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Faculty of Engineering Science and Technology

Department of Industrial Engineering

Logistic Service at Ports in Northern Norway

Case Study of the Port of Narvik

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Knut Arthur Knapskog

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Abstract

This thesis is a part of the Master of Science degree in Industrial Engineering at the University of Tromsø – The arctic University of Norway, Campus Narvik. The aim of this thesis is to improve the logistic service and increase the competitiveness of ports in Northern Norway in order to attract more port users. A literature review on the topics of logistics in seaports is presented, along with an overview over ports in Northern Norway. A survey is conducted on ports in Northern Norway where information about their logistic service and logistic challenges is put forward. Similarly, a case study was carried out on the Port of Narvik in order to gain information regarding their logistic services and logistic challenges.

Based on the results of the case study and literature review it was concluded that the Port of Narvik could improve their storage operations with a passive RFID system. It was also concluded that a passive RFID system would likely benefit other small- and medium sized ports in Northern Norway.

Acknowledgements

I would first like to thank my main supervisor for this thesis, Professor Wei Deng Solvang, for her valuable guidance throughout this project. I would also like to thank for the advices given from my co-supervisor Professor Raymond Kristiansen.

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1 Introduction

1.1 Background

Maritime transport represents the most ancient global transportation, holding an irreplaceable role in geographical discovery, culture communication and economy development in history. Ports are a vital part of the maritime transportation system, as they represent necessary hubs for distribution of goods along different routes and connection nodes among sea, road and rail. A large part of the global economy comes from maritime transport, with approximately 70 % of the global trade by value going over sea and through ports. Ports are the economic backbone of countries and a country's trade competitiveness is affected by the country's terminals and ports performances. Most ports in the world can be classified as small- and medium sized ports (SMPs), in fact the World Port Source classifies all of the ports in Norway as SMPs. SMPs are more vulnerable than large sized ports and need to stay competitive in order to survive [1-7].

The port authority of the Port of Narvik, Narvik Havn KF, see themselves as a central part of turning Narvik into a transport- and logistic center. Today Narvik already have one of the largest port in Norway and an extensive transportation infrastructure within air transport (in Evenes), railway transport, maritime transport and road transport. Additionally, the Port of Narvik, and to some extent, the other ports in Northern Norway, is connected to international transport corridors. Barents Observer reported in 2014 that the ports in Northern Norway have become increasingly competitive with the Russian arctic sea ports. The port in Murmansk have always been the largest port in the Barents region and the Murmansk region have handle the largest amount of TEU, until 2012 when the county of Nordland handled 31,7 million tons compared to the Murmansk regions 28,2 million tons. This was both due to an increase of handled goods in Nordland and decrease of handled goods in Murmansk. If the ports in Northern Norway is to continue this trend they need to attract more port users then the other ports in the region [8-10].

Technological innovation can give SMPs a competitive edge and allow them to stay competitive. Another way of achieving a competitive edge for ports is to offer value added services to port users. In today's global market there is increasing logistic service costs and requirements. Multinational companies now desire value-added services such as labeling, light assembly, repackaging and tracking of products in the logistic process. Value-added services can attract port users, which will enhance the growth of a port and its hinterland. A competitive advantage is vital in this globalized and volatile market for ports to have commercial success. One method of gaining a lasting competitive advantage is to reduce operating costs and offer value-added services. A small port is not limited to only provide traditional cargo handling services to achieve commercial success, some smaller ports have developed logistics centers that contribute to a large part of the revenue. Larger ports also offers more value-added services to increase revenue and to gain a competitive edge [6, 11].

Energy crises since 1970 have made companies in the logistic sector more aware over transport costs and inefficiencies in logistics and inventory. This led to a larger focus on cost-cutting improvements and productivity in logistics. A study published by OECD found that ports generally have 60-75% operating efficiency, where the efficiency was calculated by the volume of throughput of goods and the resources available at the seaport. It follows that there is a potential for improvement [1, 12].

A report published by the Ministry of Transport and Communications in 2015 expressed the Norwegian governments desire for an increase of transported goods on sea. The reasons being reduced environmental impact from road vehicles, safer roads for the public and reduced wear and tear on the roads. In order to shift transportation from roads to maritime transport, the competitiveness of maritime transport in Norway needs to be strengthened. The Ministry of Transport and Communications state that reliability, cost and “good solutions door-to-door” are important factors regarding maritime competitiveness. The report also stated that the Norwegian ports have influence over the cost and competitiveness of maritime transport in Norway [13].

1.2 Problem statement

This project aims at improving the logistic service and increase the competitiveness of ports in Northern Norway in order to attract more port users.

In today’s global and volatile market SMPs have difficulty competing with other ports, shipping companies choose ports mostly based on the logistics costs. For SMPs to have commercial success and growth they need to attract port users by being competitive in general cargo handling or value added services.

A case study will be carried out on the Port of Narvik and a survey will be conducted on other SMPs in Northern Norway. Based on this work a general solution will be suggested to improve the logistic service for the ports in Northern Norway, and a specific solution will be suggested for the logistic service at the Port of Narvik.

1.3 Limitations of the Thesis

This project is limited to ports in Northern Norway, and due to the complexity of a single seaport, a detailed solution will only be written for the Port of Narvik. Only the ports that are classified as SMPs by the World Port Source will be included in the survey, as very small ports are too small. The survey is made anonymous since some of the ports were unable to answer the survey otherwise.

1.4 Project approach and method

First a literature review was conducted on various topics within logistic at ports. Thereafter a case study was conducted on the Port of Narvik in combination with the port authorities at the Port of Narvik. The purpose of the case study was to gain information regarding the logistics of a port otherwise not found in literature. Then a survey was made and sent to SMPs in Northern Norway to find information about their logistic service and logistic challenges. Finally, a solution was concluded based on this work.

This thesis consists of nine chapters, the first three chapters gives the reader background information and theory relevant to the thesis. Chapter four contains the survey and the results of the survey, while chapter 5 contains the case study of the Port of Narvik. In chapter six the results of the theory, survey and case study is discussed. In chapter seven a solution is presented for the Port of Narvik and chapter eight contains the conclusion of this thesis. Lastly, in chapter nine, suggestions to future work based on this thesis is presented.

2 Abbreviations and Definitions

2.1 Glossary

SMPs Small- and Medium Sized Ports

TPL Third Party Logistics

Carrier The carrier of goods

Forwarder An organization or person that sends or receives goods

Shipping agent An agent that handles administrative tasks on behalf of a ship

Bulk cargo Is typically transported in large volumes and is unpackaged goods, liquid bulk are called wet bulk – otherwise it is called dry bulk.

3 Theory

3.1 Seaport

A port can exist either along the coastline or in a river, therefore a port is not necessarily a seaport. There are many different viewpoints used when defining a seaport, and seaport varies greatly from one another. Therefore, this paper uses a general definition that made by the Working Group on Ports [1, 14, 15]:

“An area of land and water made up on such improvement works and equipment as to permit, principally, the reception of ships, their loading and unloading, the storage of goods, the receipt and deliver of these goods by inland transport and can also include the activities of businesses linked to seaport” [16]

Seaports can be seen as both nodal systems and interchange points for transport, but a seaport is not just a location for ship and cargo services. Most seaports are nodal connections that have multimodal transport interchange, warehousing and storage, value-added logistics and cargo transfer. The nodes that are physical locations where transport may be delayed or go through some process, are called terminals [1, 15].

The assets, function, roles and institutional organization in different seaports may vary substantially from one another, even if they perform the same activities and are of the same size. The reason for this is that there are a large number of stakeholders in every port that have different ways of achieving their objectives and goals. Globalization, along with outsourcing and off-shoring, have made logistic and supply chain management an important aspect of shipping and seaports [1, 15, 17].

There are numerous functions and operations that may exist in a seaport. Naturally a seaport offers access to both sea and land transportation, and a seaport is often a nodal point for road and railways. There are also several services and facilities for ships at a seaport, including repair services, navigation aids, approach channel and pilotage, tugs for large ships, mooring and berths. A seaport can also be an energy supply base, distribution center, mercantile trading center, industrial zone and maritime leisure base. On land at the seaport some features in a seaport are the administration of vehicles, safety and security measures, environmental control, handling of dangerous cargo, storage of cargo and freight in addition to immigration, health and customs [1, 18].

Stakeholders in a port typically include the state; their involvement is usually the funding, operating and development of the infrastructure of a port. The infrastructure of a port can be defined as the area and the permanent assets that constitute the port. Another stakeholder is usually the owners of the superstructures, such as cranes and electric supply, although the substructures can be owned by the state as well. The largest group of stakeholders in a port community is the service providers, which can range from the shipping companies to customs operators. Because of the ever changing market ports find themselves inn, port authorities must adapt to be successful [5, 19].

Strategies for gaining a competitive advantage for ports are cost leadership or differentiation. Differentiation is a strategy where ports provide services other ports does not, in other words the ports specializes in niches markets. Cost leadership is a strategy where ports provides services to a lower cost than other ports. Notteboom and Winkelmans suggest in “Structural changes in logistics: how will port authorities face the challenge?” the cost leadership and differentiation strategies will not be sufficient for gaining a competitive advantage today. Rather the leading ports will be the ports that focuses on the customer need, have good port performance and are “customer-led” [19].

3.1.1 Water Terminals

The Dictionary of Military and Associated Terms defines a water terminal as follows:

“A facility for berthing ships simultaneously at piers, quays, and/or working anchorages, normally located within sheltered coastal waters adjacent to rail, highway, air, and/or inland water transportation networks.” [20]

Most of the water terminals are used for commercial purposes, other uses can be military or leisure. The functions of a water terminal is to handle the interface between land and sea, enabling services to the ships and cargo services. A seaport is often not only a water terminal, the function of a seaport is often intermodal or multimodal in that it makes it possible to transfer people or freight from land to sea. In addition there can be many water terminals at one seaport with different purposes [1, 15].

In recent years the seaports have been more specialized in operating systems and port configurations in order to effectively handle a specified trade or ship. That does not however, mean that most seaports are not multimodal [8].

One important type of water terminal for ports are container terminals, in figure 1 the basic principles of a container terminal is displayed. In figure 2 a container terminal is illustrated from the side. Truck and trains arrive from the hinterland and load or unload containers to the container yard. At the yard containers are sorted after import and export, additionally empty containers are also sorted away for refill. At the quay ships are unloaded or reloaded with containers. Container terminal operation processes can be divided into import and export operations. The container terminals vary greatly with one another in layout, size and function. However the structure is similar in different container terminals [21].

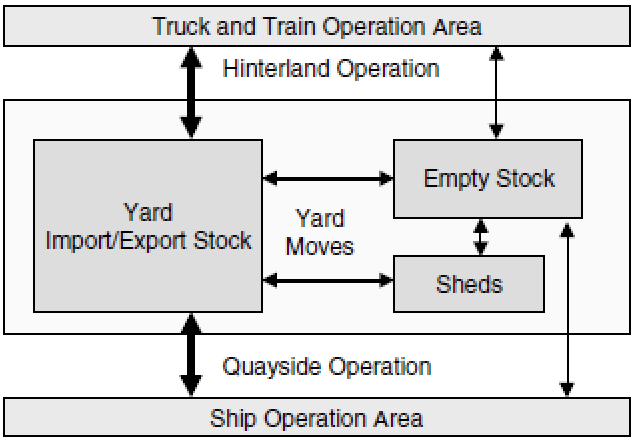

Figure 1 - Container terminal seen from above [21]

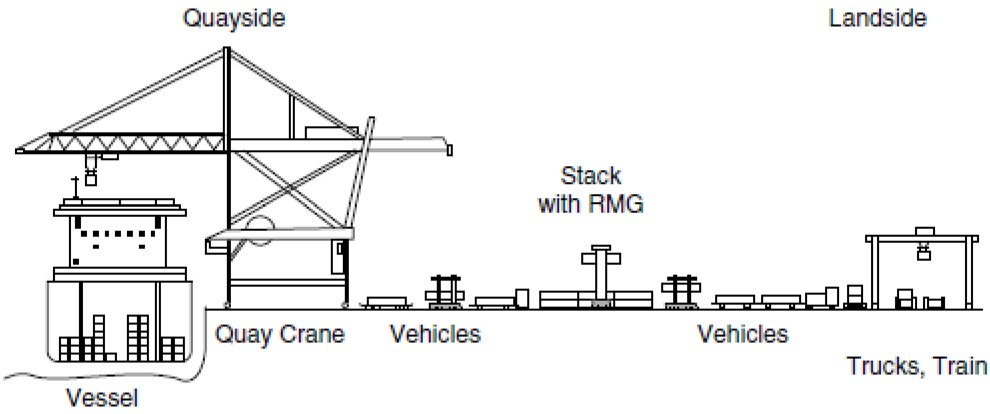

Figure 2 - Container terminal seen from the side [21]

3.1.2 Multimodal and Intermodal Transport

The United Nations defines multimodal and intermodal transport as follows:

“Multimodal transport is the carriage of goods by two or more modes of transport” [22]

“Intermodal transport is the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes.” [22]

Seaports are often inter-modal, in that there are two or more transportation systems in seaports. For example, when transporting iron from train to the seaport into transportation ships for further transportation. When a seaport is inter-modal, the organization, technology and transport of goods are integrated in order to coordinate efficiently. Seaports are inter-modal since it reduces operational time and cost, in addition to the quality and security of the transportation. Another good example of inter-modal seaports is container shipment. Intermodal transportation requires interchange points and good transportation systems. IT and communication systems need to be advanced and cooperation between stakeholders are important. In developing countries, the infrastructure are generally not good enough for intermodal seaports [8].

3.1.3 Small- and Medium Sized Ports

SMPs can be defined as ports with cargo throughput below 300 thousand tons a year. SMPs is disadvantaged compered to large ports by having less resource available to develop. Some SMPs develop because they have an advantage in location or contribute in a hub-and-spoke network. Because of their size SMPs can be more flexible when market changes occur. In order to compete, or avoid competing, with larger ports, SMPs often have their own niche in the market. In recent years the transport vessels have grown in size, which in turn have made SMPs be in a hub-and-spoke network [6, 23].

According to www.worldportsource.com Norway have 10 medium sized ports, while the rest of the 73 ports are either small- or very small sized ports. In Northern Norway the ports of Bodø, Narvik and Tromsø is classified as medium sized ports, and 19 other ports are classified as small ports [7].

Large port clients have a substantial bargaining power over SMPs since although they can ship a large amount of goods through a port, they can also easily start using another port. Today the large port clients do not only look at the logistic value of the port itself, but on the port as part of the whole logistic chain for potential transport. More specifically the cost of maritime, port and inland transport is considered when choosing a port [19].

3.1.4 Maritime-land Interface

Figure 3 illustrates the maritime-land interface in a seaport, operations performed at the interface are mainly repair and maintenance, berthing, docking and undocking, loading and unloading of cargo [15, 18, 24].

The land area behind and around a port is called hinterland. Hinterland is defined by Weigend as "organized and developed land space which is connected with a port by means of transport lines, and which receives or ships goods through that port" [25]. While foreland is defined by Weigend as "the land areas which lie on the seaward side of a port, beyond maritime space, and with which the port is connected by ocean carriers" [25].

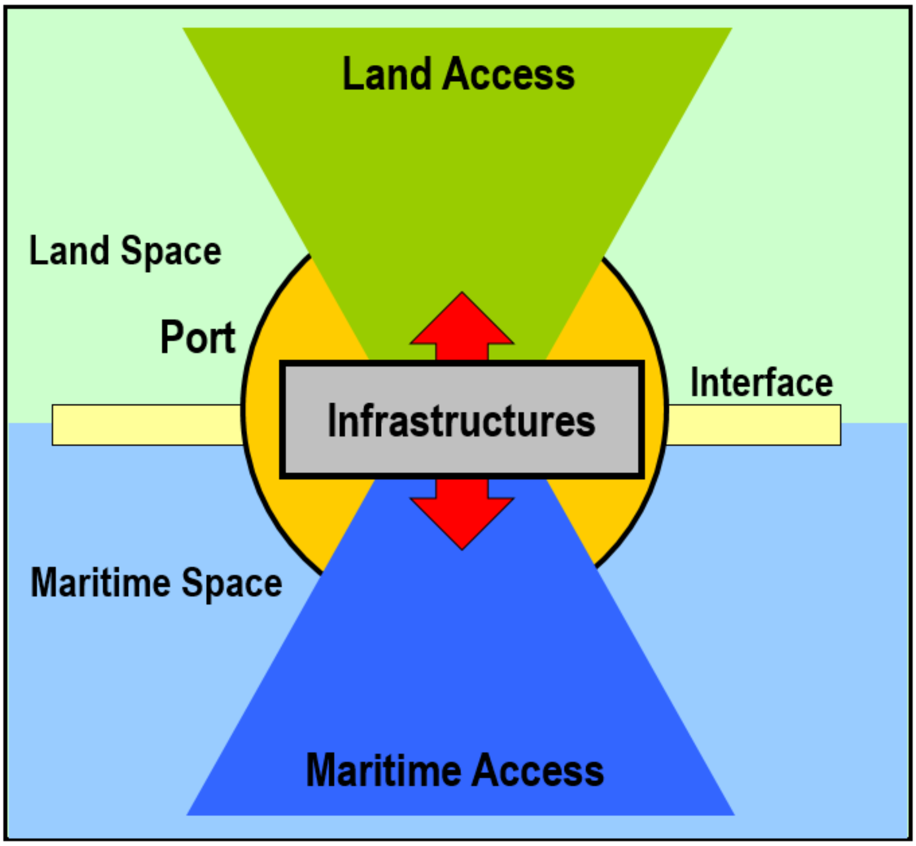

Figure 3 - Maritime-land interface of a seaport [24]

3.2 Operations at a Seaport

The logistics of onshore operations are generally far less developed and perfected than the logistics of offshore operations. It is important that the onshore and offshore operations are integrated in order to optimize efficiency [1, 15].

The usual onshore operations in a seaport are the loading and discharging of goods, storage, waste disposal, water and power refill, refuel, in addition to repair and maintenance of the seaport and transport. In addition to inbound and outbound goods at the seaport, there is also local transportation of goods. Vehicles is used for the local transportation, while vehicles, ships and trains are common means of transportation for inbound and outbound goods. The offshore operations at a seaport consists of operations revolving incoming and outgoing ships. Some ships need to be pilotage, pushed or towed when docking by tugging ships. Other offshore operations are docking, undocking and mooring of maritime transport at the seaport [1, 15, 18].

Transport vessels load and unload either by lifting the cargo or rolling the cargo, or a combination of these two methods. A port therefore often have terminals with Roll-On/Roll-Off (RORO) functions and Lift-On/Lift-Off (LOLO) functions. With RORO vessels cargo is wheeled on a ramp to and from the port, while with LOLO vessels a typical example are containers being lifted with a crane to and from the port [26].

Figure 4 shows an overview of common functions and activities in a seaport, made by UNCTAD [15]. The activities and functions are ordered by whether the goods arrive by sea or land, and whether the goods leave the seaport by land or sea.

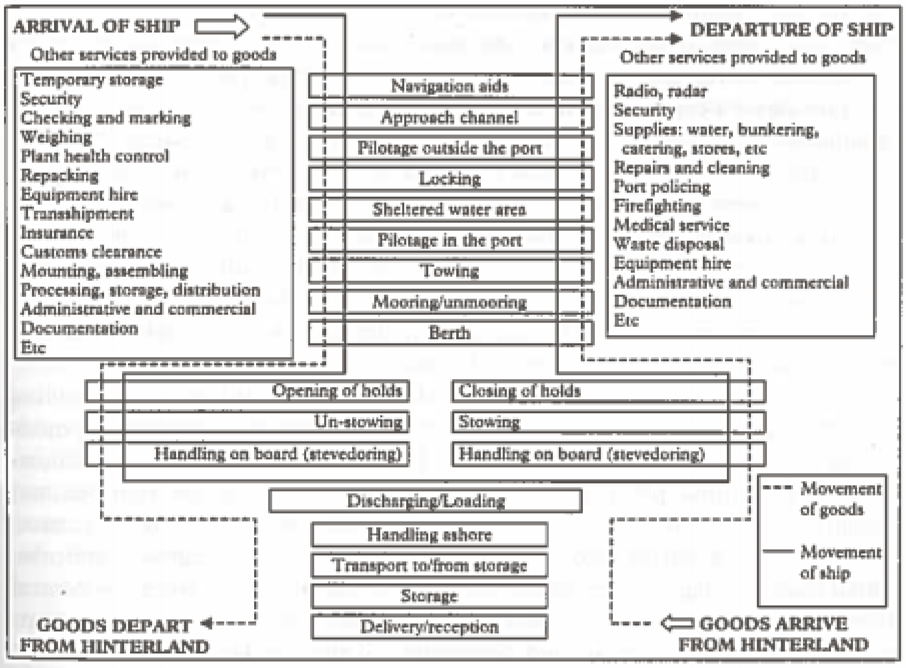

Figure 4 - Overview of common functions and activities at a seaport [15].

3.2.1 Road Terminals and Road Freight

Road transport is the most used land transport in most countries.

The vehicles connected to seaports can be divided into those who transport locally and those who transport long distances. At seaports the local transport is performed by small vehicles with special equipment. Main types of vehicles used at a seaport:

- Pick-up and delivery (PUD): Transports shipment between several locations
- Line haul: Transports shipment to or from one location.

- Straight truck
- Truck trailer
- Truck tractor

The local transport consists often of PUD or peddle runs, these happen daily in response to inbound or outbound freight at the seaport. In a peddle run the time has been divided into stem time and peddle time. The stem time is the time it takes to transport the freight from the terminal to the first pick-up/delivery or the time the driver uses to return to the terminal after the last delivery/pick-up. The peddle time is the duration of time the driver is actively transporting the freight. In order to optimize the peddle run, the stem time needs to be as short as possible while the peddle time needs to be as maximized.

Truckloads (TL) often only have one destination and therefore do not need interchange points. The terminals for TL only provides basis services need for the transport, such as fuel refill. Less-than truck loads (LTL) use terminals since they are in a so-called hub-and-spook system. Examples of terminals used for LTL are PUD terminals and relay terminals [1, 15].

3.2.2 Rail Terminals and Rail Freight

In contrast to road freight, rail freight has a larger transit period. The basic unit of freight on railways are wagonloads (or trainloads or carloads), the value of this unit depends on the freight. The wagons are specialized for the freight they are meant to carry. A “covered” wagon is used for transporting palletized goods, “Open-top” are used for transporting scrap metal. “Hopper” wagon is used for transporting solid bulk cargo, “Tank” wagon is used for the transport of petrochemical products and “Inter-modal” wagons are used for transporting containers and trailers.

The customers and carries of the freight usually agree on a contract concerning the services for the freight by means of predicting cargo volume, time and conditions. Planning the transport direction is simpler on rails than roads, since the rail tracks are less complex of a system. Usually the transport route is either point-to-point or hub-and-spoke, additionally the freight volume in the cars can be both wagonloads and less-than wagonloads. When transporting in a point-to-point route the destination and origin of route is fixed and rarely changed. Service are scheduled and rarely delayed, in addition a point-to-point route requires less resources than a hub-and-spoke route. In a hub-and-spoke system there is a tendency for being a number of less-then-wagonloads that still takes the resource required of a full wagonload. In addition, service is scheduled to the same degree as in point-to-point routes.

Sometime road and rail transport are combined by lifting semi-trailers and containers on a train to be transported, this system is simply called piggybacking. More specifically there are two systems, trailer-on-flatcar (TOFC) and container-on-flatcar (COFC). An example of this would be the rail system through the English Channel were cars are transported.

The rail terminals that are most common are interchange points and are called a hump or a marshalling yard. In this kind of terminal, the freight can be transferred to another train or the train can change tracks. There are also terminals called trans-loading terminals that are Inter-modal and can for example lift semi-trailers and containers on and off flatcars [1, 15].

3.2.3 Storage

Storage management in ports includes warehouse configuration, space determination, stock layout and placement, cross-docking and so on. There are many stocks that may need storage on a seaport and this needs to be managed. Examples are production inventory, in-transit inventory, stock in the pipeline, safety stock, cycle stock, promotional and speculative inventory, obsolete stock and seasonal stock. Sometimes holding inventory is necessary even if it increases the costs of the logistics. The reason can be to have a safety stock because of uncertainties, seasonal demand, purchase discount, production run or volume of transport. Storage is also used when there is excess cargo because of discounts archived buying large quantities. Another typical example is when there is higher delivery rate of cargo than export of cargo. Cross-docking is when freight/stock/products are combined before shipped off to a customer. Consolidation are when smaller products are combined, and break bulk are when larger freight is divided [15, 27].

If a port get an increase in cargo traffic without enough storage capacity it can create congestion with the result of decrease traffic and decreased revenue. Lacking of storage space can be remedied by vertical stacking, effective management of cargo storage areas, create new storage areas, good design of storage areas, monitoring cargo dwell time and efficient floor utilization.

Before ports used manual stock register to handle storage, nowadays barcode label technological systems, computerized systems and special warehousing software are used. Tracking technologies like RFID are also used to trace and monitor cargo at a port as part of the storage system. These systems have led to improved customer services, increased labor productivity, better accuracy and monitoring of inventory and reduced cargo pilferage.

In ports you can store goods in either in open space or closed space. Open space storage is for cargo that can be stored outside without being degraded, while closed space storage will protect cargo from damage from the environment. Additionally, stored cargo can be either short term storage (transit) or long term storage, the short term storage is often stored in an area close to the quay. Transit storage is necessary because of unexpected delays, customs inspections, cargo consolidation, imbalance of quantity between intermodal transports or it can act as an insurance against delays. A large amount of the cargo berth in a port is used for storage, naturally it is therefore important to manage the stored cargo efficiently.

Ports are not developing as fast as the cargo traffic, which makes it all the more important to watch out for insufficient storage capacity. The process of storage of goods at a port can be a bottleneck if not done properly. It is important with control of cargo-flow and efficient allocation of space. If not, the storage operation would lead to unnecessary use of time spent on searching for space, unnecessary use of human resource and machinery. Additionally, it could lead to cargo congestion and inefficient coordination of inland transport [28].

3.3 Logistic Management

Logistic management controls the inward and forward flow of services, people, information and storage in supply chain management in order to satisfy customer demand and reduce cost. In logistic management all of the activities related to logistics are coordinated, optimized and integrated in order to meet customer demand and reduce cost. In addition, other fields such as marketing, manufacturing, sales, information technology and finance can be integrated in logistic management. Logistics functions can be divided into two main categories; physical distribution and material management.

The operational parts of supply chain management are the logistical activities, otherwise supply chain management consist of the cooperation and coordination of levels, functions and staff. The logistic activities in supply chain management are procurement, transportation, fleet management, reporting, data collection, reporting, inventory management and quantification [1, 17, 29].

The logistic activities in supply chain management are procurement, transportation, fleet management, reporting, data collection, reporting, inventory management and quantification [15, 17].

A logistic management system (LMS) tracks and manages transport of goods. Because of the potential complexity of transport of goods LMS are used. LMS helps with the coordination between different parties in the logistic process. Features in a LMS can be capacity control, terminal management, integration, shipment tracking and cash management. Some other functions a LMS have is processing of shipment data and scheduling functions. Usually a LMS have to have a large amount of data to function, this data can be about the volume of goods and the number of customers, participants and agents. A LMS operator needs to have a high competence and be familiar to the logistic activates because of the complexity of the process [30].

3.3.1 Logistic Management in Seaports

Seaports in a logistics view point, usually offers warehousing and storage, value-added activities, transfer operations and cargo handling, consolidation and break bulk and information management [1, 15].

Important aspects of logistic management at seaports are customer service, the value added in logistic processes, integration of logistic in other areas and total cost and trade-off analysis. Because of the numerous stakeholders in seaports, a high customer satisfaction would raise the efficiency and competitiveness in a seaport. Examples of value added in logistic process are inventory management, postponed manufacturing or operational efficiency, to name a few. Many logistic processes are integrated with processes in order to help with tasks such as purchasing and finding total cost. When reducing costs the logistics as a whole needs to be analyzed, since a reduction of cost in a single activity would likely affect the cost of another activity. To help with the cost reduction in logistics cost trade-off analysis is utilized. With cost trade-off analysis two different activities that affect each other are changed, for example a normal analysis would be transport cost against inventory cost [1, 15].

If external organization logistic is integrated into the supply chain it could improve the planning and forecasting, process and product design, demand management and IT integration among other areas. The flow of information, services, warehouses, materials retailers and so on could be shared. However the competition in today’s market puts a halt to such collaboration in the supply chain in seaports [15].

A logistic chain can be defined as all of the activities that contribute to the movement of goods from supply to demand. Since many of these activities makes use of ports, ports is often a vital part of the logistic chain [11].

Logistics are defined by the Council of Logistics Management as: “A part of the supply chain that plans, implements, and controls efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers’ requirements” [31]

Typically, the improvement of logistic systems happens by providing better service level at lower cost than before [11].

3.4 Value-Added Services

Ports are often a key part in the supply chains both locally and globally, a functions as a distributor in the supply chain. Therefore ports are natural locations for development of VAS [32].

Value added services are services that can be seen as additional services rather than just basic services. Services that bring value to the logistic chain are called value added services (VAS). More specifically VA are services that are not entirely necessary for the logistic process but are additional services that benefits the customer. The providers of VAS benefits by gaining a competitive advantage by performing services others may not provide [11, 33].

VA is applied when a production is finished or distributed. Postponement is a value-added activity, along with reverse logistics (returned products, repair and disposal), packaging and information technology (i.e. tracking). Other VAS are warehousing and minor customization of products. VAS have an increasingly important role in seaports, as value-added activities raise the competitiveness of a seaport [1, 15].

According to the UN there are two ways for a port to make a profit in the modern market, either a productivity advantage in general cargo-handling services or from VAS. A combination of the two areas are also possible. The most productive ports are those ports that can, through efficient management, reduce unit cost or those ports that have large capacity for cargo-handling. Port customers are attracted to ports based on the cargo-handling abilities and value-added services a port can offer. If a ports do not have any VAS, transport cost would probably be the only aspect port customers would use when choosing a port [11, 32].

The challenge with competing with other ports based on general cargo-handling services in today's market is that it is based on cutting-edge technology that is available to most ports. As such it is difficult to get an advantage over other ports. Therefore, VAS are seen as a way to get a competitive edge. The most successful ports have both VAS and a productivity advantage in cargo-handling services. Ports that only offer general cargo services have the option of either improving the productivity of cargo-handling or start to offer VAS. In recent years there have been a trend for ports to start offering VAS in order to raise their competitiveness. The port users have become more demanding in recent years in regard to services offered by ports. Costumers satisfaction could be improved with the help of VAS [11, 34].

The providers of VAS in a logistic chain can be carriers, shippers, 3PL or port authorities. There are not one definitive list of VAS since VAS comes in a large variety and often depends on what the customer desires. However, common VAS services are listed below:

Some of the more common types of VAS are services related are technical support, local transportation, storage, advertisement support, customization, assembly, reverser logistics, quality control of products, tracing of goods, installing and product training. Semi-production or assembly at a port is value-added since it lowers the transportation between warehouses and factories. Some ports offer packaging and labeling, since some modern logistical processes requires packaging services to be carried out effectively, and ports are placed ideally in the supply chain to provide packaging.

Sometimes there are needs for customization of products depending on the costumer or country the product are in, some ports provide this service. Tracing of goods brings value to the supply chain, as does reverse logistics. In addition to basic storage, some ports provide inventory management for shipping companies [11, 35].

Port authorities can be influential to other port stakeholders regarding the logistic performance of a port, even though the port authorities a little direct control over cargo flow. A ports strategic advantage can be created by the developing VAS with the help of the port authorities [19].

One concept of VAS is value-added warehousing. The purpose of value-added warehousing is to combine the processes of transportation and distribution, in addition to assembling consumer products. Combining these services results in improved flow of goods, reduced storage and adds customization of goods. Some of the VAS warehousing services are listed below:

- Specialized storage
- Packaging
- Reverse distribution
- Inventory management
- Assembly/customizing
- Transloading
- Labeling/identification
- Inspection/testing

The process of value added warehousing starts with transport of goods to a terminal, for example a port terminal, and continues to a warehouse where VAS are performed. Afterwards the goods are transported to the customer [33, 36].

In todays market ports needs to understand the customers' needs and take advantage of this information by providing VAS. Therefore, ports marketing departments should be eager to get the opinions of port customers in addition to selling services. VAS is crucial for the effectiveness of ports in the context of a supply chain. The availability of providing services/products is an important factor for a port [33].

3.5 Instrumentation

3.5.1 Automatic Identification and Data Capture

Automatic Identification and Data Capture (AIDC) is technology that is used in order to identify objects and gain information of these objects, in addition to storing this information, without human intervention. AIDC is used in logistics and operations at a seaport, and they can be divide into optical character recognition (OCR) and cameras, radio frequency equipment, positioning systems and card technologies. AIDC can often be connected to EDI and TOS at a seaport.

Cameras are used in almost every seaport and is in an automated system. The purpose of the cameras is to monitor and control the terminal assets and the transaction processes efficiently, providing safety and security. OCR is a technology that is used to read and scan text on tickets and documents, in addition to identify container numbers, equipment and truck licenses.

Card technologies are used to control access and identification of people and vehicles at the seaport [15].

3.5.2 Radio Frequency Identification

Radio Frequency Identification (RFID) is wireless transmission of data through radio waves used to identify objects and the status of objects. It consists of two main parts; a tag and a reader (interrogator). The tags will be attached to an object and the status of that object would be transmitted from the tag to the reader. The tags can either be passive or active, a passive or semi-active, and each tag has a unique identification number. Active and semi-active periodically sends out radio signals to be received by a reader. Passive tags do not send out signals by themselves but uses the energy from radio waves sent out by a reader to transmit information. In other words, an active tag will send out information automatically to a RFID reader while a passive tag will be requested to send out information. After the reader receives the information, it will be forwarded to middleware. Middleware is a type of software that manages and communicates with readers. The middleware will filter, format, aggregate and collect the data received in the readers. A RFID system consist of a network of readers, the tags and software, and is used in an automatic system for capturing and storing data [15, 37, 38].

Ports where one of the first users of RFID technology and use of RFID in ports is a growing trend, the cost of RFID is continually decreasing. When ports first implemented RFID, they did so to improve the security system at ports, nowadays RFID is used for process automation and tracking of assets in addition to security. In addition, the passive RFID technology where more widely used at first, but now active RFID technology is becoming more popular. Ports typically implement RFID to get the benefits of labor productivity, increased asset utilization, in addition to safety and security. Another factor can be environmental reasons; port terminals are often visible areas located near populous locations. Therefore, ports can often be target for environmental reduction programs. RFID can be used in these programs and can also be used to optimize transportation in regards to environmental impact [38, 39].

Active tags have the advantage of a longer transmission range, and that it transmits without the help of a reader. One area active tags are particularly suited for are long range tracking of large or valuable assets. The advantage of passive tags is that they are cheaper and requires no maintenance since it has no power source and transmitter. Sometimes both active tags and passive tags are used together in a RFID system. Other technologies that can be combined with RFID are GPS and internet in order to get a real time location of objects [38, 40].

RFID readers have the ability to read several tags at once without line of sight, provided that the tags are within range of the readers. Common objects with RFID in seaports are equipment and cargo (containers, pallets and cases) and RFID are otherwise used to identify and track cargo and provides access control and security [15, 37, 40].

Some of the information that can be stored in a RFID tag are information such as product type, destination or shipment date.

RFID is used to track and identify objects such as inventory, people and assets. In contrast to for example barcode technology, RFID does not require line of sight for identification, have both short range and long range capabilities, and can store a large amount of data. RFID is also used for network visibility, operational control, safety and security. In a supply chain RFID could help with tracking the cargo itself, or the medium used to transport the cargo like trucks, container or pallets. With RFID the port terminal could be more efficient with greater visibility and automated processes. The safety of the personnel and equipment could be increased with RFID usage [21, 38].

The main organizations for standardization of RFID are EPCglobal and ISO. One standard widely used are the EPCglobal Class-1 GEN-2 RFID, also called GEN-2 RFID. GEN-2 RFID tags are passive and uses UHF between 800 and 960 Mhz. The range is about 2 – 10 meters [40].

There are three main types of frequencies used with RFID: low frequency (LF) at 58-148,5 kHz, high frequency (HF) at 1,75-13,56 MHz and ultra high frequency (UHF) at 433,840 MHz – 2,4 GHz. UHF is the frequencies most used at ports for tracking cargo, since the maximum range for the other frequencies is 1,5 meter at HF. The UHF frequencies used is different in some regions of the world, however in Europe the frequencies used are 865-868 MHz. For passive tags Gene EPC UHF can have a read range up to approximately 10 meters. Active tags at UHF can have up to 500 meters range [21, 41-44].

The benefits of a RFID system is provided to both the operators of the system, and often to the whole supply chain. RFID benefits a supply chain since it can be used to track inventory, and the tracking information is shared by the parties in the supply chain to maximize efficiency. RFID have the potential to track an item from production all the way to final delivery. RFID have the potential to optimize supply chain conditions by providing greater visibility Prevention theft is a benefit for all parties involved. In a supply chain "sense" tracking of goods with RFID have the benefits of greater efficiency, fast transportation, better security, lower insurance rates, cost reductions, routing troubleshooting, increased revenue and smaller inventory [21, 42].

Some advantages of RFID are the capability of functioning in challenging environments, large transmitting distance and "point-of-time" tracking. Advantages of usage of RFID in terminals are the wide range of applications RFID could contribute to, reduction of human error because of monitoring of operations, better supply chain visibility and integration. Better security of containers in for the whole supply chain, increased efficiency in the supply chain, automation of administrative tasks, increased labor safety. RFID can also help with the just-in-time concept in supply chain management.

The drawbacks of RFID is high investment cost, depending on the individual systems. Lack of standardization and large RFID generated data set. The cost of RFID is decreasing, and the standardization is getting better [21, 41-43].

3.5.3 Barcoding

Barcode is one of the most dominating AIDC technology used in ports and has been for a long time. The technology is used by the same principles in groceries stores, warehouses and ports alike. The oxford dictionary defines barcodes as "A machine-readable code in the form of number and a pattern of parallel lines of varying width, printed on a commodity and used especially for stock control." [45-47]

There is both 1D and 2D barcodes, 2D barcodes are also known as QR-code while 1D barcodes are simply called barcodes. Data is stored in printed code and a scanner (reader) receives the information up close and transmits it to a computer system [46, 47].

Barcodes can increase the accuracy and efficiency of logistic operations, reduce human error and reduce costs. There are several universal barcodes standard for different types of items to be marked. For a barcode system to function there needs to be a barcode scanner, barcode printer, barcode lables, software and a computer. A barcode system is very cheap and it is possible to have unique identifying numbers for each label, where relevant information can be stored [46, 47].

3.5.4 Weather Systems

Weather conditions at a seaport can delay the arrival time and service of ships. There are both long-term and short-term problems that may occur because of weather conditions, and each of these weather condition will cause a varying degree of difficulty for seaports. Examples of weather conditions that can cause problems are storms, floods, fog, ice, current, waves, tides and in some areas hurricanes. Since most of the global trade goes over sea, shut downs of large seaports can have severe effect on a countries economy [4, 48-50].

Not only will the docking and undocking of ships at a seaport be affected by the weather, but the loading and unloading operations will be affected. Seaports use several sensors and weather stations to monitor and forecast the weather, the information gained helps with decision making regarding docking and loading operation and anchor locations for safety reasons. On safety question could be if dangerous cargo should be unloaded in harsh weather. The objective of monitoring and forecasting the weather is to provide safety and minimize downtime at the seaport [50, 51].

3.6 Information Infrastructure

Information infrastructure (II) can be defined as all of the IT resources, which is the infrastructure components, which are controlled by IT operators and used in the information process. Sub infrastructure in II are application infrastructure, data infrastructure, technical infrastructure, data architecture and architecture of the technical infrastructure [52].

Computer and computer programs plays a large role in the logistic process. Some of the areas where computers are vital are; management of stock and inventory, scheduling of equipment utilization and transport movements and communication systems [1].

Information technology is loosely defined by UNCTAD in Assessment of a seaport land interface: an analytical framework as “anything dealing with computers and communication, and in particular the handling and processing information and data” [1].

There is a large amount of data available to the operators in shipping which makes information systems necessary when making important decision. The information systems helps with obtaining and processing data, in addition to representing the data. UNCTAD divides IT programs into three categories; electronic documentation and transfer of, data e-commerce or e-business, and e-marketing. Services may include tracing and tracking, virtual deal rooms for document transaction and processing [1].

Information and communication technology (ICT) is vital in seaports because of the high degree of service provision, operational complexity, time-based competitive pressures and stakeholders interaction. ICT makes it possible to transfer larger amount of data fast and efficiently between the different stakeholders [15].

3.7 Ports in Northern Norway

There are many ports along the coast of Northern Norway, where most of them belong to either the fishing industry or leisure. There are two other medium sized ports in Northern Norway in addition to the port of Narvik according to worldportsource.com, the port of Bodø and the port of Tromsø [7, 53].

With the exception of ports owned by the private sector, all ports in Norway are owned by the municipality, they are therefore the port authority. The port authority in Norway both offer services to port user and own important infrastructure at the port. Figure 5 displays the amount of LO-LO container throughput in Norway in 2012 at the uppermost map, and total throughput of goods in tons are shown in map below [13].

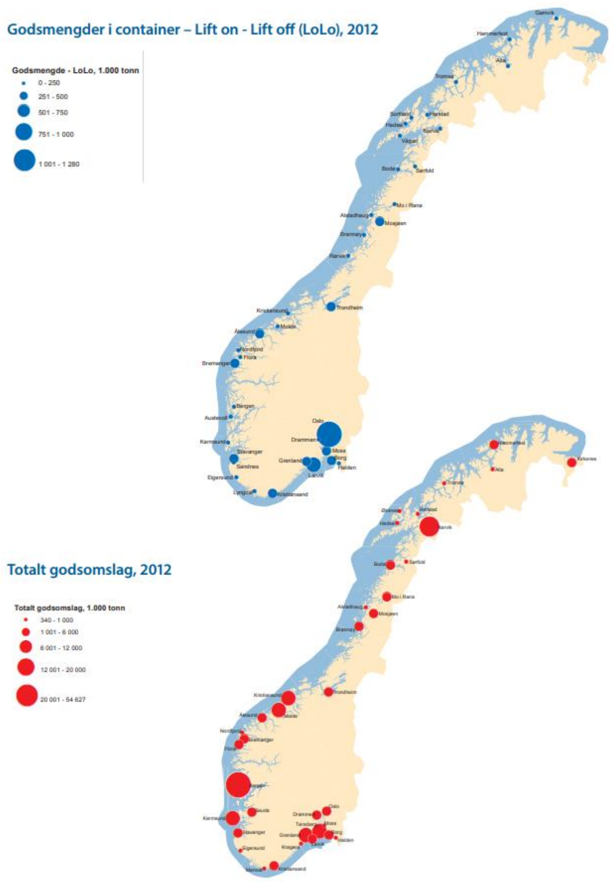

Figure 5 - The upper figure illustrates the Container Lo-Lo in Norway in tons in 2012. The lower figure illustrates the total transported cargo in Norwegian ports in 2012 in tons [13].

3.7.1 SMPs in Northern Norway

Table 1 – List of all SMPs in Northern Norway according to worldsource.com. The table shows main services provided and cargo throughput in 2012 [53, 54].

SMPs in Northern Norway										
Seaport	Water	Electricity	Waste disposal	Container	Ro-Ro	Cargo	Crusie	Wetbulk	Drybulk	Cargo transport in 2012 (tons)
Narvik	X	X	X	X	X	X	X		X	19 415 779
Hammerfest	X	X	X	X		X	X		X	4 817 843
Mo I Rana	X		X	X	X	X	X	X	X	4 151 267
Kirkenes	X	X	X	X	X	X	X			2 417 110
Brønnøy Havn	X	X	X	X	X	X	X	X	X	1 932 870
Bodø	X	X	X	X	X	X	X			1 146 440
Tromsø	x	x	x	x	x	x	x		X	967 733
Sandnessjøen	X	X	X	X		X	X	X	X	908 796
Alta	X	X	X	X	X	X	X		X	665 946
Stokmarkens (Hadsel)	X		X	X		X		X	X	516 700
Harstad	X	X	X	X	X	X	X		X	417 113
Myre-Øksnes	X	X	X	X		X				360 098
Lødingen	X	X	X	X		X	X		X	301 474
Vågan havn (Svolvær)	X		X	X		X	X			135 387
Andøy Havn				X		X	X	X	X	110 446
Båtsfjord	X	X	X	X		X		X	X	83 486
Sortland	X	X	X	X		X	X		X	82 940
Honningsvåg (Nordkapp)	X		X	X		X	X		X	76 776*
Havøysund (Måsøy)	X		X	X		X		X	X	19 080
Vadsø	X									14 011
Vardø	X	X	X			X		X	X	8 389
* Value for the Nordkapp Region										

The Ministry of Transport and Communications wants to centralize the flow of goods in Norway and have therefore identified important ports to achieve this. These ports are classified as “stammnetthavner”, loosely interpreted as the ports that together create a core transport network in Norway. These ports are prioritized funding regarding other transport infrastructure such as roads or railways connections. 32 of the ports in Norway are classified as so called “core network ports”. These core network ports have at least one terminal connected to the core transport network. The ports in Norway that are not classified as core network ports are referred names such as local ports, fishing ports or leisure ports. In table 1 above is a list of all the SMPs in Northern Norway, along with the main services provided and the cargo transport in 2012. The list is sorted by the most cargo throughput in 2012. In table 2 is a list of the core network ports in Northern Norway [13, 55].

Table 2 - List of Core Network Ports in Northern Norway [55]

Core Network Ports in Northern-Norway		
Municipality	**Port**	**Terminal**
Mo i Rana	Mo i Rana havn	Toraneset
Bodø	Bodø havn	Bodøterminalen
Narvik	Narvik havn	Fagernesterminalen
Harstad	Harstad havn	Stagnesterminalen
Tromsø	Tromsø havn	Breivika
Alta	Alta havn	Elvebakken Termialkaia
Hammerfest	Hammerfest havn	Polarbase
Nordkapp	Honningsvåg havn	Honningsvåg havn
Sør-Varanger	Kirkenes havn	Passasjerterminalen

The import and export of goods in Norway is dominated by maritime transport, in 2012 76 % of the imported goods and 88 % of the exported goods was transported on by maritime transport. In 2015 the Ministry of Transport and Communication reported that the vast majority of Norwegian ports had operating profit, where a large part of the profit came from rental of real estate [13].

The EU influences Norway's ports and the EU aims to increase the competitiveness of maritime transport and reduce environmental impact in the years to come. One of the initiatives created by the EU are the Trans-European Transport Network TEN-T, which aims at facilitate a coherent and efficient transport system in the EU. It is divided in two networks, the Core Network and the Comprehensive Network. The Core Network are the most vital ports for transport within the EU, while the Comprehensive Network includes many more ports, including the Core Network. In Norway the Port of Narvik and the Port of Oslo are the only ones that are classified as Core Network ports, while several other ports in Norway are included in the Comprehensive Network. Figure 6 displays Norways connection to the core TEN-T network. Within the Core Network Ports there are 7 ports that are seen as especially important by the government, two of these ports lies in Northern-Norway; the Port of Bodø and the Port of Tromsø [9, 13, 56].

Figure 6 - Norway's connection to the core TEN-T network, with representations of several connecting transport corridors [10].

The European Commission [56] state that: "The ultimate objective of TEN-T is to close gaps, remove bottlenecks and eliminate technical barriers that exist between the transport networks of EU Member States, strengthening the social, economic and territorial cohesion of the Union and contributing to the creation of a single European transport area."

In Norway the goods handled in ports consist mostly of wet bulk and dry bulk. In 2012 the goods transported through ports was measured as 45,4 % wet bulk and 41,7 % dry bulk, while container transport was measured to just 3,3 % and piece cargo was measured as 8,3 %. However the value of the containers can be significantly higher than bulk per volume. 96 % in volume of the transported goods through the Port of Narvik comes from the ore from Ofotbanen [13].

3.7.2 SafeSeaNet

The Norwegian government requires all ships to utilize a system called SafeSeaNet, which is an internet-based maritime single window reporting system. In this system all ships send mandatory arrival and departure information to the Norwegian authorities and seaports. This means no ship needs to send individual reports to the authorities. In addition to the seaports, SafeSeaNet is used by Customs, Police, maritime authorities and military authorities. The information sent through SafeSeaNet are: port arrival, port departure if cargo is dangerous or polluting, waste disposal, if they are crossing the Norwegian baseline, maritime security, port state control, customs declarations, border crossing or pilot requests. SafeSeaNet was established in 2005 and have improved maritime efficiency in Norway [57].

3.7.3 Automatic Identification System

AIS was established by UN in order to increase the safety of ships and the environment, and to improve traffic monitoring and maritime traffic services. In Norway AIS is used to get the position, course and speed of the ship, and the identity, vessel type and dimension of a ship, and finally the destination, estimated time of arrival, cargo and draught. Arrival and departure of ships in Narvik Harbor based on AIS can be seen in figure 7 [58].

Siste ankomster | Siste avganger | Forventede ankomster

Latest Arrivals : 2018-02-01 11:17:19

Vessel	Area	Entry	Stop
NAUTILUS ALDRA	Ankring Framnes	01 08:58	01 09:10
ANANGEL GUARDIAN	Kai 5/6	31 19:26	31 19:32
NAUTILUS ALDRA	Pir 1	31 19:25	31 19:28
NAUTILUS ALDRA	Ankring Framnes	31 17:01	31 17:17
NAUTILUS ALDRA	Ankring Framnes	31 13:19	31 13:27
NAVIOS POLLUX	Ankring Herjangen	31 11:42	31 12:05
OC PEPEL	Ankring Framnes	31 10:38	31 11:32
NAUTILUS ALDRA	Ankring Framnes	31 10:57	31 10:58
BULKNES	Kai 5/6	31 00:29	31 00:38
NAUTILUS ALDRA	Fagerneskaia	31 00:07	31 00:10

KART OVER SKIPSTRAFIKK I NARVIK HAVN:

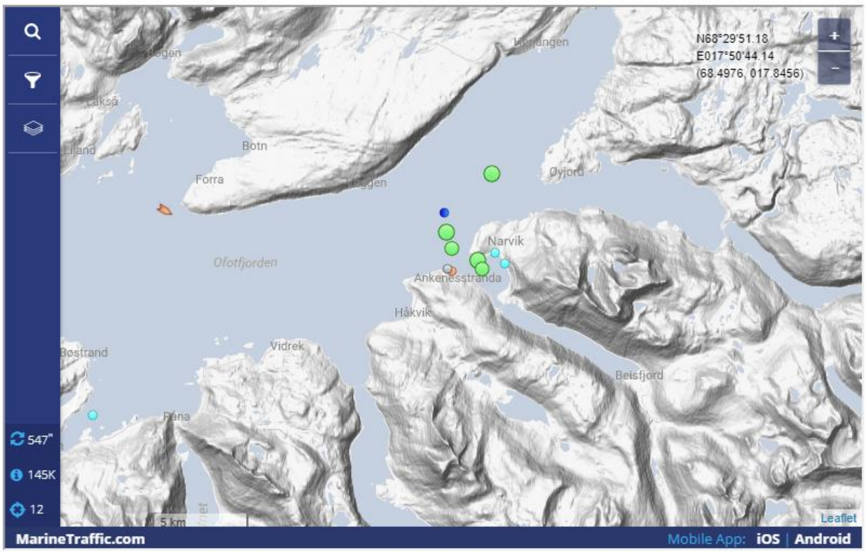

Figure 7 - Ship traffic in Narvik based on AIS and presented in MarineTraffic.com [59].

4 Survey of ports in Northern Norway

This survey is a part of a master thesis that aims at improving the logistic service in ports in Northern Norway. The purpose of this survey was to map what kind of challenges these ports have and what kind of services they provide in order to find potential improvement areas.

The questions for this survey was made based on the literature review conducted as part of this master thesis. Furthermore, the questions was made short and simple to ensure the survey got answered and there was an additional comment in the survey that asked them to elaborate there answers if they could. The Survey was divided in three parts: logistic challenges, logistic activates and value-added logistics.

Ports are complex in the sense that there are many stakeholders providing different services and have different roles. Therefore, this survey was sent to the port authorities, they have a major role in every port, in addition to an extensive overview over activities and services at a port. The port authorities in each port often have different services they provide than other ports. Additionally, the port authorities might have different oversight over operations at the port or might not want to give out information about services provided by companies at their port. Therefore, not every port authority in this survey gives out information in the same detail.

This survey was sent to every port in Northern-Norway that had over 350 000 tons of cargo transport in 2012, of these ports 7 answered.

4.1 Survey Results

4.1.1 Logistic Challenges

4.1.1.1 Does your port have any capacity challenges regarding docking of ships?

All of the seven ports report capacity challenges to some degree.

- Three of the ports have some capacity challenges caused by landside operations. Two of these ports says that it is not seen as a huge issue for the port or the shipping companies, but sometimes ships have to wait before docking. The third port have challenges with large break bulk cargo that have to be transported in high quantities in order to make a profit.
- One port have some capacity challenges regarding fishing vessels in the period of January to April.
- Three ports have insufficient infrastructure for docking ships. There is a growing trend of larger ships docking and therefore one of the ports does not have enough length and depth at the quay. Another port says they cannot handle all RO-RO ships docking and lacking of depth at the quay. The third port have challenges with receiving both cruise ships and cargo ships at the same time, and have therefore denied some cruise ships docking at their port.

4.1.1.2 Does your port have any capacity challenges regarding storage of goods at the port?

- One port have gotten request for larger area for storage.

- One port can have some capacity challenges when storing large break bulk goods. Otherwise, two ports report that they need more space for storage in the future.
- Two of the ports also report that other companies have the responsibility of storing goods at the port.
- Two ports report that their capacity for storage is adequate.

4.1.1.3 Does your port have any capacity challenges for loading and unloading of ships?

- One port says that large ships might be a challenge when loading and unloading goods. The other ports do not report any challenges.
- Four of the ports report that external companies contribute with the loading and unloading of ships at the port.
- Two port says that ships have to use their own cranes or order help from external companies.

4.1.1.4 Are there any services port users have requested that you do not provide?

- Four of the ports says that there are not any services requested by customers that they do not provide.
- The other three ports says that there have been various requests regarding land power.
- One port have been asked to make bunkering more available.
- One port have been asked for larger areas for storage.

4.1.2 Logistic Activates

4.1.2.1 What kind of shipments does your port receive?

- There is a big variance in shipment transported through the ports. One of the ports are specialized in the fishing industry. The other ports report that they receive and send out mainly break bulk cargo and general cargo such as concrete goods, timber, equipment, chemicals petroleum products.
- Only one of the ports said they specifically received containers.

4.1.2.2 Does your port have a terminal operating system? If so, what kind?

- Two of the ports says they do not have a terminal system, but the companies that handle the goods use their own systems.
- Three of the ports use Portwin, two of the ports use Shiplog and on port uses Portit.
- Two other ports report that they do not have a fully functional terminal system and are on the lookout for a "complete system" for administrating the port, such as Portwin or Portit.

4.1.2.3 Does your port have a storage system? If so, what kind?

- One port says they offer storage services, but have no storage system.
- Another port report that other companies offer storage services at their port.
- Two ports says they have no storage system.

4.1.3 Value-added Logistics

4.1.3.1 Does your port provide any of these value-added logistic services, or have received request of providing these services?

Four of the port authorities replied that they do not provide any shipping or terminal services, and they were therefore unwilling or unable to inform what kind of services that were provided in their port.

Other value-added services provided by two ports was rental of real estate to services such as storage, terminal and offices, and one port sent out customer satisfaction surveys.

A) Reverse logistics (returning, repair or disposal of products)

All of the seven ports offer waste disposal services. Otherwise one port report that the shipping companies provide reverse logistics and the two other ports says they do not provide this service.

B) Tracking of goods

One port provides tracking of goods, while two ports do not provide this service.

C) Assembly of products

All three of the ports report that they do not provide this service.

D) Customization of products

All three of the ports report that they do not provide this service.

E) Packaging of goods

One port provides tracking of goods, while two ports do not provide this service.

F) Labelling of products

One port provides labelling of products, while two ports do not provide this service.

G) Quality control of products

All three of the ports report that they do not provide this service.

H) Storage services

Two ports report that they provide storage, however on off the ports says that other service related to storage is provide by other companies at the port. One port does not provide storage services.

4.2 Survey Conclusion

A large amount of the services provided in these ports is run by companies other than the port authorities. Many of the port authorities were either unable or unwilling to divulge what kind of services other companies offer at the port.

One common denominator for all of the seven ports is that they all have at least minor challenges regarding the capacity for docking ships. Those challenges stems from either lacking of infrastructure or large amount of transportation of goods. The capacity for storage is overall good at the ports, with only two ports having minor challenges and two other ports predicting that they would need more space in the future. The unloading and loading of ships is not a challenge for the ports, the cranes used are either mobile cranes usually rented from external companies or ship cranes. According to the various port authorities there are very little services requested by customers they do not provide, the availability of land power has been requested the most.

The ports is Northern-Norway receives all kind of shipments and some of the ports specialize in special areas such as aluminum shipments or fishing. The most common goods at the ports are general cargo not transported in containers. All of the ports with the exception of one uses the terminal systems of either Portwin, Shiplog or Portit. The terminal systems is run by either the port authorities or other companies at the port. Only one port authority offer storage services themselves.

Value-added services provided in the ports ranged from reverse logistics, tracking of goods, packaging of goods, labeling of products and storage services.

5 Case Study of the Port of Narvik

5.1 Case Study Approach

The purpose of this case study is to gain information and understanding of the functions of a port in Northern Norway that is inaccessible by a literature review. Therefore, this case study will analyze a port in Northern Norway in order to suggest improvements to their logistic service.

This case study was conducted by means of meetings with a contact from the port authorities in Narvik, Maritime Security Advisor Frank Brattli, and a literature review. The port authorities was chosen as a contact point since they have a great overview of the ins and outs of their own port. Over the course of this project several visits was made to the Port of Narvik in order to gain information regarding logistic challenges, logistic activities, infrastructure, port operations and the logistic service provided at the port.

5.2 Background of the Port of Narvik

Narvik became an important maritime transport location when the Swedish government decided to transport their huge amount of iron ore through Narvik in the early 1800s. Narvik was chosen since it is an ice-free harbor all year round and because of the close proximity to the Kiruana mines. The growth of Narvik as a city and as a port is largely due the iron ore transportation. The Swedish mining company that owns and run the mine, LKAB, also have their own quays in Narvik, and should not be confused with the Port of Narvik itself. The ships used to transport iron ore from LKAB is required to inform the Port of Narvik of arrival time.

5.2.1 Stakeholders in the Port of Narvik

As in most ports, the Port of Narvik consist of several stakeholders such as; the port authorities, port customers/users shipping agents, carriers and forwarders.

The Port of Narvik is administered by the port authorities, which are called Narvik Havn Kommune Foretak. Either the port authorities or other companies situated at the port provides the logistic services at the Port of Narvik.

Below is a list containing the main companies operating in the Port of Narvik:

Shipping agents

- LKAB
- Grieg Ships Services
- Nord-Norsk Spedisjon AS

Forwarders

- Nor Lines AS – Avd. Narvik
- CargoNet
- DB Schenker
- Nord-Norsk Spedisjon

5.3 Infrastructure at the Port of Narvik

5.3.1 Information Infrastructure

At the Port of Narvik digitalization is seen as a growing trend in the port industry that have a positive impact on the port performance, for example the port authorities are interested in the concept of Internet of Things.

Currently the port authorities utilize several small systems for running the port, these systems are mainly used to gain information about the weather, inbound ships and inbound cargo. Their main system is called Harbor Master and was shaped and modified by themselves. Harbor Master incorporates information from SafeSeaNet and AIS among other information channels and contains information about arrival and departure time, cargo details and other notes. None of these systems are integrated, however some of them have the potential to be integrated.

Although the port authorities provide storage for goods, they do not have a storage system.

Closed gates and camera surveillance ensure security at the port. However, access to the quays is not strictly forbidden, only unwanted.

Today the Port of Narvik have two weather stations and uses a wide variety of sensors to measure the weather conditions. Measurements taken are the current, wind, temperature, air and tide. One website they use is https://kart.kystverket.no/ where information regarding wind speed, air pressure, wave height, current speed and water- and air temperature is shown, a picture of the website is presented in figure 8. Some of the functions at https://kart.kystverket.no/ are only available if the computer is connected to the local area network at Narvik Harbor.

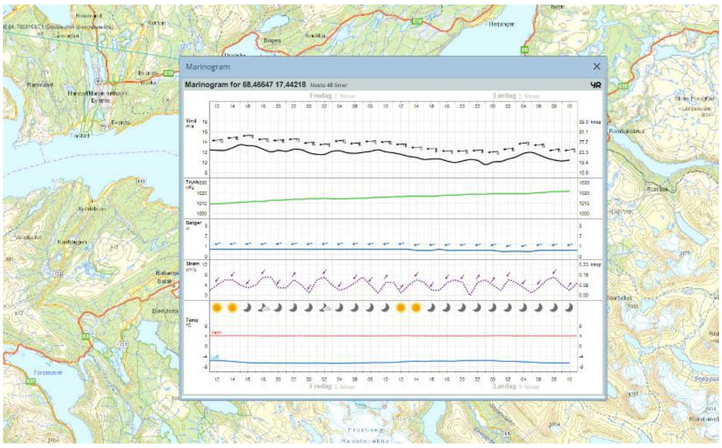

Figure 8 - Weather conditions in Narvik from kart.kystverket.no

5.3.2 Transportation Infrastructure

The Port of Narvik have excellent transportation infrastructure and have connections to maritime transport, road transport, railway transport and Evenes Airport.

At Fagerneskaien there is a direct connection to Ofotbanen railway line and the railway network. The location of Narvik is such that there is good road connections both north/south with the European road E6 and east/west with the European road E10. The port of Narvik is ice-free and a deep sea port, additionally port of Narvik is placed such that it has shelter from wind and weather. The airport used in Narvik, called Evenes, is 1 hours' drive from Narvik. A bridge is being built to cut the drive time down to 40 minutes [9, 10].

In the future there may be to new major transport corridors that might connect to the Port of Narvik and other ports in Northern Norway. These transport corridors are the Northern Sea Route and The Northern East West (NEW) Freight Corridor.

The Northern Sea Route can be depicted as a maritime route from Rotterdam, north of Norway and Russia, and then south to Shanghai. Figure 9 displays the Northern Sea route. The Northern Sea Route has a distance that is 60 % less than the distance between Europe and China through the Cape of Good Hope, and 40 % less than the distance between Europe and China through the Suez Canal. The ice problem in the Northern Sea Route is diminishing, which make the Northern Sea Route a potential major freight corridor that can benefit Narvik Harbor by proximately. Shorter distance saves fuel, time and the environment [10].

Figure 9 - Figure displaying the Northern Sea Route and the Southern Sea Route between Europe and Asia [10].

The NEW corridor is shortest freight corridor between Scandinavia and China, and from Narvik the goods can be transported onwards to USA. The NEW corridor is displayed in figure 10. The transportation time is 31 days to Narvik, the other option is to transport the goods through the Cape of Good Hope or Suez Canal, which takes longer time [10].

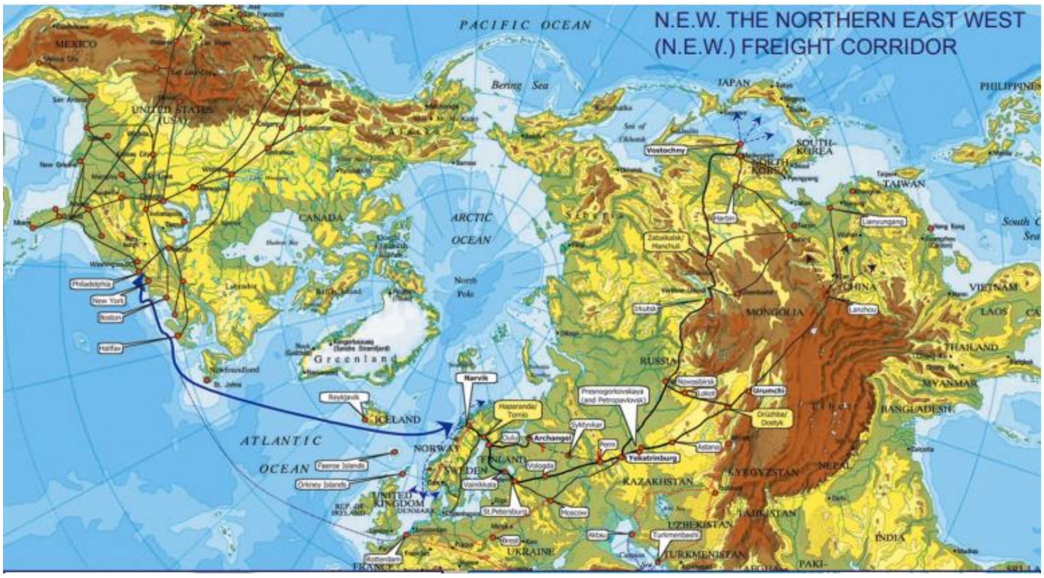

Figure 10 - The North East West freight corridor [10].

The main terminals in the Port of Narvik are the central harbor piers, LKAB's dry bulk berths and the deep-water intermodal terminal at Fagerneskaien. The deep-water intermodal terminal, also called Narvikterminalen, processes container, cruise ships, general cargo and iron ore/minerals. The central harbor processes cargo, cruise ships and passengers. The LKAB terminal only processes ore and minerals. In figure 11 the mentioned terminals are displayed.

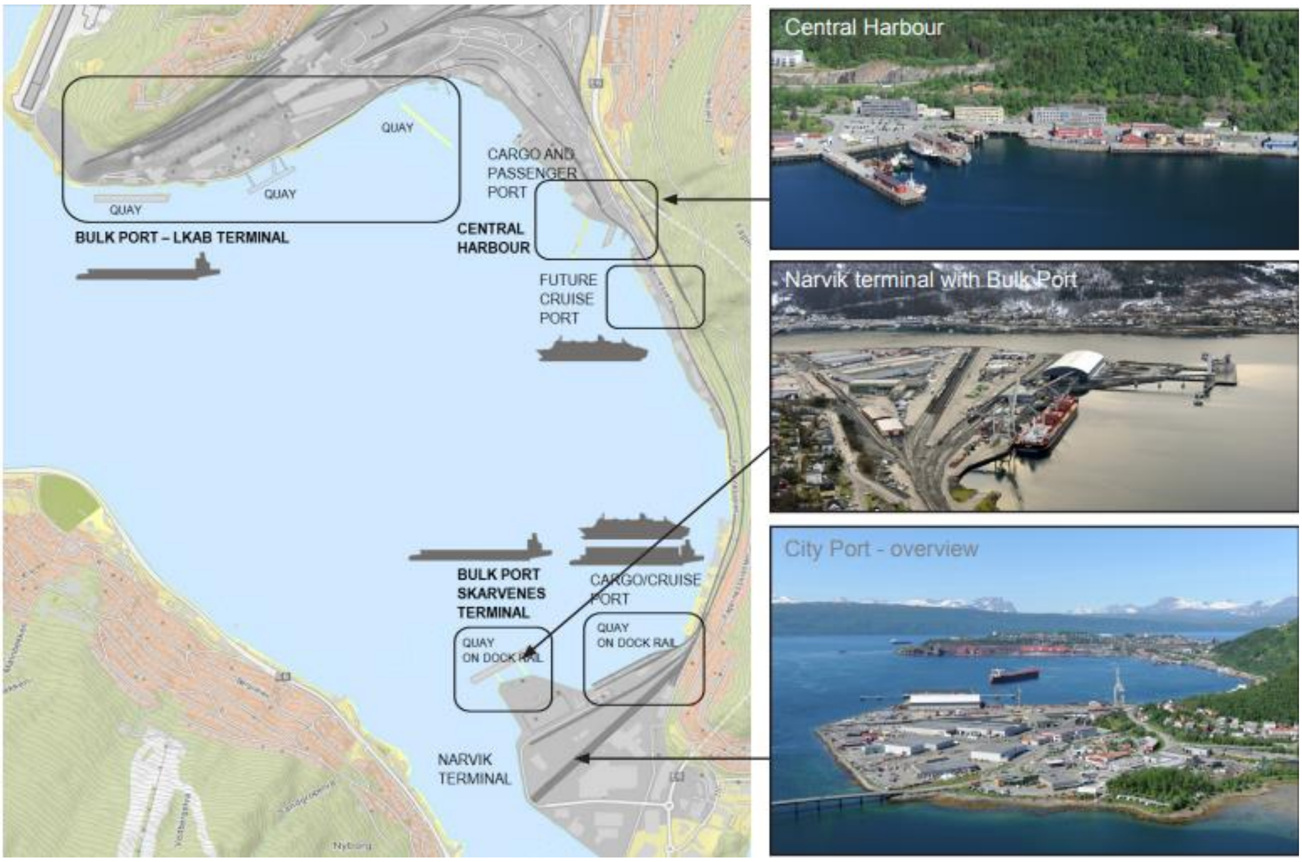

Figure 11 - This figure marks the main quays used in Narvik for other purposes than leisure; LKAB terminal, Central Harbour and Narvikterminalen [53].

Fagerneskaien is the quay used to handle containers in the Port of Narvik. The size of the quay is 50 + 230 meters, ship length is maximum 230 meters and the depth is 13,8 meters., the quay is also used to store containers. Additionally, the quay have a RO-RO ramp and railroad tracks on the quay. Fagerneskaien is also used for general cargo, dry bulk, waste management, bunkering, supply of electricity, as a waiting berth and a docking location for cruise ships. The Port of Narvik owns a 42 ton crane used loading and unloading of goods, i.e. containers, located at Fagerneskaien. Other mobile cranes are also available for customers if necessary [53].

The port authorities predict increased traffic in the future and are therefore planning on expanding their infrastructure. There are three terminals that there are plans about constructing, two ore and mineral terminals and one large terminal for general cargo and containers [10].

The Port of Narvik provides a spot for the military of Norway at the port, this spot is used for transferring goods by the military themselves.

5.4 Logistic Activities and Logistic Service at the Port of Narvik

The main operations at the Port of Narvik is docking and undocking of ships, storage of goods and loading and unloading of ships. Other operations are tugging of the large bulk ships, bunkering, monitoring of ships and waste management. One of the main income sources for the port authorities is the handling of waste disposal on behalf of visiting cruise ships. Another service the port authorities provide is renting of their container crane, along with other equipment such as mobile cranes [57].

The main assignments of anchorage is provided to the large dry bulk ships transporting iron ore on behalf of LKAB. These are very large ships that have the potential to cause damage to their surroundings, the location of this ships are therefore monitored. Radars are used to measure the positions of these ships since GPS may be unreliable because of interference. The large dry bulk ships also needs to be tugged when they are out of position, or if they are docking or undocking, the tugging is provided by private companies. Figure 12 shows one of the tugging operations in 2016.

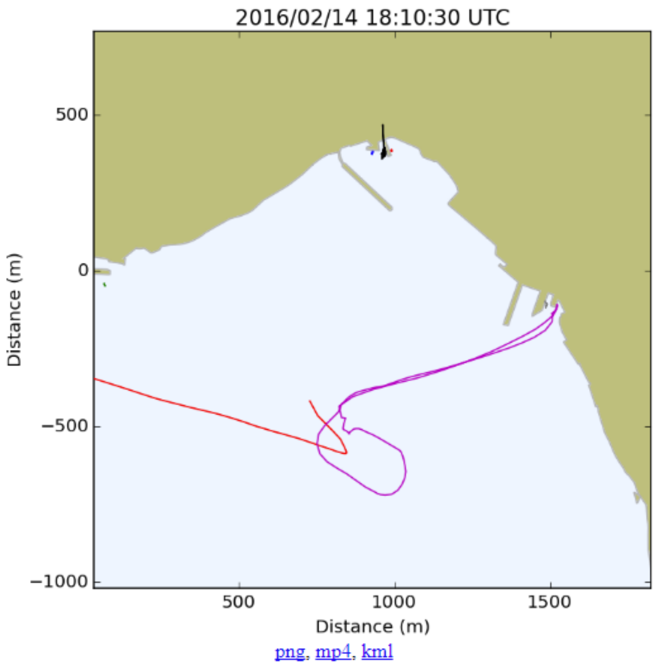

Figure 12 - Tugging operation on a bulk ship in 2016. The red line represent the bulk ship anchoring, while the purple line represents the tugging ship positioning the bulk ship [60].

The port authorities are the ones that operate the loading and unloading, in addition to the storage operation at the Port of Narvik. Shipping agents and forwarders normally take care of the administrating procedures on behalf of a carrier before they arrive at the Port of Narvik.

5.4.1 Shipments

In table 3 and table 4 are the amount of goods transported in 2012 and 2015 respectively. Table 3 is from SSB, while table 4 is from the website of the port authorities of Narvik. Table 3 includes information about the amount of imported and exported goods, the amount of domestic and international goods. In addition, table 3 shows whether the goods was transported as dry bulk, wet bulk, containers, RO-RO or general cargo. Table 4 shows the amount of iron ore, industrial minerals, consumer goods and fish that was transported in 2015 [10, 54].

Table 3 – Amount of goods transported through the Port of Narvik in 2012 in tons [54].

Amount of Goods Transported through the Port of Narvik in 2012 (tons)

	Total Amount of Goods	Amount of Goods Loaded	Unloaded Amount of Goods Unloaded	Amount of domestic goods	Amount of International Goods
Dry Bulk	32264	16367	15897	32264	0
Wet Bulk	19361291	18781124	580167	625954	18735337
Containers - LO-LO	150	0	150	150	0
Containers - RO-RO	0	0	0	0	0
RO-RO	1212	750	462	1212	0
General Cargo	20862	2824	18038	18425	2437

Table 4 –Traffic Load in Narvik in 2015 [10].

The Traffic Load in Narvik in 2015

Iron ore	20 mt/year
Industrial minerals	1 mt/year
Consumer goods	100 000 TEU/year
Fish (part of consumer goods)	200 000 t/year

The iron ore from Sweden is transported westbound, while industrial minerals are transported eastbound. Consumers goods are transported both north- and southbound, general cargo is transported east- and westbound. There are future plans of receiving liquid natural gas (LNG) at Narvik, which would then be made available for the region and for ships [10].

LKAB is planning to increase their production of iron ore, in 2012 they produced 26,3 mt iron ore and the plan was to increase the production to 50 mt iron in 2020. After the iron ore is delivered to Narvik, the returning trains carry calcium dolomite, olivine and quartzite to Kiruna [9].

In 2013 a company called Northland Resources AB (NRAB) also started to transport iron ore by railways to Narvik from Sweden. This iron ore is shipped from Narvik independent from LKAB, and does not utilize their own section of the port, rather they use Narvikterminalen. Planned transportation to the Port of Narvik in 2015 were 4-5 mt iron ore per year [9].

The supply of goods by railways from Southern Norway to Northern Norway have become competitive because of lower cost than the road transport. Approximately 95 % of the goods belonging to the major food stores in Norway destined to Northern Norway is transported on Ofotbanen. Artic Rail Express (ARE) and North Rail Express (NRE) are the two companies that run the supply operation from Southern Norway to Northern Norway. Combined transport is utilized when transporting the goods. Previously there were a lot of empty containers sent south after arriving in Narvik, however the growing fish industry has led to more of an equilibrium of goods sent north and south. In 2013 the number of goods processed through Narvikterminalen were just short of 70 000 TEU [9, 61].

In 2013 there were 22 trains in both direction each day travelling on the Ofotbanen railway line. In Norway 1 % of the railway in Norway consist of Ofotbanen, however 60% of the goods on railways came through Ofotbanen. In 2012 the goods was measured to be 30,3 million tons. 19 trains come weekly from the Oslo Alnabru cargo terminal. Transportation time is 27 hours. 20 millions of iron ore was transported between Narvik and Kiruana [10].

5.5 Current State of Logistics at the Port of Narvik

The survey conducted showed how different ports can be to one another, and the Port of Narvik is no different. One aspect of the Port of Narvik that stands out is the excellent infrastructure, for instance they were the first to get a container crane in Northern Norway. In interviews with the port authorities it emerged that the cargo traffic at Narvik from maritime transport never caused any challenges. The cruise season might also cause more traffic than normal. However, there is enough room for both ships and storage and if there is a shortage of manpower the port authorities have the option of hire people temporarily. In other words, the amount of cargo traffic in the Port of Narvik never exceeds their capabilities. There has also never been an issue with how long a ship stays docked at the port. The port has several quays where ships can dock. In recent years there have been projects around Narvik vicinity that resulted in an increased cargo traffic at Narvik, and none serious problems occurred.

Today the port authorities do not have a storage system. Cargo that are stored is placed either on the quay or inside a shed and a tape measuring roll is used to measure the amount of areas used. Afterwards the measurement is typed in a mobile application and the owner of the goods will be charged by the amount of area used. As the stored cargo is transported away the remaining area used is calculated manually.

Two instances were discussed with the port authorities when interviewing about storage challenges at the Port of Narvik. When the building of the large bridge in Narvik was ongoing, a company sent a large wire to storage at the port. This wire was stored there for much longer than needed, it seemed like the owners of the wire forgot about it. Another case that was a typical example of storage challenges that have occurred before, however it happened rarely, was when shippers of cargo reported inaccurate number of goods that needed storage. In this case it meant that the stored cargo needed to be moved more than necessary to find enough room for storage.

In addition to the container crane, there are several mobile cranes that can be rented if needed.

In interviews the port authorities said that there were not any services requested by port user that were not already provided at the Port of Narvik.

In general, the amount of transported goods is increasing, and the port authorities predict an increase in traffic. Additionally, there have been talks of new transport corridors being used in the future, and there have been talks of alleviating Gothenburg port of some of their cargo throughput.

The port authorities of Narvik and the Ministry of Transportation and Communication aims at increasing the flow of goods from maritime transport. Today there are few containers that are transported through the Port of Narvik by maritime transport, which is something the port authorities want to transport more of.

Schenker and Cargonet are the operators of inbound and outbound goods transported by road or railways at Narvik Terminal. The port authorities in Narvik are the operators of goods that are being transported by maritime transport. Shippers are required to send a waybill to the port authorities that contains information about each cargo piece.

Terminals in the Port of Narvik have restricted access by using gates that are monitored and remotely controlled. The main reason for this is to deny unwanted traffic on the quay. Additionally, some of the quays at the Port of Narvik is closed down when there are incoming ISPS ships (ships that have ISCC certificate), guards are used to admit approved persons and vehicles to the quay.

The type of the general cargo received in the Port of Narvik are pallets, lumber, barrack units, concrete constructions, large drums with wire, bridge deck and garbage balls.

6 Discussion

6.1 The Logistic Service at the Port of Narvik

The purpose of this thesis is to suggest improvements to the logistic service of ports in Northern Norway, in particular for the Port of Narvik. In the modern market the profit made by ports can come from either a productivity advantage in general cargo-handling services or from value-added services. The challenge with competing with other ports based on general cargo-handling services in todays market is that it is based on cutting-edge technology that is available to most ports. As such it is difficult to get an advantage over other ports. Therefore value-added services is seen as a way to get a competitive edge.

The Port of Narvik have excellent infrastructure with several quays, a container crane, a customized terminal system and good connections to road, railway and maritime transport. In contrast to the cargo traffic from maritime transport, the capacity at the Port of Narvik is very good. For instance, in 2017, a bridge was constructed in Narvik and a lot of cargo was transported through the port. The Port of Narvik had no issue with the capacity throughout this period, even though the cargo traffic was above normal.

Only improving the effectiveness of the docking or loading operations will therefore have little effect on the logistic service provided at the Port of Narvik. The Port of Narvik would benefit more from improvement or implementation of value added services. Value added services will increase the logistic service and the competitiveness of the Port of Narvik and can have the additional effect of attracting more port users. Attracting more port customers is an issue for both the stakeholders at the Port of Narvik and for the Ministry of Transport and Communication in Norway.

Having value added services at a port only makes sense if there is a demand for them. The port authorities told in interviews that there are not any services requested at their port that is not provided. At the Port of Narvik there are several companies providing a variety of services, the port authorities provide some themselves. The only value-added services the port authority provides is storage of goods at the port, but only the goods that are inbound or outbound through maritime transport.

Today the port authorities do not have a storage system. Cargo that are stored is placed either on the quay or inside a shed and a tape measuring roll is used to measure the amount of areas used. Afterwards the measurement is typed in a mobile application and the owner of the goods will be charged by the amount of area used. As the stored cargo is gradually transported away the remaining area used is calculated manually.

The storage area in the Port of Narvik, with the exception of the sheds, are around the quay sites. These areas are not officially closed areas for the public, but there are fences and gates with camera monitoring since the port authorities only want people who conduct business to be there.

There is room for improvement of the storage operations at the Port of Narvik, particularly since the port authorities expect increased cargo traffic in the future. The overall infrastructure of the Port of Narvik is as mentioned excellent, but the storage operations fail to achieve the same level. If the cargo traffic increases in the Port of Narvik they risk congestion with the potential result of a subsequent decrease in traffic and revenue. Technology have given storage operations in ports improved customer services, increased labor productivity, better accuracy and monitoring of inventory and reduced cargo pilferage. An inefficient storage process can lead to unnecessary use of time spent on searching for space, unnecessary use of human resource and machinery. Furthermore, it could lead to cargo congestion and inefficient coordination of inland transport.

However, increasing the efficiency of the storage operations at the Port of Narvik will doubtfully attract more port customers, since they already offer storage services. Additional services provide by storage operations such as monitoring, tracing and security do have the potential to attract more port customers. When the Port of Narvik received project load for the bridge construction, some wires were left at the port for a much longer time period than necessary. If the Port of Narvik had a storage system that traced the stored cargo at the port, the company could be notified or monitor their cargo themselves. As such, a storage system that monitored the stored cargo would be value added for the owners of the stored cargo. Two types of technology stands out in this regard, barcode technology and RFID technology. Typically barcode and RFID technology are used on containers in ports, but these technologies are also used on general cargo in ports. Normally general cargo is cheaper to transport in containers, therefore most of the literature on RFID technology on general cargo is about containers. RFID technology is also relatively new and were previously too expensive for small businesses to invest in. It is common for the contents inside a container or on a pallet to be tagged with RFID technology.

The storage operations at the Port of Narvik could improve in security, monitoring, visibility, cargo flow and labor efficiency.

Notteboom and Winkelmans suggest in “Structural changes in logistics: how will port authorities face the challenge?” that cost leadership and differentiation strategies will not be sufficient for gaining a competitive advantage today. Rather the leading ports will be the ports that focuses on the customer need, have good port performance and are “customer-led” [19]. A passive RFID system fits these criteria since the benefits will not only affect the port, but also the customer by adding service to the logistic chain.

Since the port authorities in Narvik run the majority of storage operations at the port, it would make sense if they implement a passive RFID storage system themselves in Narvik. However, for port authorities that do not operate storage at their own port it is possible to instigate an implementation for a storage system by incentives to the operators of the storage system.

6.2 AIDC Technology for Logistic Service at the Port of Narvik

RFID technology has the potential to deliver better logistic service than barcode technology since it has a few advantages over traditional use of barcode. First of all, RFID can have a larger read range than barcode. With barcode the scanner must be right beside the object, while RFID tagged objects can be several meters away from the reader. On the same note, barcode requires line of sight for scanning in contrast to RFID, who does not need line of sight to be registered. An additional advantage of RFID technology over barcode is the ability to scan many objects at one pass. This means a truck driving by RFID readers with many tagged objects would get registered automatically. RFID tags can also store more information than a barcode.

The advantage of barcode over RFID technology is that it is much cheaper to invest in. RFID also have some privacy concerns that barcode do not have. However, RFID technology would make the storage operation and monitoring process more productive and save labor costs [62]. RFID handles harsh environment better also, since the tags are more durable than barcodes.

This paper recognize barcode technology as a good and cheaper alternative to a storage system for the Port of Narvik, but recommends RFID technology since it offers better logistic service. A detailed ROI analysis is needed to distinguish which technology is best suited for the Port of Narvik when costs is included.

There are two main categories of RFID technology used in ports today, active RFID technology and passive RFID technology. While goods attached with active RFID tags have the advantage of transmitting their location at any given moment, the active tags are much more expensive than the passive tags. With active tags the port authorities would get a near real-time location on the goods at the port, which would increase the accuracy of tracing and visibility. However, with the correct setup, passive RFID technology can give a great logistic service to a much lower cost. Active RFID technology is better suited for ports with a huge cargo throughput and are only used on items that is above a certain value.

A feasibility study on RFID technology in the Port of Narvik concluded that passive RFID technology would be a viable investment, and active RFID could be a good investment in the future. The study also pointed out that RFID technology would be more attractive in the future when the costs decreased and when the technology got better standards. This study was focused on a passive RFID system for the use on containers at Fagernesterminalen. This thesis suggested system would also include general cargo, in addition to containers. [63].

The Port of Narvik will be better prepared for maritime container traffic if they have a RFID system, in addition to increasing their attractiveness for maritime container traffic.

The RFID Journal wrote an article in 2016 where they said that a RFID system is viable for many small business since the cost have decreased, especially EPC Gen 2 passive ultrahigh-frequency RFID tags [64].

6.2.1 Benefits of a passive RFID system

- More efficient stock control and easier pricing

Today the port of Narvik have no storage system and calculate the available area for storage manually. With a passive RFID system, tagged cargo would be automatically registered when transported to the port. Readers in equipment could find the cargo more easily, and it would be possible to find out which reader was last in contact with the cargo. The port authorities would get a better overview over the available storage at any given time and can use the information to consider an expansion if needed.

The port authorities charge storage fees based on how much area is used for storage and how long the area is used. With a passive RFID system, it would be faster and more accurate to find the appropriate storage fee to charge.

- Improved security

The current security measures at the Port of Narvik could be improved by a passive RFID system. If the cargo is tagged and the exits have readers in them, it would make it difficult to steal stored cargo at the port. At any rate, the cargo would have been registered by a reader before it was stored at the port, which would reduce the loss of cargo by human error.

Another factor with security at the port is dangerous cargo. The ability to monitor dangerous cargo would also give heightened security at the port.

- Monitoring and tracing of cargo

Monitoring and tracing of cargo at the port is value added to both the cargo handlers at the port and the owners/shippers of the cargo. The cargo handlers gets the benefits of better cargo flow, security, stock control and decreased use of labor. The owners of the cargo would get better visibility in their supply chain, making it easier to control their inventory and cargo flow. Additionally, the owners of the cargo also get the benefit of a heightened security for their cargo.

- Decreased use of labor

The storing and loading operations would be more efficient since it will be easier to know where there is available space and easier to find the stored goods. In other words, the workers would spend less time on the storage and loading operations. Human errors and labor costs would be reduced, there would be a decreased need for counts and manual checks and the cargo handling process would be simplified.

- Better cargo flow at the port

A passive RFID system would automate the registration of inbound and outbound cargo at the port, and equipment with RFID readers would register nearby tagged cargo. Hence, information about the arrival and the location of the cargo would be more accurate than what it would be today. Because of that, the cargo handling processes would be faster and more efficient. The coordination of cargo transport between all of the transports modes (maritime, railway and road) would be faster and less prone to human error. The Port of Narvik would get increased productivity and increased cargo flow.

- Value added to supply chains related to the Port of Narvik

More efficient stock control, improved security, monitoring and tracing of cargo, decreased us of labor and better cargo flow at the port benefits all of the shipping companies that utilize the Port of Narvik. It gives the companies value added logistic service they might not get elsewhere.

- Raised competitiveness for the Port of Narvik

If a passive RFID system is implemented in the Port of Narvik it would raise their competitiveness relative to other ports. As a consequence, the Port of Narvik may attract new port customers and users, or make the existing port customers utilize the port more.

6.2.2 Drawbacks of a passive RFID system

- Tagging of general cargo

The main drawback of implementing a passive RFID system is the requirement of cargo to be tagged with RFID tags. For the Port of Narvik to achieve the benefits of RFID completely every piece of cargo, both containers and general cargo, should already be tagged with RFID. However, the shipping companies might not want, or are unable to tag their cargo before it arrives at the Port of Narvik. If the Port of Narvik have to tag each cargo themselves it would require use of labor, which would be time consuming and costly. Then the benefits of a RFID system would have to outweigh the resources used on tagging the cargo.

Before implementing a passive RFID system at the Port of Narvik, the port authorities would have to talk to the shipping companies utilizing the port and try to make them agree to tag their cargo.

- Investment cost

The investment cost of a passive RFID system consists of technological infrastructure and training of the labor force. As mentioned earlier, a study in 2016 concluded that it was economically sound to invest in a passive RFID system for containers in the Port of Narvik. However, that study did not include general cargo, where the tagging of the cargo is the main challenge considering the use of resources. Below is a list of costs that must be considered with a passive RFID system [41].

  - RFID readers
  - Tags
  - Software
  - Server
  - System integrations
  - Annual maintenance
  - Training
  - Labor
- Interference

Regular RFID tags are prone to interference, but it is possible to buy tags to combat this deficiency without too much cost.

6.3 Passive RFID system

The suggested passive RFID system for the Port of Narvik will be limited to Fagerneskaien for simplicity. The port authorities sometimes store cargo on the other quay areas, but Fagerneskaien is the most used storage area. Additionally, Fagerneskaien is the only quay with direct access to the railway system. The suggested passive RFID system is based on similar systems meant for only containers, as the principles remains the same [65].

A passive RFID system for the Port of Narvik should have the function of a storage system and should monitor the cargo at the port.

6.3.1 Readers

The passive RFID system in the Port of Narvik would need several readers. These readers needs to be compatible with the chosen RFID standard. There would be a need for stationary readers at the railway entrance and road entrance. There must also be a reader in at least one mobile crane and one forklift, the reader would be installed in the mechanical arms. Lastly, a handheld reader is needed.

6.3.2 Software and server

When choosing a software it is important that it either has the functions required of your RFID system, or that it is easily customizable. Another factor to consider is how compatible the software would be to other system used at the port.

6.3.3 Standard

When choosing which standard to choose for passive RFID it is important to choose a standard that is widely used elsewhere. The reason for this is twofold; it would make the RFID system available to tags from many shipping companies and the technology would be cheaper. The Port of Narvik should choose an EPC Generation-2 UHF RFID standard since it is a global standard used all over the world, including Norway.

6.3.4 Tags

As the chosen standard is the EPC Gen2 UHF the frequency will be ultrahigh frequency, giving a longer range than the other available frequencies. The range goes from around 2 – 10 meters, depending on the setup.

6.3.5 Cargo operations with passive RFID

Ideally each piece of cargo would already be tagged with a passive RFID tag when it is shipped to the Port of Narvik. And in the future that may be the case since the use of RFID is increasing, but the port authorities cannot expect every cargo to be tagged today. Therefore, the port authorities should give incentives for the shippers to tag the cargo before sending it. For example, with a discount on storage fees, or make the storage fees for cargo without tags more expensive. The incentives should only be used in the start in order for the shippers to realize the value added in tagging their cargo.

A passive RFID storage system would obviously not work if the cargo is not tagged. There are two types of storage, in-transit storage (short term) and long term storage. If the inbound cargo is not tagged and only in-transit storage, it should not be tagged since it provides too little value for the effort. The in-transit stored cargo is stored for a too short of time period. If the inbound cargo is not tagged and is there for long term storage it should be tagged, since it would get the benefits of passive RFID technology.

Before implementing RFID technology, the port authorities should cooperate with other stakeholders at the port and get them on board with the use of passive RFID technology. RFID technology benefits everyone in the supply chain and should be instigated by both port authorities and shippers.

The size of the general cargo shipped in the Port of Narvik is usually the size of one pallet load. If the size were smaller it would be more expensive to tag every piece of cargo, although it might be worth it for small valuable shipments.

Inbound or outbound cargo in maritime transport would be registered by a mobile crane if it is a LO-LO operation, or by a handheld reader if it is a RO-RO operation. Inbound or outbound cargo from road or railway transport would be registered by a gate in each entrance. Thereby making sure that every inbound or outbound tagged cargo would be registered when the cargo is moved into or outside Fagerneskaien. The forklift and the mobile crane would move the cargo at the port with readers installed in their mechanical arms. This would make it easier to locate the stored cargo and would make it possible to see the last time each piece of cargo was moved.

The port authorities should also consider to make a permanent stock layout, which would make it easier to store goods and easier to find out how much area which is being used.

6.4 Passive RFID system for ports in Northern Norway

Ports in general varies greatly with one another, as was clear in the survey conducted in conjunction with this thesis. Therefore, to suggest one solution to improve the logistic service in every port in

Northern Norway is not possible. However, a passive RFID system could benefit a port if the port have capacity issues or expect capacity issues in the near future.

In contrast to the Port of Narvik most of the ports included in the survey had some capacity challenges. A detailed study must of course be made to know if a passive RFID system should be implemented or not in a port. Two of the ports reported that they expect capacity issues with storage in the future. And, as discussed earlier, neglecting storage capacity can result in a decrease of cargo throughput and revenue. A passive RFID system is not the only solution, but it comes with a great deal of benefits. If a port does not use a system similar to RFID today, implementing RFID would provide monitor and tracing service, improve the security at the port, decrease the use of labor, raise the competitiveness at the port, improve the cargo flow and bring added value to their supply chains. Before deciding to implement a passive RFID system, it is important to talk to the shipping companies and find out if they would be interested in the use of a RFID system. If the port authorities are not the operators of storage at the port, they can still instigate a process for implementation of a RFID system.

If more than one port implements RFID for general cargo or for just containers it would likely benefit all of the ports, since it would attract more port users to Northern Norway. In addition, it would bring added value to supply chains operating in Northern Norway.

A storage system such as passive RFID is beneficial to all of the ports since it can make the loading and unloading more efficient and therefor levitate some of the capacity issues those ports have. Time is one of the key costs drivers in maritime trade, it follows that if ports could speed up the cargo flow, it would profit the ports. The key challenges to overcome before implementing a passive RFID system is whether there is a return of investment and if they can get most of the cargo to be tagged before arriving at the port.

7 Design of Storage System for the Port of Narvik

The boundaries of the suggested passive RFID system at Fagerneskaien is shown with red lines in figure 13. There are two road connections to the restricted area, one at the bottom left corner and on at the upper right corner. Only entrance at the upper right corner, marked Vehicle gate, will be used in this system. The gate will have a reader installed in order to register any inbound or outbound tagged cargo. Another gate will be the Railway gate, the gate is placed where cargo is transferred between railways and Fagerneskaien. The Railway gate will also have a reader installed to register inbound and outbound cargo. The tagged cargo from maritime transport will be registered by reader installed in the mechanical arm of a mobile crane if it is a LO-LO operation. A RO-RO transfer will be registered by a handheld reader.

The handheld reader will also function as a backup in case of instances such as malfunction in the other readers. The last reader will be installed in the mechanical arm of a forklift that will be used to move tagged cargo at Fagerneskaien. Both the mobile crane and the forklift can then be used to easily and accurately locate specific cargo.

The types of tags used should be EPC Gen2 UHF, and the other RFID components needs to be compatible with the tags.

Figure 13 – Illustration of the outline of the suggested passive RFID system.

The installation time of a similar system for a Norwegian company, Minera Norge, took four weeks. RFID readers along with GPS was installed in forklifts in order to accurately locate tagged pallets with slate tales under snow. The system use passive EPC GEN-2 RFID tags, and has been a great success and increased the company's productivity [66]. Since the systems are similar, the installation time for a passive RFID system at Fagerneskaien would probably be the same.

The cost of RFID technology has decreased over time, for a passive RFID system the infrastructure is the most expensive features of the cost. Below is a rough estimate of what this system would cost the port authorities at Narvik, excluding expenses such as installing and training. The numbers are taken from a provider of RFID technology [67].

One handheld reader: $2500-$4000

Four fixed readers: 4 x $2000

Tags: Depends on the quantity and what type of tags, Smart labels cost $0.3 in quantities of 5000

Software for both handheld readers and fixed readers: $17k-$150k.

8 Conclusion

Based on the discussion from the results of the literature review and the case study of the Port of Narvik, a passive RFID system would improve the logistic service at the Port of Narvik and have the potential to attract more port users. The storage system at the Port of Narvik have a large potential for improvement, and a passive RFID system would increase the productivity and add value to the customers and the port operators. Before implementing a passive RFID system cooperation between stakeholders at Narvik is vital, furthermore a ROI analysis is recommended because of the high investment cost.

The survey answered by seven ports in Northern Norway showed that there are some capacity issues today or in the near future. A passive RFID system would levitate capacity at the ports and bring value to the port customers, which have the potential to attract more port users. If several ports in Northern Norway implemented a passive RFID system, it could benefit every user of the RFID system. A detailed study on each port is needed to decide if a passive RFID system should be implemented in each port.

9 Further Work

Before deciding to implement a passive RFID system in the Port of Narvik a more detailed study must be carried out. An analysis should be made on which kind of setup for a passive RFID system that would fit the Port of Narvik. Additionally, a ROI analysis should be conducted for the implementation of a RFID system at the Port of Narvik. A survey should be made to the stakeholders, particularly the shippers, at the Port of Narvik to examine if they are interested in partaking in a passive RFID system.

A detailed study could also be made on the other large ports in Northern Norway to find out if a passive RFID system would be valuable for them.

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