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Optimizing the container logistics process of raw materials at Boliden Harjavalta

DEGREE PROGRAMME IN LOGISTICS
2023

Author(s) Nikkanen, Tomi	Type of Publication Bachelor’s thesis	Date November 2023
	Number of pages 34 pages 0 pages of appendices	Language of publication: English

Title of publication

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Degree Programme

Degree Programme in Logistics

Abstract

This thesis was implemented to raw material logistics to from Port of Rauma to the Smelter of Boliden Harjavalta and introducing different phases of the logistic chain. Qualitative research was implemented, and various data sources were applied on defining and measurement phase. The final analysis was interpretative due to the uneven flow of arrived containers that caused overtime.

The research target of the thesis was to evaluate the capacity of the different phases of the logistic chain and investigate what actions are needed to increase the total capacity of throughput when applying normal 40 hours of working per week. The evaluation process was done according to the guidelines and theory base of the Lean philosophy.
The main method of the study was DMAIC and bottle-neck analysis, and both were implemented in action.

During the study, the logistic process was defined and chopped to smaller subprocesses, these phases were measured based on the available existing data and the remaining gaps were filled with the help of professional parties involved. Then the achieved data was analyzed with the bottleneck analysis to find the subprocesses to be focused on. Finally, improvements were applied to certain phases, and controlling was done by following the increased capacity on a weekly basis.

The purpose of the thesis is to optimize container logistics of raw materials. After the proposed improvements, Boliden Harjavalta would be able to increase the volume of raw materials in containers and decrease the operating expenses (OPEX) per received tonnage. According to the study, existing logistic process achieved notifiable improvements in capacity and can be considered to sensitively optimized that before implementation the LEAN philosophy.

Keywords: container, optimizing, DMAIC, bottleneck, LEAN

CONTENTS

1 INTRODUCTION

The purpose of this thesis is to investigate the various phases of container logistics of raw material flow from Port of Rauma to the Smelter of Boliden Harjavalta and evaluating the total capacity of the logistic chain. The target is to measure the individual capacity of all the phases, analyzing the bottlenecks and making improvements for the certain phases to achieve an increase for the total capacity. The evaluation process should be done according to the guidelines and theory base of the Lean philosophy.

By optimizing the container logistics in general, Boliden Harjavalta would be able to increase the volume of raw materials in containers and decrease the operating expenses (OPEX) per received tonnage.

In the theory section the Lean philosophy will be studied in general, and its various tools are investigated, and suitable ones are chosen to be implemented in this study. On the second partition of theory, the meaning capacity in general is defined and applicable portion is implemented to capacity of containers.

2 RESEARCH OBJECTIVES AND METHODS

In this chapter the targets and research questions are introduced, limitations are determined, and ethical issues are taken into account. This is qualitative research, and the data sources can be variable, and analysis is interpretative.

2.1 Target and methods

The research target of the thesis is to evaluate the capacity of the different phases of the logistic chain and investigate what actions are needed to increase the total capacity of throughput when applying normal 40 hours of working per week. The main method of the study will be DMAIC and bottleneck analysis, and both will be implemented in action.

In this qualitative research the data will be collected from variable data sources of Boliden Harjavalta and blind spots are fulfilled with personal interviews. The documentation of standard operation procedures and authors own personal observations are applied as well. The analysis of the data of this study can be seen as interpretative in some perspectives when considering the reasons behind the deviations in processing of containers. On Table 1, the differences between quantitative and qualitative research are compared.

Table 1. Differences between quantitative and qualitative research. (Uwe, 2011)

	Quantitative research	**Qualitative research**
Theory	As a starting point to be tested	As an end point to be developed
Case selection	Oriented on (statistical) representative, ideally random sampling	Purposive according to the theoretical fruitfulness of the case
Data collecting	Standardized	Open
Data analysis	Statistical	Interpretative
Generalization	In statical sense	In a theoretical sense

2.2 Research questions

Due to the target of lowering operating expenses (OPEX) from containers logistic process of raw materials, one of the major concerns was related to the capacity and the unbalanced capacity of the process. Therefore, to be able achieve the targets, the following research questions were raised, and this thesis provides answers to them.

1. How to define the capacity of the logistics chain?
2. What are the bottlenecks in logistic chain of containers and how to improve those?

2.3 Limitations

The material quality is limited to only one type of quality and packing method to be able to achieve similar results. The outside temperature is estimated to be between +5 and +25 degrees Celsius and the driving condition of the trucks will be estimated to be among normal traffic. On later phases these results might be amplified to other qualities as well and to variable type of packing methods like big bags.

2.4 Ethical issues

Ethical issues can be found from the targets of this thesis and how they are presented to different parties. Most of the people have normal reluctant reactions when increasing the capacity is mentioned. These worries need to be taken seriously and explained the targets and the reasons thoroughly to all parties. The common mistake is not involving and participating people from the beginning when identifying possible bottlenecks and calculating capacities. In this thesis all the people are taken into account, and they have had opportunities to open up freely about their thoughts and feelings.

3 BACKGROUND INFORMATION

This thesis is implemented to container logistics of raw materials from Port of Rauma to the Smelter of Boliden Harjavalta and introducing different phases operated by various subcontractors of the logistic chain of containers.

3.1 Boliden Harjavalta

Boliden AB is a Swedish multinational mining and metal refining company, and they have a vision to become the most climate friendly and respected metal provide in the world. Boliden Harjavalta, as a part of Boliden group, is located at Satakunta region, Finland in three different locations, Harjavalta, Pori and Mäntyluoto. Boliden Harjavalta has approx. 550 employees and annual revenue of over 400 million euros. Boliden has been the biggest taxpayer in Satakunta region multiple times in the past decade. (Boliden Harjavalta, 2023)

Boliden Harjavalta produces pure copper, nickel matte, precious metals, and sulphuric acid by smelting concentrated ores from various mines around the globe. At Mäntyluoto, Boliden Harjavalta has receiving, warehousing and transportation facilities for concentrates arriving by vessels in bulk form. At Harjavalta, where most of the employees, both smelters and sulfuric acid plants are located, is the main operation location for the company. At Pori, where the tank house is located, facilities are used for purifying the copper anodes to copper cathodes with electrolysis process. (Boliden Harjavalta, 2023)

This thesis is focused only on Harjavalta, and the beginning of the copper smelting processes where the raw materials that are similar to sand, are transported to smelter’s warehouse for further processing eventually into the pure metals.

3.2 Logistic chains and existing process

Some raw materials are transported to Boliden Harjavalta in bulk form and packed into standard 20 feet container. A typical shipment is approximately 700 WMT (wet metric ton) and is divided into 30 containers. Each container can hold up to 26 WTM of bulk material, but the normal loading weight is approx. 22 WMT. The agreed delivery flow with the supplier is weekly based and each week a one 30 containers shipment should arrive in the Port. (Peltomaa, 2022)

In the purchasing contract, the normal incoterm for the shipment is agreed to be CIF-Rauma. That means the seller is responsible for the freight and insurance costs until the material arrives at Rauma. The same contract defines the number of free days and if the container is not returned to Port in two weeks from the vessel's arrival, the buyer needs to pay demurrage to the shipping company. This is financial input for running the containers smoothly and efficiently through the logistics chains and discharging processes. (Peltomaa, 2022)

Figure 1. Container vessel at Port of Rauma. (Dimedia, 2023)

Port to Terminal

All containers included in the same shipment will arrive at Port of Rauma within the same feeder vessel from major container ports at European Continental. A typical container vessel is showed in Figure 2. The arrival day can be any day of the week, but normal arrival day is Tuesday. Three days before arrival the Boliden staff will handle the documentation and containers can be released to Boliden's subcontractor for delivering the containers to Terminal. (Tuori, 2023)

The containers are transported to Terminal at Sievari industrial area with normal truck and trailer combination and each truck can carry two containers at once. At Terminal, the loaded containers are lifted down into dedicated places using fork lifter. During the summer times, the containers stacks are outside at asphalt area, but in wintertime the containers are stored in a warm warehouse to avoid any freezing. Terminal area is shown in Figure 3. (Nurmoranta, 2023)

Figure 3. Terminal area at Sievari. (Dimedia, 2023)

Terminal to Smelter

From Terminal the containers are delivered to Smelter by three axle truck with hydraulic tiltable trailers. This type of truck that can be seen in Figure 4, has been chosen since these are the most compact type of trucks that can take full loaded containers and tilt the bulk material to the discharging hopper. Each container is weighted by truck scale on the arrival point to Smelter area and combination of truck, container and material is considered as gross weight. After the container has been successfully discharged, the truck and empty container goes back to truck scale for tare weighing. The net weight of the material is calculated subtraction of the gross weight and tare weight. (Nurmoranta, 2023)

Figure 4. Container at discharging point. (Dimedia, 2023)

After the container is weighted, it will be delivered to the washing station and lifted to the ground for visual inspection. Next step is for washing the containers with semi-automated washing system. Since the washing and inspection process takes time approximately 20 minutes per container, the truck is not waiting there, but instead it will pick up a previously washed container when heading back to Terminal. From the Terminal the cleaned containers are transported back to the Port when calling for the next full containers. (Kunnassalo, 2023)

Receiving process

The purpose of the receiving process is discharging containers, transferring the material from into the warehouse and collecting samples with automated sampling system from the material flow. The frequency, speed and other parameters of the process can be adjusted by based on the quantity and physical nature of the material. (Boliden, 2022)

The truck driver drives the container next to grid, opens the doors of the container and makes precuts for the plastic liner that covers the material. When the traffic lights change from red to green, it is visual signal for the driver that process is ready to take next container. The driver will tilt the container up to a 45-degree angle with hydraulic mechanism of the truck and the material goes through the floor-level grid into feeding hopper as in Figure 5 is visible. The liner material will be removed from the grid by front loader for further recycling process. (Boliden, 2022)

Figure 5. Container at discharging point. (Dimedia, 2023)

The sampling process among the weighing process are both crucial phases when determining the commercial value of raw materials. The possible errors or failures in these processes can be very expensive and due to the nature of sampling, it can be seen as a unique phase and there are no second changes, for example re-sampling the material. The high importance and unique nature of this allows the discharging process to be the pusher and puller of the logistic chain. That means the capacity of the sampling system generates the base line of scheduling the logistic chains. (Boliden, 2022)

4 CAPACITY

4.1 What is capacity?

The term "theory of capacity" can be quite broad and may have different meanings depending on the context in which it is used. It can be seen as psychological capacity such as cognitive capacity that refers to the limited ability of an individual to process and handle information, or attention, and memory capacities. Another approach is an economic capacity which commonly refers to the maximum output or production capability of a firm or an economy. It involves understanding how much a system can produce efficiently, considering factors like resources, technology, and labor. This could also be associated with the concept of capacity utilization, which measures the extent to which an enterprise or the overall economy is using its productive capacity. The third approach is the physical capacity and in the context of engineering or physics, the theory of capacity usually refers to the maximum load or stress that a material or structure can withstand before undergoing deformation or failure. This concept is crucial in fields such as structural engineering and materials science.
(Zacks & Hasher, 1993)

4.2 Capacity in containers

The standard shipping containers used in the transportation of goods via sea, also known as intermodal containers. These containers have become standard in international trade, making it easier to load, unload, and transfer goods between different modes of transportation, such as ships, trains, and trucks. These standardized containers play a crucial role in the efficiency and cost-effectiveness of the shipping industry. (Ismail, 2008)

Capacity, in the context of containers is usually referred in TEU’s (TEU - Twenty-Foot Equivalent Unit) and the two most common sizes are 20 feet and 40 feet (FEU - Forty-Foot Equivalent Unit). A standard 20 feet container with dimensions is shown in Figure 6. The containers are subject to weight limits imposed by international regulations and transportation infrastructure. These limits include the maximum gross weight (the total weight of the container and its contents) and axle load limits for transportation over roads and railways. This maximum gross weight for both container types is 30 480kg and common net weight varies between 26 500kg to 28 500kg depending on the size and manufacturer of the containers. The type and nature of the cargo can also affect the practical capacity of a container. Some goods may have weight distribution considerations, and certain cargoes may have specific handling requirements. (Ismail, 2008)

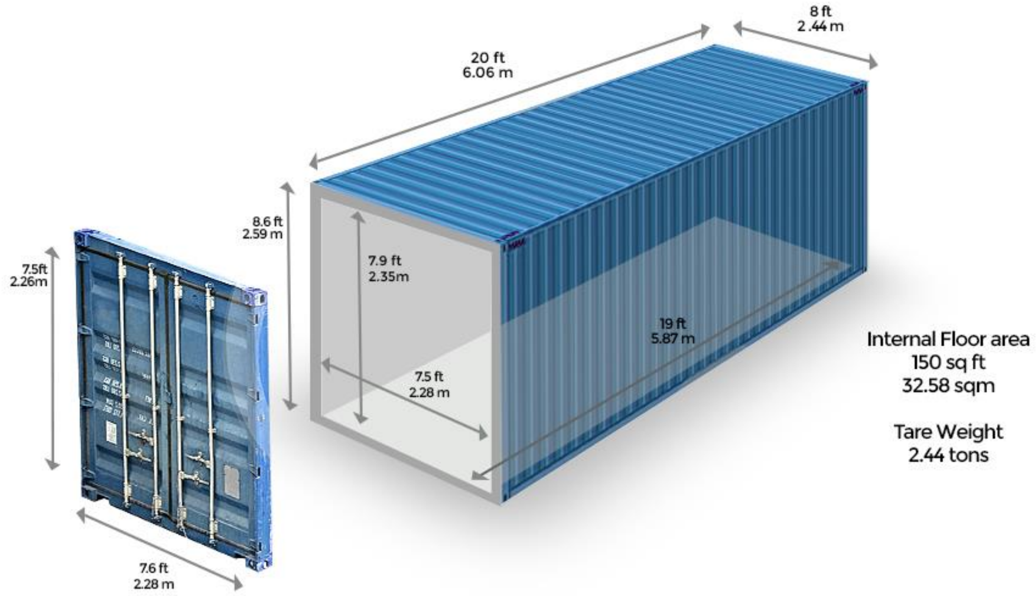

Figure 6. Dimensions of the standard 20ft container, (Voltrans, 2023)

5 PROCESS DEVELOPMENT UTILIZING LEAN

5.1 Origin of the Lean

The Lean is Japanese origin philosophy of using variable management practices to improve efficiency by eliminating waste. It was firstly applied in the manufacturing business and from there it spread into other business areas like health care, food services and business administration. Since the spread has happened during it success, the original name “Lean Manufacturing” has simplified just into “Lean.” The Lean has a history from Toyota Production System (TPS), which were developed during the World War II in Japan. The purpose of Lean philosophy is to increase customer satisfaction by fastening and smothering processes and reducing lead times. (Bradley, 2012)

5.2 Tools of Lean

There are a lot of various kinds of tools in Lean philosophy. The most common and well-known tool of Lean is the 5S method. The idea in the 5S is to keep the working environment clean and in structed order and therefore achieve better quality and efficiency. The name of 5S comes from the following words: Sort, Set in order, Shine, Standardize and Sustain which are the different phases of the process. (Trust, 2020)

Andon is another commonly known tool of Lean philosophy. The key ideology of the Andon is based on sharing information openly and making it visible to all parties. Using traffic lights to share status information above to the process phase is typical usage for Andon. This method allows that the status of the processes can be checked all at once just by looking at the traffic lights and based on the colors, the information is shared. (Lynn, 2022)

Kanban is a tool of Lean that can be used for visualizing process steps by dividing them into different phases based on the statuses of the process. The Japanese word *“Kanban”* means board or sign. A common dividing ratio for phases is backlog, doing, review and done and a good example is to use these in the pull process systems. (Kanbanize, Kanban, 2022)

Takt time is a suitable Lean tool for reducing waste from processes. With Takt time tool, the subprocesses shall be determined individually based on demands, and then adapt all phases together into main process. The benefit of the tool is achieving savings when optimizing process based on customers' demands, it will reduce over production and saving materials and storing costs. (Kanbanize, Takt Time, 2022)

5.3 Six Sigma

Lean Six Sigma has roots in Toyota Production System from 1950's, but the actual method is created by Bill Smiths in 1980's when he was working on Motorola. The aim of the method is to reduce time, defects, and variability in processes. Other benefits when Six Sigma is successfully used, can be increased customers loyalty and employee morale. Both are results of lacking defects in the process. (George, 2002)

Six Sigma has two important development tools, DMAIC and DMADV. DMAIC is more known of these two used for the improving of existing processes and DMADV is used when creating a new product of service from zero. (George, 2002)

5.4 DMAIC

DMAIC is also created by Motorola in the 1980's and from there it is spread worldwide across the globe as an optimizing tool for various processes. DMAIC stands for Define, Measure, Analyze, Improve and Control. (George, 2002)

Defining phase is to determine the issues that need to be solved, determine the opportunities for improvement and customer requirements.

Measure phase is for measuring the current existing process as it is in the beginning. Different numeral indicators can be created and measured.

Analyze phase is for analyzing collected data in measure phase and determine the causes for defects or variations.

Improve phase is for making improvable changes for the points of defects or variations was found on the process.

Control phase is for controlling the improved process and following the success by measuring it again and calculating benefits.

The Six Sigma and DMAIC are excellent methods for different organizations for optimizing their business processes, reducing waste, and improving efficiency in different phases. The main principle is focusing on the customer, continuously improving processes, and using collected data for decisions. By implementing all these factors, it could improve quality, efficiency, customers satisfaction, create savings and be competitive advantage compared to the others.
(George, 2002)

5.5 Bottleneck analysis

In Lean thinking, the goal is to eliminate waste and improve the flow of value through a system. Bottlenecks can hinder this flow and reduce the overall effectiveness of a process. 7. It can be used as analyzing the fundamental concept in operations management, process improvement, and project management. It also involves identifying the specific point in a system or process that limits its overall capacity, efficiency, or throughput. Understanding and addressing bottlenecks is crucial for optimizing processes and achieving desired outcomes. (Womack & Jones, 1996)

The name of the model, bottleneck, comes from the narrow shape of the bottle that limits the outpacing and this is visualized in Figure 7.

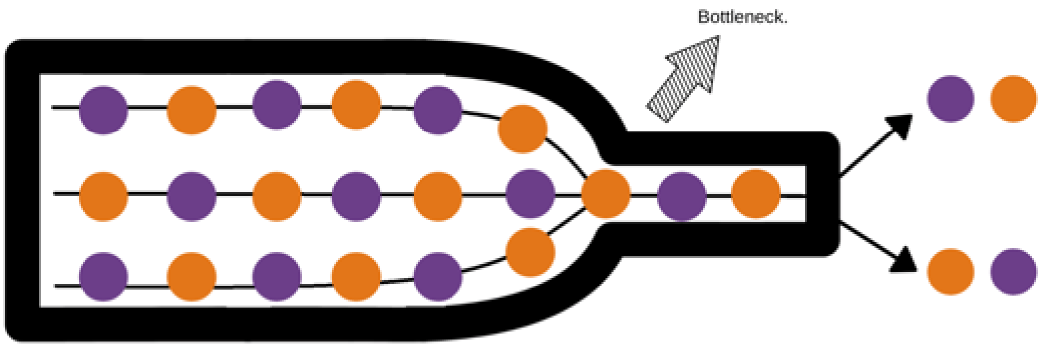

Figure 7. Principle of bottleneck, (Limited, 2023)

It can also be seen as a critical element when improving productivity, reducing costs, or enhancing the overall performance of processes in various industries, from manufacturing to services. It helps organizations focus their efforts on the areas that have the most significant impact on achieving their objectives.
(Womack & Jones, 1996)

6 DMAIC FOR THE EXISTING PROCESS

6.1 Defining the process and phases

The defining process started with very traditional way in Finnish working life. In the first phase, we gathered with all the different parties of the process, meaning we invited people from logistics, warehousing, discharging, and supervising as well into the Conference Center in Yyteri, Pori. There we created a friendly atmosphere with good food, drinks and sauna and then let each party open up their mind and point out the biggest roadblocks of the container discharging process.

Identified phases were divided as following and process order is shown in Figure 8.

- Manifest and custom clearance, documentation
- Delivery from Port to Sievari, external delivery
- Warehousing phase at Sievari, storing
- Driving and weighing, internal delivery
- Discharging and sampling, receiving
- Container cleaning, washing

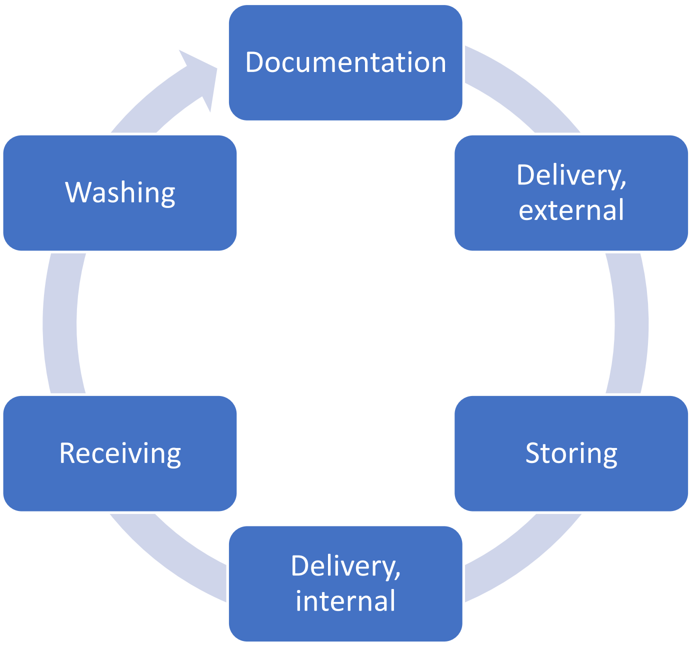

Figure 8. Different phases of container chain in process order

The outcome of that evening was a success. We managed to find a few minor but very notable improvements such as improved portable stairs for the truck driver when opening container doors and explaining in detailed of the meanings of the traffic lights in discharging area. The major outcome of the evening was realizing that we have in each step, a common enemy, and that is waiting.

6.2 Measuring performance of different phases

After identification, all phases of the container chain were measured based on data from various sources and it was confirmed by interviewing several peoples of the chain. The target is to determine the capacity of different phases with processed containers per week with normal 40 hours of working.

Documentation of the containers

The processing time for documentation phase was a bit difficult to measure since the variation between the qualities and deliveries can be significant. In normal conditions and when all is going fine, the documentation of one typical 30 containers batch takes around 2 hours. Based on the quick calculation of 600 containers' weekly capacity, it was discovered that the documentation is at a totally different level comparing to other phases and no further investigation needs to be considered.

External delivery from Port to Terminal

Based on the idea that containers need to be deliver in full units and their amount per one working shift would be quite low, the measuring of the external delivery flow of the containers was done in a spreadsheet calculation instead of following the truck.
The distance between the Sievari terminal and the Port of Rauma is with trucks approximately 60km and the route is shown in Figure 9. The estimated driving time based on Google Maps is 49min which is rounded above 50min.

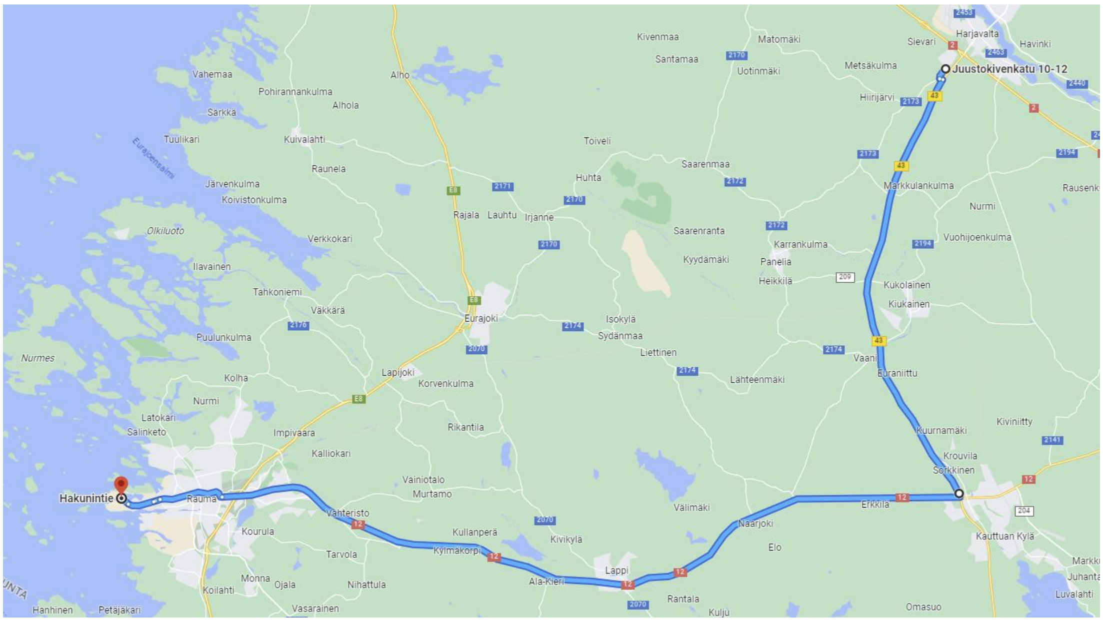

Figure 9. The map and route from Terminal to Port

The following example schedule is generated based on the driving time and estimating the remaining amount of time. The data cannot be verified by the GPS data since these trucks are waiting for the installation and therefore in this case the data is estimated in Table 2 and verified by interviewing the transport coordinator. (Nurmoranta, 2023)

Table 2. Example schedule for an external delivery day

Time	Activity
07:00	Day starts at Sievari
07:00	Truck at Sievari, trucks heads to Port
07:50	Truck arrives Rauma, ready for containers
08:10	First two containers lifted on
09:00	Truck arrives to Sievari
09:20	Containers are lifted off; truck is ready to go
10:10	Truck arrives Rauma, ready for containers
10:30	Second two containers lifted on
11:15	Lunch break of 45min
12:05	Truck arrives to Sievari
12:25	Containers are lifted off; truck is ready to go
13:15	Truck arrives Rauma, ready for containers
13:35	Third two containers lifted on
14:25	Truck arrives to Sievari
14:45	Containers are lifted off; truck is ready to go
Duration	**Activity**
00:50	Driving time between Sievari and Port
00:20	Time of lifting two containers on/off truck
00:45	Lunch break

The conclusion of the exercise was that with one truck, the driver can deliver six full containers from Port to Terminal in one day. In total, it makes 30 containers per week.

Storing containers at Terminal

The storing capacity is calculated from the surface of the area at Sievari Terminal that is dedicated to the containers and comparing that to physical size of the standard 20 feet container. The reserved area for the containers is approximately 4000m2, as are demonstrated in satellite image in Figure 10. With an estimated ratio of 75% to 25% between the storing and operating, it allows to store up to 200 containers when a surface of one individual 20 feet container is 14,8 m2 each. Since half of the capacity is reserved for empty containers, the capacity should be at least 100 containers per week. In practice when containers are constantly moving in and moving out from another side, the capacity can be significantly higher than is necessary in the process. (Nurmoranta, 2023)

Figure 10. The map of container area in Terminal

Internal delivery from Terminal to Smelter

The total time of this phase was recorded from historical data from Boliden Harjavalta truck scale database. The average time of completing the whole phase was 53 minutes from first gross weighing phase into the second gross weighing phase. The remaining minutes of the internal delivery chain is done by cutting the chain into smaller measurable links, estimating them individually in Table 3, and then combining the sum for the time of one single container delivery for Terminal to Smelter.

Table 3. Example schedule for an external delivery day

Time	Activity
07:00	Day starts at Sievari
07:05	First container lifted to truck
07:12	Truck arrives to scale
07:13	Gross weighing process completed
07:16	Truck arrives to discharging place
07:20	Container opened
07:22	Container empty
07:26	Discharging completed
07:30	Truck arrives to scale
07:31	Tare weighing process completed
07:34	Truck arrives to washing place
07:42	Dirty container changed to clean one
07:48	Truck returns to Sievari
07:52	Empty container stored
07:58	Second container lifted to truck

The total time for one delivery is measured to be 53 minutes and with zero to plus five minutes variance, the capacity can be estimated to be around 1 container per hour. Taking consideration of lunch and coffee breaks, the practical capacity with 7 working hours per day reduces the weekly container capacity of 35 containers per week. This estimation is verified by interviewing the transport coordinator. (Nurmoranta, 2023)

Receiving containers at Smelter

The receiving facility has a belt conveyor system with adjustable feed rate. The power of the system is usually set to maximum to achieve the 70 tons per hour feed rate. Based on the historical data from Boliden Harjavalta process data base, a typical load of one container, 22 tonnages of material, is passed through the system in 24 to 27 minutes. The operator needs approximately 3 to 5 minutes as safety intermission after every container to ensure that all material has being processed, and sampling phase has successfully been completed. This data can be measured as well from the same data source. Figure 11 below shows the gaps between the processed containers and timing on the breaks as well.

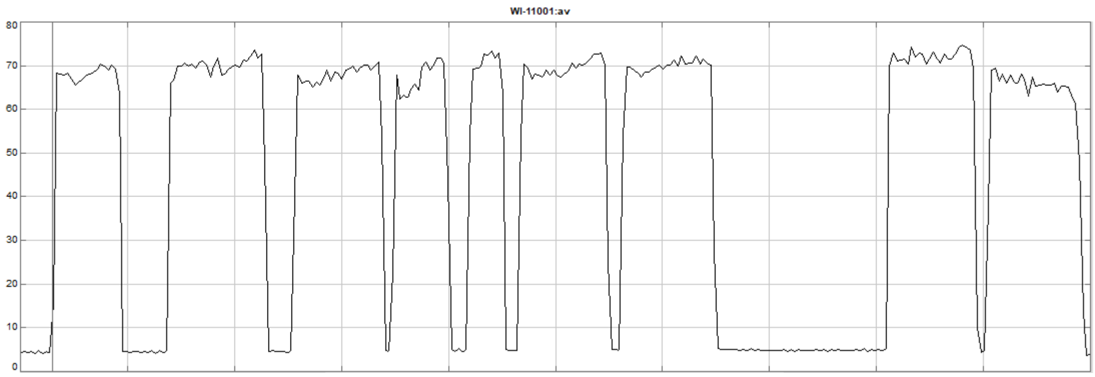

Figure 11. Graphics from the process analysis database. (Harjavalta, 2023)

The total time for processing one single container is a total of 30 minutes. Taking consideration of lunch and coffee breaks, the practical capacity with 7 working hours per day would be 14 containers per day. Since the operator of the receiving process is also responsible for cleaning the system and delivering the collected samples to the Sampling Department for further processing, it reduces the capacity down to 40 containers per week.

Washing of the empty containers

Unfortunately, the main logic of the washing station is not implemented into the Boliden Harjavalta process analyzing tool and therefore cannot be investigated in detailed level. The estimation of capacity of the process is done by interviewing the operator. (Kunnassalo, 2023)

The washing and inspection process of a single container takes approximately 20 minutes per container and with constant flow, the operator can process through three containers per hour. When applying the normal eight hours of working per day, theoretical capacity would be 24 containers per day. When theoretical capacity would be 120 (5 x 24) containers per week, but taking consideration of lunch and coffee breaks, the practical capacity with 7 working hours per day reduces the weekly container capacity down to 105 (5 x 21) containers per week.

6.3 Analyzing the collected data

The baseline in this data collecting was 40 hours per week and when theoretically there is 168 hours per week, the capacity for all different phases can be multiplied up to 4,2 times just by increasing new shifts and using existing equipment. However, most of the phasis excluding documentation is linked to next or previous steps, multiplying a single phase just causes other types of issues when the chain is no longer working synchronized.

The capacities are collected to chart (Figure 12) and the first look appoints that the documentation with ten times higher capacity rating, is not the area of focusing. Next one the washing and storing can be dropped out with double capacity compared to other remainers.

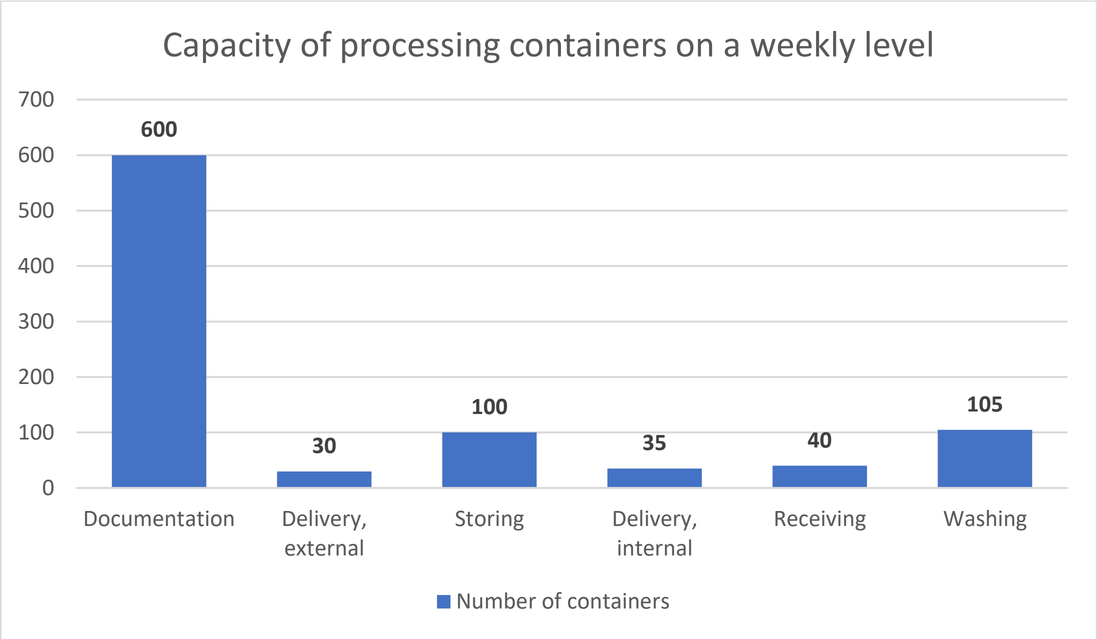

Figure 12. Capacity of processing containers in different phases after empirical evaluation.

Based on the future needs, multiplying the capacity by increasing the number of shifts is excluded from options, next the focus will be on which phases has a potential of increasing the capacity with adding more resources (human and machinery) that can be operated inside normal business hours. The capacity can be doubled with a second truck and driver in both external and internal delivery phases and if needed, the storing capacity can be expanded by appointing more area for the containers. The receiving phase needs closer attention to and is clearly the focus of the study.

6.4 Improving and optimizing the process

The receiving phase is one of the three phases with lowest capacity and the only one that cannot be duplicated with parallel phase. This phase also determines the cycle of logistic chain and can be seen as the crucial phase of the optimizing due the nature of being the pushing and pulling element of the processes. The pulling element since, the operator needs to process previous flow before allowing the next one to be discharged. The pushing element since, the container cannot pass further phases until it is being discharged.

The improving process for the receiving phase started with common agreement of the goals and the changing of the philosophy of daily scheduling from hours into number of containers. As an example, if the daily target is set to 10 processed containers, the first common coffee break should be taken after the first three consecutive containers are being processed, not after the two hours of working at nine o’clock in the morning.

The second improvement to be tested was replacing five days (Monday to Friday) per week and eight hours per day standard shifts with four days (Monday to Thursday) per week and ten hours per day. By pressing the same amount of work under the fewer days, it allowed the maintenance team to have weekly access for the facilities at prime time during business hours, for example preventive maintenance tours. Another approach would be to increase the satisfaction of the employees by having longer weekends as a balance of a few extra daily hours.

6.5 Control the achieved performance and following up

The performance was followed up regularly in a weekly meeting and reported the achieved capacity to the management team. There were a lot of different variables and uncertainty in vessel arrival flow and adjustments needed to be done during the follow up, but the outcome was clear.

7 RESULTS

The follow-up periods were two 15 weeks in a row on both sides of the collaboration development day in spring 2023. The period called “Before” was weeks number 5 to 19, from the beginning of February until Mother’s Day in middle of May. The period called “After” was weeks 26 to 40, from Midsummer eve to beginning of November. Some of the weeks in spring were excluded due to the annual maintenance break at Smelter and therefore the process wasn’t driven to full capacity.

During the follow up, the weekly number of containers were calculated and deviations from normal are briefly explained. Lacking containers was a common reason for not achieving the full capacity. The target was set to 40 containers based on the capacity of receiving process.

7.1 Capacity before

The performance in the “Before” period was on average 41,9 containers per week when excluding the lack of containers in weeks 8, 9, 17 and 18 and overtime weekends 10 and 12. However, the daily and weekly capacity is not constant and there are lot of variables. When excluding the days without any processed container, the daily capacity was 9,8 containers on average. The graphics of accomplishment in before stage together with target level is collected from management report and visualized in Figure 13.

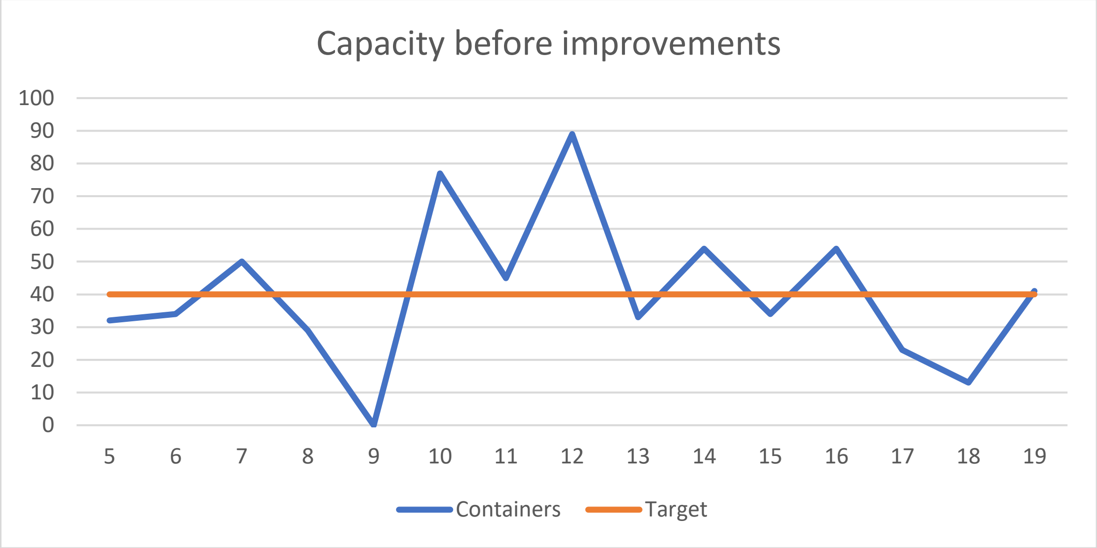

Figure 13. Container capacity between weeks 5 to 19

7.2 Improvements

In the collaboration day, we individually agreed to reduce the waiting by settling common times when all links of the chain for example starts working, it which state they will have the lunch breaks, how to improve communication together if there would be delays nor other deviations in the process. At a further phase during the summer, we started the trial of 10-hour working days.

Delivery internal

No major changes need to be made, since the two trucks arriving at the discharge phase within 30 minutes intervals were already in use. Understanding the principle of the traffic lights increased awareness of the process and can implementing traffic lights be seen as one practical example of visual Lean management.

Receiving process

First, by increasing the working hours during the days, but keeping the estimated breaks the same, the processing hours rises from 88% to 90%. According to the local personnel agreement, all breaks are included in the normal working hours, this benefit is mainly academical instead of it would have any practical impact on this. The majority impact of this change came from focusing on the timing between the containers and calculating containers instead of hours. By adjusting the steel plates that stabilizes the material flow and having only four sample delivery trips to Sampling Department instead of five.

7.3 Capacity after

The performance in the "After" period was on average 59,4 containers per week when excluding the lack of containers in weeks 31, 32, 35, 37 and 39. Since capacity exceeded the arriving containers, no overtime was needed during the period. When excluding the days without any processed container, the daily capacity was 14,3 containers on average. The graphics of accomplishment in after stage together with target level is collected from management report and visualized in Figure 14.

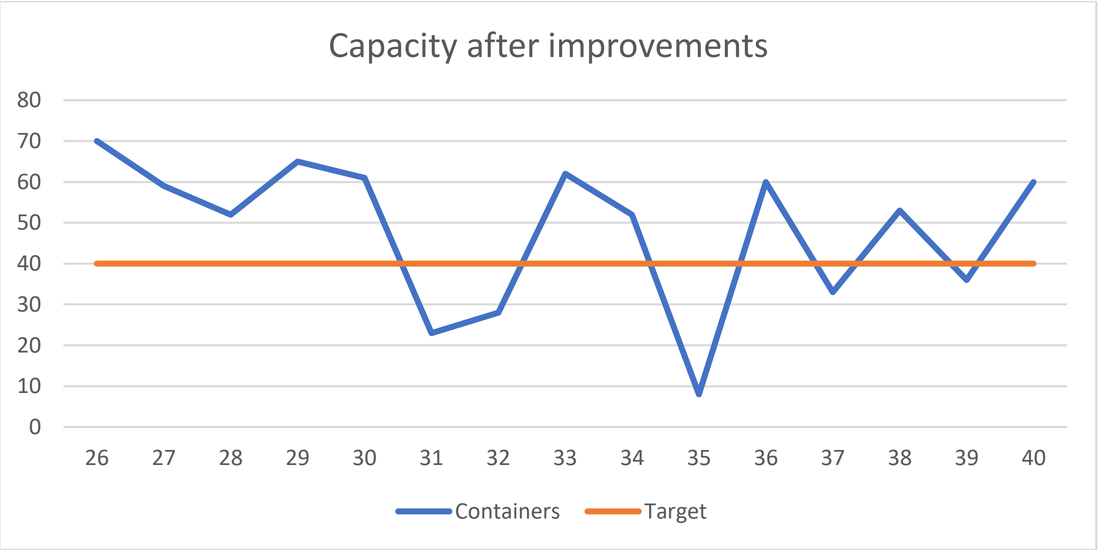

Figure 14. Container capacity between weeks 26 to 40

Figure number 15 shows improvement at receiving process that was made to the logistic chain in spring 2023. The capacity has increased to 40% on a weekly basis.

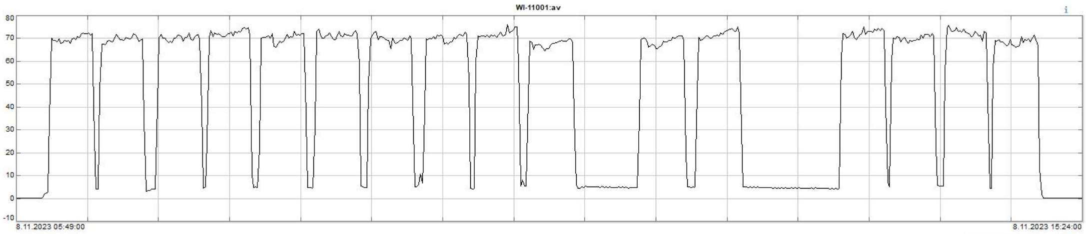

Figure 15. A total of 16 discharged containers with two breaks. (Harjavalta, 2023)

8 FINDINGS

The original plan was to study only one certain subprocess of the logistic process, but eventually it widened since the owner of the process had necessarily need to “find balance” for the total process. Therefore, the study was expanded from the original scope.

The research questions of this thesis were answered by theoretical evaluation and by measuring existing data from various data sources and complementing the missing values with interviewing the key personnel and operators of the different phases of the logistic chain.

The first question was, how to define the capacity of the logistics chain? This question was solved with the help of DMAIC methodology. In this study, the logistics chain was first defined, divided into smaller measurable phases, and then all phases were individually measured for completing the understood of the capacity. Due to the nature of the process, the phase with smallest capacity determines the total capacity of the process.

The second question was, what are the bottlenecks in logistic chain of containers and how to improve those? This was answered by applying the bottleneck analysis to the capacities of different phases to determinate the focus area. Firstly, all phases were measured and evaluated the capacity of handling containers on 40 hours weekly periods. Then the bottleneck analysis is applied, and phases were evaluated in three categories. The phases that have overcapacity and not be focused on this stage, the phases that have a possibility for duplicating and finally, the phases that need to improve by other methods. The documentation, storing and washing phases were set to overcapacity category, both external and internal deliveries to possible to duplicate and receiving phase considered to be the bottleneck without possibility to duplication.

Once the phases were defined, measured, and analyzed, the improvement actions mostly focused on receiving phase while the improving communications and 4x10h working periods impacted widely to the whole logistic process.

The ethical concerns of the study were taken into account by participating people from the beginning and by letting them share their thoughts of the process. The importance of the participation of all the links of the chain is mandatory to achieve any progress when developing processes. Collaboration days are an excellent way to let the people be properly introduced and have the possibility to be heard. The importance of people understanding their role in the supply chain nor spending free time afterward can neither one to be underestimated.

Based on the study and impact of the actions and efforts of all parties, weekly capacity rises from 41,9 containers up to 59,4 containers per week which creates a total improvement of 41%. While there was some uncertainty in these numbers, due to the different moving variables in the process and for example in vessel arrival flow. Both of these numbers individually represent a total average of measurement points of up to 15 weeks and that is approximately 600 containers is the nominal capacity would be 40 containers per week. With the high number of containers processed during that period, it can be estimated for covering all the smaller deviations for individual containers. Although the results could improve by increasing the follow up period when the time goes further, the schedule demanded to stop measurements to week 40. Still and all, based on the numbers and the sentiments of the author, these enhancements presented in this study can be seen as a great success.

While container shipment occasionally missed the feeder connection from major ports of Continental Europe to Rauma, it caused uneven balance to container flow, need for overtime and in some cases the lack the containers to be processed. By expanding the study further to the source of supply chain and optimizing the complete route, it might be a worth of future research.

9 BIBLIOGRAPHY

Boliden. (2022). *Standard operation procedure.* Harjavalta: Boliden Harjavalta.

Boliden Harjavalta. (2023, September 1). Retrieved from One of the most efficient copper and nickel producers in the world: https://www.boliden.com/operations/smelters/boliden-harjavalta

Bradley, J. R. (2012). *Improving Business Performance With Lean.* New York: Business Expert Press, LLC.

Dimedia (Director). (2023). *Boliden Harjavalta - Responsible handling of raw materials is the core of our business - how do we do it?* [Motion Picture].

George, M. (2002). *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed.* McGraw-Hill Education.

Harjavalta, B. (2023). WI-11001:av. Wedge 8.2.

Ismail, R. (2008). *Logistics managemetn.* New Delhi: Excel Books.

Kanbanize. (2022, February 20). *Kanban*. Retrieved from Kanbanize: https://kanbanize.com/kanban-resources/getting-started/what-is-kanban

Kanbanize. (2022, February 02). *Takt Time*. Retrieved from Kanbanize: https://kanbanize.com/continuous-flow/takt-time

Kunnassalo, T. (2023, October 31). Personal interview. (T. Nikkanen, Interviewer)

Limited, M. (2023, 11 11). *Bottleneck Analysis*. Retrieved from Lean Management Tools: https://www.mangolive.com/lean-management-tools-bottleneck-analysis

Lynn, R. (2022, February 12). Retrieved from Planview.com: https://www.planview.com/resources/guide/what-is-lean-manufacturing/andon-lean-manufacturing/

Nurmoranta, E. (2023, November 02). Personal interview. (T. Nikkanen, Interviewer)

Peltomaa, J. (2022, March 22). Personal interview. (T. Nikkanen, Interviewer)

Trust, D. L. (2020, January 15). *What is 5S*. Retrieved from Qualityinfo: https://qcin.org/nbqp/knowledge_bank/uploads/2020/09/1600506696_205-Quality-Info-Journal-15Jan20.pdf

Tuori, A. (2023, May 12). Personal interview. (T. Nikkanen, Interviewer)

Uwe, F. (2011). *Introducing Research Methodology.* London: SAGE Publications.

Voltrans. (2023, November 11). *Voltrans Logistics*. Retrieved from Container Dimensions (metric): https://voltransvn.com/container-dimensions-metric/

Womack, J. P., & Jones, D. T. (1996). *Lean Thinking : Banish Waste and Create Wealth in Your Corporation.* New York: Simon & Schuster, Inc.

Zacks, R. T., & Hasher, L. (1993). *Capacity theory and the processing of inferences.* Cambridge: Cambridge University Press.