT devices have the capability to dynamically adapt with the changing contexts and take actions based on their operating conditions, users context or sensed environment.
2. *Self-Configuring:* The devices have a capability of allowing a large number of devices to work together to provide certain functionality. These devices have an ability to configure themselves, setup networking and fetch latest software upgrades with minimum manual or user intervention.
3. *Interoperable communication Protocol:* IOT devices can communicate with other devices and within infrastructure.
4. *Unique Identity:* Each IOT devices has a unique identity and a unique identifier. The IOT devices interfaces allows users to query the devices, monitors their status and control them remotely.
5. *Integrated into Information Network:* IOT devices generally integrated into the information network that allows them to communicate and exchange the data with other devices and systems. The grate feature of IOT is that they can be dynamically

discovered in the network by other devices or the network and have capability to describe themselves to other devices or user applications.

2.1.3. Benefits of Internet-of-things

The key benefits of Internet-of-things are described by (Mattern and Floerkemeier 2010)

- *Communication and cooperation:* The IOT objects have the ability to combine with the internet resourced or even with each other to make use of data and service, and update their state.

- *Addressability:* Within the Internet-of-things, objects can be located and addressed via discovery, look-up or name services, and hence remotely interrogated or configured.
- *Identification:* IOT Objects are uniquely identifiable with the use of unique identity. RFID and optically readable bar codes are good examples of technologies with which even passive objects are identified. Identification enables objects to be link to information associated with the particular object and that can be retrieve from a server, provided the mediator connected to the network

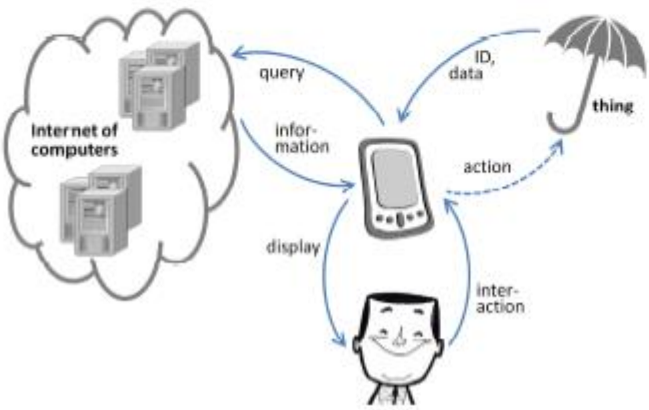


Figure 7 Identification Process of Things(Mattern and Floerkemeier 2010)

- *Sensing:* objects collect information about their surroundings with sensors, record it, forward it, or react directly to it.
- *Actuation:* Objects contain actuators to manipulate their environment. Such actuators can be used to remotely control real-world process via internet.
- *Embedded information processing:* the embedded objects and Smart objects has a feature of storage capacity and a microcontroller. These resources can be used to process and interpret the information from the sensor and provide the product memory.
- *Localization:* smart things are aware of their physical location, or can be located. Using the RFID sensors devices to capture and retrieve the data.
- *User interfaces:* Smart objects can communicate with people in an appropriate manner (either directly or indirectly, for example via a smartphone). Innovative interaction paradigms are relevant here, such as tangible user interfaces, flexible polymer-based displays and voice, image or gesture recognition methods.

2.1.4. IOT Elements:

As authors (Al-Fuqaha et al. 2015) explained in their survey paper that, understanding IOT building blocks helps to gain a better insight into the real meaning and functionality of the IOT as shown in Figure 8.

a) *Identification:* Identification is a fundamental for the IOT to name and the services with their demand. However, there are many identification methods are available I the market for IOT like |Electronic Product code, Ubiquitous codes. Then the second most important point is addressing the IOT objects, it is critical to address the objects and to differentiate between the object ID and its address. Distinguishing between the objects identification and address is imperative since identification methods are not globally unique, so, addressing assists to uniquely identify objects. In addition, objects within the network might use public IPs and not private ones. Identification techniques are used to provide a clear identify for each object with in the network.

b) *Sensing:* The IOT sensing means gathering data from related objects with in the network and sending it back to the a data warehouse, database or cloud. The collected data is analyzed to take specific actions based on required services. According to author (Mattern and Floerkemeier 2010) the IOT objects collect information about their surroundings with sensors, record it, forward it, or react directly to it.

c) *Communication:* The IOT communication technologies connect heterogeneous objects together to deliver specific smart services. Mainly the IOT nodes should operate using lower power in the presence of lossy and noisy communication links. The RFID is the first technology used to realize the M2M concept.

Figure 8 IOT Elements(Al-Fuqaha et al. 2015)

d) *Computation:* Processing units like microprocessors and microcontrollers and software applications represent the brain and the computational ability of the IOT. Cloud platforms are another important computational part of IOT. These platforms provide facilitates for smart objects to send their data to the cloud, for big data to be processed in real time and eventually for end users.

e) *Services:* IOT services can be categorized under four classes

- *Identity-related Services:* This services are the most basic and important services that are used in other types of services. Every application that needs to bring real world objects to the virtual world has to identify those objects.

- *Information Aggregation:* This Services collect and summarize raw sensory measurements that need to be processed and reported to the IOT application.
- *Collaborative-Aware Services :* This Services act on top of Information Aggregation Services and use the obtained data to make decision and react accordingly
- *Ubiquitous Services:* This services however, aim to provide Collaborative-Aware Services anytime they are needed to anyone who needs them anywhere. The ultimate goal of all IOT applications is to reach the level of ubiquitous services

f) *Semantics:* Semantic in the IOT refers to the ability to extract knowledge smartly by different machines to provide the required services. Knowledge extraction includes discovering and using resources and modelling information. Thus, semantic represents the brain of the IOT by sending demands to the right resource.

This master thesis is mainly based on the first three elements of the IOT i.e. identification, sensing and communication. The Identification of objects discussed using GS1 global standards in section. Whereas sensing and communication are based on using of RFID and identifying the current information flow between the companies, using VSM and Data flow diagrams discussed in sections.

2.1.5.IOT Challenges:

By Understanding the vision of the IOT, it reveals that implementation IOT in Logistics is not an easy task. It encompasses many challenges that need to be addressed before adapting it. Some of the challenges are discussed below:

a) Security and Privacy: Security presents a significant challenge for the IOT implementations due to the lack of common standard and architecture for the IOT security. IOT is a heterogeneous network; in this, it is not easy to guarantee the security and privacy of users. The main idea of IOT is based on the exchange of information between billions or even trillions of Internet connection objects. Therefore, the major problem in IOT security that has not been considered in the standards is the distribution of the keys amongst devices(Al-Fuqaha et al. 2015).

b) Scalability: The scalability of the IOT refers to the ability to add new devices, services and functions for customers without negatively affecting the quality of existing services(Al-Fuqaha et al. 2015).

c) Availability: Availability of the IOT must be recognized both in the hardware and software levels to deliver real-time services for customers. Software availability refers to the capability of the IOT applications to provide services for everyone at different places simultaneously. Hardware availability refers to the existence of devices all the time that are compatible with the IOT functionalities and protocols(Al-Fuqaha et al. 2015).

2.2. Logistics and Supply chain Management

The supply chain management is the broader concept compared to logistics. Author Martin Christopher explained in his book that, Logistics is essentially a planning orientation and framework that seeks to create a single plan for the flow of products and information through business. Supply chain management builds upon this framework and seeks to achieve linkage and coordination between processes of other in the value chain as shown in Figure 9. The supply chain management is defined as *the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole*(Christoper 2011). In other words, the supply chain management is a network of organizations those are involved in upstream and downstream with independent process and activities take over to provide a value to customer or end user.

The most important point in Logistics is that any firm is not able to control its entire material flow from foundations of raw materials to the point of final consumers. So in order to have a smooth production the companies are supported by their suppliers or distributors. In this whole process from raw materials to final consumption, most of the companies will participate to satisfy the customer needs, all parties should involve in this, and the information sharing between the parties plays a major role to satisfy the customer.

According to the Logistics Council Management, the term Logistics means *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 form point of origin to point of consumption for the purpose of conforming to customer requirements*(Basu and Wright 2008*)*. The logistics system includes different organizations and involves different activities that supports the operations. It also includes the different activities those held in different functional units in a firm, the organizational structure would be design in a way that there should be the communication among the units. The information flow plays a major role in the firm because, the information resources is used to facilitate communication between the different players involved in the logistics process and allow access to make decisions with the use of data provided.

According to (LAI and Cheng 2009) *A logistics system starts with the provision of raw materials, in-process inventory and finished goods by suppliers. The management actions, that is, planning, implementation and control, provide a managerial framework for firms to perform and required logistics activities to attain such business goals as the creation of time and place utility and the reduction of cost.* The main goal of Logistics system is to combine and coordinate all the organizational players in material management and physical distribution in such a way that the consumers served in the most profitable way. In order to achieve this every organization should balance their inbound and outbound logistics.

The main core elements in the logistics system are Customer service, order processing, Inventory management and transportation

Customer Service: According(LAI and Cheng 2009) the customer service refers to the quality with which flow of goods and services is managed. The customer service represents the output of the logistics system and plays an important role in creating, developing and maintaining customer loyalty and customer satisfaction because it is where the customers directly experience the products and services provided by the firm. Therefore, this describes that all about receiving the right goods to right customer in right time with lowest cost possible.

Order processing: This is all about collecting the sales order and transmitting the information's to different departments. The information collected will provide useful data for market analysis, financial estimation, logistics operations and production(LAI and Cheng 2009). The order processing plays the major role in the logistics activities because the information is important to getting goods and services to customer and generates the product movement and service delivery.

Inventory Management: It is all about managing the inventory and try to keep it as low as possible and serve the customer demand with low cost. . The main challenge of inventory management lies in the firm's ability to determine when various items should be ordered, how much to order and how often to meet customer demand while minimizing from the perspective of cost*(*LAI and Cheng 2009)

Transportation: It is all about moving of the goods between parties in the supply chain. Managing transportation is considered with selecting and utilizing the appropriate modes, routing and soon. In the other hand, improved transportation management can lead to increased sales, increased market share, and ultimately to increased profit contribution and growth (LAI and Cheng 2009)

In any organization, the value chain plays a prominent role. The value chain is nothing but all the parties belonging to the same chain and they challenged to improve the base firm value in proportion to its final customers. However, all parties in the value chain together working to satisfy the end user needs. According to (Weele 2010), The value chain is composed to value activities and a margin, which is achieved by these activities.

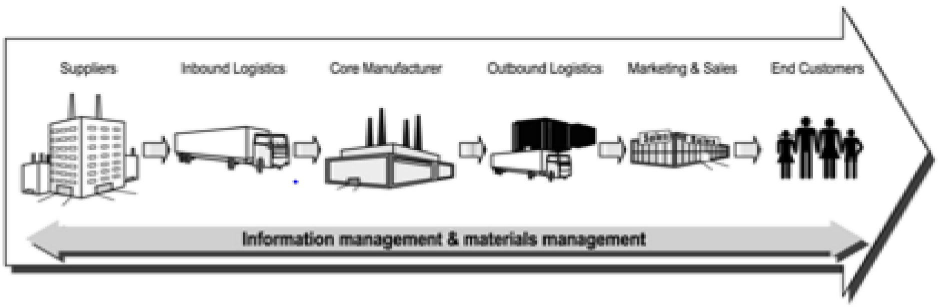


Figure 9 Supply chain Process (Schaar 2013)

2.2.1. Inbound Logistics

The inbound logistics simply described as a flow of goods and information from suppliers to the conversion center. From the above Figure 9 the inbound logistics is defined as the flow of information and physical goods from both customers and suppliers to the business or conversion center (Basu and Wright 2010). According to (Weele 2010) these activities are related to receiving, storing and disseminating inputs to production process such as inbound transportation, incoming inspection, material handling, warehousing, inventory control and reverse logistics.. Authors Lai and Cheng explained in their paper that the main objective of inbound logistics is to meet the needs of a firm for inbound items in an orderly, efficient and low-cost manner. The Inbound logistics activities are those activities involving receiving, sorting and disseminating inputs to the operations areas. The thrust of inbound logistics is to satisfy the operations needs of the manufacturing and service operations line (LAI and Cheng 2009).

2.2.2. Outbound Logistics

The outbound logistics simply described as a flow of finished goods from the manufactures to the consumer. From the above Figure 9, the flow of goods and information from the conversion center to the customer constitutes the outbound logistics(Basu and Wright 2010). According to (Weele 2010) these activities are associated with collecting, storing, and physically distributing the final products to customers such as finished goods warehousing, material handling, outbound transportation order processing and scheduling. Authors Lai and Cheng explained in their paper that, the main objective of outbound logistics is, subjected to a specified level of customer service, to minimize the cost involved in physically moving and storing the items from their point of production to the point they delivered(LAI and Cheng 2009). It mainly deals with the movement of finished goods, storing and procession of orders for organization outputs.

2.2.3. Manufacturing Environment

Nowadays, the manufacturing environment became more customized. The market has changed dramatically in last 25 years; the manufacturing companies should always to deal with dynamic demand situations, product variety, lead-times etc. Their main goal is to satisfy the customer with their specific requirements. Customization became an emerging trend. The customer interaction with the manufacturing companies is increased. Most of the companies are moving towards products and process customization. In early days, Manufacturers used to produce standardized products and components and store them in warehouse as an end inventory. Moreover, customers are no longer satisfied with the standard products and they expect more customized and unique products to full fill their requirements. The procurement function should be able to meet the material requirements related to operations management and inbound outbound logistics(Weele 2010). The operations may have different structures among manufacturing companies and their processes.

2.2.3.1. Engineer-to-order manufacturing environment:

The engineer-to-order manufacturing defined, as a production situation in which products are manufactured to meet a specific customer needs by unique engineering or significant customization. These companies typically supply capital intensive, advance and customized products in low volumes in fulfilment of customer orders.(Sjøbakk, Thomassen, and Alfnes 2014). Each order have different variations, specifications and the design based on customer requirements. In the ETO strategy, customer requirements have direct impact on the design and engineering stage of a product, pulling the product through the entire production process(Gosling and Naim 2009). However, this type of production system is highly expensive, more customized and labor intensive. In ETO supply chain the customer order decoupling point is normally located at the project starting stage i.e. design stage as shown in Figure 10. Therefore, the customer is highly involved in designing the product. According to (Gosling and Naim 2009) the customer order decoupling point(CODP) is a stock holding point that separates the part of the supply chain that responds directly to the customer from the part of supply chain that uses forecast planning. ETO companies vary in terms of degree of vertical integration in various levels of the product structure(Sjøbakk, Thomassen, and Alfnes 2014).

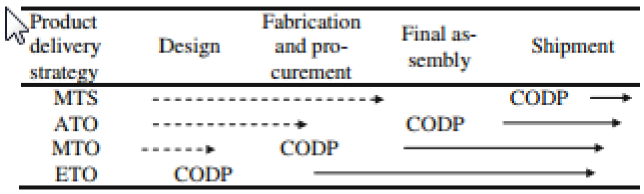


Figure 10Productions situation and CODP (Olhager 2003)

Characteristics of ETO:

The engineer-to-order companies mainly deals with the complex products, which requires high customer integration for product structure and low volume of the products. These products sometimes consist mix of standardized and customized components with a high degree of product variety and long lead times. The main challenges for ETO companies are production planning and control, handling change orders, product quality and material waste etc. therefore, the ETO companies faces a lot of risk in production of the complex products, based on technical time risk , financial risk etc. because of uncertainty in product specification. The below Figure 11 explains the characteristics of the different manufacturing environments.

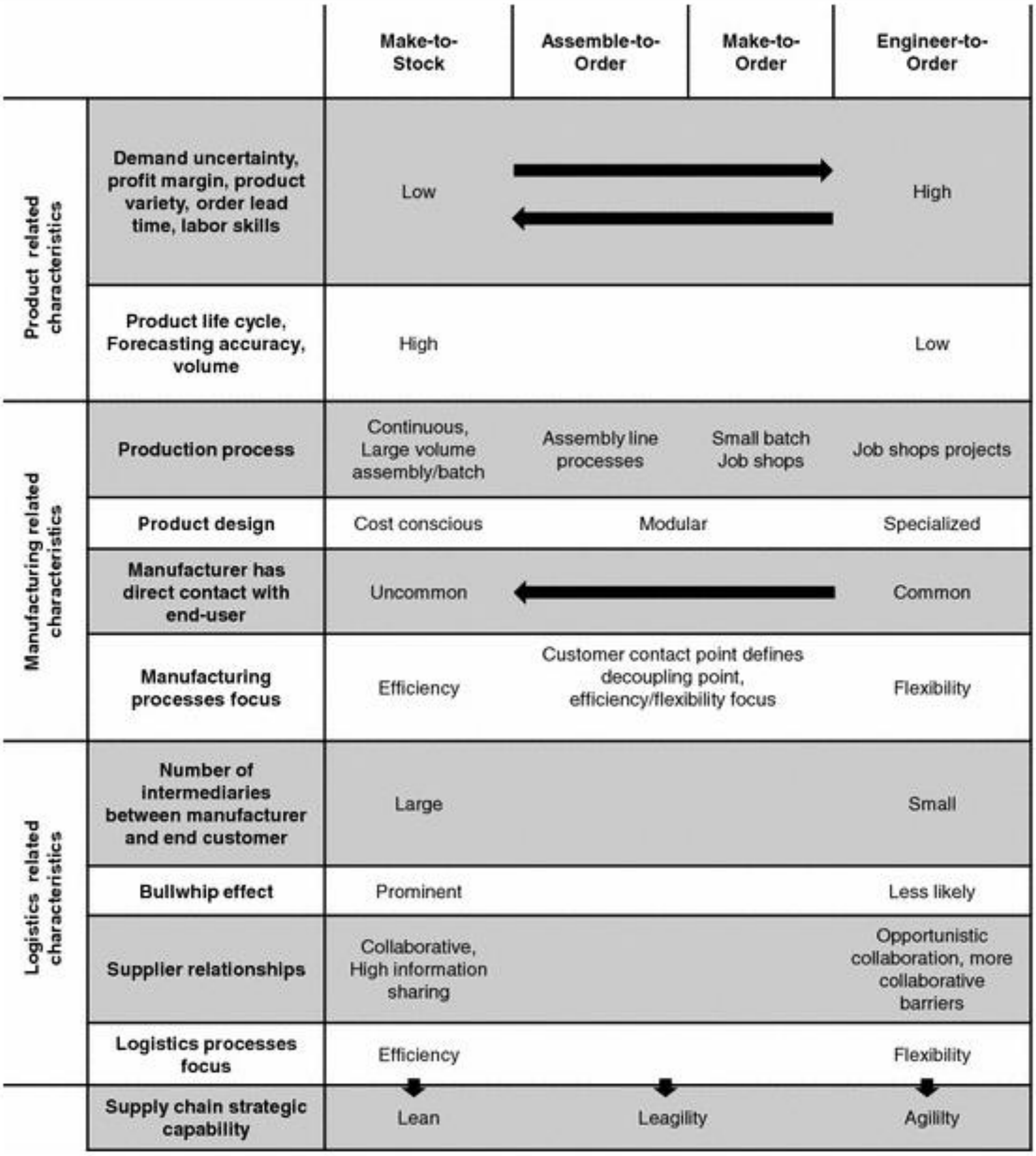


Figure 11 Comparison of Supply chain strategies with manufacturing Strategies(Hofmann, Beck, and Füger 2012)

The strategy of ETO manufacturing companies is different when compared to other manufacturing strategies like MTO and make-to-stock (MTS). Moreover, ETO companies does not have inventory in their production system, because customized products. Each projects have different design and characteristics so, the lead-time of the delivery may increase see appendix 5. In ETO products, the total response time includes various elements like, project lead-time, lead-time of supplies, lead-time of Manufacturing, lead-time of assembly and lead-time of distribution(Rodrigues and Oliveria 2010).

2.2.4. Importance of Information sharing in Supply chain Management

Increase in the global competition, the organizations are focusing on the core business concept and outsourcing the other production process. This creates a bilateral dependence, sharing of the information about real demand between two trading partners can enable the development of products that better meet customer's needs. Moreover, highly coordination among actors can leads to the supply chain integration. The supply chain integration can reduce the costs and improve the dynamic demand which can ultimately lead to more satisfied customers and the elimination of waste, both of which should, in the end, produce better results(Popa 2012). The supply-chain visibility depends on degree of coordination among the actors in the supply chain. The lack of information sharing i.e. low visibility can increase the supply chain risk and costs.

As authors Kaipia and Hartiala described in their article that, Supply chain visibility does not mean sharing all information with all partners in the supply chain, but rather that the shared information should be relevant and meaningful. End-to-end visibility can be defined as *the sharing of all relevant information between supply chain partners, also over echelons in the chain.(*Kaipia and Hartiala 2006). In engineer-to-order companies the forecast is based on orders receiving form, the downstream. Moreover, the planning and production in ETO companies is based on the goods received from the upstream. The information plays very important role in ETO manufacturing companies because this can increase their cost and lead time of the products.

2.2.5. Value Stream mapping(VSM)

The main objective of using Value stream map in this thesis, is to map and visualize the information flow and material flow of the thruster product FU-100-LTC-2750-2050KW internally and externally of tier1 supply chain. Normally, the value stream map tool is not proposed for Internet-of-things, it is a Lean tool used to identify the wastes in the production flow. Even though, I would like to use the VSM for mapping because it visualizes each material flow with identification of goods (internal article numbers) and information flow internally in the companies. The main intention is to observe the present context of identification flow at each process with internal article numbers and internal information flow and external information flow.

Any manufacturing organizations first step is procurement, they buy the raw materials form their supplier and convert them into finished goods through a series of production processes. The raw material value is increased and finally it becomes the whole finished goods. According to (Nash and Poling 2011) a value stream is the material flow from the point of requested need to closure of all activity after product and service has been provided. In a manufacturing setting, the overall value stream is defined as from the point an order is received to the point the product delivered and payment received from the customer.

The author's (Chen and Meng 2010) described in their article, the value stream mapping is a technique with a pencil and paper that helps people to see and understand the flow of material and information as a product makes its way through the value stream. The elements of VSM include customer loop, production control, supplier loop, manufacturing loop; material flow with goods identification, information flow and lead time with critical path that make us have a full view of the whole supply chain from customer's requirements to supplier's delivery. This mapping tool used to understand the flow of goods and information between the parties in the value chain and inside the production process of a particular focal firm. This tool also provides the details about each process or activity, inventory between activities, times between processes, timeline, and mostly important here, the information flow from customer through the production process and to supplier as well as the material flow from the supplier through production process to the customer. The information flow appears on the top of the map and the material flow in the middle and the time line in the bottom. *The Value stream mapping helps us to understand where we are (Current State, AS-IS), where we want to go (Future State, TO-BE) and map a route to get there (Implementation Plan), which can create a high-level look at total efficiency, not the independent efficiencies of individual works or departments*(Chen and Meng 2010).

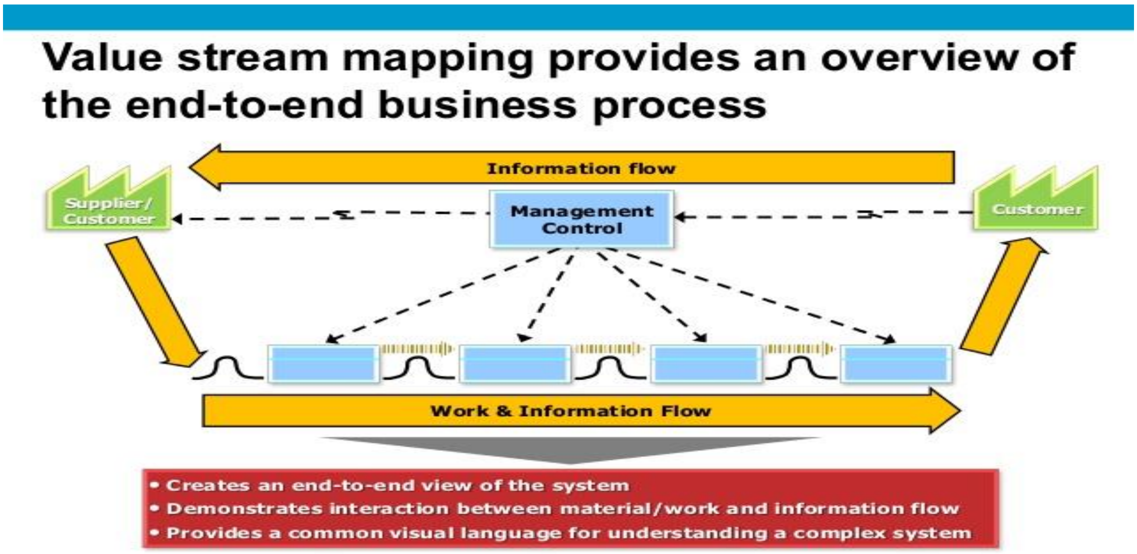


Figure 12 Value Stream Mapping (consulting 2015)

Why Value stream Map?

According to Authors (Rother and Shook 2003) the VSM helps to more than just a single process level in production and provides a common language for talking about manufacturing process. It also shows the linkage between the information flow and the material flow, no other tools does this see Figure 12. They also explains that material flow and information flow are two sides for a dice. In a manufacturing industry the production flow is a movement of materials but people should also consider there is another flow i.e. information flow which helps each process what to make next. There are five focusing steps to create a value stream mapping for a focal firm.

In this thesis, the moment of material flow consist of the identification of goods and the cycle time (i.e. the actual time taken to the production of the part). The pictorial representation of identification shows us the flow of ID and how many components are included to finish the final product (i.e. the over view of BOM). The second part is the information flow, as discussed earlier the importance of information flow in the supply chain. The visualization of information flow shows, how actors are performing with their task and mutual dependence among the actors in the supply chain.

As discussed in earlier section, that ETO companies have a different style of production system, they are more flexible and specialized production process. Plotting the VSM for the ETO companies is the one of the challenging part in this thesis.

Value stream mapping in ETO companies

As we discussed in earlier sections, regarding ETO manufacturing strategies that they have high level of product variety, complexity, and flexibility and low production volumes. The product variety characteristic of ETO creates more challenges in the material flow and production. Each product that they develop at the companies does not contain the same material flow. The main intention of using VSM in ETO companies is analyse of the material flow, information flow, services and customer–buying experience (Thomassen, Alfnes, and Gran 2015).

The VSM in ETO environments difficult to map multiple products with different routings and that it lacks suitable economic measures for value to other typical manufacturer performance parameters. The value in ETO companies includes analysis of the products, services and customer-buying experience. For example customers are more willing to have the shorter lead-time in delivery, in spite of price then it would become the value-adding factor to be fastest. The VSM of ETO companies needs to analyse all steps in manufacturing(Modrák 2014).

According to (Thomassen, Alfnes, and Gran 2015) the values stream mapping has two main draw backs for ETO manufacturing:

- The method does not address the challenges of identifying and mapping value streams in manufacturing environments where the product structure are complex and routings are intertwined.
- The customer order decoupling point is merely considered as frame condition for future state design, and how to position the decoupling point is not sufficiently addressed.

<u>Value Stream Mapping Approach:</u>

According to (Rother and Shook 2003), the Value stream Mapping tool helps us to visualize more than just the single process level in production and shows the linkage between the information flow and the material flow. Material flow and information flow are two sides of the same coin. However, generally there are five focusing steps to create a value stream mapping for a focal firm they are selecting a Product Family. The current state map start, the future state drawing and Work plan. On the other hand, the authors (Thomassen, Alfnes, and Gran 2015) proposed an approach for value stream mapping in engineer-to-order manufacturing system. the proposed approach consist of two main parts, first part deals with drawing the current state map and second part deals with designing the future state map. They also suggest that while drawing a VSM for ETO manufacturing companies it may be necessary to carry out each step in several iterations.

Step1: Select a product family:

According to (Thomassen, Alfnes, and Gran 2015)the product family is essential for defining an appropriate overall scope of the value stream. In ETO Manufacturing system this is a most critical and challenging part due to high complexity of products and irregular process routings. In order to identify the specific product family, a product-process matrix drawn to make groups of products with the same processing steps and work content matrix is plotted to analyse total operator time variation.

Step 2: Identify Critical Value stream:

The critical value stream is based on the product and its processing time. The Bill of Materials (BOM) is mapped for the selected product and the lead-time is analyzed for each branch components on the critical path are identified. A temporary BOM is drawn to show graphically the lead time and global value chain of supply and production(Thomassen, Alfnes, and Gran 2015).

Step 3: Identify Customer order Decoupling Point:

The customer order decoupling point is important in ETO companies as discussed earlier sections. Because this is related to share the resources and bottlenecks. In ETO the order based engineering lead time and the order based production lead time are parts of the delivery time and needed to be addressed in the CODP analysis(Thomassen, Alfnes, and Gran 2015).

Step 4: Map Critical Value Stream:

The current state map is designed based on the VSM modelling framework with standard icons and metrics as shown in Figure 13below. In ETO companies a high level of VSM is required to show the demand rates, process routing and lead time(Thomassen, Alfnes, and Gran 2015).

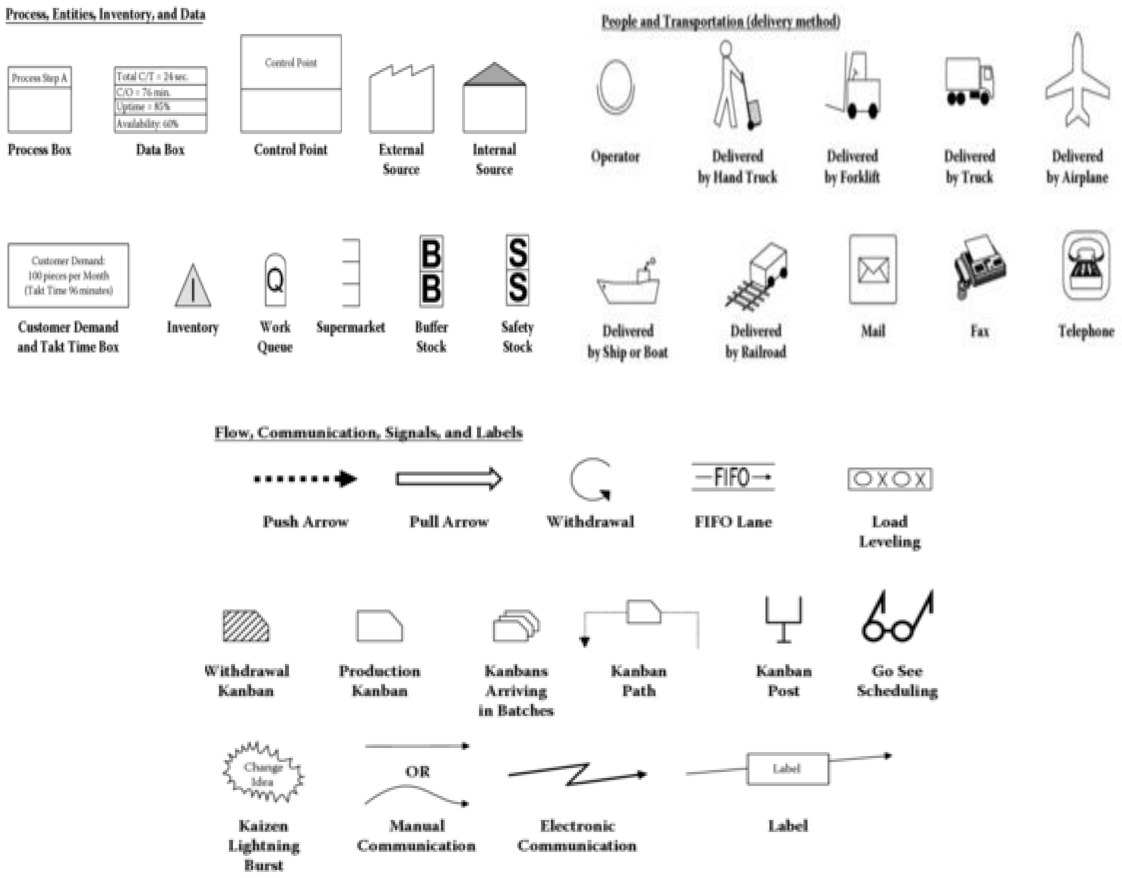


Figure 13 Basic Value Stream Mapping Icons(Nash and Poling 2011)

2.2.6. Data Flow Diagrams:

The data flow diagram is one of the suitable method to outline the data and process flow modelling in the supply chain. A data flow diagram (DFD) uses various symbols to show how the system transforms input into useful information(Shelly and Rosenblatt 2011). It is a structured system methodology with graphical nature and easily understandable. DFD also provides the analyst with the ability to specify the system at logic level and separates the task of analysis and design.

Why Data flow Diagrams?

When it comes to transmission of how the information flow described among the actors in the supply chain and how the information transformed in the process, the DFDs shows solution for these problems. A DFD shows how data moves through an information system but does not show program logic. It describes in brief that what the system will do, rather than how it does. It provide a researcher the detailed information flow among the actors and mainly focusing on process and information flow across the actors(Shelly and Rosenblatt 2011).

In this thesis, the main intention to use the DFD to show the detailed information flow internal and external supply-chain of the proposed companies. According to (Donald 2016) the DFD are the method of choice over technical descriptions for three principal reasons.

- DFDs are easier to understand by technical and non-technical audiences
- DFD can provide high level system overview, complete with boundaries and connections to other systems
- DFDs can provide a detail representation of systems components.

DFDs help system designers and other during initial analysis stages visualize a current system.

2.2.6.1. DFDs components:

A DFD is a graphical representation and it is composed of four basic components that illustrates how data flows in a system: entity, Process, Data store, and Data flows. The symbols for plotting the DFD is shown in Figure 14.

i) *Entity:* As author, Donald explained in this article that, an entity is the source or destination of Data. Entities either provide data to the system like sources or receive data from it like sink. The sink are usually external to the organization(Donald 2016).

ii) *Process:* The name itself describes the transformation of input to some output. The process is the manipulation or work that transforms data, performing computations, making decisions or directing data flows based on business rules(Donald 2016). Moreover, the process consists of three different segments like reference number of the process, description of the process and occurrence of the process. The process should at least have one data flow in and out.

iii) *Data Store:* A data store is where a process store data between process for later retrieval by that same process or another one. The data store is updated using different processes(Donald 2016).

iv) *Data Flow:* It is a movement of data between the entity, process and the data store. Data flow portrays the interface between the components of the DFD(Donald 2016).

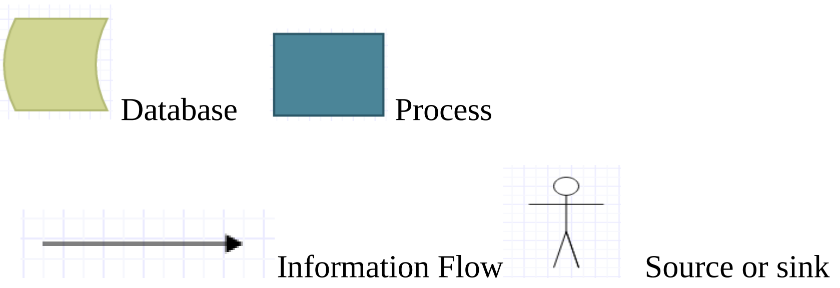


Figure 14 Data Flow Diagram Symbols

As author, Donald explained in his article that the Data flow between entities would be difficult because it would be impossible for the system to know about any communication between them. The advantages of using DFDs are it provides a quick and easy project code and easy to learn and understand the visualization. The disadvantages are plotting DFD for large system can be difficult to understand and time consuming(Donald 2016).

2.3. Global Standardization

The technology development in supply chain industries brings new business models in combination with the internet like e-business and e-services etc. to market, e-procurement, e-auctions and e-communication over internet will be more efficient if developed on common based standard platform. The global standards is a comprehensive set of methods and rules allowing the user community and affected industry groups to submit and influence the creation and maintenance of globally agreed standards and guidelines . However, this can improve the communication and lead to vertical integration in the supply chain.

2.3.1. Why Global Standards?

Information sharing is the main perception in global standards, the availability and transparency of information sharing between different actors, across the supply chain will improve the vertical integration across the supply chain. However, this could be achieve through the high level of collaboration and companies should have good Information technology. The transparency of trace and track technology requires a certain level of interoperability across the supply chain participants.

Information sharing can address three key areas in a product life cycle: Greater sharing of information about consumer trends and market trends between trading partners can lead to greater insights into consumer behaviour, enabling both partners to serve better the consumer. Sharing information about real demand between two trading partners can enable the development of products that had better meet consumers' needs. Sharing of accurate, real-time operational information between the two trading partners can lead to better use of assets in the supply chain. This can improve product availability and consumer satisfaction at the point of purchase. Accurate information is the basis of any commercial enterprise. This is particularly true in the fast-moving, quick-response world of manufacturing and retail (Popa 2012) .

The global standards improve the visibility in a dynamic Logistic chain by the awareness and control over specific information related to products orders and physical shipments, including transport and logistics activities and the statues of events and milestones that occur prior to and in transit(Ryan 2013).

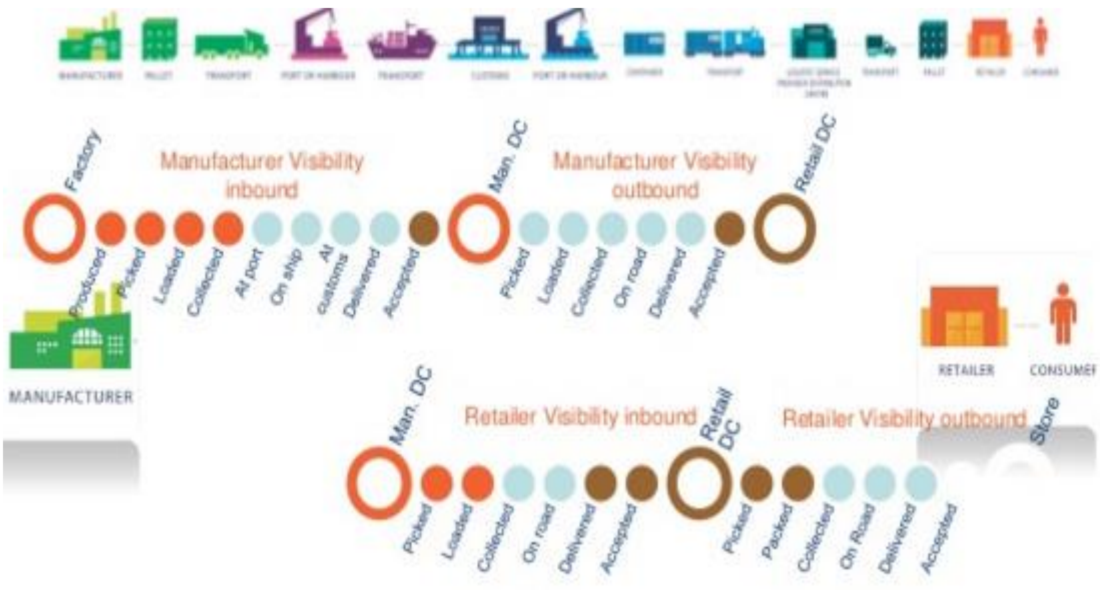


Figure 15: Supply chain Visibility(Ryan 2013)

The main advantages with global standards is to improve the productivity in logistics system and improve the trace and technology. In these global standards, the standard identification code of the container is accessed thorough internet. With this access to real time information about the flow of products and transactions in the supply chains, the companies make the decision dynamically and reduce the cost. Therefore, in order to achieve this the companies in the supply chain should have the same language and same identification keys as show in Figure 15.

2.3.2. GS1 Standards

The GS1 is a non-profit organization that develops identification and sharing of the data across the supply chain. According to (GS1 2015a) GS1 standards create a common foundation for business by uniquely identifying, accurately capturing and automatically sharing information about products, services and move efficiency and securely through supply chain as shown in Figure 16 . They enable visibility through exchanging of authentic data and empower business to grow and to improve efficiency, safety, security and sustainability. The GS1 system of standards can help trading partners to uniquely identify individual products, trading partners, locations, logistics units, assets, shipments and services and linking the physical flow of goods to the information flow all along the supply chain by capturing and share data.

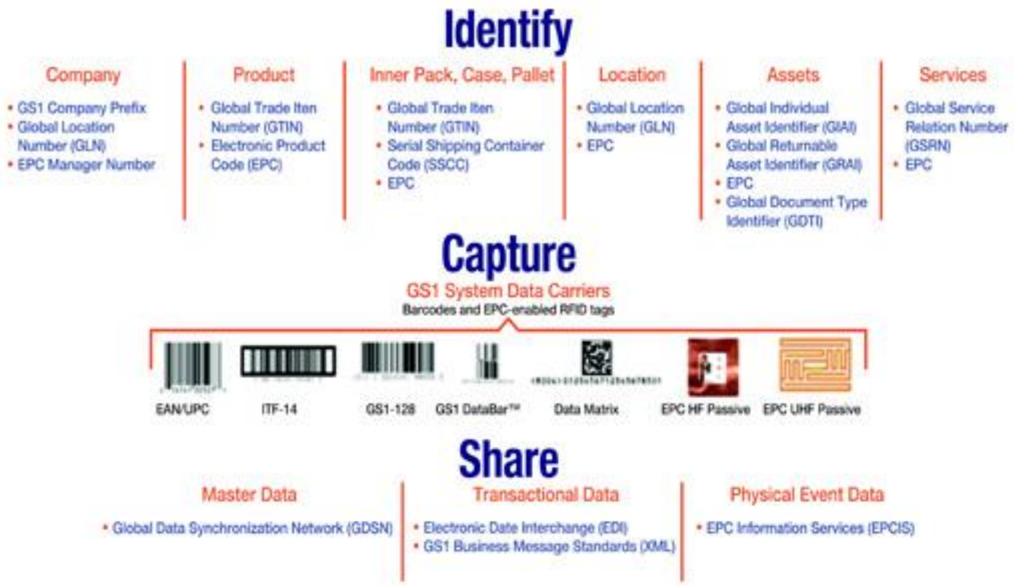


Figure 16: Gs1 Architecture (Gs1 2016)

The GS1 Chairman Mike McNarma explained that without GS1 companies would have created many point-to-point solutions, which would have been very difficult to operate and very expensive as well. Without GS1 data quality initiatives, every retailer would have had to check the quality of every manufactures data: again expensive and difficult (GS1 2015a).

In logistics, the GS1 provides visibility of goods moving from source to consumer. They enable an integrated infrastructure and an alignment of supply chain process such as delivery management, warehouse management, inventory management, transport management and asset management. These standards enable the Logistics service providers should focus on providing value added services to their clients: support transport operators with advance planning and execution; contribute to safer and more efficient borders so products arrive faster; and enable accurate inventory and optimized forecasting and ordering. The Gs1 standards also provide an up-to date information about their shipments so that they can make good decisions and dynamic planning about production system(GS1 2015b).

The Transport & Logistics industry involves the movement of goods using multiple transport modes, including road, rail, air and maritime. Similarly, this industry involves a wide variety of parties such as consignor and consignee, freight forwarders and carriers as well as official bodies like customs and port authorities. The combination of logistics channels and parties implies an opportunity to simplify asset and shipment identification using GS1 Identification Keys and sharing this information between carriers and other service providers(GS1 2013b).

The GS1 standards mainly consists of two elements: Automatic Identification standards and communication standards

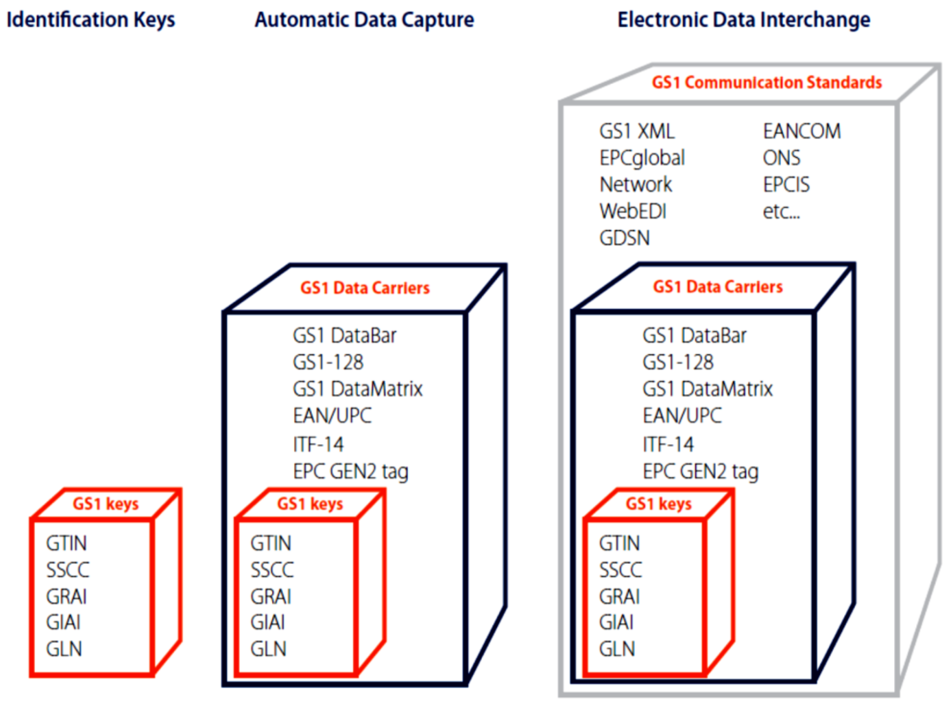


Figure 17: Gs1 Standards (Semianiaka and Silina 2012)

2.3.2.1. Identification

Identification of material plays a major role in logistics and supply chain management. The GS1 provides an automatic unique identification standard for different units. GS1 identification standards include standards that define unique identification code, which may be used by an information system to refer unambiguously to a real-world entity. ID keys enable the organization to assign standards identifiers to products, documents, physical location and more see Figure 17. GS1 ID keys provide companies efficient ways to access information about items in their supply chains, and share this information with trading partners(Gs1 2016).. This identification standard consists of Identification keys and data carriers. These are very important in information sharing across the supply chain. There exists different ID keys for different assets or domains like GTIN, GLN, SSCC, GRAI, GIAI, GSRN etc.

i. Global Trade Item Number(GTIN):

All assets start their life cycle as a trade item and identified by a global trade item number (GTIN). Once a company acquires such a trade item (e.g. logistics service provider, pool operator or another company), the company may classify that item as an asset. Each asset requires an appropriate identifier to ensure efficient asset management(GS1 2013b). Because, most of the companies typically use their own product identification number for assets i.e. the same product might have several GTIN numbers. Therefore, Industry wide cooperation, governmental control or other means are needed to establish global identification of items(GS1 2013a). GTIN identifies trade items, which are priced, ordered or invoiced at any point in the Supply Chain. This enhances visibility and lays the foundation for capturing and sharing information in an efficient and collaborative value chain(GS1India 2016).

Composition of GS1 Identification Keys for GTIN:

0614141.112345.400

CompanyPrefix .Itemnumber.SerialNumber

- *Company Prefix:* GS1 standards provided some company prefix numbers based on location of company. For example, Norway Company Prefix starts from 700-709. GS1 Company Prefix is a unique number assigned by the local GS1 organization to each subscriber company(GS1India 2016).

- *Item number:* The item reference number is a unique number assigned by the subscriber company to each individual entity like its products, locations, shipments etc.(GS1India 2016).
- *Serial Number:* The Serial Number, assigned by the managing entity to an individual object.

ii. Global Location Number (GLN):

In the value chains the operations of flow of goods form from physical location to other. The ability to have visibility to these movements is an essential element in any supply chain. GLN used to identify the physical locations and parties where there is a need to retrieve pre-defined information to improve the efficiency of communication with the supply chain. In logistics, physical locations are essential dimensions of planning, control and execution processes(GS1 2013b).

GLN identifies locations (physical, operational) and legal objects. Physical Location indicates structures such as a building, warehouse, loading dock, or even a specific shelf within a store. Whereas, operational indicates the data receivable points like EPC code and RFID read points and a legal entity indicates a company. GLN, as opposed to a proprietary internal numbering system, provides a standardized way to uniquely identify locations. GLN is a pre-requisite for key applications such as efficient electronic commerce and Global Data Synchronization(GS1India 2016).

Components of Identification keys for GLN:

0614141.112345.400

CompanyPrefix .Location number.SerialNumber

iii. Serial Shipping Container Code(SSCC):

The Serial Shipping Container Code (SSCC) is the GS1 Identification Key for logistic units in the GS1 System. Logistic units are goods packed together for transport and storage. Logistic units take many forms a single box containing a limited number of products, a pallet of multiple products or an intermodal container containing multiple pallets see Figure18. As a logistic unit moves through the supply chain, a series of events occurs that defines the information related to the unit. The whole supply chain process of manufacturing, finished goods distribution, transportation, and deployment into the marketplace adds layers of information related to the logistic unit.

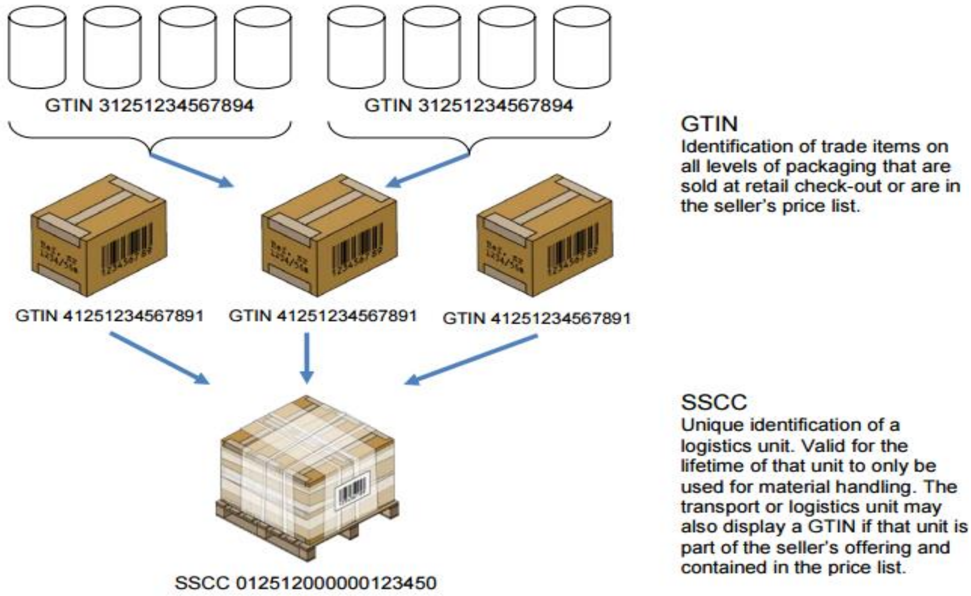
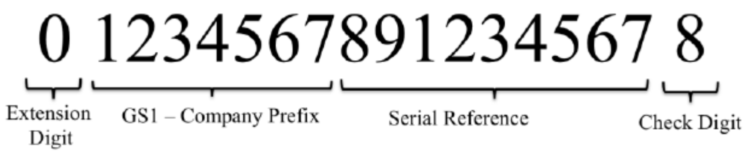


Figure 18: Serial Shipping Container code(GS1 2013b)

The SSCC provides a single, global means of uniquely identifying logistic units, which can be any combination of items packaged together for shipment. This code can be re-used and it has a unique 18-digit number that comprises an Extension Digit, GS1 Company Prefix, Serial Reference and Check Digit, which remains the same for the life of the logistic unit to which it is assigned.

Components of Identification keys for SSCC:



Extension digit: The Extension Digit can have any value from 0 to 9 and is used to increase the numbering capacity of the Serial Reference. Its use is at the discretion of the company allocating the SSCC(GS1 2015c).

Company Prefix: GS1 standards provided some company prefix numbers based on location of company. For example, Norway Company Prefix starts from 700-709. GS1 Company Prefix is a unique number assigned by the local GS1 organization to each subscriber company(GS1India 2016).

Serial Reference: The Serial Reference is a serial number created by the company allocating the SSCC. The simplest way to allocate the serial number is sequentially(GS1 2015c).

2.3.2.2. Capture

GS1 data capture standards currently include definitions of bar code and radio-frequency identification(RFID) data carriers which allow GS1 identification keys and supplementary data to be affixed directly to a physical object, and standards that specify consistent interfaces to readers, printers, and other hardware and software components that connect the data carriers to business applications(Gs1 2016).

2.3.2.2.1. RFID

RFID (Radio Frequency Identification) is a wireless communication technology, used to identify the tagged objects. In the current situation, the manufacturing companies were using this technology for traceability and visibility of the goods and pallets. RFID is becoming a cost-effective technology in day-to-day life. However, RFID is a two-way communication device, which is connected directly to an item, or pallet or case. The RFID has an ability to be a networked without any human interference. According to (Hunt, Puglia, and Puglia 2007), the Wal-Mart and DOD incorporate RFID technology into their supply chains in 2003 with the aim of enabling pallet-level tracking of inventory, Wal-Mart issued an RFID mandate requiring its top 100 suppliers to begin tagging pallets and cases by Jan 2005 with EPC(Electronic Product Code) .

Why traceability is important?

Globalization become a strategy for current manufacturing companies. Most of the manufacturing companies were moving to customization of the products than producing the standardized goods. The pressure form the customers are also increased, they required unique product with different functionalities etc. therefore, the manufacturing companies were focusing on traceability and visibility for producing the goods according to dynamic demand and interests. Traceability in manufacturing helps manufacturing ensure compliance with government regulations; better protects its brands, consumers, and performs rapid, focused and cost effective product tracking and tracing that minimize financial impact (Wang 2014). Traceability can reduce the costs, the cost integrated with production, checks penalties and reducing recalls can hold potential savings. By forecasting the information from the current procedure of their products, the future trend or the probability that accident happens is estimated, remedy measures can be adopted to the warning can be given ahead(Sun 2012).

<u>How RFID enable traceability in extended supply chain Networks?</u>

The Auto identification technology is a new way for controlling information and material flow in large production or supply networks. RFID belongs to an Auto ID and capturing technologies like barcodes, touch memory etc. RFID technology uses radio frequency to identify the products in the given supply chain. An RFID system consist of three major layers(Wamba and Boeck 2008):

a) <u>Tags:</u> also called as transponder containing a chip, which is attached to, or embedded, in a physical object to identify. Tags are made of hard copper coil consisting of an integrated circuit (IC) and data is stored in the IC and transmitted through antenna to the reader. RFID tags can be passive (no battery) and active (self-powered by a battery). Tags can be read-only, where stored data can be read but not altered. RFID tags can provide vast amount of information compared to barcodes(Attaran 2007).

b) <u>Reader:</u> also called interrogator and its antennas, which communicate with the transponder without requiring a line of sight. Readers using an attached antenna capture data from tags then pass the data to a computer for processing. The information exchange between RFID tag and reader is comprehensive, including everything from numeric data on the carton to manufacturing details(Attaran 2007).

C) Host server equipped with a middle ware application that manages the RFID equipment filters data and interacts with enterprise applications.

<u>EPC global Network:</u>

The Electronic product code (EPC) global network aims to provide real-time data about individual items as they move through global supply chain (Glover and Bhatt 2006). The EPC Network is a method for using RFID technology in the global supply chain by using inexpensive RFID tags and Readers to pass EPC numbers and then Leveraging the internet to access large amounts of associated information that can be shared among authorized users. Moreover, products with an EPC tag have the ability to communicate with their environment and make to trigger basic dimensions relevant to their management such products are also called smart products (Wamba, Lefebvre, and Lefebvre 2007).The EPC global network offers the potential for increased efficiency and accuracy in tracking products between trading partners(Glover and Bhatt 2006).

Electronic product code Information Services (EPCIS) defines a standard interface for capturing and sharing EPC related data.it provides a way to share high volume, detailed information about material movement and status among trading partners. The EPCIS does not address purchasing, forecasts, biding billing etc.(GS1 2010).

RFID enabled real-time visibility and traceability significantly improve the supply chain inventory management and shop floor management by improving the automatic goods receipt as shown in Figure19.

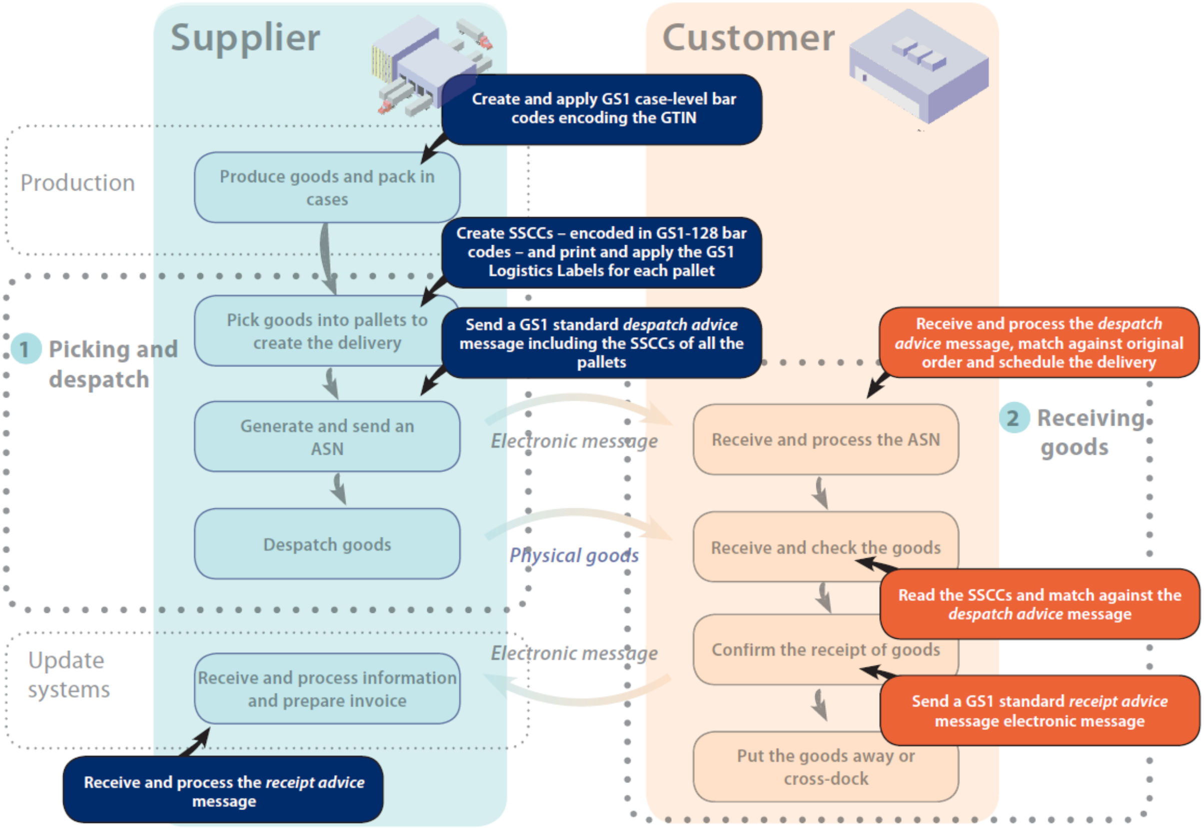


Figure 19 Automated goods receipt(Gs1 2016)

2.3.2.3. Share

The information sharing of GS1 include data standards for master data, business transaction data, and physical event data, as well as communication standards for sharing this data between applications and trading partners. (Gs1 2016). Master data is a static information about products, location contracts and prices. This master data is stored in GDSN (Global Data Synchronization network) and available through scanning or reader. The GDSN enables trading partners automatically share their business data with each other. This means that the required information regarding the product or pallet shared and updated between the actors in the supply chain(Gs1 2016).

In order to obtain this the companies should register in the global register data pool, which is secured and organized by GS1. The below Figure20 shows how the GDSN works

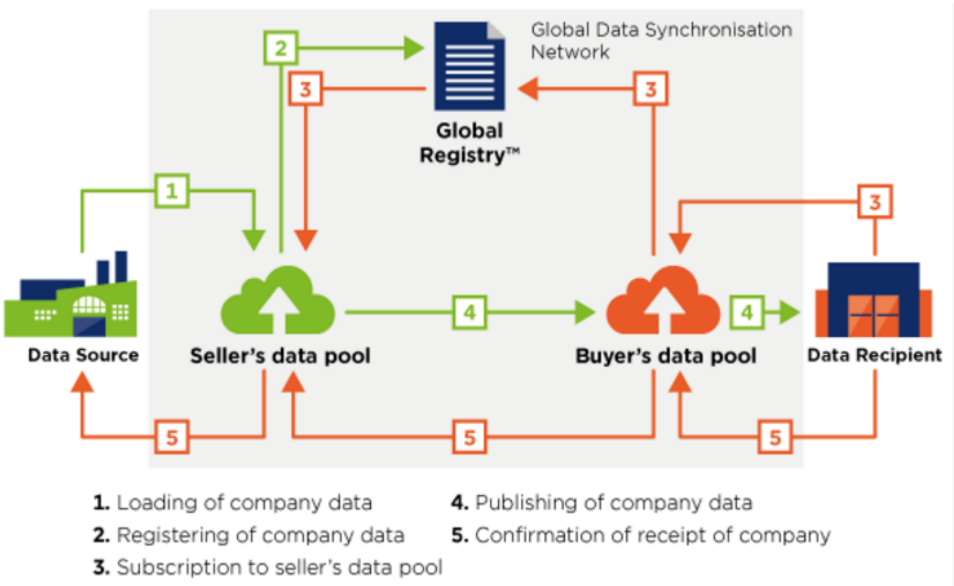


Figure 20 Global Data Synchronization Network(Gs1 2016)

2.3.3. Benefits of Global Standardization

The use of global standardization of products provide a great number of befits for actors in the supply chain. The global standards can improve the supply chain visibility, traceability and information sharing internally and externally. There are some most common benefits discussed below(GS1Goregia 2011):

- Accurate and Efficient storage management
- Automatic capturing of product data and automatic re ordering
- Reduce errors and improve productivity at check out.
- Reduce inventory, labour and administrative cost.
- Improves the logistic operation and enables the total traceability of products through demand and supply chain.
- Enables the transmission of massages through electronic data interchange.

2.4. Integration of Internet-of-things and Logistics

Traditionally, logistics and distribution networks based on a combination of material and information flow between various supply chain participants. The network contains various nodes, and all of the nodes require manual intervention for decisions, actions and issue resolution. Now, consider a scenario where products have sensors and embedded tags. As they move across the supply chain, their Code Halos interact with various partner and in-house systems in warehouses and distribution centers. The flow of material becomes completely autonomous, and various decisions will be made using information captured by readers throughout the supply chain(Prasad.Satyavolu et al. 2014).

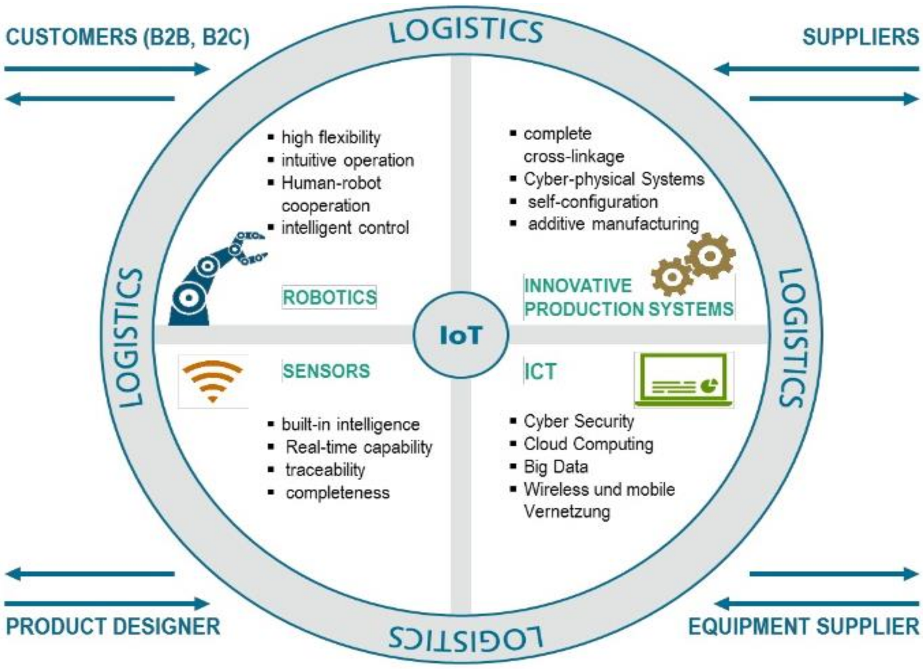


Figure 21 Significant Future Areas of Implementation of IOT in Logistics(Huelsmann 2015)

IOT systems can enable location tracking, remote inventory level monitoring and automatic reporting of material consumption as they move through the supply chain. According to the (Ferreira, Martinho, and Domingos 2010) basic logistics function are to transport "right goods and the right quantity and right quality at the right time to the right place for the right price"(See table 1 in Appendix). According to (Bassi et al. 2013) the application of IOT in Logistics improves not only the material flow but also the global positioning and automatic identification of freight as shown in Figure 21. IOT expected to bring profound changes to the global supply chain via intelligent cargo movement. This will be achieved by means of continuous synchronization of supply chain information and seamless real-time tracking and tracing of objects. It will make the supply chain transhipment, visible and controllable, enabling intelligent communication between people and cargo goods.

2.5. Summary of Literature Review

Research Question	Internet-of-things	Logistics
1	**Identification**	**VSM , DFD using for AS-IS situation**
2	**Identification**	**GS1 standards for TO-Be situation**
3	**Sensing and communication**	**RFID and GDSN To-BE**

3. Research Methodology

This section will present the research methodology that will be used in this dissertation. Section 3.1 demonstrate the brief explanation about research method and design. Section 3.2 followed by the Case study methodology and design. Section 3.3 describes the data collection methodologies and section 3.4 describes different type of data collected for this thesis.

3.1. Research Method

The research methodology is a way to systematically solve the research problem, whereas research method is a type of process or methods used to solve the research problem scientifically. The research methodology has many dimensions and research method do constitute a part of research methodology. Moreover, it is necessary to know the logic behind the methods and use in the context of research study. The researcher should also be able to explain the use of particular research method or techniques in their research study(Kumar 2008).

The research methodology is an essential part in preparing a research plan, and what type of methodologies assuming in order to find the outcome. According to (Rajasekar, Philominathan, and Chinnathambi 2013) the research Methodology consists with the explanation five main issues 1) why the particular research study undertaken 2) how to formulate the research problem 3) what are the types of data were collected 4) what particular method should be used 5) why a particular analysis of data used. The study of research methodology provides the necessary training in choosing methods, materials, scientific tools and training in techniques relevant for the problem chosen.

The approach of research design is based on the type of research method, analysis and the data that used to find the answer for the provided research questions. Each research can be categorized into one of the research methods; they are Qualitative research method and Quantitative research method. According to author Thomson, the qualitative research is multimethod in focus, involving an interpretative, naturalistic approach to its subject matter. The qualitative research studies belongs to their natural settings, attempt to make sense of or interpret the phenomena. It also involves the studied use and collection of variety of empirical material for further research. The Qualitative research plays an important role in analysing the manufacturing operations and aiming to get the meaning and describe the situation, and to investigate the why and how decision-making. Whereas, quantitative research uses numbers and statistical methods and based on numerical measurements of specific aspects of phenomena. It seeks general description or test hypothesis and sampling strategies(Thomas 2003).

As shown in the Table 1 research methodologies classified according to the type of data used and the type of analysis preformed on the data. The type of data can be empirical, which is data gathered for analysis from the real world, often via surveys or case studies. The fata may also be modelled data, which means it is either hypothetical or real world to be artificially manipulated by a model(Ellaram 1996).

		Type of Analysis	
Type of Data		Primary Quantitative	**Primary Qualitative**
	Empirical	Survey data Secondary data Statistical analyses	**Case studies** **Observation** **Limited statistical analysis**
	Modelling	**Simulation** **Linear programming** **Mathematical programming** **Decision analysis**	**Simulation** **Role playing**

Table 2 Basic Research Design (Ellaram 1996)

From the above understanding of research methodology, the following master thesis is purely primarily qualitative research study. Therefore, the research method based on the empirical data from interviews and documents provided by the companies. However, this qualitative research study mainly focuses on the peoples experience in detail by using a specific set of research methods such as in-depth interviews, focus group discussions, observations, content analysis, visual methods and life histories. The objective of this research is that the approach allows identifying the issues from the study of findings and understanding the meanings and interpretations.

3.1.1. Research Design

The research design is the blueprint that enables the investigator to come up with solutions to the problems and guides in various stages of research(Frankfort-Nachmias and Nachmias 1996). It can deal with at least four problems: what questions to study, what data are relevant, what data to collect and how to analyse the results(Yin 1994).

Author Yin explained in his book that the research design is *an action plan for getting from here to there*, where here may be defined as the initial set of questions to be answered and there is some set of conclusions. It can be much more than a work plan. The main purpose of the design is to help to avoid the situation in which the evidence does not address the initial research questions(Yin 1994).

The purpose of the research can belongs to any of these research strategies: Exploratory, descriptive and explanatory. Exploratory research focuses on identifying key issues and key variables, whereas Explanatory research can be conducted to explain the phenomenon. Whereas descriptive research provides the description of the observed phenomenon (Yin 1994).

The proposed thesis, is consuming exploratory, descriptive and explanatory behaviour, because main intention of the project is to discover the present identification of good, information flow and material flow with the use of value stream map and data flow diagram this shows exploratory. Moreover, the thesis provides an explanation the present identification of goods and information flow in the level 1 supply-chain of proposed companies this shows descriptive research design. However, understanding the present context and identify the causes, and shows the ways to perform better this shows explanatory.

According to(Yin 1994), the five components of a research design are especially important:

a) *Study Questions*: These questions explains that what type of research should apply in the study. The questions should be explained clearly in the words “Who”, “What”, “Where”, “Why” and “How”. These questions will provide the important evidence regarding the most significant research strategy to be used. In this master thesis, the Section 1.4 explains study questions.

b) *Study proportions:* The proportions show the way of direct attention to something that to be observed within the scope of the thesis. The study proportions also provides a support to reflect important theoretical issues and support the writers where to look for significant evidence. In this master thesis, the study proportions are presented in Section 3.2.1.

c) *Unit of analysis:* The unit of analysis is associated with the way initial study questions have been defined. Proportions would still help to relevant information about this case. Selection of a suitable unit of analysis is done after the study questions are prepared. The unit of analysis is defined in the research problem section 1.3.

d) *Linking data to proportions:* The name itself explains that linking the data to proportions. The main idea is several pieces of information from the same case may be related to same theoretical proportion, means the tools and techniques that are used to analyse of data. This also provides a solid base for the analysis. In this master thesis this is done in the Section 4.1

e) *Criteria for interpreting the findings:* the main purpose of this component is to interpret the collect data and this can be done by using statistical test, but it might also be about identifying and discussing other clarifications that do not support the explanations of your results. Chapter 4 Analysis is all about our interpretation and data to support the above mentioned research questions.

3.2. Case Study Method

As (Yin 1994) described in his book, a case study method is an empirical inquiry that investigates a contemporary phenomenon with its real life context, especially when the boundaries between phenomenon and context are not correctly evident. A case study can be qualitative and quantitative. The purpose of this study is to deals with efficient management of inbound and out bound logistics using the technologies. Therefore, the case study approach is suitable for this topic because, the case study approach is considered as the investigation of value added activities and sources of these within a real world environment would be used.

According to(Yin 1994)some qualitative research follows ethnographic methods and seeks to satisfy two conditions a) the use of close up, detailed observation of the natural world by the investigators and b) the attempt to avoid prior commitment to any theoretical model. A case study may be Explanatory and Exploratory research which describing an event and the design of case study may be in different ways either single case study or multiple case studies. In brief a case study allows investigation to retain the holistic and meaningful characteristics of real life events(Yin 1994).

For this dissertation, the selected topic surely related to qualitative research because, this research requires an ethnographic method, which involves the collection of variety of data and creates an understanding of relationships. Moreover, the selected approach is a single case study of the flow of a single product item tunnel thruster FU-100-LTC-2750-2050KW within and across the companies and desires to analyse the production process and information flow from raw materials to utilization of finished goods. The purpose of this master thesis is to investigate and discover the present information flow and material flow inside and across the companies. The Value stream-mapping tool helps to describe the material flow and information flow inside the companies and the Data flow diagram helps to describe the information flow across the companies. In order to construct the Value Stream Mapping for the supply chain, I will held the interviews with the staff members and on-site visits helps to investigate the information flow and time. Therefore, this topic needs an in depth understanding of case and require to develop an in depth description and analysis of the case. Somewhat it is related to an in-depth qualitative analysis of a particular thruster information flow and material flow.

3.2.1. Case study design

According to author (Kumar 2008) to design a case study methodology in the thesis four steps should be carried out.

a) *Selection of cases and identification of situation:* the researcher should decide which unit has to be taken into studies and develop the research questions based on the purpose of the study.
b) *Collection and Recording of Data*: The researcher should use different techniques and tools to collect the documents, life histories, observation, interviews, questionnaires, schedules etc. and they should be very careful in the collection and recording data.
c) *Interpretations of Data:* Analysis and interpretation of data are considered highly skilled .The collected evidences must be classified explained and integrated. The interpretation must be logical and convenient form.
d) *Report writing:* it is an important part of any type of research. The report must be in such a manner that the reader should be able to understand and validity of the conclusions.

Data collection for case studies can rely on many sources of evidence. The very important six sources of evidence are direct observation, participant observation, interviews, archival records, documentation and physical artifacts(Yin 1994).

There exists some advantages and disadvantages with case studies, which helps to identify the merits and face challenges in this thesis. The case study methodology based on the real life context and easier for data collection. In this thesis, two companies were involved and have more experienced people to interview and it is easy to understand the situation and problem exactly. This also helped to build the further analysis and interpret the things in the study. However, Brunvoll and Kleven are two different ETO companies and having different manufacturing environments with various events and outcomes. However, Kleven being a manufacturer for ship building producing different types of ships each year based on the customer order, for the ships the lead time is higher and it include different products, varieties and supplier in its value chain. Therefore, the complexity of connecting between various events in the production line will be higher. Moreover, Brunvoll being a manufacturer for whole thruster system producing different varieties based on customer orders, they also have different varieties, value chain and suppliers. The major problem faced in this thesis, was getting an information from the companies acquired longer time.

3.3. Data collection Methodologies

Once the research problem is defined, research design and research method is evaluated the next step is to collect a required data for the study. Data collection can be done in two different forms: primary data and secondary data. Author Kumar describes in his book, that Primary data refers information that is generated to meet the specific requirements of the investigation at hard and secondary data refers to information that is collected for purpose other than to solve the specific problem under investigation(Kumar 2008). The researchers are responsible for collecting the relevant data depending upon their interests of study. The primary sources of data can include direct observations, interviews, and questionnaire. Whereas secondary sources of data includes books, journals, websites and Emails etc. table

Primary and secondary data sources can be divided into two different categories, qualitative and quantitative. The below Figure 22 shows the various sources for collecting primary data.

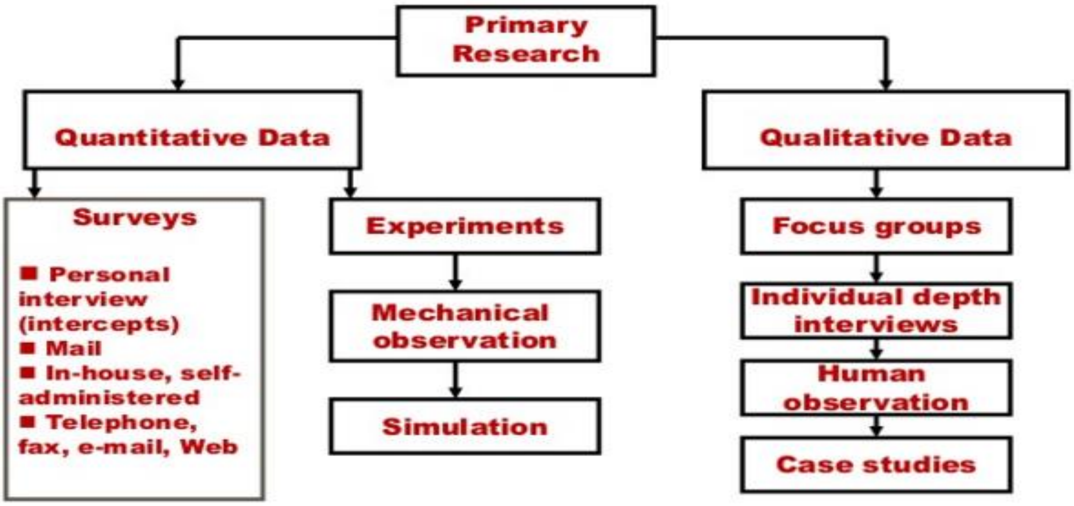


Figure 22 Primary Research Methods and Techniques(Parab 2013)

The qualitative data collection technique is well suitable for this thesis. From the above Figure22, the qualitative research of primary data collection is based on the in-depth interview, focus groups, observations and case studies. The secondary qualitative data collection is based on literature review, journal articles, documents and annual reports from websites etc. The main reason for selecting the qualitative method for this thesis was to obtain the quality of able for this study. According to the research question defined in the above section1.3, and considering time, the understanding of production line in two different companies, identifying the information flow and evaluating the material flow between the companies, is an appropriate qualitative approach of data collection obtained.

Even though, the value stream map in this thesis consists of some calculations. However, professor at NTNU and SINTEF employees already designs some of them observe in appendix Figure 6. As described in above sections that, the Quantitative research is numerical methods and includes statistical data and calculations. In this thesis, some of the numerical calculations was defined before and some of them are used to analyse the data further analysis and explains the real time context without any statistical methods. Therefore, this thesis fits to purely qualitative research, based on brief explanations of theories to support the analysis and validate the obtained data.

3.4. Study Propositions

As we discussed in the earlier section 3.1.1, the study proportions deals with the identification of relevant evidence that is suitable for the selected study through various data collection sources.

3.4.1. *Direct observation*

As discussed in earlier section the direct observation is one of primary data source. According to (Kothari 2004) the observation becomes a scientific tool and the method of data collection for the researcher, when it serves for a research purpose, is systematically planned and recorded and is subjected to checks and controls on validity and reliability. Observation evidence is often useful in providing additional information about the topic being studied(Yin 1994).

In this thesis, the direct observation mainly helps to formulate the answer for the first and second research questions discussed in section1.3. Brunvoll gave permission to walk in production area and office. This is a casual observation, which helped to observe more ongoing process and information flow inside the company and chance to make observations. This direct observation is also connect with the data collection interview.

The direct observation data source has some merits and demerits. The major strength, it helps researcher to gather information, which could not easily be obtained, of he/she observes in a disinterested fashion and researcher can validate the information by questionnaire. The demerits are the problem of observation control is not solved and it may narrow down the researcher range of experience(Kothari 2004).

3.4.2. *Interview Method*

The interview method is one of the most important sources of data collection. The interview method of collecting data involves conversation in oral and verbal. This method can include personal interviews, telephone interviews and Email interviews(Kothari 2004).

- ***Personnel Interview:***

Personal interview method requires a person known as the interviewer asking questions generally in a face-to-face contact to other persons. This sort of interview may be in the form of direct personal investigation or it may be indirect oral investigation(Kothari 2004). In this thesis, the personnel interview helps to formulate the first research question: "*How can information flow be mapped for tire-1 suppliers and customer for the given companies?"* Moreover, the personnel interview helps to empathetic in what way the things work in real life situation. The floor visit at Brunvoll Company was conducted in December 2015 and the first personnel meeting with Ragnar O Hovind the manager of the business services was to comprehend the over view of the information flow and present use of information technology system at the company and discussed about the identification system at the Brunvoll company. The first meeting with follow the present technical system and generalized the problem at Kleven to understand the current situation at their warehouse. The interview with the manager at warehouse and transportation and Project manager is mainly conducted to analyze the in-depth issue in Brunvoll after taking a prior appointment from the managers. I also conducted some informal meetings and conversations with the Kleven and Brunvoll managers during the workshops held in the project execution time, together more information about the problem situation and present work flow.

- ***Email Interview:***

The Email interview is the cheaper and easiest communicating technique used to gather more information. During the personnel interview session I forgot to ask some questions to the managers and send the questionnaire through the email and the managers at Brunvoll send the replies to the questionnaire. This technique is also very helpful to update the information and less time consuming. It was very hard for me to get appointment with the managers for the first time because they were very busy with their own schedules. The Table 3 shows the overview of the personnel and Email interview sessions.

Date	Name of Interviewer	Position	Company
15-12-2015	Floor Visit	Workshop	Brunvoll
19-02-2016	Tore Roppen	Director of Supply Chain	Kleven
04-03-2016	Ragnar Hovind	Manager BBS	Brunvoll
16-03-2016	Espen Rod	Researcher Logistics	Møreforsking Molde AS
03-05-2016	Hatwig Banzer	Manager at Warehouse and Transportation	Brunvoll
03-05-2016	Frank Mundal	Production Planner	Brunvoll
03-05-2016	Frode Ortan	Project Manager	Brunvoll
04-05-2016	Karolis Dugnas	Production Planner	Brunvoll
10-05-2016	Hartwig Banzer	Manager at Warehouse and Transportation	Brunvoll
12-05-2016	Frank Mundal	Production Planner	Brunvoll

Table 3 Personnel Interview/Email Interview at Brunvoll and Kleven Companies

3.4.3. Reliability and validity

Reliability and validity is used to evaluate the quality of the research. Reliability is defined as the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. The validity and reliability are two factors which any qualitative researcher should be concerned about while designing a study analysis results and judging the quality of the study(Golafshani 2003). The theory of reliability is misleading in qualitative research.

The personnel and Email interviews with the managers in Brunvoll Company was the major sources of data in this master thesis. To ensure reliability in qualitative research, examination of honesty is crucial(Golafshani 2003). The data from the annual repaorts, previous records and from the companies is also a realiable sources as it is an evidence from the earlier knowledge. However, deprived of validity and reilability is insignificant regardless of its quality information. The validity in qualitative research is used to measure the reseach performed.

Test Validity and Reliability:

In this thesis the validity and reliability in the research findings is obtained by using the triangulation method. Triangulation is typically a strategy for improving the validity and reliability of research or evaluation of findings and further elaborated as triangulation has risen an important methodolofical issue in natualistic and qualitative approached to evaluation [in order to] control bias and establishing valid propositions because traditional scientific techniques are incompatible with the alternative epistemology(Golafshani 2003). In my master theisis, multiple sources are used for trinagualtion, Email interiwies, personnel interwies and documents provided by the company. The use of these sources make stronger the validity of my thesis and authorization from the reliable resources. Therfore, to support my theisis I have used significant literature reviews to create the reality and gain honest research agenda. In this master thesis the triangulation is deliberate as the purchase order is recieved from kelven and I follwed the same purchse order with brunvoll to gather the relevant information about the material flow and delivery information form different managers to know the actual AS-IS situation.

4. Analysis

This section provides analysis and discussion that has been derived from the results and findings. This section is divided into three major parts first part shows the internal supply networks at each company, their information flow and material flow. The second section focuses on the Information flow in the external supply chains among the companies. The third section shows the standardization of identification.

4.1. Supply Chain Network

This section is divided into three different parts: the first part focuses on the material flow and basic finding, second part focuses on findings of internal supply chain networks and third part focuses on the external supply chain networks. Later chapters in this section describes the standard identification and present information flow problems.

4.1.1. Process Network – Description and findings

The Process is described as a sequence of tasks that transforms several raw-material (inputs) into one unique finished goods (output) to create a value to the customer. The process network for organizations is that, the upstream supply networks of the focal firm involve a large number of suppliers to create a value in the downstream. In order to manage the supply chain network without fail and add value to the customer, the information flow and material flow should be maintained, updated and planned efficiently. The value stream map is designed with different process and information flow within the organization, and data flow diagram is designed and shows the information flow in external supply chain network as shown in Figure23.

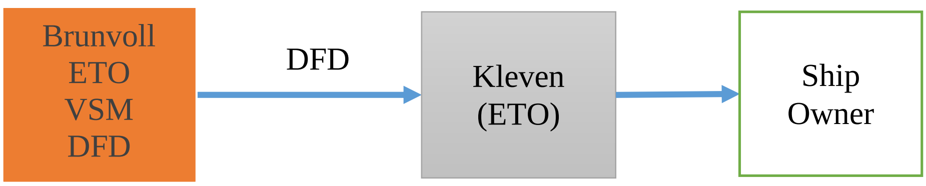


Figure 23 Process network

Kleven is an ETO company, purchases the raw materials and produces the final product. They mainly focus on core activities like assembly and testing and have a complex supply chain network in upstream, which includes a lot of suppliers. Whereas, Brunvoll also an engineer-to-order company, they build thrusters at in-house like production and assembly. They also purchase raw materials form different suppliers, have a complex supply network in upstream, and ship yard at the downstream.

In this thesis, to identify the information flow inside the companies and across the network, the scope is narrowed and selected Brunvoll as a supplier for Kleven. This thesis does not focus on the quantity of material purchased or cost associated with purchasing or production. The focus is more about the information flow and identification of goods internally and between the companies to improve the supply chain visibility.

The research being limited, to a single product item thruster FU-100-LTC-2750-2050KW in the family of tunnel thrusters and disregarded other thrusters for the ship to narrow the findings with the limited time span. Moreover, the thruster is an engineer-to-order product and have a long lead-time, approximately 16months to deliver the product.

4.2. Integration of IOT and Logistics

As deliberated in earlier section 2.4 by integrating the Internet-of-things technologies into the Logistics, we can accomplish enabling location tracking, remote inventory level monitoring and automatic reporting of material consumption as they move through the supply chain eventually reducing the inventory cost and improve the dynamic material flow. In section 2.2, it clearly explained that the Logistics was a movement of goods form the upstream to downstream to create a value to the customer. Whereas, the Internet-of-things (IOT) can improve the communication and sense among the objects/ goods with their internal and external environments. By combining the IOT technologies with the Logistics, we can obtain the improvement in material flow and information flow to ensure a systematic, organized flow of goods to attain the profits and revenue.

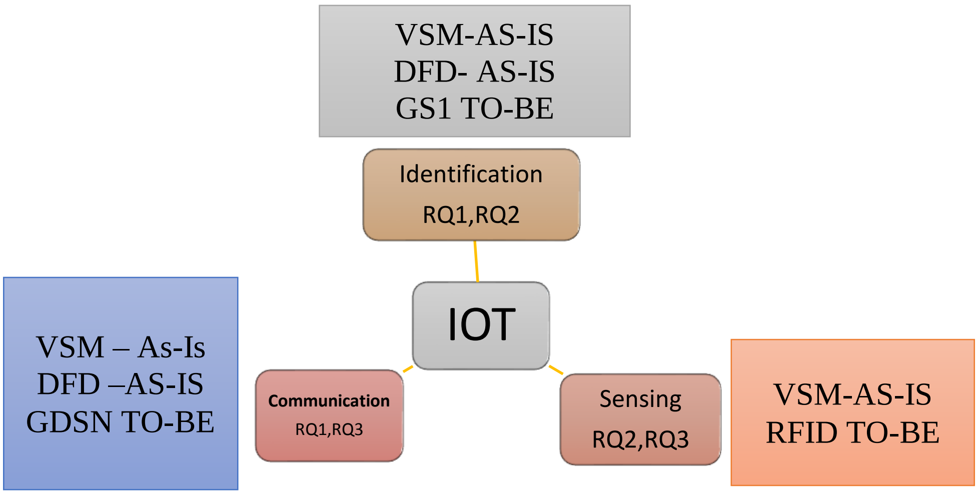


Figure 24 Integration of IOT and Logistics

Step 1: Identification:

This step delivers the answer for the first research question presented in section 1.3.

"How are products and product components currently identified in the material flow and information flow of the internal and external supply chain of an ETO company?"

As explained in the above Figure 24 and section 2.1.4, the first step in IOT elements is identification and the base focusing step of digitization is giving all things a name. In this thesis, the first research question is focused on the identification of the present information flow, material flow with component's identification in the proposed companies. However, to obtain this the fundamental process is to plot the value stream map and data flow diagram for selected thruster FU-100-LTC-2750-2050KW product. This step is very important, because it militaries and focus on the whole value stream of the thruster form raw material to the final utilization for the companies Brunvoll to discover the scope, approach, process i.e. finding the information flows in internal and external supply networks.

4.2.1. *Internal supply Networks*

The internal supply chain refers to a sequence of activities performed within a company that accomplish a product to the customer. The Internal supply chain is based on the tasks like sales, production and distribution. The integration of these functions in the internal supply chain could increase the company's performance and services. This step is very important because it visualizes and explains the present internal information and material flow with ID of the companies. However, the value stream map approach in this step shows the overall presentation of the internal supply networks of the Brunvoll value stream with material flow and information flow of the FU-100-LTC-2750-2050KW product.

4.2.1.1. Value Stream Map

As explained in the above section 2.2.5, value stream is defined as all the actions that are required to receive the order, schedule it, obtain necessary raw materials, produce it and deliver it to the customer. A VSM helps to see and understand the flow of material and information as a product. Included in the VSM are methods for receiving orders, methods for communicating information about production requirements i.e. scheduling system, the locations and amount of inventory, the current processing and cycle times for all process steps, the distance travelled between process steps and so on(Sproull 2012). All these information present in the value stream map helps to identify the present information flow and material flow of the product in the companies.

In this thesis, the main intention of using a VSM to visualize the flow of material with their ID's i.e. internal article numbers. However, in real context the VSM doesn't carry any identification of the goods, it clearly explains the information flow and material flow from raw materials to final product. But, I would like to use the material identification part in the VSM that gives the overview of the material flow, and raw material included (BOM) in-order to develop the final product. Therefore, by involving this I would like to analyze and show visually, how hard it will be to track for the raw materials in future those are used to prepare the final product. Because the ETO companies have a greater product variety, the use of internal article number identification create more challenges for them to identify the spare parts and define the component list. The first step in the VSM is selecting a product family.

4.2.1.1.1. Product Family

As the theory explained in the section 2.2.5, the first step in the value stream mapping process is to select the product family and setting the boundary conditions. In this thesis, the selection of product family is composed with all the activities form raw materials to processing of finished goods to the customers in the downstream. Moreover, the company describes the FU-100-LTC-2750-2050KW product is an engineer-to-order product, designed and customized with some specific functionality suitable for the vessel. However, discussing about the boundary conditions, the value stream mapping obtained in this thesis is limited only to the flow of raw materials to the finished goods for a single product item FU-100-LTC-2750-2050KW and a single component flow in that product i.e. Propeller Section. Moreover, the production process for the engineer-to-order products may not be similar. Therefore, the research is limited for a single product item and its information flow and material flow in two companies.

4.2.1.1.2. Identifying the Critical Value stream

The critical values stream identification is done using Bill of materials. During this thesis, I tried to get the whole picture of BOM but, it is very hard to get the information about the BOM, for this product. Moreover, the Project manager Frode Ortan explained that the 80-90% of the BOM were obtained prior to design stage. Most of the components are standard, and some components are customized. If some products are new and customize, they create a new internal article number for that products. The internal article number are standard for the components. The sample Figure of BOM is shown in Figure31.

4.2.1.1.3. Identify Customer Order Decoupling Point

In this specific project, the customer order decoupling point is at design phase. Moreover, the Kleven Company sends the design specifications and requirements to Brunvoll and then they start the design process. For the products like FU 100-LTC-2750-2050KW tunnel thrusters, it is required to have drawings of hull to design the tunnel part for the thruster.

4.2.1.1.4. Current State Map

As explained in the section 2.2.5, the current state map shows the present situation form start to finish in the entire value stream for a particular propeller section of product FU 100-LTC-2750-2050KW at Brunvoll. In this thesis, the material flow of the VSM was designed by the SINTEF and NTNU professors (see appendix figure 6) and the information flow, material identification deliberate by me. The professors at NTNU and SINTEF they performed this VSM for the implementation of Lean at Brunvoll. Moreover, I re-designed the VSM with the same material flow and time line diagrams for the perspective of showing information flow and material flow with identification internally at Brunvoll. This section covers the main idea of the research, a brief explanation and pictorial representation of material flow with identification, information flow and inventory at each stage of the value stream of the propeller section shown in Figure26. The second part shows the information flow and material flow at the external supply chain.

<u>Current state map at Brunvoll:</u>

However, for the products like make to stock, the production process starts from demand forecasting; but for the products like an engineer-to-order, the process starts from receiving the order and contracting. Mange Goran Lyngstad the Vice President of manufacturing and supply chain explained in a work-shop that, the Brunvoll has the internal communication with sales design and production departments. Moreover, these departments has the communication with customer, the production department also maintain the communication with the suppliers as shown in Figure25 below.

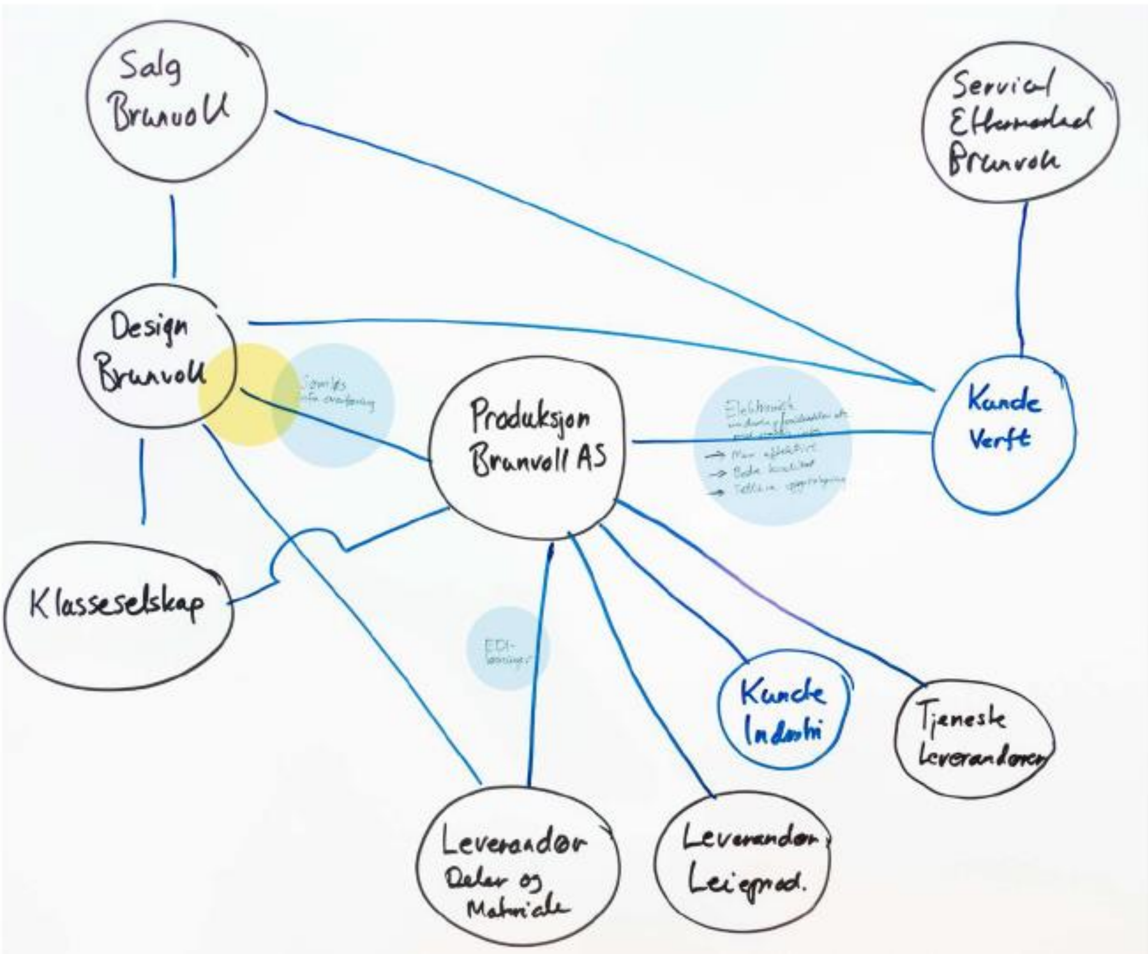


Figure 25 Brunvoll internal supply networks (ManuNet4.0 Workshop)

i. *<u>Receiving orders:</u>* The clients approach the sales department of Brunvoll first and make negotiations to build thrusters for their ships. As all, we know that Brunvoll is a sole supplier for a whole thruster system and they have clients from all around the world. The ETO production system is a pull production system. Moreover, the contract negotiations take a lot of time and it's also depends on the specifications given from the clients. Once the contract is finalized and signed, next the sales department receives the purchase order from the Kleven and creates it's as a new project. Next, this purchase order is forwarded to the project manager.

The purchase order that, received from Kleven (see appendix Figure 3) does not contain any detailed description of the product. Moreover, the PO contains only the information about the project number, SFI codes, the number of thrusters, description about delivery terms and condition with tentative dates, delivery address and marking of delivery. The PO also consists of the order conformation terms, drawing's delivery terms, documentation, certificates and approval before the delivery date of the vessel to the ship owner.

ii. *<u>Design:</u>* As we discussed earlier, the customer order decoupling point in ETO system is the design phase. From the Figure25, Figure 26 and Figure 28, it is clearly shown that the design department internally integrated with the Brunvoll Company and the design engineers take the whole responsibility of designing the thrusters based on the specifications given by the Kleven. As discussed earlier that during the purchase order, the Kleven Company do not know about the detailed specifications of the product. So, this step is most important for the ETO companies and clients, because at this phase, the company knows the detail description of the thruster and analyzes the BOM for the thruster system.

The design phase at Brunvoll is mostly divided into four sub phases:

- *Dimensional drawings:* This phase starts right after the purchase order arrives, and a discussion meeting arranged by the Project manager and finalizes with the project plan and the requirements for the project. At this stage, the drawings are not related to the specific project but sharing main dimensions and overview of the thruster system with the Kleven. The preparation time for these drawings takes at least one week of time to send to the client.

- *Main dimensional drawings*: However, the basic dimensional drawings were finished then the engineering department people start with the main dimensional drawings. At this stage the work related to detailed drawings with the exact dimensions and detailed descriptions about electrical and mechanical machinery and their connections. The product that we are dealing in this thesis is a, tunnel thruster, the designers requires the drawings of the ship hull to design the tunnel for the hull. Therefore, its Kleven's responsibility here is to share the hull drawings with Brunvoll. These Engineering drawings takes at least four weeks of time.

- *Review:* Once the main dimensional drawings were sent to the client, the Brunvoll wait to get a review form the customer. The time taken to get reviews is three weeks. The Project manager also discussed that they will receive mainly reviews in the electrical drawings but not in mechanical drawings. To solve these problems the Project manager conduct separate interface meetings with engineers and clients. With these meetings, the problem will be solved.

- *Drawings for construction:* Moreover, the reviews of main drawings were confirmed and the next step to design the absolute drawings for construction. They will use around six weeks between review and prepare final drawings for construction.

- Documentation: Once, the final drawings for construction is finished and designed. The Brunvoll starts preparing documentation based on drawings with Bill of Materials and parts that they use with the different thruster system.

As soon as the drawings are finished the engineering department uses smartteam and convert the drawings into ERP and update the ERP system. The Overall communication between the Brunvoll and Kleven is performed through Emails for reviewing and sending documentation, etc. Their primary communication base is an Email and phone. The next step in the process is planning, purchasing and receiving the raw materials form the supplier.

iii. *Purchasing:*

From the direct interview method with Hovind manager BBS at Brunvoll, it is revealed that the Brunvoll has 80%of the standard material for the preparation of the thrusters and 20%of the material is customized on the thruster class and on the project. Moreover, from the Email interview with Hartwig Banzer the manager at warehouse and transportation department, it is reveals that, the purchasing of the materials depends up on the specifications provided by the client in the contract. The standard materials like raw, casted, steel, plates and axis, components partially machined or purchased components for assembly are purchased based on stock evaluations executed by the ERP system. In the personnel interview, the project manager also explains that, the order was placed for long lead time materials during the primary drawing phase. Production orders and prognosis generate demand; the stock balance is continuously checked by ERP system, PO’s are issued and activated for the suppliers. Special materials qualities and component’s, to satisfy class requirements was purchased for each product separately. The ERP system at Brunvoll helps the purchaser to gain synergies by purchasing bigger lots from various suppliers.

iv. ***Receiving material:***

Brunvoll purchases mainly FCA factory (approx. 70% of all inbound merchandise). In FCA terms of delivery contracts the seller's assistance is required by the buyer to deliver the goods at the contracted place at buyer's costs and risk. They receive an order confirmation with a date and allocate the pick-up information from their suppliers. Internally shipping part is informed prior to ready date to arrange transport. The remaining goods are purchased DAP (Delivery at place) or DDP (Delivery Duty paid). In such a case the shipping department at Brunvoll receives an arrival notes from suppliers. Then the shipping department can clear the goods at customs based on Estimated time on arrival (ETA) date. When the ETA date does not match with the delivery date in the order confirmation, then the ERP system places a notification that there is an occurrence of mismatch and informs the purchaser. Additionally, they have trust over each supplier and their delivery performance.

Hatwig Banzer also mentioned that, the Brunvoll contacts their supplier maximum of four interactions per average pick up. Because, generally the request is followed by purchase order and finally check to prior ready date, then the shipping coordinator steps into confirm the pick-up. So, they only use tracking system for airfreight shipment and small items sent by courier. Some suppliers have a basic Internet based tracing and tracking system. However, in general the Brunvoll checks with their supplier via phone or email if there is any urgent shipment expected.

v. ***Inbound Warehouse:***

The manager of warehouse and transportation explained that, all incoming goods were registered into ERP system as shown in Figure 28. There is a quality loop included for some type of goods, depending on supplier's quality performance. Goods are received and stored inside the warehouse, sometimes sent directly into production. Normally, the PO is the easiest identification which is mostly used by the both parties. The incoming goods marked with the Brunvoll internal article number and also contains the packing slip with the supplier reference in addition.

vi. ***Production Control:***

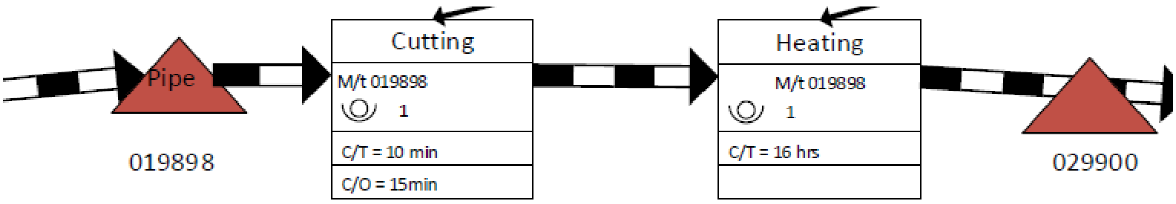
In the present situation, the Brunvoll Company using an ERP M3 system for creating the production plans and manage the work order flows. From the personnel interview with Frank Mundal (Production planner at Brunvoll), it is revealed that, the work order is reported and entered into the system manually by the workers in the ERP system. The work plan is prepared one month prior to the production. However, some of the process in the production are based on the MRP system and prepared based on of the project work order and set them as MTS.

During the Production, they do not perform many modifications with the Mechanical equipment but face all-time changes in the Electrical equipment. Furthermore, once the product is finished, tested and ready to ship they fill up an internal BSV form which contains of about the component list used for further tracking system of the project. If the customer orders for the spare parts, they use the PO and project as a reference number and use the charge number present in BSV for back track within the classes. The planner is responsible for the making the tracking of inbound goods and delays in production. If there are any delays in production, then the planning department reports to the project manager, and he will contact with the customers.

The Figure 26 shows a clear picture of the value stream map with the internal article numbers and the production process. In this, we can observe that there exists a parallel process and the material is transported from the same inbound warehouse.

vii. *Cutting and Heating:*

From the Figure 26 we can observe that, the first parallel process is cutting and heating. The process is for cutting and heating the material that is required for preparing the propeller shaft. They receive the pipes with certain length of pieces. Consequently, they should cut them into the required length based on drawings. The cutting of each piece takes an average of 10minutes and heating of cutting pieces takes 16hours. They obtain heating during the night. The below Figure is a part of VSM that, clearly shows that the article number that goes into this process is 019898. The article number that comes out from the process and stores at inventory next to the machinery is 029900. As soon as the process is finished the worker's stores in the buffer space next to the heating machine and update the information in ERP system. The c/t is a cycle time and c/o is the change over time and the triangle represents the buffer locations.



viii. *Machine for process:*

The process this machinery is to place sleeves between the pipes. As shown in the Figure 26, this is a serial process connected with the cutting and heating. So, the same article number flows into this process i.e. 029900. This machine takes approximately one hour to fix the jackets to the pipes and stored in the buffer next to the machine. The product stored in the buffer consists of the article number 019884.

ix. *Machine M57:*

As shown in the Figure 26, this is a parallel process with respect to the cutting and heating machineries. In this process, the input is the propeller shaft Axel contains with an article number of 039942 that goes into the machinery. The main process of this machinery is drying or freezing the material. Then the third machine #3M57 uses to combine the pipe and axel for the propeller. Then the semi-finished product comes out from this machinery stored in the buffer with an article number 019644 and updates in ERP system.

x. *<u>Flense Machine process:</u>*

As shown in the Figure 26, this process is the third parallel process from receiving of the raw material and entering into the flense machinery. The article that goes into this machinery is 041149. The process of this machinery is to cut flense into the required number of pieces. Once the process is finished it is stored in the buffer with an article number 041148. Then the workers update the information manually in the ERP system.

xi. *<u>Shrink on Flens process:</u>*

As shown in the Figure 26, this process combines all the parallel process into one part. This machine takes the article number's 019644 and 041148 particles the pipe and axels and flense to combine them into a single part. From the personnel interview with the production planner, it is revealed that in some cases the production process until this machinery can be MTS. So, they will prepare the pieces and place into their inventory. From the Figure 26, it is clearly shown that the inventories before these process carry 36 days. The semi-finished product that comes out of this machinery is stored into the buffer next to this machine with an article number of 038698.

xii. *<u>Mounting the propeller shaft:</u>*

A shown in the Figure 26 this process is a serial process next shrinking of flense. This is a main process of partly positioning the propeller shaft axel. The article numbers that enter into the process is 038698(shrink of flense), 033017(crown wheel) and 19367(storehouse outer). The crown wheel were purchased raw materials, placed in warehouse and step in directly from inventory into the process. This process takes around 2.5 hours to mount the parts. Once the mounting is finished it sent to the buffer next to the machinery with an article number given 20082.

xiii. *<u>Mounting UV unit:</u>*

This is a serial process after mounting the propeller shaft as shown in Figure 26. This process takes a lot of inputs into the machinery. Some of them are propeller axel (20082), gear housing (19572&19574), capsule Gearbox (19313), cover gearbox (19515) and yoke boss propeller (19418) etc. The material that arrive into this process is purchased material and stored in the inventory with a specified article number. The mounted product that comes out of this machinery consists of an article number 20083 and manually updated in ERP and stored in the buffer space.

xiv. *<u>Together positioning:</u>*

This is the serial process connected with mounting UV unit, in this process they will place all together with the thruster system like propeller blade, motor stand, tunnel, stag tunnel, fuse wire, gear provides, K parts, elastic coupling unit etc. Due to time pressure, I could not get the information regarding the article numbers for these products. The output form this product is given as article number 103616, this article number is the final article number given to the thruster, and the prepared thruster is stored in the buffer next to the machinery and sent the function testing.

The Function testing is the pace where they test the build thruster working properly or not. This point is also an ID coupling point for the product. At this point, the company knows all the information i.e. BOM about the thruster with their article numbers.

xv. *Shipping Complete Thruster:*

As shown in the Figure26, this step is the serial process after preserving the whole thruster in the outbound warehouse. However, in this outbound warehouse, the thruster stays approximately 23 days and delivered with the different components like control cabinet, main panel, electric motor, electric coupling unit, pump supplies and touch tank. Moreover, at this stage the ware house department prepares the documents and the packing list and sent to the customer. The delivery information process is clearly explained in the next section external supply chain and Figure 30. Approximately the transportation time of the shipment to Kleven takes 1.6 days.

The figure 26, is viewed only for a particular thruster section i.e. propeller production and until the mounting uv unit the production process is only for propeller production. From this we can observe that the number of raw materials with ID are involved in this process. Overall from the above discussion, the decoupling point for identifying the components included in the thruster is at the function testing or factory aided testing. However, the whole products that Brunvoll dispatches to the Kleven is known, only when they are delivering the thruster to the Kleven. The finished thruster is given an article number of 103616 at the stage of FAT testing. The total time taken to prepare the thruster is 115.7 hours, and the lead time is 157 days.

From the Figure 26, we can identify that, the time taken between the FAT i.e. the decoupling point for identification and final delivery is 28 days. In this mean time the company prepares the required documents and consignment list that is to be send to the customer, 14 days prior to delivery and with the shipment of goods. The other components those are dispatching with the final product are arriving from the inbound warehouse. So, these components are outsourced.

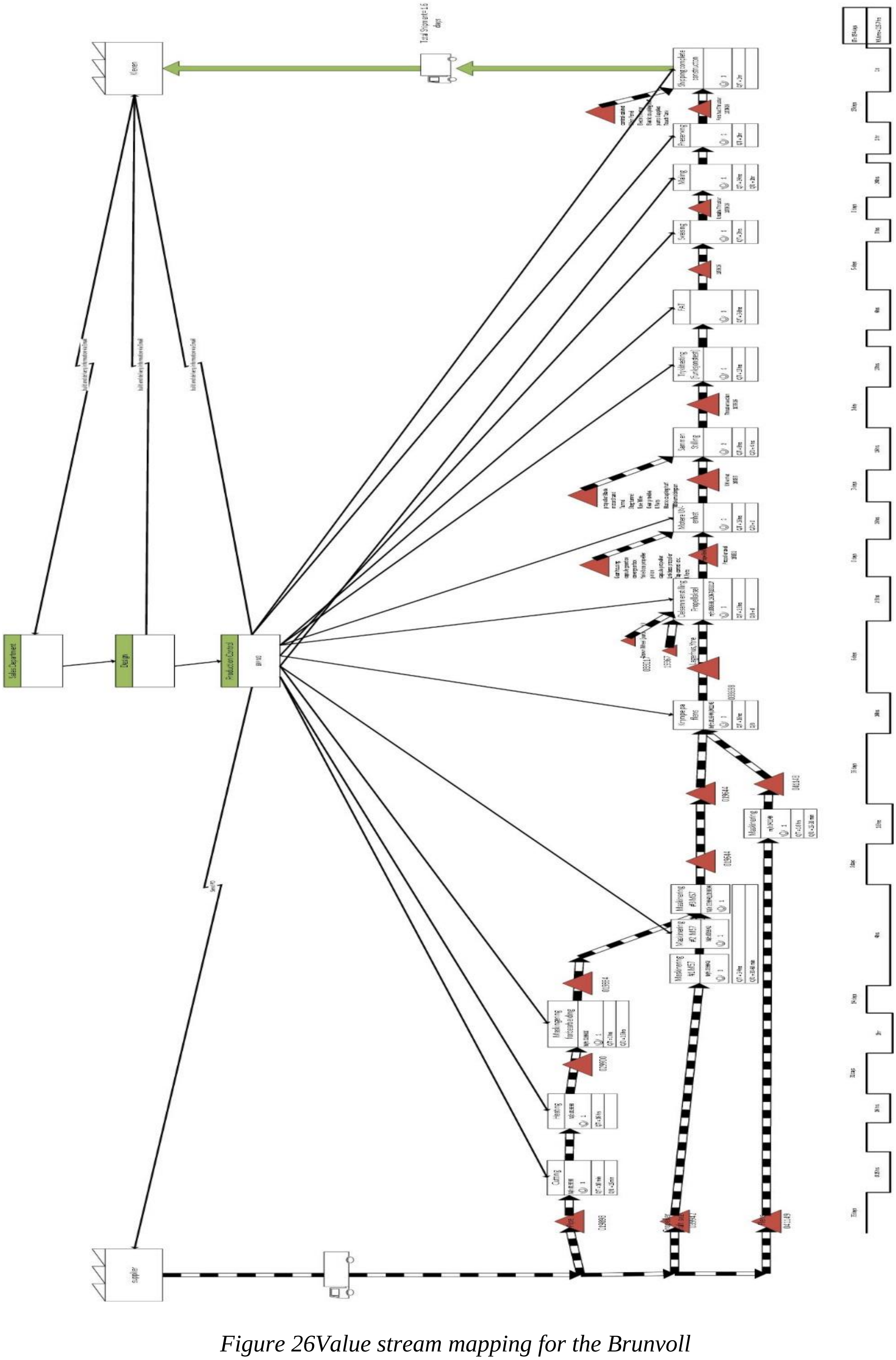


Figure 26Value stream mapping for the Brunvoll

Current State Map at Kleven:

Due to the lack of time and support system from the company, it is difficult to get more information to plot the value stream map for the Kleven. Moreover, the company also discussed that it is very difficult for them to get all the information. Moreover, the hull of the ship is prepared in the Poland and the fore body of the tunnel thruster should be shipped to the Poland. They also mentioned that the mounting and testing of the thruster can be done in Kleven verft or some other place. During the interview procedure, I observed that they would like to have a perfect procedure to identify the inbound products at their warehouse with specific to their drawings.

Figure 27 Kleven production system (Manunet4.0 Workshop)

The above Figure27 clearly explains that the Kleven receives an order from the ship owner. The company is mainly focused on their core business and outsourcing more than 80% of the parts. The Figure 28 explains that the Kleven outsources design, service, finance, components etc. Moreover, they have an enormous upstream supply chain and maintaining this type of supply chain is also very difficult and found a high dependency on the suppliers. Therefore, requirement of traceability are very important for them.

4.2.1.2. Data Flow Diagram

As described earlier section 2.2.6 that the data flow diagram is one of the best methods to outline the data and process flow modeling in the supply-chain network. A DFD shows how data moves through an information system but does not show program logic. It is an easy understandable and pictorial representation describes the process flow in the present situation. In this context the data flow diagram is divided into two section

DFD for Building the contract:

From the Figure28, it is clearly described that, the Building process, purchasing goods from the supplier then to production and delivery. In this DFD, it is clearly shown that the Brunvoll uses an ERP M3 system internally, and the external communication i.e. between suppliers and customers is through E-mail.

As we described in the earlier section, the production process for the Brunvoll ETO companies starts for building the contract. Kleven approaches the Brunvoll's sales department to build the thruster for their vessels and perform negotiations. If the negotiations are successful, they sign the contract with Brunvoll to make the thruster for their vessels. After the contract is signed, the Kleven releases the purchase order and sends to the sales department at Brunvoll. The sales department creates it as a project and forward it to the project manager.

The Project Manager Frode Orten explained that once the contract is finalized the sales department will transfer the project based on the purchase order to the project manager. From this state and until the thruster is mounted on the ship and tested the project manager is responsible for the project and client's contact the project manager for further queries. He also discussed that, they will create a new template in the ERP M3 system with respect to the received purchase order.

The categorization logic in the Figure 28 explains that grouping the project. As soon as the template is created in the ERPM3 system the project manager will conduct the meetings with responsible persons or managers of the different departments like design, planning, purchasing, production, etc. and get the overview of the project. During the project execution stage the project manager conduct several meeting with different department managers and get know updates about the project. Then the next step in this project design phase.

In the above section, the design phase process and the important steps in design phase were described clearly. As soon as the main dimensional drawings were done then, the engineers use the smartteam software to prototype the design and update the drawings in the ERP system as shown in Figure 28. The Project manager transfers these documents to the Kleven and places a request for the review. Once the review report is received the engineering department makes the necessary corrections and updates the drawings into the ERP M3 database. The planning department retrieves the information from the ERP database, makes the necessary planning and BOM (products list) required for the project and updates in the database. Then the purchasing department retrieves the information for the required material and places the PO for the suppliers.

The overview of purchasing is described in the above section. The purchasing department is responsible for placing the PO for the suppliers and tracks the material until it reaches to inbound warehouse and updates the ERP system with the inbound material. The Purchasing department uses a standard email process to track the information from their suppliers.

As soon as the raw material is received at the warehouse then the production department starts the production based on the planning updated in the ERP system. However, when the production is finished the finished products are sent to the outbound warehouse and ready to deliver.

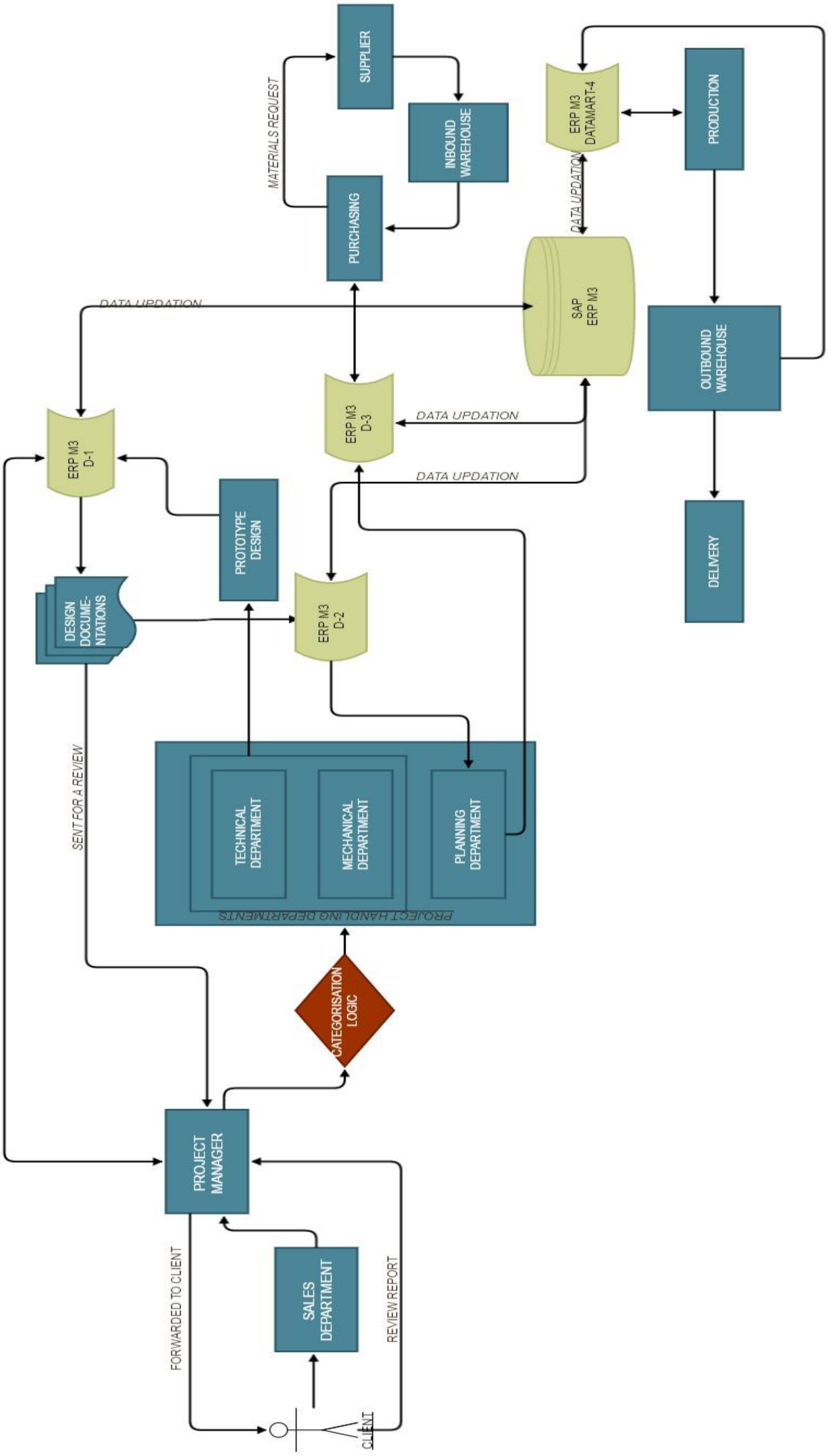


Figure 28Data Flow Diagram for Building the Project

4.2.2. External supply Networks

The external supply chain refers to activities performed outside a company that accomplish a service or delivery of a product to the customer. The external supply chain is based on the factors like demand, environment and supply. The increase in the information flow and communication in the external supply chain could increase the company's performance and services. This step is very important because it visualizes and explains the present external information and material flow of the companies. The Data flow Diagram in this step shows the external supply chain networks across the Brunvoll and Kleven with information flow of the Product FU-100-LTC-2750-2050KW.

4.2.2.1. DFD for Outbound delivery process

From the value stream mapping, Figure26 we can observe that the final step is preserving and shipping complete construction, and from the Figure 28 final step in the DFD is delivery. This step explains a detailed view of the outbound delivery process. As described in the earlier section that the Kleven receives varieties of components on the pallets at their inbound warehouse. In the value stream map Figure 26, it is clearly shown that the final shipment consists of the thruster with other components like control cabinet, main panel, electric motor, and electric coupling unit, pump supplies and touch tank. These components are outsourced and placed at outbound warehouse.

From the Figure 30, the outbound delivery process at Brunvoll starts from the identification of shipment goods. This is the main step for the company to identify the shipments because the company uses internal article numbers and identifying the require material that is suitable for one particular thruster is difficult. However, the company uses the internal article numbers for the family of products but not for a specific product. So, then it is difficult for the warehouse employee to identify the components that is required to the specific thruster.

From the personnel interview with manager at warehouse and transportation department, it is clearly understandable that, in the present context the identification of products is done by the unit number. This unit number (2050) is an internal number for finished products as shown in Figure 29. Each unit number is sub-divided into the element number, and element number is given to the components. Using unit number and the element number, the company can trace the component used in the thruster for further after sales service.

▼ 30393	10425,10426,10427,10428,10429,10430,`373	KLEVEN VERFT AS			2. Working - 30
2050 - 10425 BOW FORWARD	FU-100-LTC-2750-2050 kW	13/51	690V-60Hz	15.05.2015	
2051 - 10426 BOW CENTER AFT	FU-100-LTC-2750-2050 kW	13/51	690V-60Hz	15.05.2015	
2052 - 10427 BOW CENTER FORWARD	AR-80-LNC-2100-1500 kW	11/43	690V-60Hz	15.05.2015	
2053 - 10428 BOW AFT	AR-80-LNC-2100-1500 kW	11/43	690V-60Hz	15.05.2015	
2054 - 10429 STERN FORWARD	FU-100-LTC-2450-2050 kW	13/51	690V-60Hz	15.05.2015	
2055 - 10430 STERN CENTER	FU-100-LTC-2450-2050 kW	13/51	690V-60Hz	15.05.2015	
2056 - 10431 STERN AFT	FU-100-LTC-2450-2050 kW	13/51	690V-60Hz	15.05.2015	

Figure 29 Brunvoll Identification of Goods for shipment (By Brunvoll)

After the identification of the goods is finished then the warehouse employees prepare the delivery checklist based upon the purchase order number, order reference number and the project number and update into the ERP system see Figure 30. Formerly this delivery list or picking list is further sent to the warehouse. The employees at the warehouse pick the required products and gets ready for transportation. To perform these whole process they have 23 days of lead time. From the personnel interview, it is clearly clarified that the Brunvoll Company implemented ERP system in 2012. However, this system is in preliminary stage. So, during the early stages of ERP the company used manual delivery system in order to maintain a synchronization of both systems.

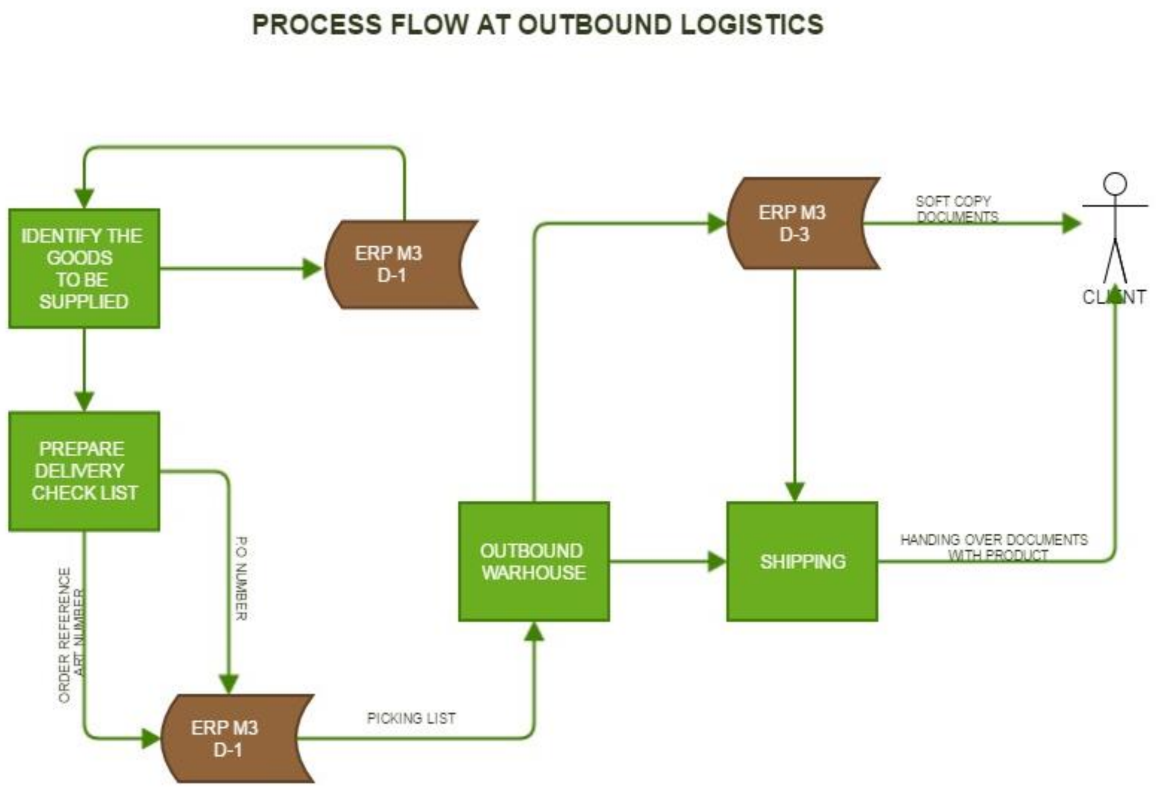


Figure 30 DFD for outbound delivery Process at Brunvoll

The warehouse manager is responsible for generating, the packing slip, consignment notes, content list and updating them into the ERP system. After documents are prepared the project manager transfers these documents (soft copy) to the Kleven as a prior notice to the shipment of the goods. The content list consists of project id, yard no, and a unit number as shown in appendix Figure7. The packing slip also consists of the project id, yard number and unit number as shown in appendix Figure7.

In the present situation, the overview of the project and documentation is prepared in PDF format and send via email 14 days prior to delivery based on the customer request present in the contract. If there is no request present in the contract the pre-advice or notification is 2to3 days or at the time when truck leaving from the factory.

During the delivery of the shipment, the company provides the information about the document's consignment notes, packing slip on the pallets. However, the products consist of the element number and internal article number. Each single pallet is differently packed based on the yard number and PO number. In this particular project, the Brunvoll delivered 52 different packages to Kleven.

In this section the main observation is, when the Kleven receives the material on the pallet it contains the Brunvoll internal article numbers, PO number and Project number. During the contract the Kleven do not have any information about the component list, they knew only about the type of the thruster product model number. So, this creates the new challenges in the present system to identify the received products based on the ship drawings and fit them into ship. The main intention of this section, is to understand the present situation of company's information flow, internal article numbers of material flow in the internal supply chain and information flow and process flow in the external supply chain and to investigate the cause of the problem.

4.2.3. Standardization of Identification

This section provides the solution for the second research question

"To what extent is standard identification schemes used in ETO information flow?"

As explained in the above section that identification plays an important role in implementing the Internet-of-things (IOT). The standardization of product identification can reduce the cost of not meeting customers in right time and improve the traceability of the product. From the above value stream mapping Figure26, it is revealed that the identification of the product at each stage of the process internally and moved to their way to final utilization. In the process of writing this thesis, the Brunvoll Company mentioned that their primary focus information flow of production internally from design to production and externally from supplier to production and from production to customer. However, Kleven's focus is to improve their design process.

Once again, if we go back and revise the product that we are dealing in this context is an engineer-to-order with long lead time around 12 to 16 months of time and sometimes delays in the delivery may occur due to some consequences. However, the engineer-to-order products are based on the dynamic demand planning, if the delays occur in the supply chain, it can lead to delays in the project delivery. The information sharing among the actors in the supply chain is important for the dynamic demand planning situation. The engineer-to-order manufacturing system is a one-piece production flow with the minimum amount of raw material inventory in ware house and inventory of finished goods depends on the pull system form the customer.

Implementation of global data identification standards ensures dynamic demand planning to meet demand and supply via automatization of transaction between the actors in the supply chain. This can reduce the cost and risk of delays and not meeting to customer.

4.2.3.1. ID coupling point

The ID coupling point for the manufacturing companies helps to obtain the smooth material flow and analyze the number of parts incorporated to prepare the final items. As we discussed that unique material identification plays a greater role in identifying the goods with their specifications and helps for traceability. According to the information delivered by the company that the present use of material identification is an internal article number for the parts. The engineer-to-order companies is mainly pull based systems, i.e. a demand-driven supply chains. So, the ID coupling point is mostly at delivery stage in engineer-to-order companies. However, the production process and customer order decoupling point for an engineer-to-order companies starts from design.

From the personnel interview, the project manager explained that once they received the purchase order from clients, the first step is to create a template with respect to the project number and PO number in ERP system. However, at this stage the Brunvoll knows 80%of the accurate information regarding components required for the project and rest 20% is known during the engineering drawing's analysis phase. He also mentioned that some of the pre-defined components might change during engineering design phase. Once the design phase is finished then the list of components is defined i.e. Bill of Materials (BOM). The BOM is defined briefly with internal article identification numbers and component's names and suppliers as shown in Figure31. Then the ERP gives a signal to the purchasing department for further procedures.

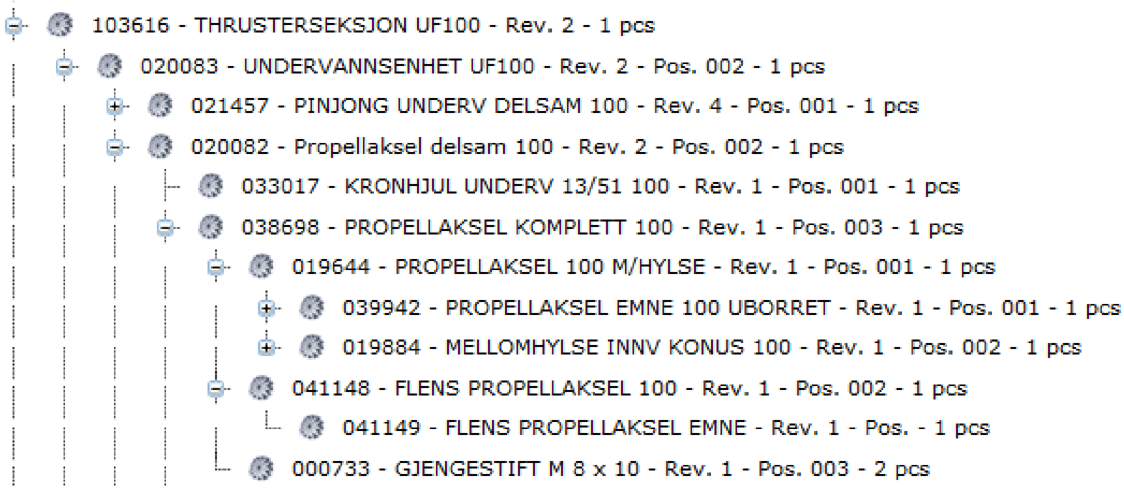


Figure 31 Sample BOM for Thruster FU 100 (By Brunvoll)

The company also addressed that most of the changes were done during the review of the design phase, and they won't acquires various corrections in mechanical designs, but they acquire in electrical drawings. The production planner also reveals that they do not get many changes during production of mechanical equipment but in electrical equipment, it happens quite often.

Manufacturing Strategy	Design	Procurement and Manufacturing	Assembly	Distribution
Make to stock	ID-CP - →			CODP ——→
Assemble-to-order	-------------------	ID-CP - - - - →CODP	——————————→	
Engineer-to-order	CODP ——————————————→			ID-CP ——→

Table 4: Id coupling point and CODP for different manufacturing strategies.

From the above Table 4, it is clearly described that, in the current situation the ID coupling point is observed in distribution phase for ETO companies. From Figure 26 VSM, clearly shows that, the final id coupling point is at FAT testing phase. During the manufacturing stage, the Brunvoll knows about the detailed identification of the components that going into the production, but things might change until end and include some other parts during the production process. Therefore, change obtaining during the production process is quite often at Brunvoll.

As we go in detail to our problem statement, misplace of synchronization between the components received and the drawing's for the Kleven Company. The main cause for this is, the detailed lists of components of the thruster system are not structured until the factory aided testing and distribution phase. As we discussed earlier that, the packing slip contains the description of the component. The lack of detailed component's identification during the production process and assembly, creates an adaptation problem for IOT technologies in ETO companies.

The Hovind at Bunvoll Company also described that, they receive the material at inbound logistics with their internal article numbers. The suppliers are flexible for them to send the material with their specified internal article numbers. As we discussed in the above section, that the Brunvoll receives the material, mainly of FCA factory. So, in this situation the Brunvoll is responsible for the material that they are going to receive, and it is a high risk for them.

Moreover, the adaptation IOT technologies in ETO environments can improve the inbound logistics system and smooth the material flow. Because they are flexible production environments and have the benefit for great visibility of the production flow. This is briefly described in the suggestion part, that how the GS1 standards help to improve the operations in ETO companies. However, in the present situation, these companies have not yet focused on the implementing the product standardization plan but, the enclosed suggestions for the companies could help them in further implementations.

5. Suggestions and Conclusion

This section presents the suggestions of the present research paper, findings and recommendations to further analysis of the research problem.

5.1. Suggestions

While exploring this paper, I still have to finalize the third research questions which I would like to discuss under suggestions. Moreover, the implementation of the Internet-of-things at Brunoll and Kleven are in the starting process. The suggestions present in this section may or may not be applied. However, I have tried my level best to comprehend and promote attempt to investigate the utilization of standardization and information sharing, that helps to improve the operations in ETO.

Future Supply chain Visibility:

This section provides the solution for the third research question

"How can IOT-technologies improve the operations of ETO-manufacturers and approach the efficiency of MTS?

From the above sections, it is clearly described that the inbuilt characteristics of the ETO manufacturing are flexibility, product variety and low production quantity. Whereas MTO, MTS consists of more efficient product system, standard product and large production quantity. The MTS is low cost and lean process and ETO is high cost, specific and more Agile process. Therefore, the efficiency of ETO companies compared to MTS is quite low, this pose a challenges that Can ETO be as efficient as MTS by using IOT-technologies? Can agile ETO companies be lean?

The ETO Company's faces more dynamic planning system, the information sharing and event-based technology can improve the dynamic planning and become more efficient as static planning system. In this part, the main aim of the thesis is to provide the ways to improve the dynamic planning system of ETO companies and make them more efficient as MTS.

5.1.1. Global standardization

As we discussed earlier in the section 2.4 that the global standard is a comprehensive set of methods and rules, which improves the communication and lead to vertical integration. The information sharing plays a prominent role in any type of relationship. Sharing an accurate, real-time operational information between two partners can improve the better use of assets and save time in the supply chain. At present situation, the Brunvoll, company does not know the BOM until the FAT phase, and they use their internal article numbers for the further tracing of information. Here I would like to suggest the company to get register into the GS1 standards. Then the Brunvoll can get an access with the global registry. Where they can have a global uniquely identifiable company code. With the help of global company code, they can create a unique identification for assets and products.

By creating a Global trade item number for each product or thruster or shipment components could help them to identify the product according to the drawings and improve the visibility by creating a global naming directory. As discussed earlier GTIN identifies the trade items, which are priced, ordered or invoiced at any point in the supply chain. This is the foundation step for the implementation of IOT technologies and further improving the capture and sharing of information in the supply chain.

The Brunvoll Company should also focus on inbound logistics and purchasing of goods in order to reduce the risk of the inbound goods. Here I would like to suggest the Brunvoll should ask their suppliers to provide the GTIN for the products that they deliver to Brunvoll. This can help them for further tracking of the goods in the upstream supply chain.

From the email interview, the production planner explained that, the Brunvoll use the BSV forms filled after production of the thruster is finished. These forms are filled internal use to gather the information about the products that they produce, and it contains the details about the charge number, material quality, etc. In the present situation, this form helps them to track the information about the thruster for future.

Here I would like to suggest the Brunvoll Company to use a standardized GTIN this can help them to track the information in the future. So, the GTIN printed on the thruster can identify the thruster at any stage in the supply chain and provide its qualities and component information though the electronic data interchange and master data system. This can also be used for future tracking system of the product for spare parts, etc. Figure 32 is an example of GTIN and its flow of products implemented in a fish industry. In this it is clearly observed the implementation GTIN at each state can improve the supply-chain visibility and easy to track the raw materials included in the product.

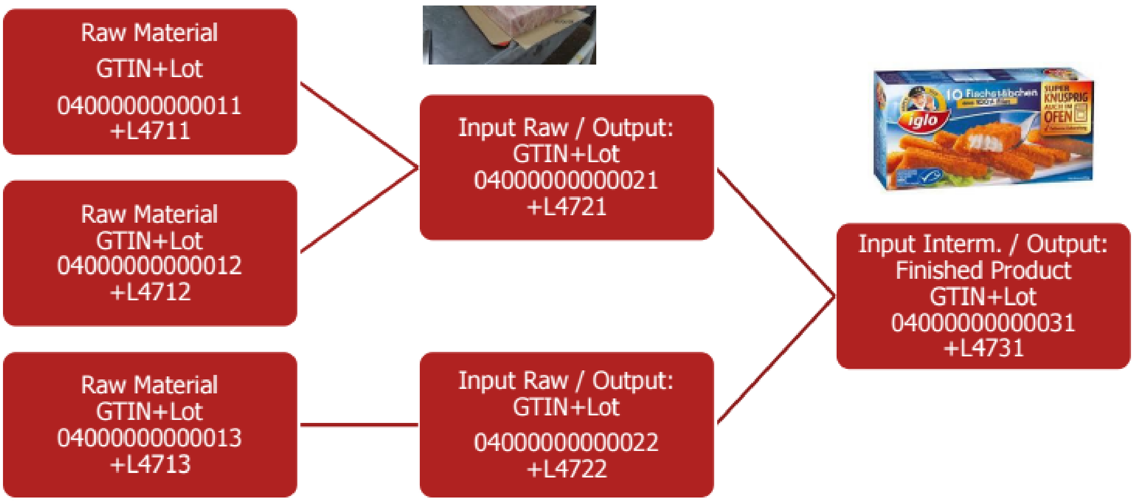


Figure 32 GTIN example(Gs1 2016)

As we discussed earlier that, the Kleven receives a variety of components and material on the pallet and it's time-consuming and very difficult for them to identify the products based on the packing slip. From the above discussion and Figure 26, I observed that the time between ID coupling point and delivery of goods I about 28 days. Here I would like to use a tool i.e. Component or part identification (CPID) of GS1 standard, the component/part identifier is available for business process where products are identified by the buyer. The buyer instructs his supplier on how to identify and mark the product to deliver him(Gs1 2016). I would like to suggest that, Brunvoll should share the final component list after the FAT testing stage, then Kleven should spend a bit time perform the detailed drawings and design the component identification codes (CPID) that match to their drawings and send back to Brunvoll and ask them for putting them of the components that they are going to deliver. However, this is available for business processes, where items are identified by the manufacturer of the finished goods and instruct their suppliers on how to identify and mark the components and parts delivered to them. This could easily solve the problem of shipping the several components at same time and reduce the number of shipments.

During the personnel interview session, Hartwig shared his personnel experience that when he worked at rail company in Germany. They receive a parcel of 1920 containers, and everything was packed in a reverse order based on the requirement sent by the company. This type of the system should be designed and worked before shipment. So, it does not consume any time to identify the goods, remove from the container and assembly.

Nowadays, the company is using the SSCC on the pallet generated by the ERP system. However, previously they used the packing slip manually entered and attached to the components individually on the pallet (see appendix Figure 7 c). In the section2.4.1 it is discussed clearly that the SSCC provides a single global means of uniquely identifying logistic units, which can be any combination of items packed together for shipment. The SSCC consists of a company prefix and serial reference to identify the goods.

5.1.2. Electronic Data Interchange

As discussed above the communication is the third aspect in the IOT technology and digitization. The information sharing and communication among the actors play a prominent role. As discussed in the above section the standardization is the foundation for the communication. After standardization, the next step is traceability. Traceability plays an important role in the external supply chains for ETO companies. However, the risk of not having a trace and track technology is high in product identification, delays in production, missing and misplacement of goods. The Dataflow diagram shows the exact information flow between the companies during building the contract and delivery of the goods.

5.1.2.1.RFID

In the earlier section, it is explained clearly that, the list of components for the thruster system is available for the delivery phase. There is missing a flow of goods with an automatic goods receipt message. As per the contract between Kleven and Brunvoll the documentation regarding the shipment of the goods sent through email prior to the 14 days of the delivery date. Then the goods were shipped from Brunvoll to Kleven within a delivery time of 1.6 days. Traceability of goods is not provided. If something is missing, the Kleven write an email to the Brunvoll Project manager asking about the goods that were missing. Then the project manager ensures the cross verification about the goods with the warehouse manager and production manager. This is a lengthy process and time consuming. The adaptation of RFID technology can improve the product visibility among the supply chain

As we discussed in the earlier section 2.4.2.2.1 that RFID is a two-way communication device which is connected directly to an item and provide the information flow as the product moves across the supply chain. RFID is having the ability to track products as they move though the different process at supply chain and create the fascinating method for improving the information flow. The RFID is capable of identifying the products at the item level. This is performed through the data capacity on the tag that is used to identify the product. The RFID application is easily incorporate with the ERP system. AS mentioned earlier that RFID consist of three major layers i.e. tags, reader and middleware.

The EPC (Electronic Product Code) of the RFID tag provides with a unique product identification code on the item level. This EPC code on the RFID tag helps to track and trace the information of the product or item separately. The EPC can cope up with the existing gs1 standard identification system like GTIN, GLN, and SSCC. The use of RFID with GS1 standards improves the visibility of the supply chain system.

5.1.2.1.1. The link between GTIN and EPC code:

As we discussed earlier that the GTIN contains the numbering system includes the company prefix, item number or serial number with 13 digits. However, the EPC code is also a numbering system incorporates with filter and partition, company prefix, item reference, and serial number. So, the GTIN can be used to build a unique EPC code as shown in Figure33. The main difference between two product identification systems is, GTIN identifies a particular class of the object, does not identify a single product item. Moreover, the EPC is unique for each tag and product. Therefore, to match the GTIN with EPC code, GTIN should be created with serial number.

However, the serialized GTIN EPC scheme is used to assign the unique identification for the trade item that belongs to a specific product family. In the present situation, the company uses the internal article numbers, and the use of the SGTIN can improve their product visibility and allow traceability of the product in the downstream. The below syntax and the Figure33 show the correspondence between SGTIN and the EPC.

Syntax urn: epc: id: stgin: company prefix. ItemReference. SerialNumber

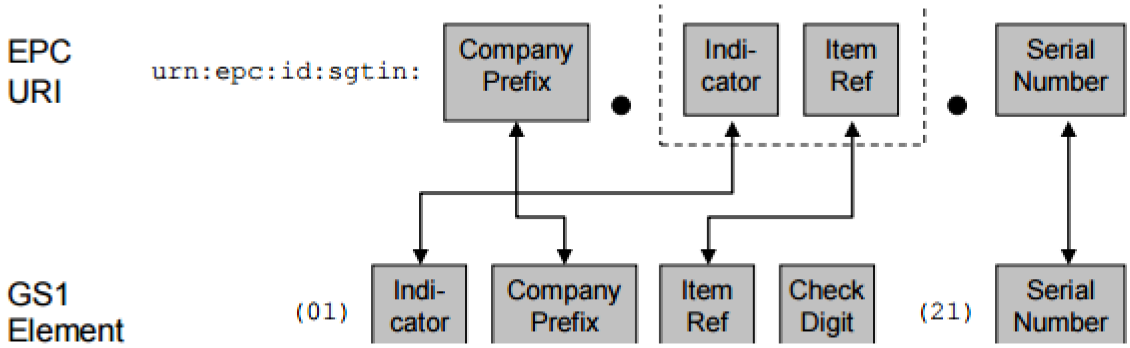


Figure 33 Correspondence between SGTIN and EPC(Gs1 2016)

The fundamental part of using the RFID system is tagging the products based on the EPC code with is integrated with an SGTIN.

The GS1 supports the EPCIS to share the captured information from the RFID tag into the middleware network across the participants in the supply chain. The RFID provides a trusted platform for information sharing because, the information sharing for the actors in the supply chain is crucial for not misusing their information by the other participant.

From the personnel interview, the Project manager shared his experience humorously that he should say sorry all times to their customers for not receiving the expected goods on time and have some re-shipments. He also explained that the main cause of the reshipment is during the delivery the warehouse workers forget to dispatch some parts within the shipment. So, in order to overcome this problem, I would like to suggest the company to implement the RFID tags for their products, because these are ETO products and valuable in the ship building. Therefore, the missing or misplacement of goods costs enormously for the Brunvoll Company as well as increases delays in production and their reputation can also be challenging.

If they connect the RFID antenna at their outbound warehouse, the tags can be declaimed and events were created. According these events they can identify the goods they dispatched with respect to the delivery list of products this can reduce their burden, cost of reshipment and time saving.

Here I would also like to suggest the Brunvoll to ask their suppliers to send the products with the global identification or use of RFID this can improve their visibility, dynamic planning system and avoid their delays in production and smooth the flow. If the Brunvoll Company adopts the RFID and the GS1 standards in their outbound logistic, they can improve their supply-chain visibility and reduce their rework rate. The standardization of the product identification and use of RFID enables to improve the visibility of the final product flow across the supply chain.

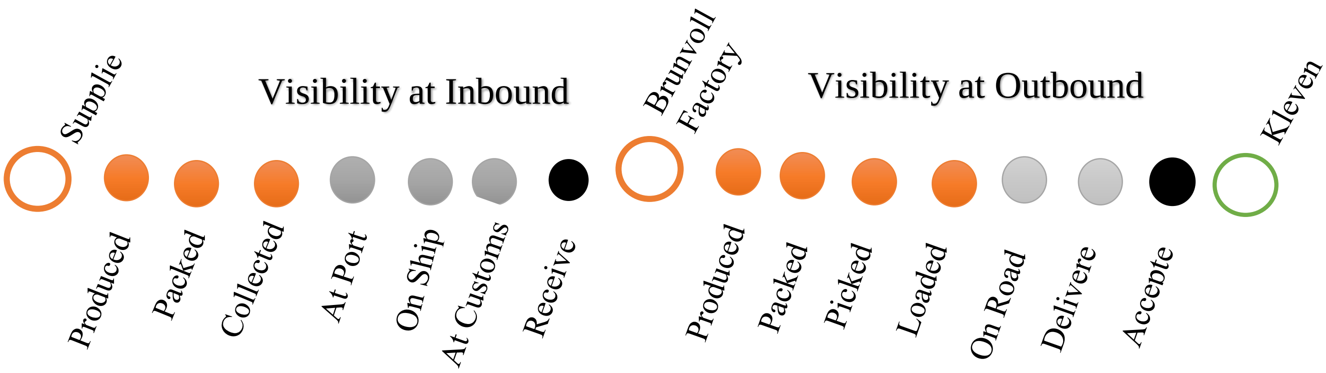


Figure 34 Future Brunvoll Supply Chain

The above Figure 34 explains the future state of the Brunvoll supply chain visibility with the use of RFID and Global standardization. The orange circles represent activities those are performed at the outbound warehouse of the companies, the ash color circles represent the ongoing process between the companies and the black circle represents the accepted event occurred once the product is received at the destiny. The implementation of the future visibility into a company, one should follow the GS1 Core business vocabulary (see appendix figure 8). So, the use of standards should be revised and conformed through GS1.

5.1.2.2. Data Synchronization

As we discussed earlier in the problem statement, one of the major issues is also a data synchronization, scope of availability of data and sharing among the actors in the supply chain. From the personnel interview, it is revealed that the base foundation for communication between the companies is E-mail. The Brunvoll uses the Email conversation with their suppliers in addition to customers. Email is good at the primary stages for building the contract. However, during the project execution stages, the conversation between the parties might increase in different perspectives like updates about production and delivery status etc. The company uses the Email conversation for the tracking system, and for the components that they should receive from the supplier.

Here for this problem, I would like to suggest that, to design and develop an external database system where the companies can share the information about product visibility with a high abstraction. In order to achieve this, the GS1 standards sharing system is the perfect suitable i.e. Global data synchronization system (GSDN). However, we discussed earlier that the global data synchronization is a process designed to help the supply chain partners keep on the same page by ensuring the basic data of products and material stored by one company matches the corresponding data in the system of their business partners. This is a place where there is an availability of the communication, information sharing, tracking and tracing of goods. GDSN able to coop with the standardization like GTIN and GLN. Therefore, this can improve the visibility and share the important information among the actors in the supply chain on same platform.

From the personnel interview with the Project manager it is revealed that, Brunvoll is ready to share the information about the production status, delivery documents and shipment documents through a database. However, cost comes into the matter and who should pay for these type of database. Moreover, the use of data base is helpful and time saving between companies.

When I speak with the companies regarding data sharing in the data base, an important question arises from that whether this procedure is secured. The security of data problems arises. The companies were not interested to share the data in a global database. In order to overcome these problems, providing an authentication is an important thing.

Here I would like to suggest that, creating a global data sharing can reduce the burden on the project manager and help to identify the goods. This process is time saving, reduces the cost and rework-rate etc.

The VSM tool in this research provides a new phase of the identification. Moreover this is a lean tool. I would like to use this for the identification of products with in the material flow and information flow. No other tool provides this much detailed view of information flow and material flow. I would like to suggest, that this implementation of VSM in the IOT is the foundation step and propose for further researches.

5.2. Limitations and Further research

5.2.1. Limitations

There always exists some limitations, which cannot be avoided. The availability of resources, time, information and support system can limit the understanding and knowledge in case study method.

The main limitation of this thesis was changing data, Figures and information regard to the Brunvoll and Kleven Company. The implementation of the Internet-of-things (IOT) is a starting process, and the companies are focusing to understand the concept and gathering more information though workshops and meetings for understanding the concept. Getting information from the companies took a longer period, some of the given information is based on the available resources in online. Therefore, if possible the reliability and validity of the data should be checked. Although, I have tried to justify my research through theoretical approach.

Another limitation was; this study is not related to the cost calculations or identifying the cost of present method and future methods. The main focus of this thesis to identify the present information flow and material flow system and suggest for improvements with new technologies where time is also another crucial factor for me as a student. Different thruster present in PO provides complex outcomes. So, focus in only one thruster system was complicated and challenging.

5.2.2. Further research

During the thesis writing and definite limitations on time, some issues and topics can be further analyzed for research in the future.

- Identifying the present information flow and material flow at Kleven can also be the further research. Because, the communication with their design department was their main goal of implementing the newer technologies.
- As discussed above the cost calculation for comparing two systems i.e. traditional and new technology with RFID can be research work for further. How much the company can save from the implementation of the new system is also a primary goal for the managers.
- The further analysis of implementing the Global data synchronization network can also be the research works to support companies.

5.3. Conclusion

The Journey of proposing the internet and communication technology system for the logistics system is an ongoing process and will continue to improve the efficiency by traceability in the process. The traceability, automatic goods receipt and information sharing among the actors in the supply chain are advantages. The concept is very simple, but very hard to adapt, building an attitude of constant pursuit for perfection and developing the global identification products, capturing and data-sharing technologies can open doors to traceability, improve efficiency and develop trust.

In this thesis the use of focusing power of the Internet-of-things and Logistics system to concentrate on significance areas and improve the overall performance of the company. The use of right tools like value stream map, Data flow diagrams and GS1 Standards application of the Internet-of-things (IOT) provides a strategic advantage for flow management and traceability.

The main aim of this case study is to identify the present information flow and material flow at internal and external supply chain networks, propose tools to improve the traceability of goods in external supply networks and improve the supply-chain visibility by creating a path to extended supply chain networks. Therefore, the present research is limited to FU -100-LTC-2750-2050KW product to analyze the material flow and information flow , finding inbound material identification flow and outbound material identification flow using appropriate tools to resolve the problem of traceability in the external supply chain. However, the cost of the production is not analyzed as a part of this thesis because of time limitation and broad discussion.

Value Stream mapping and Data flow diagrams guided to seek an answer for the first research question. The performance of the inbound logistics, outbound logistics, and identification of the present information flow and material flow with identification is identified. From the research conducted, the identification and proposing IOT technologies to improve ETO operations was the main area of focus to improve the information flow and material flow because of the lower visibility there is an increase of re-work and delays in production and delivery.

After identifying the AS-IS the situation in the supply chain the next process of sensing and communication GS1 standards and RFID shows the best possible way to improve the system. This step is the foundation for improving the traceability across the supply chain. RFID serves as the improving process for sensing and also constructs the path for improving the information flow to reach the goal of vertical integration. GDSN offers a great platform for the communication between the participants in the supply chain. It keeps all the actors on the same page and provides the access to the relevant data. Use of GS1 standards, RFID and GSDN tools is further suggestion to the company to get answers to the questions of what this thesis aims for i.e. improving the supply-chain visibility by developing a smooth information and material flow.

6. Appendix

Figure 1: A service order Hub at Brunvoll (Brunvoll 2015)

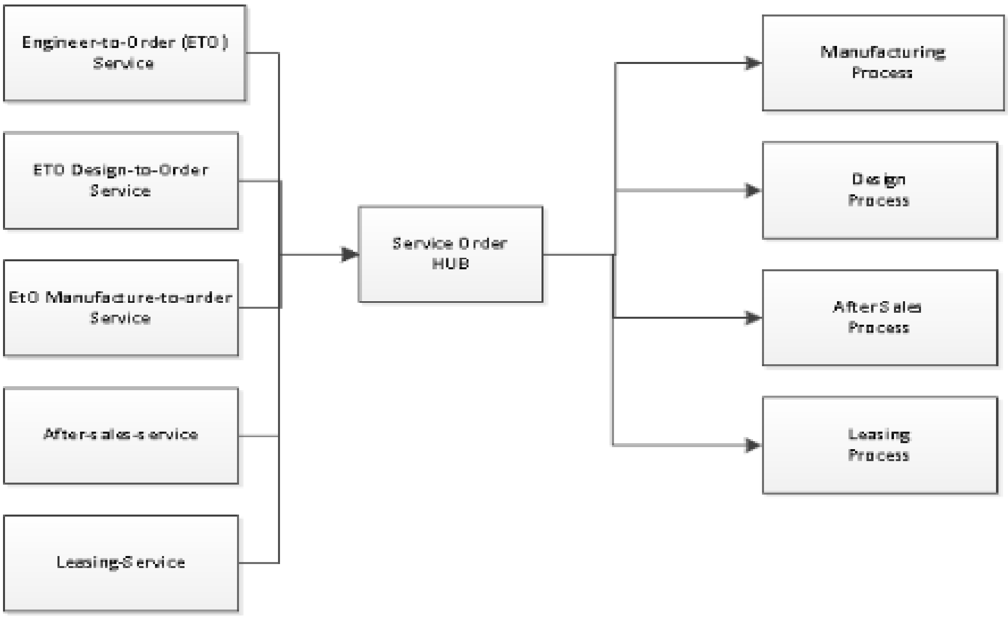


Figure2 : Tunnel thruster system at Brunvoll **(Brunvoll 2015)**

Figure 3: Purchase Order Received from Kleven (By kleven)

KLEVEN

KLEVEN VERFT AS
6065 ULSTEINVIK

BESTILLING 54228

BRUNVOLL AS
STRANDGT. 4-6

6415 MOLDE

Dato	14.01.2014
Side 1 av 3	
Dykkar ref	Bernt Riksfjord
Innkjøpar	Jarl Ole Vada
Tekn. saksb.	
Leveringsmåte	Standard
Leveringsbet	DAP Incoterms 2010
Betalingsbet.	Terminfakturering

Leveringsadresse:
Kleven Verft AS

6065 ULSTEINVIK

Fakturaadresse:
Kleven Verft AS
6065 Ulsteinvik

TLF: 70 01 91 00
www.kleven.no

FORETAKSREGISTERET
NO 983145302 MVA

Bank: 6568.05.22108
SWIFT: NDEANOKK
IBAN: NO 42 65 68 05 22 108

Pos	Vår artikkel Deres artikkelnr	Betegnelse Deres betegnelse	Antall Dimensjon	Enhet	Enhetspris Prosjekt	Lev.dato SFI	Total NOK
		BN 373 - BRUNVOLL THRUSTER SYSTEM					
		Refers to offer Dated 22.01.14 and mails 05.12.2013 and send you our Purchase Order based on this offer.					
1		Tunnel Thruster Units Type FU-100-LTC-2750-2050 kW	2,0		0,00 373	30.06.14 404000	0,00
		See delivery time for Thruster Tunnels for welding into hull in text below.					
2		Retractable Azimuth Thruster U Type AR-80-LNC-2100-1500 kW	2,0		0,00 373	30.06.14 404000	0,00
3		Tunnel Thruster Units Type FU-100-LTC-2450-2050 kW	3,0		0,00 373	30.06.14 404000	0,00
		See delivery time for Thruster Tunnels for welding into hull in text editor below.					
4		Agreed Total Price	1,0		[redacted] 373	30.06.14 404000	[redacted]

BESTILLING 54228

BRUNVOLL AS
STRANDGT. 4-6

6415 MOLDE

Dato	14.01.2014
Side 2 av 3	

Pos	Vår artikkel Deres artikkelnr	Betegnelse Deres betegnelse	Antall Dimensjon	Enhet	Enhetspris Prosjekt	Lev.dato SFI	Total NOK

Delivery time:
Thruster Tunnels: 06.04.2015
Retractable Azimuth Thrusters: 06.04.2015
Tunnel Thrusters forebody: 30.06.2014 yard in Poland, Wisla
Tunnel Thrusters afterbody:30.06.2014 yard in Poland, Crist
Rest of equipment:01.06.2015

Delivery terms:
General Terms and Conditions for Kleven Verft AS
DAP Kleven Verft AS
DAP yard in Poland
General Conditions NL01 E

Delivery adress:
Kleven Verft AS
6065 ULSTEINVIK

Reg. Marking of delivery:
All deliveryes shall be marked with "KP373", Kleven Verft's Yard No., Purchaseorder No. Both on goods, List of contents and Consignment note.

Reg. List of contents and Consignment note:
List of contents and Consignment note shuld be sent to us by E-Mail before shipment of the goods with the Purchaseorder No. written on the documents.

Agreed Price for complete delivery:

Figure4 : Key attributes of IOT(Simona Jankowski et al. 2014)

S-E-N-S-E	What the Internet of Things does	How it differs from the Internet
Sensing	Leverages sensors attached to things (e.g. temperature, pressure, acceleration)	More data is generated by things with sensors than by people
Efficient	Adds intelligence to manual processes (e.g. reduce power usage on hot days)	Extends the Internet's productivity gains to things, not just people
Networked	Connects objects to the network (e.g. thermostats, cars, watches)	Some of the intelligence shifts from the cloud to the network's edge ("fog" computing)
Specialized	Customizes technology and process to specific verticals (e.g. healthcare, retail, oil)	Unlike the broad horizontal reach of PCs and smartphones, the IoT is very fragmented
Everywhere	Deployed pervasively (e.g. on the human body, in cars, homes, cities, factories)	Ubiquitous presence, resulting in an order of magnitude more devices and even greater security concerns

Figure5: Different manufacturing companies strategies(Rodrigues and Oliveria 2010)

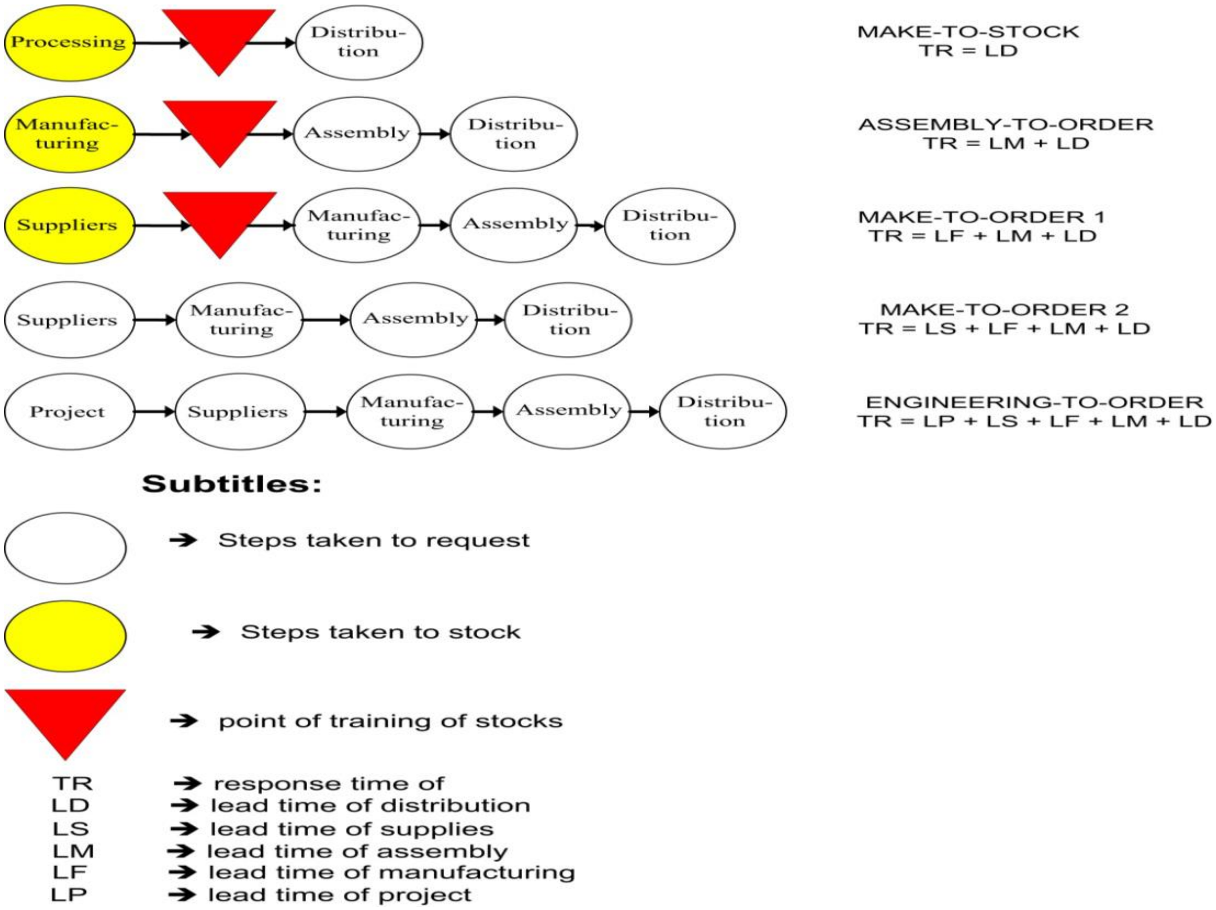


Figure 6: Brunvoll Value Stream Map given by NTNU and SINTEF (By Moreforsking)

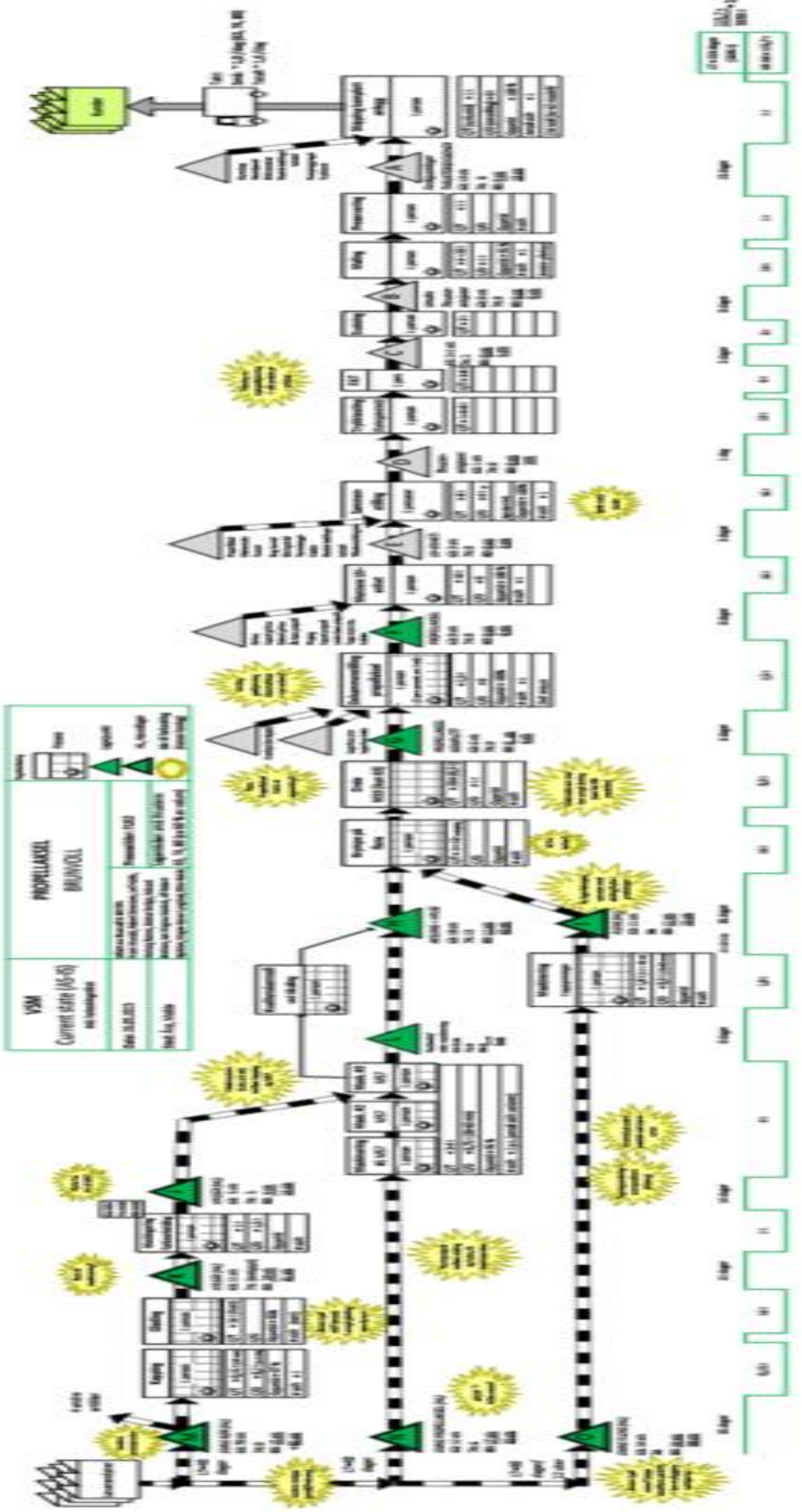


Figure 7: Packing Slip at Brunvoll (By Brunvoll)

a) Consignment list:

▼ SHIPPING DOCUMENTS	
07.07.2015 Memo	SHIPPING DOCS. - CONTROL CABINETS 9. Sent
29.05.2015 Memo	SHIPPING DOCS. - 2XFU100 (GEARBOX) 9. Sent
11.05.2015 Memo	SHIPPING DOCS. - 5 x COUPLINGS FOR FU100 9. Sent
23.03.2015 Memo	SHIPPING DOCS. - 1 AR 80 + Pallets 9. Sent
18.03.2015 Memo	SHIPPING DOCS. - 1 AR80 + HPU´s 9. Sent

P-30393 NB. 373

BRUNVOLL

		NET:	GROSS:				CMB
CLL. 1	AZIMUTH UNIT COMPLETE, P. 10427	15200	15200 kgs.	6,4	2,6	2,65	44,10
CLL. 2	AZIMUTH UNIT COMPLETE, P. 10428	15200	15200 kgs.	6,4	2,6	2,65	44,10
CLL. 3	THRUSTER UNIT UA 80, P. 10427	8400	8400 kgs.	2,6	2,3	3	17,94
CLL. 4	THRUSTER UNIT UA 80, P. 10428	8400	8400 kgs.	2,6	2,3	3	17,94
CLL. 5	HPU, P. 10427	1525	1400 kgs.	2	2	2	8,00
CLL. 6	HPU, P. 10428	1525	1400 kgs.	2	2	2	8,00
CLL. 7	PRESSURE TANK COMPLETE/HAND PUMP, P. 10427	170	120 kgs.	1,3	0,8	0,8	0,83
CLL. 8	PRESSURE TANK COMPLETE/HAND PUMPP. 10428	170	120 kgs.	1,3	0,8	0,8	0,83
CLL. 9	HOSE SET AR80, P. 10427	105	60 kgs.	1,2	0,8	0,4	0,38
CLL. 10	HOSE SET AR80, P. 10428	105	60 kgs.	1,2	0,8	0,4	0,38
CLL. 11	GUIDING COMPLETE, P. 10428	300	270	1,2	0,8	0,4	0,38
CLL. 12	TANNKOPLING KOMPLETT HALVDEL, P. 10427 - 10428	120	90	0,8	0,6	0,4	0,19
CLL. 13	SLANGESETT, P. 10427	90	40 kgs.	1,2	0,8	0,6	0,58
CLL. 14	SLANGESETT, P. 10428	90	40 kgs.	1,2	0,8	0,6	0,58
CLL. 15	LOOCKING UNIT AR 80, P. 10427	520	500 kgs.	1,3	0,8	0,6	0,62
CLL. 16	LOOCKING UNIT AR 80, P. 10428	520	500 kgs.	1,3	0,8	0,6	0,62
		52440	51800 kgs.				145,48

KLEVEN VERFT AS

DAP ULSTEINVIK, NORGE

X Lann |

b) Packing Slip: (By Brunvoll)

BRUNVOLL

PACKING LIST NO. 96761

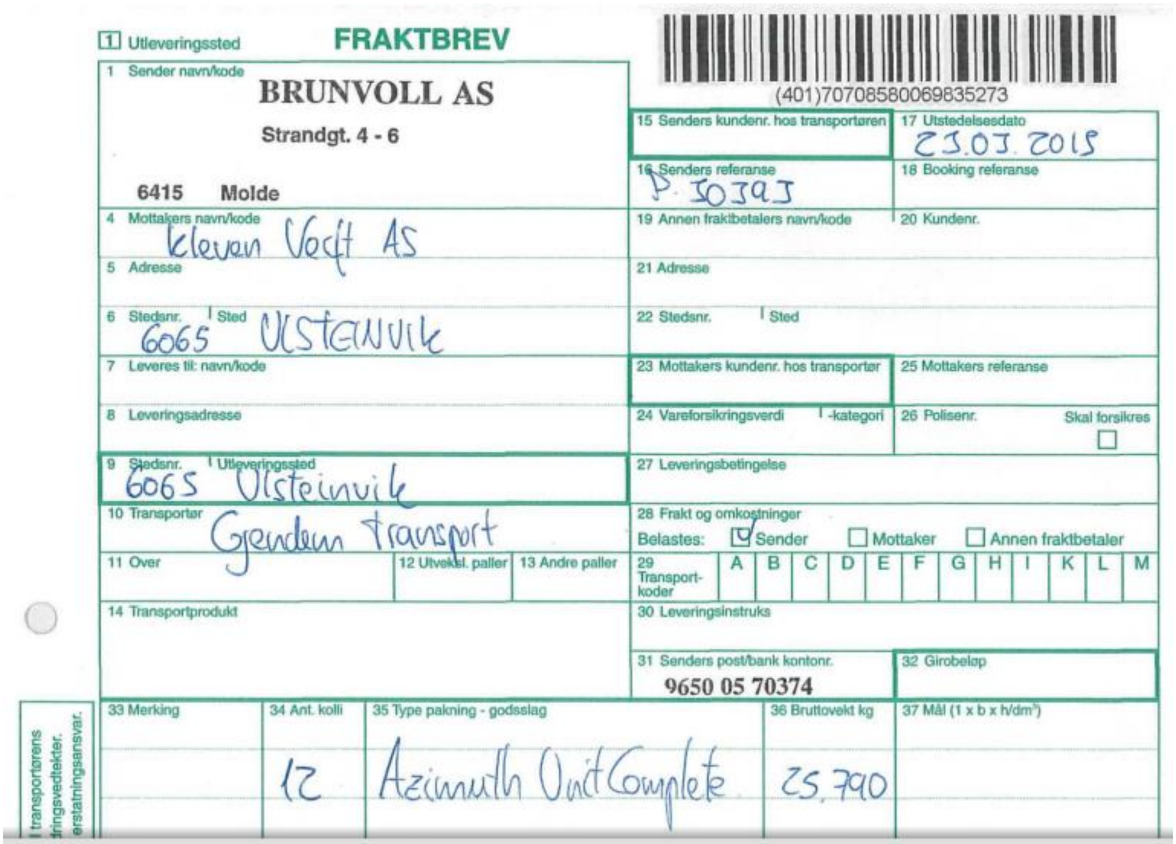
Invoicing Adress:
Kleven Verft AS
6065 ULSTEINVIK
NORWAY

Delivery adress:
Kleven Verft AS
6065 ULSTEINVIK
NORWAY
MARK: "KP373"

Marking:	Deres ordrenr./ Your order no.	Dato/ Date
BESTILLING 54228	KLEVEN "NB 373"	11.05.2015
Prosjekt nr. / Project nr.	**Anlegg nr. / Plant no.**	**Pakkseddel nr. / Packing list**
30393	10425	
Forsendelsesmåte / Shipment by	**Lev. bet. / Terms of delivery**	
TRUCK	DAP Ulsteinvik, Norge	

Art no.	Description		Quantity Ordered	Quantity Delivered
	BOW FORWARD			
024261	ELASTIC COUPLING HALF 100	1	1	1

c) Manually entered Packing slip: (By Brunvoll)



1 Utleveringssted **FRAKTBREV**

(401)70708580069835273

1 Sender navn/kode: **BRUNVOLL AS**, Strandgt. 4 - 6, 6415 Molde

4 Mottakers navn/kode: Kleven Verft AS

5 Adresse

6 Stedsnr. / Sted: 6065 ULSTEINVIK

7 Leveres til: navn/kode

8 Leveringsadresse

9 Stedsnr. / Utleveringssted: 6065 Ulsteinvik

10 Transportør: Grenden transport

11 Over | 12 Utveksl. paller | 13 Andre paller

14 Transportprodukt

15 Senders kundenr. hos transportøren

17 Utstedelsesdato: 23.03.2015

16 Senders referanse: P. 50393

18 Booking referanse

19 Annen fraktbetalers navn/kode | 20 Kundenr.

21 Adresse

22 Stedsnr. | Sted

23 Mottakers kundenr. hos transportør | 25 Mottakers referanse

24 Vareforsikringsverdi | -kategori | 26 Polisenr. | Skal forsikres ☐

27 Leveringsbetingelse

28 Frakt og omkostninger — Belastes: ☑ Sender ☐ Mottaker ☐ Annen fraktbetaler

29 Transport-koder: A B C D E F G H I K L M

30 Leveringsinstruks

31 Senders post/bank kontonr.: 9650 05 70374 | 32 Girobeløp

33 Merking	34 Ant. kolli	35 Type pakning - godsslag	36 Bruttovekt kg	37 Mål (1 x b x h/dm³)
	12	Azimuth Unit Complete	25.790	

Figure 8: GS1 Core Business Vocabulary (Gs1 2016)

Table 1: Logistic functions and information systems features to implement them.(Ferreira, Martinho, and Domingos 2010)

Functions	Features	Barcode	RFID
right goods	Identification	Full	Full
right amount	Tracing	Partial	Full
right place	Location Tracking		Full
right quality	Monitoring		Partial
right time	Real-time responsiveness		
right price	Optimisation		

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