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Terminal layout plan

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Description

The thesis was implemented at the terminal of Posti in Jyväskylä during the spring of 2017. The terminal's current layout had faced only minimal changes after it was built in 2008. During the years, however, the terminal had faced changes in its processes due to the expansion of the terminal, changes in volume and acquisition of new customers. The purpose of the thesis was to create a layout plan which would improve the effectiveness, material flows and safety of the terminal. Researching possibilities of combining transports between the freight and postal sides of the terminal was also needed.

Information of the current state of the terminal was gained through observation, by researching data collected from the information systems of the company and by using a questionnaire. Through the current state analysis of the terminal, the problem areas were determined.

The thesis resulted in two layout design choices. The first layout design was a design that centered on the idea of improving material flows by shortening transport distances and reducing congested areas in order to reduce the possibility for accidents. The second layout design was aimed towards the future, as it required some structural changes to the terminal. The first layout design was chosen as the recommended layout. Implementation of the layout proposal depends on the decisions of the company.

Keywords
Layout planning, terminal, freight, cross-dock

Miscellaneous

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1 Introduction

The purpose of this thesis was to create a new layout plan for Posti's logistic terminal located in Jyväskylä. Posti is a government-owned company that operates in postal, logistic and e-commerce services. It had a revenue of 1650 M€ in the year 2015 and it currently employs around 20 000 staff members. Posti's operations are divided into four different business categories which are postal services, parcel- and logistics services, Posti Russia and Opuscapita, which operates in financial management. Posti has operations in 10 different countries.

Posti's terminal in Jyväskylä is located in the industrial area of Seppälänkangas. The old layout plan for the terminal was created in 2008, when the facility was first built, with minimal changes made to it over the years since then. An extension part for the terminal was built in 2014, to accommodate the postal and parcel services. The goal was to create a functional layout that would improve the overall safety, flow of materials and the intralogistics aspects of the terminal.

1.1 Purpose and goal of the thesis

The current terminal layout is outdated. There have been no major changes to the layout since 2008, and since then, many of the processes within the terminal have changed, and several new customers have been acquired. The terminal layout needs to be changed in order to meet the new intralogistics requirements.

The terminal is divided into two segments, and the first one is the cargo terminal that was built in 2008. The other segment is an extension part that handles the postal goods, and it was built in 2014. Posti wants more cooperation between these two different parts of the terminal, because right now the parts of the terminal act individually and the space in transport units is not fully utilized. The strict timetables of postal deliveries compared to cargo deliveries and the difference in vehicles (interchangeable containers in the cargo trucks and fixed containers in the postal trucks) has made combining these two sides difficult.

A layout plan that would cater for the needs of both sides of the terminal was needed as well as finding ways to combine the transports and enable better cooperation, if possible. Optimizing transport distances, the flow of materials and improving safety of the terminal were also an important part of the design.

1.2 Scope and limits of the thesis

The thesis was limited to creating a new layout plan for Posti's terminal in Jyväskylä. Implementing a new layout plan or any changes to the terminal were not included in the thesis. The plan included both sides of the terminal, the cargo terminal and the extension part which houses the postal services. The thesis focused on making changes to the intralogistics aspects of the terminal layout. The yard area and processes tied to that were excluded from the study.

1.3 Research problems and research methods

The two main research problems were formed and they were given sub problems as well to discern the problems from the current layout. The main research problems and the sub-problems were;

- Why is there a need for a new terminal layout?
    - What are the problems of the current layout?
    - How do these problems affect the efficiency and safety of the terminal?
- What should the new terminal layout be like?
    - How to utilize the terminal space in the most efficient way?
    - What type of layout models can be utilized?
    - How to combine postal and cargo transports?

Research methods are usually described as quantitative and qualitative, and the differences between the two methods have been a topic of discussions for a long time.

Qualitative and quantitative studies are manners of approach, which in practice are hard to differentiate from each other, because they can be understood as orientations that complement each other. Qualitative and quantitative methods do not block each other out. On the contrary, they can be used to support each other by handling research questions with both methods, or by choosing different methods for different sectors of the study. (Hirsjärvi et al. 2009, 136;160)

For example, qualitative research can work as a pre-study for quantitative research or vice-versa, but they can also be used side by side. A wide quantitative survey-study can create the basis for forming meaningful, comparable groups for qualitative interviews. (Hirsjärvi et al. 136-137)

According to Hirsjärvi et al. (2009, 134), the three basic research strategies can be broken into three categories, and they are listed below:

- Experimental study
- Survey- study
- Case study

The thesis consists of a literature review of the topic, a review of the current state of the terminal and proposals for its layout, material flows and safety. The central research for the thesis was collected by using a questionnaire, and data was also collected from the information systems, theoretical materials in the form of books and scientific studies, and based on the author's own observations in the company.

In this thesis, both quantitative and qualitative research methods were used. Mainly qualitative methods were used to collect the research material, and once the material was in the correct numerical form, the material was analysed using quantitative methods. The qualitative research part acted as a type of a pre-study for the quantitative part.

1.4 Survey

One way to collect data is through surveys. As a term, it means collecting standardized data with questionnaires, interviews and observations where the subjects for the survey are gathered from a sample group. Standardization means that if, for example, the aim is to find out what educational background the respondents have, the question must be asked in the same way from all the participants of the survey. The data that is collected through surveys is usually processed quantitively. When designing a survey, one must consider the structure of the survey in order to determine when the participants are supposed to answer freely and when more structured answers are desired. One of the greatest benefits of surveys is that it is possible to reach a large sample of people with them, to acquire research data with a relatively small amount of time and effort. (Hirsjärvi et al. 2013, 193-194)

1.4.1 Controlled survey

One method of making a controlled survey is called an informed survey, which means that the person studying the phenomenon hands out the survey forms in person. The person can go to workplaces, schools, events and to places in general where the pool of people selected for the survey are available. The researcher will then explain the purpose of the research, answer questions and give a review of the survey. The participants will fill out the forms and return them through mail or to a pre-agreed location. (Hirsjärvi et al. 2013, 197)

One of the strengths of these informed surveys is that they offer a very high rate of responses, which is usually around 100%. Absenteeism or scheduling issues are in these cases mostly to blame for in the case of a drop in response rates, for example, if someone is working in a different shift or has a day off. (Fowler 2002, 65)

2 Terminals

Terminals in logistics can be considered warehouses with a very fast throughput. The main difference is that in terminals the goods are very rarely shelved. Instead, they are stored on the floor level of the terminal. The main principle of a terminal is the ability to move received goods within the same day. Terminals usually have a specific rhythm according to which outbound and inbound cargo from other regions are transported during the night, whereas the delivery of goods to customers and pickup of new deliverables is done during the day. (Hokkanen & Virtanen 2012, 23)

Cargo terminals are usually geographically located in transportation "knot-spots" where transported cargo is aggregated. In these terminals, it is common for cargo to change the transportation method from one to another, such as from a small delivery truck to a semi-trailer. (Karhunen, Pouri & Santala 2004, 395)

The freight that arrives at a terminal already has an end customer and, thus, the delivery address is known. Arriving goods can be less-than-truckload shipments or even full-truckload-shipments, the arriving freight is unloaded from vehicles and then staged and consolidated into bigger units until it is finally shipped to its destination, whether it is another terminal in another region or the end customer. Figure 1 shows how terminals are located in the distribution network which consists of several terminals located in different regions. (Hokkanen, Karhunen & Luukkainen 2011, 137 - 138)

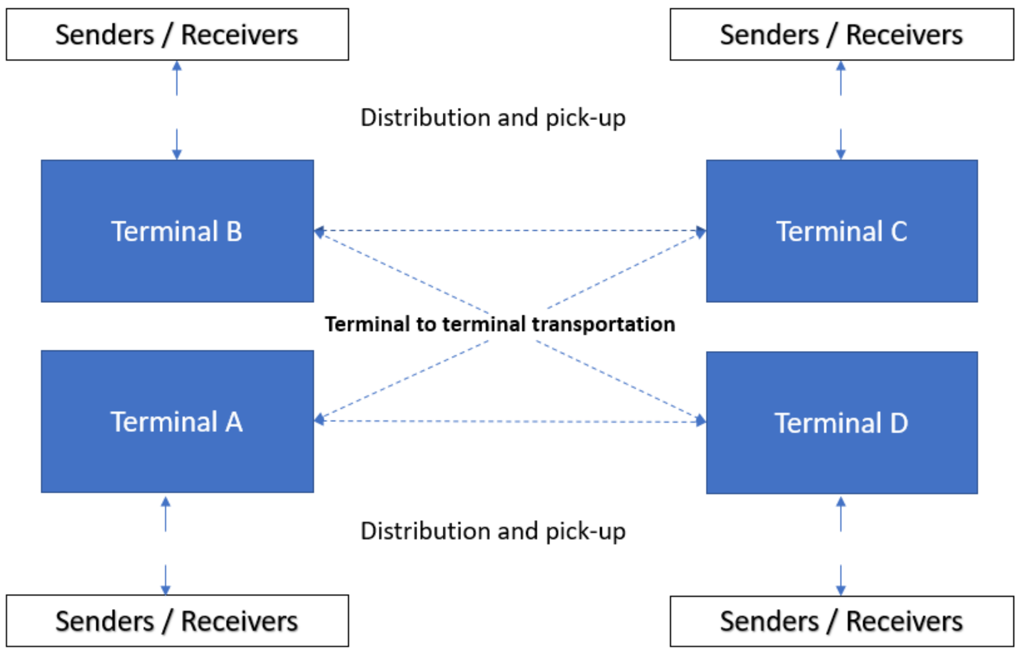

Figure 1. The placement of terminals in a distribution network (Adapted from Hokkanen et al. 2011, 138)

The main principle and processes of terminals are very similar to cross-docking, where there is no inventory, and the goal is to move goods through the facility as fast as possible. The ideal situation would be where the incoming shipments would directly be transferred to the outbound vehicles with no storage in between. In cross-docking, the main processes are receiving, sortation and staging of freight and dispatching. (Rushton et al. 2010, 232; Belle, Valckanaers, Cattrysse 2011, 1)

2.1 Material handling equipment

The most commonly used material handling equipment in terminals are electric and non-electric pallet jacks and different types of forklifts.

Larger material handling equipment requires more space, so choosing equipment that gives the best results while wasting the least amount of space is important. A warehouse that mostly handles palletized items should manage with a forklift that has a lifting capacity of 2000 kilograms. Choosing the right type of forklift is important in order to reduce the space that is lost in aisle widths. There are many different types of forklifts with different lifting capacities. The type of forklift that terminals and warehouses should choose depends on the materials and weights that need to be handled. (Karhunen et al. 2004, 325, 337)

Counter-balance forklifts

Counter-balanced forklifts are forklifts in which their centre of mass is in the back. In this way the heavy back will form a counter balance to the handled mass so that the forklift will not tip over when carrying these loads. (Karhunen et al. 2004, 325-328)

Counter balance forklifts are equipped with large rubber tyres so they can be used both indoors and outdoors. Counter balance forklifts are fast and agile machines with good manoeuvrability (Karhunen et al. 2004, 328) Attwood & Attwood (1992, 162), concur that forklifts are very flexible because of being able to lift, stack, lower, transport and load, which makes them an ideal all-around material handling tool inside a terminal. As a rule of thumb the recommended aisle width for a counter balance forklift is 3,5 – 4 meters. (Karhunen et al. 2004, 337)

Electric pallet jacks

Electric pallet jacks can be operated while standing, walking, or sitting. The electric motor takes care of handling the physical loads. Due to its seemingly easy nature to operate, but still being a fast and heavy machine, using an electric pallet jack can create dangerous situations if handled carelessly.

While using an electric pallet jack one needs to consider the machine's ability to handle ascents, for example, when loading a vehicle. Different electric pallet jacks can have very different abilities regarding their ability to handle ascents. (Hokkanen et al. 2011, 102)

Pallet jacks

Pallet jacks are manually operated trucks with two forks. They are operated with a pump action lever, and it will raise the forks of the truck to lift pallets off the floor. The truck can then be pulled manually and the pallet deposited at the required floor location in the warehouse. It is most useful in situations that only require moving the pallet short distances and infrequently, for example, when delivery truck drivers use it to deliver pallets to customers. (Rushton et al. 2010, 236)

2.2 Packaging units

Most supply chains are structured around the unit load concept, whereby goods are transported, stored and handled in standard modules. The use of such unit loads enables transport, storage and handling systems to be designed around modules of common dimensions. (Rushton et al. 2010, 234)

Pallets are the most commonly used packaging units in freight terminals, and the most common two out of these pallets are EUR- and FIN-pallets. Their respective dimensions are 800x1200mm for EUR-pallets and 1000x1200mm for FIN-pallets (Karhunen et al. 2004, 307)

The dimensions of these standardized pallets are measured so that when transporting freight, the least amount of space is wasted inside the transportation unit. Using these standard pallets leads to improved performance within the whole supply chain because speeding up the transportation process will affect not only the transportation company, but the end customer as well.

Pallets are either the aforementioned type which are exchangeable or expendable pallets that are made of cheaper materials, such as plastic or fibreboard. An increasing number of industrial corporations pack their goods onto expendable pallets due to their poor compatibility with standard pallets and the measurements of the products they manufacture. Moreover, arranging the change/return process for standard pallets is not seen as cost effective. (Karhunen et al. 2004, 311)

The dimensions of expendable pallets vary based on the product that they are used to transport. To ease the handling of these pallets, they are usually measured in a way that the length or width of the product does not exceed the length or width of the pallet. (ibid., 312.)

Steel framed cages are especially useful when transporting heavy items. The dimensions of the cage is 1220x815mm with an indoor height of 740mm and the maximum load of 1200 kg. It is possible to fold down the sides of the cages to save space when transporting or storing them. Four cages can be stacked on top of each other, if the load capacity permits it. (ibid., 307 -314.)

The term bundle in logistics is generally used for describing long freight items or panels and slabs. They can, for example, be made from steel, metal, wood or plywood, and they are manufactured to be used with various applications. These bundles can be so long or big that handling them indoors can prove to be very difficult. Therefore, in most places there are outside loading areas where they are loaded onto vehicles by using specialized equipment that can handle such loads. (ibid., 318.)

3 Main processes in terminals

The main processes in terminals are consisted of receiving cargo, movement of materials and loading. The added-value is the service given to the customer by reducing problems created by the distance and time factors. The freight that arrives to terminals already has an end customer, for that reason the items are labelled with a postal area-code number to help simplify the sorting process. There are lanes inside a terminal and each lane has a sign that hangs above them with a name of a city that consists of several postal code-area numbers, the cargo is sorted with these numbers into the right lanes from where it is loaded onto outbound trucks. (Hokkanen et al. 2011, 137 -138.) The material flow inside a terminal should be clear, signposted and have markings on walkways and pathways. Clear markings give the flow more clarity which helps with the overall effectiveness of the terminal. (Slack, Chambers & Johnston 2004, 220.)

3.1 Receiving and unloading

Unloading cargo from a transportation unit is a process that requires expertise and concentration. Constant attention must be paid to how pallets and items are placed in the units; can the pallet withstand the load, how the items are placed on pallets and where the centre of mass is located on the pallet. While unloading items from units, a certain amount of caution should be applied not to cause damage to the items that are being unloaded or to the vehicle itself. A very common mistake is that the forks are pushed in too deep, thus hurting the pallets behind the one being handled. Forklifts that are equipped with sideshifters make the unloading process a bit easier, as it allows easier placement of the load without having to reposition the forklift. (Hokkanen et al. 2012, 106)

Processes in unloading according to Karhunen (2004, 374),

- recognizing the items (making sure the goods are meant to be unloaded here)
- giving the permission to unload units (avoiding unnecessary labour)
- checking the condition of the goods (broken packages, leaking packages)
- checking the number of the goods and comparing them with the bill of lading
- marking quantity and quality deficiencies to the bill of lading

- Signing the bill of lading

3.2 Material handling

Material handling as a term refers to the process of moving materials within an organisation. The material handling process should be done as efficiently as possible, as each time materials are moved, it costs money, time and the probability of mistakes and accidents increases. Because of these reasons, only necessary movements between operations should be carried out and with appropriate equipment. (Waters. 2009, 19, 391.)

In terminals, the movement of materials is tied into moving the materials between inbound and outbound operations. The movement of materials inside a terminal can be done manually by workers using material handling equipment, such as forklifts, or by an automated system such as a network of conveyor belts. The choice of material handling equipment depends on the type of terminal. A terminal that mostly operates in palletized goods should choose a forklift. A conveyor system could be used in a terminal that handles high volumes of small packages. (Belle et al. 2011, 11; Hokkanen et al. 2011, 108.)

3.3 Loading

One of the most important factors and a process that every loading process should start with is to make sure that the unit or vehicle being loaded will stay put during the loading process to prevent vehicle creep. The unit can be secured by applying wedges behind the wheels or by attaching the unit to the dock with chains or cargo straps. Constant observation to the movement of the unit is necessary, movement of the loading unit can, in the worst-case scenario lead to serious accidents. The carrying capacity of the unit should also be ascertained before loading and the weight of the material handling equipment that is being operated. (Hokkanen et al. 2011, 113-114.)

Freight must be staged before it is loaded, and according to Bartholdi & Gue (2004, 238), the sequence in which the loading process takes place can vary depending on several factors such as:

- The need to build tightly packed loads
- Placing fragile freight on top
- Loading units to create delivery loads with several stops
- Building “nose loads” where the front of the trailer will be loaded with freight that does not require unloading until it reaches the end customer

Certain trade-offs must be considered when deciding on how to load transportation units. Loading the units optimally and creating tightly packed loads takes more time and resources, but might lead to scheduling issues. Loading the units more loosely requires less time and resources and makes sticking to deadlines easier, with the possible downside of needing more vehicles to transport the same amount of goods. (Belle et al. 2011, 41.)

The loading process is an activity that usually needs to be handled within a short time span, the process can be made easier by preloading units such as trailers or interchangeable containers before the transportation vehicle for that unit arrives. When using this technique, the vehicle fleet must have a greater number of extra containers and trailers than vehicles. (Rushton, Croucher & Baker 2010, 292.)

4 Safety leadership

Safety leadership means the comprehensive management of safety, both self-employed and law regulated. It combines procedures, methods and leading of people with the idea of continuous improvement of safety within a workplace. This continuous improvement requires planning, action, and monitoring. The basis for good safety leadership is that the leadership of the company is committed to this type of thinking in order to receive positive responses and cooperation from the personnel.

One of the central tools of safety leadership is risk assessment. With risk assessment, the need for improvement in the workplace as well as the effects of the work environment can be assessed. Safety leadership ensures the know-how, participation, and motivation of personnel in regard to safety. Safety culture, the way in which a company acts in regard to safety, affects safety leadership, and this should be a part of the normal every day work for managers and workers alike. The connection between safety culture, management, and leadership can be seen in Figure 2. (Turvallisuusjohtaminen 2010, 6)

Figure 2. Safety culture explained (Adapted from Turvallisuusjohtaminen 2010, 6)

4.1 The central elements of safety leadership

There are clear starting points and necessities for safety leadership. The creation of safety policies, risk assessment, measuring, monitoring, and documentation as well as ensuring the effective flow of information. Safety leadership also requires a system that allows feedback so that the company can assure that its own policies are constantly being improved. An employer must always have safety policies or principles that define the common goals of safety. Safety policies give the statements of the management in regard to safety as well as the definitions of the operating principles and for cooperation with the personnel. The central elements of safety leadership regarding organizing is defining operational systems, operational responsibilities and duties as well as ensuring that there are enough resources to reach these goals. (Turvallisuusjohtaminen 2010, 7.)

A good assessment of the current situation that covers the risk and operational evaluation gives the basis for safety. There are different tools that can be used to assess the current situation and evaluate risks. In order to achieve the chosen goals, monitoring must be done and compatible measurements must be chosen. Know-how, correct attitudes and motivation are also needed in order to achieve and uphold the desired level of safety. Versatile styles of informing are needed to support the leadership process in these matters. (ibid.)

A good safety leadership model must encourage everyone to use their own creativity and wit. It must support and advance decentralized decision making. The system cannot replace the internal input of an individual or a small community, instead, the system should be endowed with elements that are meant to join the assets and positive dynamics of the group into the upkeep of safety. The upkeep and continuous advancement of safety culture should be understood as a responsibility for the whole workforce, not just the management. (Kerko. 2001, 23-24.)

4.2 Safety leadership in regard to law

The work safety law does not require a safety leadership system. The responsibilities displayed in law, however, are based on the main principle of safety leadership, and the same central elements are embedded in the law. To fully meet the responsibilities of work safety, the law requires systematic and long term tracking of procedures and workplace circumstances, with which the safety and health of the personnel is confirmed. The employer is required to clarify and improve workplace health and safety in collaboration with the personnel. (Turvallisuusjohtaminen 2010, 10)

Work safety law dictates the control of systematic safety at a common level. The employer can, however, choose the best methods and ways to execute those regulations. The common elements of safety procedures that are defined in the law are:

- work safety action plan, which can be understood as a generalized action policy or as a detailed action agenda
- recognizing harm- and hazard factors, and removing them or evaluating their meaningfulness, which means risk assessment
- education and guidance given to the employees
- constant monitoring of the work environment and workplace community
- keeping risk assessments and action agendas up to date

(ibid.)

4.3 Company safety

Company safety means the complete control of all safety related issues that support profit targets. It is used to guarantee the legal operational requisites, the disturbance free operations of production and activities, and protection of the company's staff, assets, information and environment from accidents, harm, and criminal activities. Security work in practice is comprised of pre-emptive actions in order to avoid accidental and harmful situations and the creation of readiness plans in the case that these accidents or harmful situations happen. The entire safety of a company is comprised of many different sectors, and they all need to be taken care of. Figure 3 shows the different sectors and their terms, and how they fit into the overall company safety. (Kerko 2001, 21-22.)

Figure 3. The sectors of company safety. (Adapted from Kerko 2001, 22.)

The safety leadership system that is built upon the concept of company safety gives the requisites for a common system, where a certain base action serves all the sectors of safety. The central thing in all of this, is the fact that all the sectors related to safety are being led and organized with the same principal actions. These unified actions also guarantee that the safety issues and sectors are handled with the same principals. (Kerko 2001, 21-22.)

4.4 Work safety

In an article published by Turun Sanomat (11.4.2017, 11) it is mentioned that in 2016, insurance companies made reparations to over 101 000 people due to work related accidents. The amount of accidents had risen by 3% from 2015. Twenty people were killed in work related accidents, which was five less than in the year 2015. The article also mentions that in the early 2000's the mortality rate from work related accidents was around 40 – 50 per year. The biggest increases in work related accidents happened in construction, transportation, and administrative and supportive services. Even though the amount of accidents had risen from the previous years, accidents that lead to death have seen a significant reduction.

A lot of people and machinery move around in terminals and warehouses at the same time, increasing the risk for occupational accidents. Work safety problems in terminals and warehouses are often related with moving heavy loads, manual lifting, disorder and untidiness within aisles and work spaces, and hectic work rhythm. At the top of severe occupational accidents are hurting yourself on a foreign object, slipping or falling, material handling equipment such as a forklift tipping over etc. When almost half of work related accidents are related to getting injured by a foreign object, slipping, or falling the importance of the cleanliness of the warehouse increases. The aforementioned reasons for accidents can be reduced with the use of ergonomic material handling equipment that helps to reduce the strain caused by manual work, using more ergonomic applications can reduce lost work days and thus lower the costs derived from them. (Karhunen et al. 2004, 410; Lahmar 2008, 10.)

Work safety rules according to Hokkanen (2011, 111.)

- Lifts and movement of materials should be done with proper equipment
- Personnel lifts should only be done with equipment meant for them
- When moving around with forklifts, take others into consideration and move accordingly

An increasing number of companies have proceeded into zero-tolerance when regarding work related accidents. Every accident that occurs is one too many, and every accident can be avoided. In many places the frequency of these accidents are followed very publicly, for example, by placing display boards in visible places, where people can see how many accident free days there have been and how long the longest accident free period has been. This type of informing and acknowledgment of the issues helps workers implement safer work habits into their own actions. (Hokkanen et al. 2011, 115-116.)

Every accident is usually preceded by a significant number of “close-call” situations. By reducing these situations, one can affect the number of actual work related accidents as well. To every serious bodily injury that occurs it can be estimated that around 600 dangerous situations occurred that did not, however, lead into serious bodily injuries. (Hokkanen et al. 2011, 116-117.)

5 Risk management

Risk management is a process that companies and individuals use to determine and chart risk factors. It is a pre-emptive strategy to prevent the possible loss of resources. Risk management is used to prepare for harmful situations that could negatively affect the operations of the company. (Dorfman 2007, 43.) Risk is the chance that an event might happen, it is not the event itself. Risks happen due to the uncertainty of future, even if the best methods and forecast analyses are used to chart and assess the situation, the uncertainty of these things can definitely be reduced, but they cannot be removed entirely. (Waters 2009, 474.)

According to Vesterinen (2011, 111), the main purpose of risk management is to ensure error free operations in all situations, risk management has three core elements that are;

- Identifying the risks
- Assessing the risks
- Designing appropriate responses to the risks

Risks can be divided into two different categories, accident and business risks. Accident risks only have negative effects and in the case that they occur, they are in one way or the other harmful to the operation of the company. Accident risks can be evaluated in relations to their probability and consequences. Accident risks can also be managed and controlled for example, through insuring. Business risks are different in nature than accident risks, and they cannot be analyzed with the same methods. Business risks revolve around the entrepreneurs’ know-how, professional skills, ability to cope with the workload and the ability to make the right decisions. Business risks can also have positive effects in contrast to only negative effects. For example, when an investment is successful and creates profit. Business risks are closely tied to strategic decision making, investments and expected and actualized profits and costs. Business risks mean the risks involved in normal business activities that the company undertakes in order to maximize profit. Accident risks are more closely tied to the operational activities and mean that something unexpected and harmful happens. The difference between accident risks and business risks can be seen in figure 4. (Flink, Reiman & Hiltunen 2007, 23.)

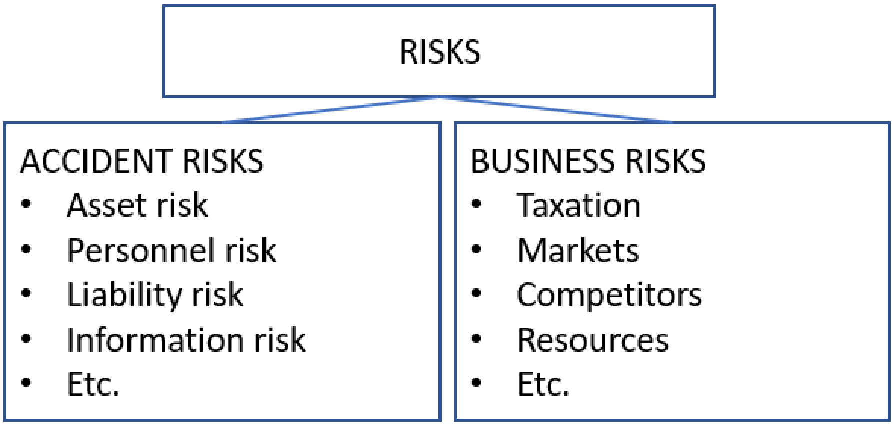

Figure 4. Explanation of business and accident risks. (Adapted from Flink et al. 2007, 24.)

5.1 Risk assessment

Risk assessment is the part of risk management where all of the identified risks are assessed in terms of probability and effect. Probability of the risk means the probability at which the risk might occur. The effect of the risk means the amount of harm it can cause to the business if it occurs. There are different tools available for assessing risks, the simplest tools can be assessment charts where the consequences and probability of the risks are defined by a certain scale. (Vesterinen 2011, 114-115.) Examples of simple chart assessment tools can be seen in Table 1 & Table 2.

Table 1. Example of risk effect assessment chart. (Adapted from Flink et al. 2007, 26)

Catastrophic	Numerous loss of human lives or loss of > 1 000 000 €
Serious	Personnel damage or loss of > 500 000 €
Major	Possible personnel damage or loss of > 100 000 €
Minor	Property damage in range of 1000 € – 100 000 €
Minimal	Property damage with values < 1000 €

Table 2. Example of risk probability chart. (Adapted from Flink et al. 2007, 26)

Extremely unlikely	Once every 1000 years
Very unlikely	Once every 100 years
Rare	Once every 50 years
Quite likely	Once a year
Likely	Once a month

Risk to put simply is, the probability of the risk multiplied by the consequences of the risk. Even though the objective effect of risks can be assessed with the previously mentioned tools, people assess and view risks in different ways. Risk perception and assessment is done based on an individual's own beliefs, attitude, emotions and cultural and social feelings. People form a unique understanding of risks through their own judgement and assess them partially intuitively, not just based on objective facts and research knowledge. Many qualities of the risk affect the way that risks are assessed and viewed. For example, a familiar and every day risk is usually considered a lesser risk than an unknown but rare threat. (Flink et al. 2007, 26-27.)

5.2 Identifying the risks

Identifying risks should be the beginning point for the risk management process, because unknown risks cannot be managed. Identification of risks in the simplest terms means identifying risky and dangerous situations before they happen by using various methods. To identify the risks it is important that the methods and tools used to identify them are versatile and that a single person or group can reliably assess if the risk could potentially happen and what would the cause of that be. Through risk identification, it is possible to find out hidden risks that the individuals doing the identification might have had no knowledge of. (Flink et al. 2007, 131.)

5.3 Analyzing the risks

The purpose of risk analysis is to recognize the risks of the chosen target area or process and assess the probabilities and consequences of these risks. A prerequisite of a successful risk analysis is that the ones working in the area or process that is being analysed are taken into the risk analysis from the beginning. The ones performing these actions and processes in the company are the best persons to explain their own work, and how their work is dependant of and how it affects other processes. In risk analysis, the risks are put in to order by importance based on which are the biggest, most acute, and most important risks to repel. Risk analysis should consist of analysing the cause-and-effect of risks, not finding guilty parties. (Flink et al. 2007, 136-137.)

5.4 Managing the risks

Once the risks have been identified, they can be managed and decisions can be made on how to proceed. Based on the results of the risk assessment, decisions are made on how to proceed with the risks. The decisions are based not only on the risk, but the costs and probabilities to implement these changes. Sometimes it is much costlier to prevent a risk from happening, than letting the accident happen and paying the costs. There are some different ways to go about handling risks, these are listed below. (Flink et al. 147)

Transferring. This means the way of transferring the responsibilities of the risk either partially or completely to some outside party. The most typical way this is done, is insuring, where the insurance company takes care of the damages and reparations. Another typical example is the use of subcontractors and subcontractor networks, where a part of the risks is transferred onto the subcontractors. (ibid.)

Removing. This means the removal of certain risks in entirety. The entire activity that the risk is associated with can be removed from the companies processes completely or a too risky area of business is sold off because it is deemed too risky. This method has some trade-offs between the risk and the expected profit. (ibid.)

Keeping. This is the opposite of removal, basically when profits are too tempting so the activity is done even with the threat of the risk happening. All activities and operations have some type of risk and uncertainty of the outcome, so every time an action is made it is a knowing choice to take that risk. The chance of a risk happening can still be considered and prepared for, to reduce the effects of the risk. (ibid., 148)

Reducing. This is the method where the things affecting the risks are done under consideration and changes are made so that the probability and consequences are reduced. For example, many companies that use subcontractors have more than one subcontractor, so even if one of those contractors has problems and is unable to deliver what is promised, it does not seize up the entire business. (ibid.)

One of the recent challenges in risk management has to do with the employees of the company, and increasing their knowledge and awareness of risks. Risk management is increasingly more about the organisation and individual learning. Risk knowledge means understanding the things that can cause risks and what are the effects of those risks if they happen. (ibid., 153.)

6 Layout planning

Layout is a term that refers to the design of a production systems physical parts such as machinery, equipment, storage areas and passageways in a facility (Haverila, Uusi-Rauva & Miettinen 2009, 475.) The main objective, and the process that every layout planning process should start with is the efficient study and design of material flow. The aim is to minimize transportation distances and transportation times of materials when designing where to place workstations. The layout determines how efficiently processes inside the terminal are operated because of its effect on the flow, time, handling effort of materials and work safety. (Haverila et al. 2009, 482; Attwood, P. & Attwood N. 1992, 128, 162.)

Layout planning is a complicated process, that is affected by several variables. Creating a layout is always a compromise, because finding a solution that takes every variable into account optimally is usually not possible. (Haverila et al. 2009, 480-481.) Layouts rarely stay the same for long periods, the need for changing layouts depends on the type of business, there can be new customer acquisitions, changes in demand or changes in processes. Layouts should be designed with long term flexibility in mind and with the possibility to accommodate future changes or expansions. (Slack et al. 2004, 220.)

Stock and Lambert (2001, 417), list factors that a good layout can increase

- Improve material flow
- Reduce costs
- Improve customer service
- Improve employee working conditions

6.1 Material flow

The layout of a warehouse or terminal can be designed in different ways, depending on the form of the plot and how the warehouse buildings are placed on that plot. There are three common material flow designs that can be applied; through-flow, U-flow and corner-flow. The illustrations of these designs also show how to place items in the warehouse based on the SKU picking volumes. A = biggest volume, C = smallest volume. The biggest volume items are placed near the packaging and shipping area, to shorten the distance needed to travel. (Karhunen et al. 2004, 370.) Managing the material flow requires the implementation of several design choices. Through successful material flow planning it is possible to achieve significant savings in costs. (Haverila et al. 2009, 464.)

In through-flow terminals (see figure 5), the inbound doors are located on one side and the outbound doors are located on the other side. Through-flow terminals usually have no problems with congestion, but travel distances are longer and having doors on both sides of the facility requires access through two separate gates or a perimeter that allows travel around the outside of the facility. (Richards 2011, 161.) Warehouses that have a rapid turnover of goods such as cross-docking facilities usually use through-flow, because of the unlikeliness that the loading and unloading docks will fit on the same side of the facility. (Rushton et al. 2010, 297-298.)

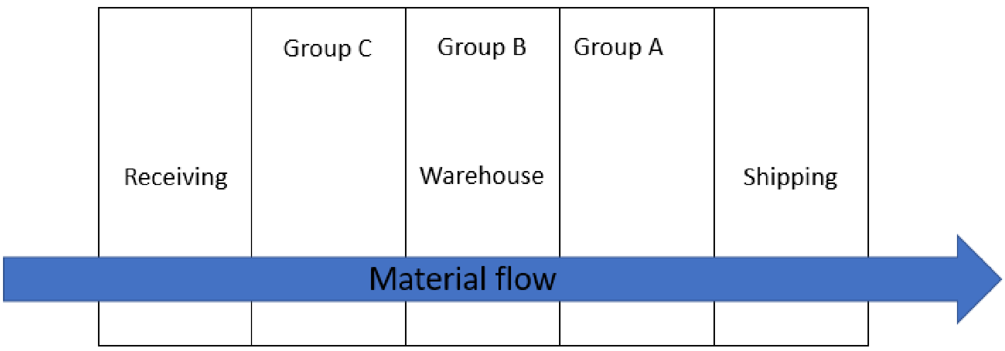

Figure 5. Material through-flow in a warehouse. (Adapted from Karhunen et al. 2004, 370.)

U-flow terminals as depicted in Figure 6 have inbound and outbound docks on the same side of the facility, which enables better utilization of dock doors but can create congestion issues. The biggest benefit of the U-flow design can be achieved in facilities where the outbound and inbound activities occur at different times of the day, such as receiving goods in the morning and shipping the goods in the evening. (Richards 2011, 161; Rushton et al. 2010, 297- 298.)

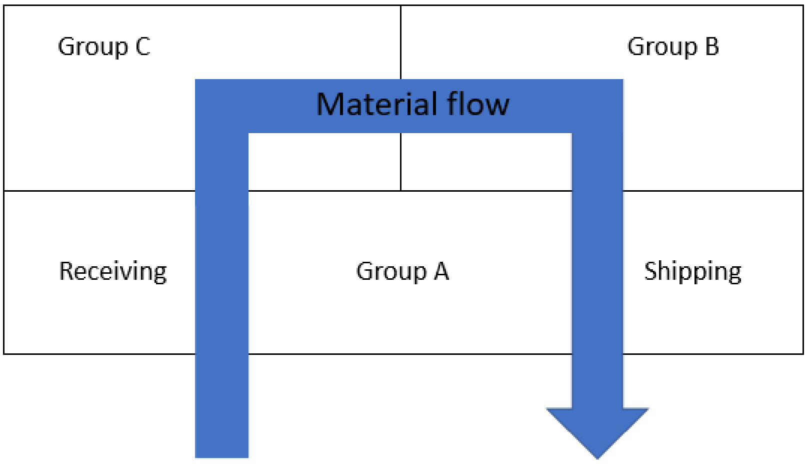

Figure 6. Material U-flow in a warehouse. (Adapted from Karhunen et al. 2004, 370)

As seen in figure 7, in corner-flow terminals the material flow does a turn inside the terminal and the shipping doors are on either side adjacent to the receiving doors. Using a corner-flow design instead of a through-flow design allows the use of smaller plots, as it does not require as much space. (Karhunen et al. 2004, 370.)

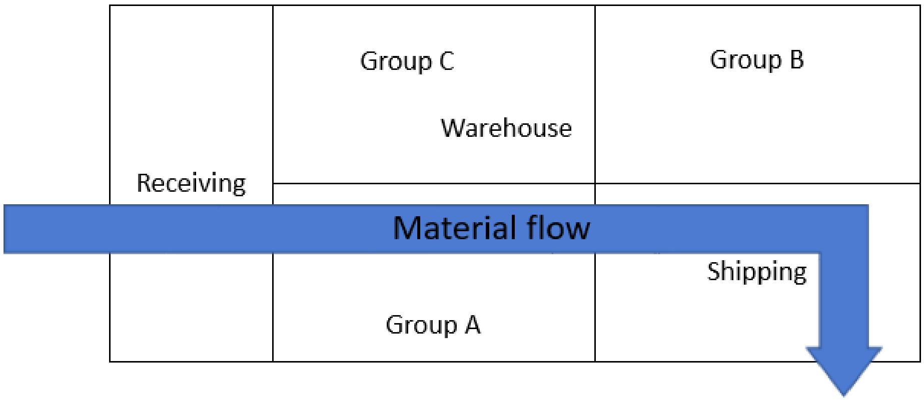

Figure 7. Material corner-flow in a warehouse. (Adapted from Karhunen et al. 2004, 370)

Figure 8 shows an example of material flow analysis, with this analysis rough estimates of routes and volume can be explained and examined visually, the thickness of the lines determining the volume of the flow. The lines can also be shown as percentage of the total volume. The purpose of the analysis is to gain information about the direction and volume of material flows inside a facility and to discover possible bottlenecks or constraints in the flow. Material flow analysis can be done based on SKU's, volume, units or handling times, the method chosen should be the one which gives the best information regarding the issue at hand. The results of the material flow analysis provide visual information of material flows, and the largest flows are usually the ones that should be taken under closer inspection. (Kervola 2016.)

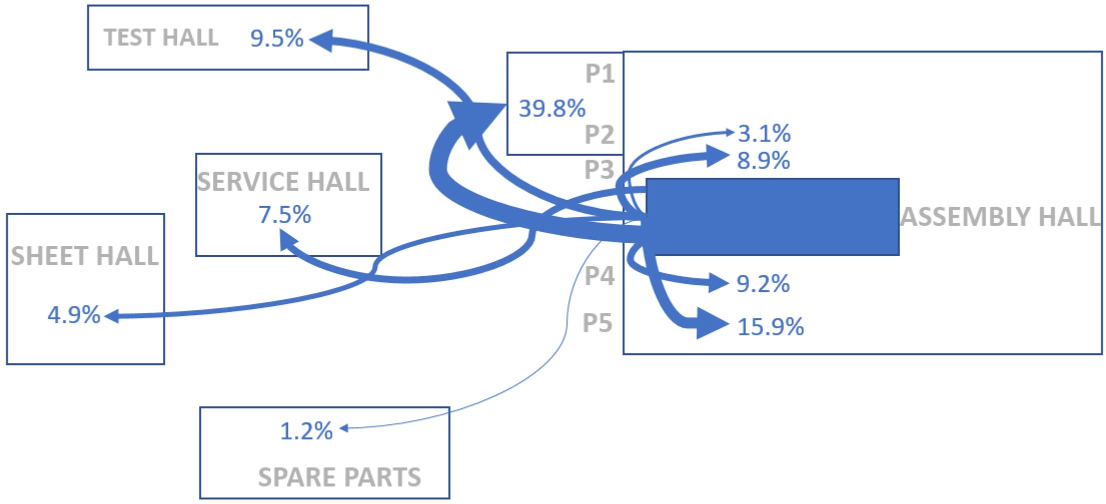

Figure 8. Example of material flow analysis (Adapted from Kervola 2016.)

6.2 Layout planning in a cargo terminal

Terminals are usually long and narrow facilities with truck doors facing each other that are spread throughout the facility as depicted in Figure 9. The material flow in such a facility is the result of designing where the strip and stack doors are located in the terminal, the amount of information there is of incoming shipments upon arrival and the types of material-handling equipment used. (Lahmar 2008, 156) Bartholdi and Gue note that handling cargo in terminals is very labor intensive manual work that includes moving an assortment of freight. An easy way to reduce unnecessary labor is to redesign how inbound and outbound trailers are assigned to doors in the terminal to improve freight flow. (Bartholdi & Gue 2000, 1)

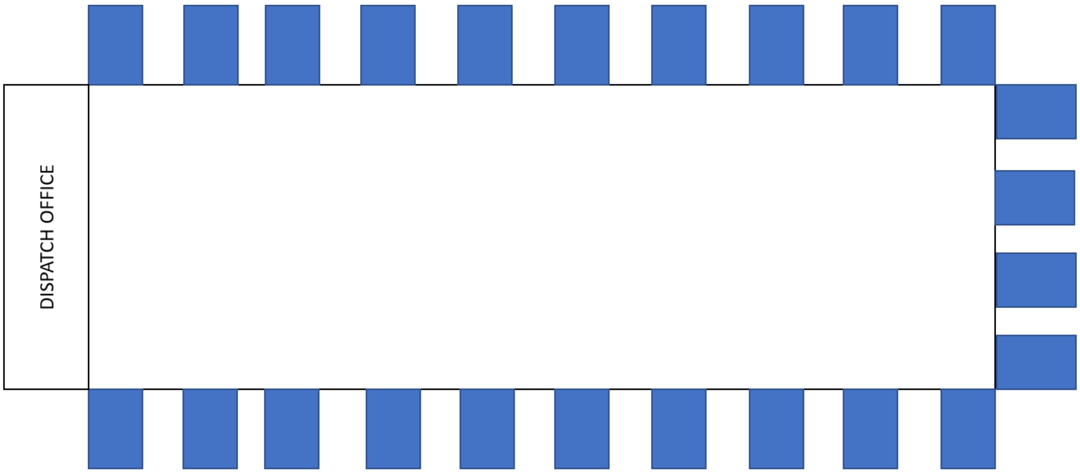

Figure 9. A typical layout for a freight terminal. (Adapted from Bartholdi et al. 2000, 1)

Designing and optimizing layouts in cargo terminals is usually centered around the idea of reducing door-to-door distance. This can be done by assigning inbound and outbound trucks to doors by calculating the weighted distance between regions, to minimize travel distances between them. Very often however, measuring travel times with shortest door to door distance is in fact, not accurate. The realistic travel time across the terminal depends on many variables, such as the type freight moved as well as local work rules that can dictate how specific types of freight should be moved. (Bartholdi & Gue 2000, 824.)

According to Pranav, Desphande, Yalcin, Zayas-Castro & Herrera one of the biggest issues when locating doors in terminals is congestion. As the main objective is to reduce distance traveled by assigning high volume docks close to each other it can create congestion. Solving the door locating problem can be done by using heuristic methods, mathematical models or simulation models. (Pranav et al. 2007, 100.)

As in any layout process whether it be terminals, cross-docks, or warehouses, historical demand data should be evaluated in order to discern the amount of space needed and processes to handle. The processes, will of course depend on the type of facility that the layout planning process in being done in. Possible future developments and changes that will alter the pattern should also be taken under consideration. (Emmett 2005, 208-209.)

6.3 Understanding terminal operations

When a trailer or loading-unit arrives at a terminal, it is usually assigned to a door. Terminals often have two types of doors; stack and strip. Receiving docks are called strip doors, they are doors where trailers are emptied of their goods completely. Strip doors can be occupied by any trailer regardless of its origin or contents. Once the trailer is emptied of its contents it is pulled out of the strip door and replaced by another trailer that needs to be unloaded. Loading docks are called stack doors, they are doors where trailers are parked to receive freight for specific destinations. Once the trailer is loaded, it is pulled out of the stack door and replaced with an empty trailer to receive freight to the same destination. Stack doors will always receive freight for the same destination. (Pranav et al. 2007, 94; Bartholdi et al. 2000, 824-825)

Determining how many stack doors a terminal needs is relatively easy to solve, since it is usually known how many regions and destinations a terminal has to serve. Depending on freight volume to the destination, the number of doors can differ for each destination, a high-volume destination will need more stack doors than a low volume one. Most of the issues revolve around deciding the right amount of strip doors inside a terminal. (Bartholdi et al. 2004, 237)

The “best” doors inside a terminal are the ones that are located in the center of the terminal, because they have the shortest distance to other doors and thus have the shortest range to move materials from. Doors that are located in the sides of the terminal have the longest transportation distances inside a terminal and are thus considered the least favorable doors. (ibid.)

Because the freight must be consolidated and staged before it is loaded onto trucks, there needs to be a staging area. These staging areas are usually located directly in front of the stack doors. The amount of space reserved for these staging areas affects the overall effectiveness of the loading dock. If there is too little space to maneuver around the dock, it will create congestion and then again, too much space will lead to waste. The correct size for a staging area depends on several factors, such as the type of freight that moves through the terminal and the type of material handling equipment used. (ibid., 238)

6.4 Terminal layout design choices

Bartholdi and Gue suggest a method where regions with the highest volume flow are placed in the centre doors of the terminal, however offsetting them slightly. In this method, most of the material flow is located in the centre of the terminal. An example of this can be seen in figure 10. The blue lines represent flows of volume, the longer the line, the bigger the volume. The black squares in the figure are strip doors and the white ones are stack doors. By placing strip doors near the high-volume stack doors, it will reduce travel times because most of the freight received from the strip doors is sent to these regions, and offsetting the highest volume stack doors from each other reduces congestion in the centre of the dock. Regions with the least amount of activity should have their doors placed in the corners of the terminal to avoid having to move large quantities of freight for long distances. (2000, 829.)

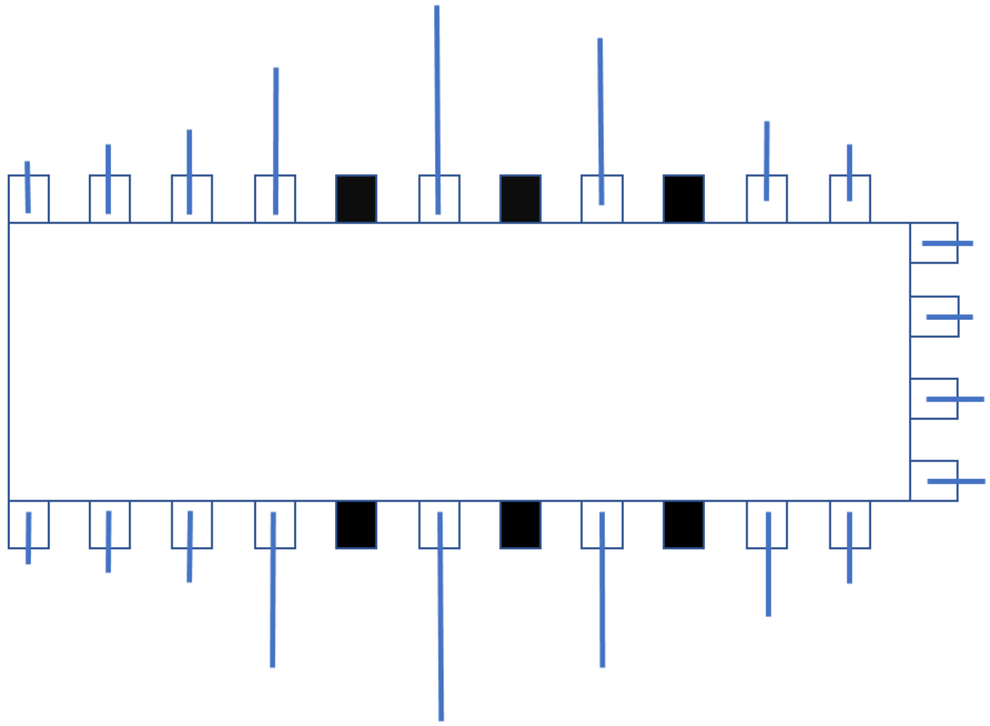

Figure 10. Center-flow terminal example. (Adapted from Bartholdi et al. 2000, 830)

Slack et al. (2004, 221-224), present a general heuristic method for designing layouts which consists of five distinguishable steps that will guide the user through the design process. Formulas are used to calculate the effectiveness of the layout in terms of total distance travelled or as the costs of movement, in terminal and cross-dock situations calculating the total distance travelled could be more accurate. To calculate the total travelled time, a flow record chart should be created that shows the number of loads between each station, an example of a flow chart can be seen in Table 3. The lower the effectiveness score is after calculations, the better the layout is.

Table 3. Flow record chart example. (Adapted from Slack et al. 2004)

From \ To	A	B	C	D	E
A		20	-	15	19
B	13		10	-	20
C	8	17		12	9
D	7	6	-		14
E	21	11	13	12	

After the flow record chart is created a formula is used to calculate the total travel distance, the formula can be seen in formulation 1.

$$\sum FijDij \; i \neq j \qquad (1)$$

Where,

F_{ij} = the flow of materials in loads or trips per a certain period of time from work center *i* to work center *j,*

D_{ij} = the distance between work center *i* and work center *j.*

The five steps in process layout design:

- step 1 - collect information of the work centers and of the flow between them
- step 2 - draw a layout that shows the work centers and the flow between them, putting the centers with the largest flows closest to each other
- step 3 - adjust the layout to consider the constraints of the area into which the layout must fit
- step 4 - draw a layout showing the actual work center areas and distances that materials or customers must travel. Calculate the effectiveness of the layout either as total distance travelled or as the cost of movement
- step 5 - check to see if exchanging any two work centers will reduce the total distance travelled or the cost of movement. If so, make the exchange and return to step 4, if not, make this the final layout

Bartholdi & Gue (2004, 240), also present a similar heuristic method in their research, their method is related more into layouts in terminals and cross docks and it revolves around the dock door assignment problem, which relies heavily on the "best" door method. The approach is:

- step 1 – construct an initial layout
- step 2 – assign the strip doors to the "best" doors
- step 3 – assign the stack doors with highest flow to the second-best doors
- step 4 – assign the stack doors with lowest flow to the remaining doors
- step 5 – interchange pairs of doors to find improvements

Tsui & Chang created a mathematical model which can be seen in formulation 2. The model can be used to solve the dock door assignment problem. Their model however, only allows that strip and stack doors only serve one location or region. Which in real-life applications of cross-docking or terminal operations is highly unlikely. (Tsui & Chang 1992, 283 – 286.)

(2)

Minimize:

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{m=1}^{M}\sum_{n=1}^{N} \mathrm{DijWmnXmiYnj}$$

Subject to:

$$\sum_{m=1}^{M} Xmi = 1 \qquad i = 1,2,\dots,I, \qquad 1)$$

$$\sum_{i=1}^{I} Xmi = 1 \qquad m = 1,2,\dots,M, \qquad 2)$$

$$\sum_{n=1}^{N} Ynj = 1 \qquad j = 1,2,\dots,J, \qquad 3)$$

$$\sum_{j=1}^{J} Ynj = 1 \qquad n = 1,2,\dots,N\,, \qquad 4)$$

$$Xmi = 0 \; or \; 1 \quad m = 1,2,\dots,M\,, I = 1,2,\dots,I\,,$$

$$Ynj = 0 \; or \; 1 \quad n = 1,2,\dots,N\,, j = 1,2,\dots,J\,.$$

Where,

M = number of origins,

N = number of destinations,

I = number of strip doors

J = number of stack doors

w_{mn} = number of trips required by the material handling equipment to move items originating from m to the cross-dock door where freight destined for *n* is being consolidated

D_{ij} = distance between strip door I and stack door j

s_m = volume of goods from origin m

S_i = capacity of strip door i

r_n = demand from destination n

R_j = capacity of stack door j

Decision variables;

x_{mi} = 1 if origin *m* is assigned to strip door i, x_{mi} = 0 otherwise,

Y_{nj} = 1 if destination *n* is assigned to stack door j, y_{nj} = 0 otherwise.

The formulation created by Tsui & Chang (1992, 283-286) is explained in more detail below:

- 1) Ensures that each strip door is assigned to one origin
- 2) Ensures that each origin is assigned to one strip door
- 3) Ensures that each stack door is assigned to one destination
- 4) Ensures that each destination is assigned to one stack door

Zhu, Hahn, Liu & Guignard (2009, 1229-1232), found some things that could be improved within this model, namely the problem that it assumes that strip and stack doors only serve one destination or region. They solved this by adding some additional parameters and recreated the model, which can be seen in formulation 3.

With the model that they created, strip doors can be assigned to contain multiple origins if the capacity of the strip door *Si* can accommodate them. And the same goes for stack doors, which allow multiple destinations if the capacity *Rj* allows it.

(3)

Minimize:

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{m=1}^{M} DijWmnXmiYnj$$

Subject to:

$$\sum_{m=1}^{M} SmXmi \leq Si \qquad i = 1,2,\dots,I, \qquad 1)$$

$$\sum_{i=1}^{I} Xmi = 1 \qquad m = 1,2,\dots,M, \qquad 2)$$

$$\sum_{n=1}^{N} rnynj \leq Rj \qquad j = 1,2,\dots,J, \qquad 3)$$

$$\sum_{j=1}^{J} Ynj = 1 \qquad n = 1,2,\dots,N, \qquad 4)$$

$$Xmi = 0 \text{ or } 1 \qquad m = 1,2,\dots,M, i = 1,2,\dots,I,$$

$$Ynj = 0 \text{ or } 1 \qquad n = 1,2,\dots,N, j = 1,2,\dots.,J.$$

Where the additional parameters are,

S_m = volume of goods from origin *m*,

S_i = capacity of strip door *i*,

r_n = demand from destination *n*,

R_j = capacity of stack door *j*.

Detailed information about the formulation created by Zhu et al. (2009, 1229-1232) is listed below:

- 1) ensures that the capacity of strip door Si is not exceeded
- 2) ensures that each origin gets assigned only one strip door
- 3) ensures that the capacity of each stack door *Rj* is not exceeded
- 4) ensures that each destination is assigned only one stack door

Mathematical models such as the two that were previously presented have some restrictions when applying them to real-life situations in cross-docks or terminals. They have great usability as tools to find valuable information and new insights about the problem, but creating a layout based directly on the information gained from them is risky. Terminals and cross-docks are dynamic environments that have a lot of moving parts within them, problems and unanticipated incidents do occur quite often, and that is where flexibility is needed.

Some of the things that the mathematical models assume are:

- all trucks are available all the time
- loading and unloading processes can be started immediately after docking
- required workforce and material is always available
- infinite capacity for temporary storage
- internal congestion is not considered
- trucks are either outbound and inbound, not both
- information concerning arrival times, content of loads etc. is always accurate
- does not take possible equipment fails, early or late arrivals into account

Directing workflow, assigning trucks and taking care that deadlines are met with vehicle departure times are all decisions that are usually made by the terminal supervisor or dispatcher in real time, as things rarely go as planned. Information gained beforehand through freight manifests or information systems is not always accurate and vehicles can arrive late due to weather conditions, vehicle fails etc. The freight might also be different from the information that is received beforehand. Creating too strict layouts that do not allow flexibility and having unrealistic assumptions do not allow efficient operations. (Belle et al. 2011, 39 – 42; Gue 1999, 419 – 427.)

7 Current state analysis

In this segment, the current state of the terminal will be analyzed, door allocation, freight staging areas, problem areas within the terminal. Volume information and calculations. The size and shape of the terminal applies constraints to the possibilities of layout planning. The terminal in Jyväskylä is an I-shaped building, it is 35 meters wide and 128 meters long. The total floor space of the terminal spans around 3900 square meters, of which 280 square meters are rented out to Olvi Plc. An illustration of the current layout of the freight side of the terminal can be seen in in figure 11. The full layout of the current layout can be seen in appendix 1.

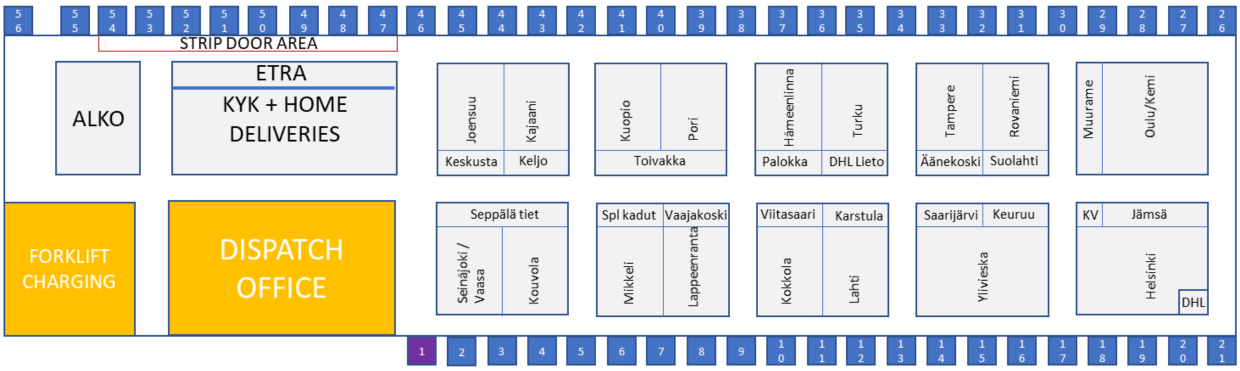

Figure 11. Current terminal layout.

7.1 Terminal lanes and aisle width

The freight terminal has 12 lanes, 10 of these lanes are used for staging outbound freight to other terminals and for distribution Jyväskylä region. These 10 lanes are 13x13 meters in size, and they have different regions located in them, depending on the time of day. During the day, the whole lane is in use for Jyväskylä region freight, and during the evening and night, most of the lane is occupied by freight outbound to other terminals. The terminal lanes have signs above them, which indicate the region that they are used for.

The freight side of the terminal has 56 doors, that are spread out through the building, the doors are used to load and unload transport units. One of these doors, which is the door number 1, is equipped with a scissor-lift that enables the loading and unloading of smaller vehicles, such as vans, this door is used for customers who come into the terminal with a smaller vehicle to pick-up or deliver goods. Doors 2 through 46 are used as stack doors for specific regions, and doors 47-54 are used for unloading vehicles, it is the so-called strip-door area.

The postal side of the terminal has 12 doors, which are located all on the same side. The staging areas for the postal goods are located in between the doors, as they have enough space in between them to store cages and trolleys. The postal side does not have a strip door area, instead the doors that are reserved for a specific region are used for both the loading and unloading processes of said region.

7.2 Material flows

The material flows in the terminal consist of varying types of freight, long items such as bundles and other and heavy freight is unloaded and loaded in the yard area of the terminal with a wheel loader. The nature of the material flows within the terminal depend largely on the decisions of the terminal supervisor and dispatcher, as they decide to a large extent at which doors transportation units will be unloaded and what “nose-loads” will be kept, and which will be unloaded entirely. A large number of freight moves through the strip-door area, where the incoming units are entirely stripped of their contents.

The material in the staging areas changes depending on the time of the day. During the night, the material heading to other terminals is loaded onto transportation units. And after all the transports to other terminals have left, the Jyväskylä region freight is pushed in to fill up the entire area. An illustration of the movement of the materials in the staging areas can be seen in figure 12.

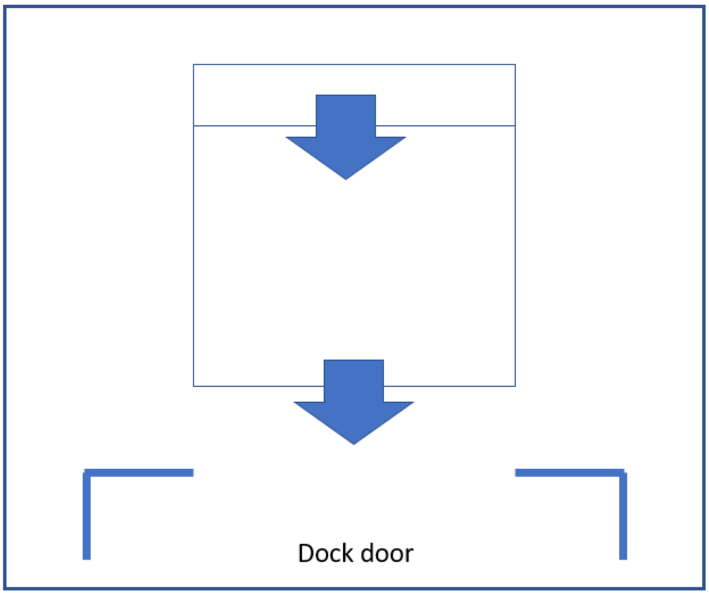

Figure 12. Material flow of staging areas

7.3 Material guidance in the terminal

The material is guided with zip-codes, each region has certain zip-codes tied to them and those zip-codes are within that regions delivery routes. The freight that is distributed in Jyväskylä region has full zip-codes listed in table 4. The freight that is distributed to other terminals only has the first three digits of the zip-code as seen in table 5, as they are sufficient enough to indicate the region that the freight is bound to. The same region names and zip-codes are listed on the signs that hang above the assigned terminal lanes.

Table 4. Guidance list of Jyväskylä region freight

Name of the region on the lane-sign	Zip-codes included in that region
Seppälä (tiet)	40320-40350, 41310
Seppälä (kadut)	40320-40350
Keskusta	40100, 40200, 40520
Keljo	40500, 40530-40740
Toivakka	41410-41460, 41630-41770
Vaajakoski	40400-40420, 40800-40820, 41400
Hankasalmi	41490-41580
Palokka	40250-40270, 41120-41240
Karstula	43490-43960
Saarijärvi	41260—41270, 43100-43480
Keuruu	42700-42930, 42520-42660, 41900-41980
Suolahti	44200-44220, 44260-44280, 44300-44370
Äänekoski	44100-44190, 41290, 44400-44480
Muurame	40900-40950
Jämsä	41800-41800, 42100-42440
Viitasaari	44500-44970
Laukaa	41325-41390

Table 5. Guidance list of terminal-to-terminal freight

Helsinki	001-011, 012-017, 018-038, 041-049, 051-089, 091-109
Hämeenlinna	111-149, 312-313
Lahti	151-199
Turku	201-219, 221-226, 227-259, 314-315, 321-325
Pori	261-299, 328-329, 386-389
Tampere	301-311, 316-319, 326-327, 331-385, 391-399
Kouvola	451-479
Kotka	481-499
Mikkeli	501-529, 571-578, 587-589, 761-775
Lappeenranta	531-568, 586-586, 591-593
Seinäjoki	601-649, 662-668, 693-695, 697-699
Vaasa	651-661
Kokkola	669-692, 696-696
Kuopio	701-759, 776-796
Joensuu	581-585, 594-598, 797-839
Ylivieska	841-869, 929-929
Kajaani	871-899
Oulu	901-928, 931-939
Kemi	941-959
Rovaniemi	961-999

8 Research results

8.1 Risk assessment

To assess the risks in the terminal, a questionnaire and observations were conducted to locate the riskiest places in the terminal, where accidents are most prone to happen. I was also given access to the records of work-related accidents that had happened at the terminal during the year 2015 and 2016. From those records, I was able to discern the places where work-related accidents had happened in the past.

A thesis revolving around the safety and risks of the terminal in Jyväskylä was conducted by Ville Moilanen in 2015. Many of the suggestions based on that thesis were implemented into the terminal, which improved the safety of the terminal. Due to the fact that an in-depth research regarding the overall safety of the terminal was already conducted, I decided to concentrate on a specific shift on which I would conduct my research on. The night shift was chosen as it is the time of day when the terminal has the most personnel working in it, creating an opportune chance for accidents to happen. Improving the safety issues of the terminal could also speed up the processes of the night shift, which directly affects the other processes done during the morning and day shifts. The risk assessment tool used to discern the probability and effect of the risk was a 3 x 3 model chart, which can be seen in table 6.

Table 6. Risk effect assessment chart

Likely	3.Medium Risk	4.High risk	5.Extreme risk
Unlikely	2.Low risk	3.Medium Risk	4.High risk
Highly unlikely	1.Insignificant risk	2.Low risk	3.Medium Risk
	Slightly harmful	Harmful	Extremely harmful

The risks noticed during the observation period were written down and compiled into a chart, which can be seen in table 7. In the table, the area, responsible party, cause and effect, and the suggestions to fix these problems are presented. In the risk category, the risk is evaluated with the use of the assessment chart.

Table 7. Risk assessment chart of the terminal during night shift

Area	**Risk is caused by**	**Possible effect of the incident**	**Risk**	**Suggestions for improvement**
Strip-door area	Too many forklifts in the area, causes congestion	Slows unloading processes, possible forklift collisions, material damages	Likely and slightly harmful =Medium risk	Distributing the strip-door area differently, not placing all strip doors in one area
Strip-door area	Personnel traveling by foot in the area, mostly drivers	Slows unloading processes, possible personnel damages, material damages	Unlikely and extremely harmful = High risk	Instruct drivers to wait in their vehicles or in the break-room if they have no business in the area

Pedestrian pathway near the dispatch office	Mostly drivers walking from their vehicle to the dispatch office	Personnel damages, slows down movement of materials and unloading processes, material damages	Unlikely and extremely harmful = High risk	Instruct drivers to enter the dispatch office from the other side of the building, which doesn't have forklift traffic near it
Main forklift pathway	Many forklifts in the same area, congestion created by traffic from strip doors	Slows down movement of materials and unloading processes, possibility for forklift accidents	Likely and slightly harmful = Medium risk	Expanding the width of the main pathway by reducing the size of staging areas

Continuation

During the observation period, most of the risks that were seen had to do with pedestrian movement in the terminal, as well as the congestion of certain areas. A lot of activity is centered around the strip-door area, there are a lot of forklifts, personnel walking on foot, freight, a lot of moving parts centered around one relatively small area of the terminal. The confrontations between forklifts and persons walking on foot can cause very serious injuries, and the risks in that category will be placed in category 4, which is a high risk. The chance for accidents like this are unlikely, but they can have serious repercussions if they occur.

Forklift collisions in the area are much more likely to occur, but they usually have a much smaller impact. The most common result from forklift collisions is slight damage to the forklift. But even so, every collision has the potential to have serious results. The risks involving forklift and forklift collisions are placed in category 3, which is medium risk.

8.2 Risk assessment questionnaire

To get more research material of the risks in the terminal, a questionnaire regarding the safety of the terminal was conducted. The questionnaire was done as an informed survey targeted towards specific individuals in the terminal, more specifically the terminal workers who work the nightshift. During the nightshift, there can be as many as 40 – 50 people working inside the terminal, making it the most likely time for accidents to happen. During other shifts, the traffic in the terminal is much smaller and the risks of an accident happening are also lower. The questionnaire that was conducted can be seen in appendix 2.

The main purpose of the questionnaire was to ask the personnel who work the night shift of the riskiest places within the current layout. This information gained from the questionnaire would then be taken into analyzed and compiled to see how it compares against the issues that were brought up during the observation. The material from the observation and questionnaire would then be taken under consideration, when designing the new layout. With the goal being to remove these risks, or at least reduce their effectiveness.

8.3 Results of the questionnaire

The questionnaire was distributed to 15 participants, who work as terminal supervisors or as forklift drivers. 80% of the answerers were people working for subcontractors and 20% were working for Posti. A majority of the questionnaire participants had worked at the terminal for more than 5 years.

All the accidents that had happened in the terminal only caused material damages, mainly to forklifts or freight. The accidents happened in the aisles or strip-door area while moving materials, the reasons given for the accidents were congestion of these areas. Due to the "light" nature of the incidents, they most likely have not been reported through the accident and close-call system of Posti. Forklift collisions are a quite common occurrence in the terminal, and as they are so common it can make them seem less risky in the eyes of the terminal workers. As it was brought up in the literature review, people can view everyday common risks to be less serious than they might actually be. In figure 13 the breakdown of percentages can be seen of the accidents and close call situations, and the areas that they happened in.

Have you been in a work-related accident or a close-call incident between the years 2016-2017?		
Close-call situation	2	13 %
Work related accident	4	27 %
No	9	60 %
Did the situation lead to,		
Material damages	4	100 %
Personnel damages	0	0 %
Sick leave	0	0 %

In what area of the terminal did the incident occur?			
Close-call situation	Strip-door area	1	50 %
	Main aisle	1	50 %
Type of incident	Almost collided with another forklift	2	100 %
Work related accident	Main aisle	3	75 %
	Strip door area	1	25 %
Type of incident	Forklift collision	4	100 %

Figure 13. Accident and close-calls in the terminal

When asked the question of the most dangerous area in the terminal, over 70% of the participants felt that it is the area where the strip doors are located. Main reasons mentioned for this were that during peak times it is very congested, visibility is bad, and that the doors are simply located too close to each other. There are 8 doors in the strip area, and many forklifts work there in very close proximity to each other, creating an opportune chance for accidents to happen. The breakdown of answers for the question can be seen in figure 14.

What areas do you find the most dangerous in the terminal		
Aisles	3	20 %
Strip-door area	11	73 %
A certain lane	1	7 %

Figure 14. The most dangerous areas in the terminal

The information gained from the questionnaire proved useful, as it displayed the thoughts of the people who work the night shift. Information regarding some accidents, such as forklift collisions have not been reported through the systems of Posti, so this information could've never been attained without this type of questionnaire. The results gained from the questionnaire and observations were similar, and pointed out the risk areas that need to be addressed with the new layout proposals.

8.4 Material flow analysis

The material flow analysis was done based on historical data of the freight volumes and through observation. The historical data was exported out of the dispatching software of Posti. The software displays accurate enough data of incoming freight, it displays each individual unit including its origin and destination. The software shows freight volume in kilograms and in palletmeters, which is a more tangible unit and commonly used in terminals. The volume data was then processed and imported into excel, where a flow record chart was created to see the volume between different regions.

The freight that arrives from other terminals has already been pre-staged, so quite often there are big “nose-loads” and those nose-loads do not require any further staging or unloading. These nose-loads were excluded from the calculations when discerning the amount of material that flows through the terminal, only the materials that physically travel through the floor of the terminal were considered in the calculations. Also, the freight that is unloaded in the yard area, such as bundles and other large objects were excluded as they are unloaded and loaded specifically in the yard area and thus do not affect the indoor operations of the terminal.

One thing that distorts the material flow are the nose-loads, as each region has multiple possibilities of what regions freight they will use to create them. As an example, Turku will create nose-loads to Kajaani, Ylivieska, and Rovaniemi, the one that they create can change daily depending on what region they have most at their disposal in their own terminal. Due to these aforementioned reasons, the material flow can change daily, as the disposition of these nose loads changes.

To gain reliable enough information of the flows, three months of historical data was processed to find out what the biggest volumes are, and to find out what regions should be located close to each other. Seasonal changes affect the material flows as well, but as it was found out from the data, the ratio between the regions does not change too much. And that means that the biggest volume region will still be the biggest, whether it be during peak or slow season. The average volumes for three months resulted in the values shown in figure 15. The information gained from these calculations makes it possible to place the regions based on volume to achieve the best results.

Region	AVG
Kajaani	16,6
Ylivieska	15,5
Joensuu	11,4
Tampere	10,1
Mikkeli	10,1
Kuopio	8,7
Helsinki	7,4
Pori	6,9
Turku	6,6
Kokkola	6,4
Oulu/Kemi	6,3
Lahti	6,1
Lappeenranta	5,7
Rovaniemi	5,2
Kouvola	4,3
Seinäjoki/Vaasa	4,2
Hämeenlinna	4,1

Figure 15. Average freight volumes by region.

8.4.1 Observation

The observation method was used to discern how many units are unloaded during the night-shift at the strip door area. For three days, the units that arrived there were observed and listed, and because each unit has a unique number, it was later checked from the information system by using these numbers, what freight those units contained. The information was then compiled into excel, where it was examined more closely. During the strip-door observation, the average amount of freight that flows from the strip doors was 189,1 palletmeters, while the total freight that was moved through the terminal was 401,8 palletmeters. During these observations 48,7% of freight flowed from the strip doors to the staging areas. The calculations for one day can be seen in appendix 3. The calculations also show the percentages of the volume for each region, which correlate with the data received from the material flow analysis.

The biggest regions by volume receive a large of number of freight from the strip-doors. The number of units that are unloaded at the strip-doors depend on the decisions of the terminal supervisor and dispatcher, as they make the calls on where to park the containers and trailers, and what “nose-loads” will be kept and which will be unloaded entirely. Due to this, the volume coming from the strip doors might change a bit, but it can be expected that at least 40% of the total volume is moved through those doors.

8.4.2 Transportation distances

Decreasing transportation distances is an efficient way to improve the productivity of the layout. In terminals, the second phase of material movement process usually happens empty, especially when unloading vehicles. The forklift driver will move a pallet to a certain staging area, and then drive back to the vehicle he was unloading with empty forks. Reducing the distance, the forklift driver has to move the materials with empty forks directly affects the effectiveness of those processes.

To make it possible to calculate the decrease in transportation distances, the transportation distances of the current layout were measured. The strip-door area was taken as the area of interest, as it was previously expanded upon, a significant amount of freight flows from there. The calculations for the transportation distances can be seen in appendix 4. The distances were measured as meters, the routes that were used to calculate the distances were the routes that are most commonly used in the terminal. From these calculations, it is then possible later, to calculate possible improvements in transportation distances from the created layout proposals.

9 Layout proposals

The created layout proposals consider the material flows during the night, and their effect and usability when thinking of morning, day, and night. During the day, the terminal has a much smaller material flow than during the night, and it’s possible to utilize more of the doors to unload goods. The goal was to design the layouts in a way that they would support each of the different shifts.

The biggest priority was the night shift, as it is the most critical shift due to the largest material flows, critical timetables and limited capacity. To cut down the costs of having to make orders for extra trucks because there are goods leftover, or having constant timetable issues, a good layout is needed that will support the operations. The Jyväskylä regions were placed in the terminal based on personal experience, observations, and volume data. In the original layout design, some of the regions had staging areas that were too small for them, and others had staging areas that are unnecessarily big for the volume that they receive. Certain regions were placed close to each other due to their geographical location, to enable cooperation between them if capacity problems occur.

Due to the lack of volume data regarding postal transports, no significant changes were made to the postal side of the terminal. The postal side has 10 doors all located on the same side, with the staging areas located right next to the doors. As the postal side already has very short transport distances, and there are no issues with congestion in the staging areas, changes to the area cannot be justified. The layout for the postal side of the terminal can be seen in appendix 9. The scheduling for the night shift can be seen in appendix 10, and the scheduling for the morning and day can be seen in appendix 11.

9.1 Layout proposal 1

The focus with the first layout proposal was to shorten the transportation distances within the terminal and to make changes that would reduce the effects of the safety concerns that came up in the questionnaire. As a large amount of freight is unloaded at the strip doors, and it is moved through the terminal, shortening the transportation distances from the strip doors to the staging areas of regions that have a high volume is very important.

The strip doors were split into two areas instead of one. By reducing the number of forklifts that operate in one area, this aims to reduce the congestion that is created in those areas as well as the safety issues caused by congestion. In the current layout design, the risks of an accident happening were the highest at the main pathway and at the strip doors. By distributing the strip area into two locations it will reduce the number of forklifts that operate in one area, and it will also direct the material flows to the main pathway from different directions. With these changes, the risk of an accident happening should be reduced. Having strip door areas in two different locations gives the terminal more flexibility, as it gives the dispatcher more freedom on where to assign units based on the freight that the units contains.

The amount of stack doors that were given to the regions are based on scheduling, as well as the amount of trucks that transport freight to those regions during the night. Regions have different amounts of trucks that transport the goods of said region, the number of trucks varies quite a lot, some regions only have one truck transporting the items during the night, and some regions might have as many as five. The scheduling of some regions however, makes it possible for some regions to have a smaller amount of stack doors than they have trucks.

To give a detailed explanation of the design of the new layout, the terminal was divided into grids. An illustration of the layout proposal is displayed in figure 16. The grids will be discussed in detail in the following segment, what regions those grids accommodate, and why they are placed there. The full layout for the first proposal can be seen in appendix 5.

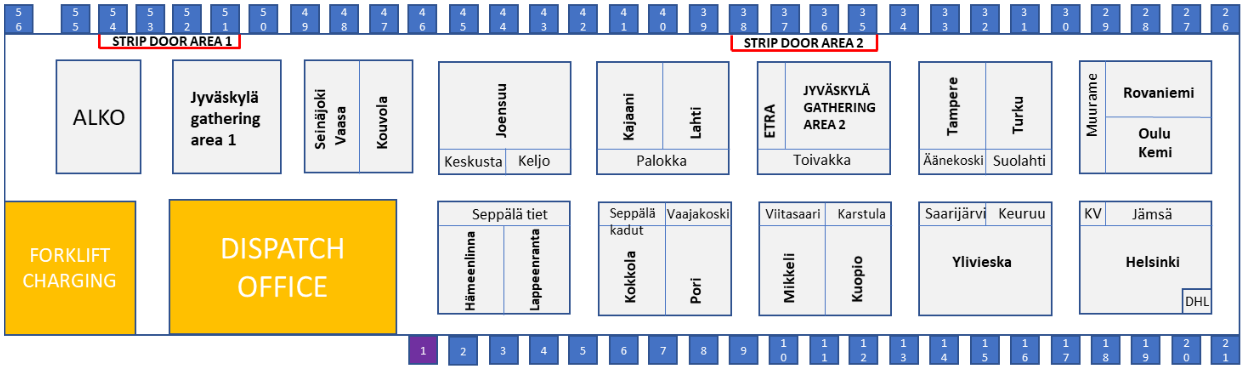

Figure 16. Illustration of the first layout proposal.

Grid 1

The grid is split in two equal sized lanes. The one closest to the dispatch office is occupied by Hämeenlinna and the other one is used to stage freight for Lappeenranta. Both regions are one-truck lanes, and each of them have two stack doors assigned to them, one for the trailer and one for the container. Hämeenlinna operates from the doors 2 & 3 and Lappeenranta from doors 4 & 5. These regions are placed in the corner of the terminal due to the low amount of freight they receive. Lappeenranta is placed closer to the pathway, because the trailer that arrives from Lappeenranta is usually sent back there, meaning that the trailer is stripped at said regions stack door. During the day, the entire area is used for Seppälä tiet, which is the region with the highest volume in Jyväskylä. It is located close to both strip door areas, and close to the dispatch office, as this region usually requires supervision from the dispatchers to get everything delivered, that's why it is placed within visual distance from the dispatch office.

Grid 2

The grid is split in two equal sized lanes. Kokkola and Pori occupy this grid. Kokkola is a 3-truck lane, but due to the scheduling of the route, two stack doors are enough for it. Doors 6 & 7 are reserved for Kokkola. Pori is a one-truck lane; its operations are handled from doors 8 & 9. During the day, the area used by Kokkola is reserved for Seppälä kadut and the area used by Pori is reserved for Vaajakoski. Seppälä tiet is a region in Jyväskylä that receives the second highest amount of freight. It is placed next to Seppälä tiet, as this enables cooperation between the two.

Grid 3

This area is occupied by Mikkeli and Kuopio. Mikkeli has the doors 10 & 11 and Kuopio has doors 12 & 13. These areas receive a lot of freight, and nose-loads from the same regions, so having them placed close to each other reduces the transportation distances. During the day, the area used by Mikkeli is reserved for Viitasaari and the area used by Kuopio is reserved for Karstula.

Grid 4

Grid 4 is used to stage freight for Ylivieska, it receives a high volume of freight from Jyväskylä and other regions as well, so it requires the entire area of the grid for smooth operation. It is a 5-truck lane, and doors 14 – 17 have been reserved for the stack and strip operations. Ylivieska receives most of the freight from the units that arrive from Hämeenlinna and Turku, the units that arrive from Hämeenlinna are unloaded at doors 38 – 35 and the ones arriving from Turku usually contain a nose-load to Rovaniemi, so they are unloaded at doors 29 – 27. It is located very close to these doors so the transportation distances are short. During the day, the area is reserved for Saarijärvi and Keuruu.

Grid 5

This grid is used to Stage freight that is bound for Helsinki. Doors 18 - 21 have been reserved for this regions operation. Helsinki is a 5-truck lane, the isolated area in the corner is ideal for it, as this area can be handled by one forklift driver that handles all the strip and stack operations in this area. The nose-loads that are pre-built for Helsinki, usually require some type of handling, such as tagging DHL and international freight so more space is required. During the day, the area is used to stage freight for Jämsä.

Grid 6

Staging area 2 is split in two, and it is occupied by Rovaniemi and Oulu/Kemi regions. Doors 25 - 22 have been reserved for Oulu/Kemi and the doors 29 - 27 have been reserved for Rovaniemi. This area is handled by a subcontractor that handles all the strip and stack operations in the area, the isolated location for this is ideal. This area receives a lot of "nose-loads" from southern regions, so material flows "from the floor" are quite low. During the day, the area is used to stage freight for Muurame.

Grid 7

This staging area is split in two, it houses the regions of Turku and Tampere. Doors 34 & 33 have been reserved for Tampere and doors 32 - 30 have been reserved for Turku. Both regions are 2-truck lanes, due to the truck scheduling Tampere will manage with 2 doors. Having these two regions close to each other is beneficial, as freight heading for Turku is usually loaded onto units heading to Tampere if the capacity for Turku is not enough. During the day, the area used by Tampere is reserved for Äänekoski, and the area used by Turku is reserved for Suolahti. Äänekoski and Suolahti are placed in the same grid due to their geographical location, if either of the regions has problems with truck capacity, the other one can help.

Grid 8

Grid 8 is located across the second strip door area. The grid is divided into three parts, the disposition of these parts can be seen in figure 17. The transportation units that contain freight for Etra are unloaded at door 38 – 35, so the area to stage that freight is located right next to them. The Jyväskylä gathering area 2 can be used to gather Jyväskylä specific freight that require special handling or transportation, such as freight that has a certain time-window for delivery. Toivakka only receives a few pallets daily, so the area received for it will also accommodate the recycling units that are in the terminal.

Figure 17. Disposition of grid 8.

Grid 9

This grid is housed by Kajaani and Lahti, Kajaani has the doors 42 – 40 and Lahti has the door 39. Kajaani is the region that receives the highest amount of freight out of all the regions, it is located very close to both strip door areas to reduce the transportation distances, it is operated with two trucks, but due to their scheduling 3 doors are required. Lahti is a region that is transported with one vehicle. The lack of transportation capacity of the freight side is compensated by using the units from the postal side of the terminal, the freight is transported to doors 55 & 54 for these purposes if needed. During the day, the area is used to gather freight for Palokka, which is a high-volume region in Jyväskylä.

Grid 10

This entire grid is occupied by Joensuu. The entire area is reserved for Joensuu due to the type of freight that arrives from there, as most of it requires special handling and a lot of space. Joensuu is a 3-truck lane, and doors 45 – 43 are reserved for its operations. During the day, the area is occupied by Keskusta and Keljo regions of Jyväskylä. These regions have delivery routes that are quite close to each other, and placing them together helps them to plan their routes optimally and help each other out if needed.

Grid 11

This area is occupied by Seinäjoki/Vaasa and Kouvola. Seinäjoki and Vaasa have the doors 50,49,48 and Kouvola has the doors 47,46. Seinäjoki/Vaasa is a region that very often has a part of its freight driven to the postal side of the terminal to utilize fill rates to their maximum capacity, therefore it is located closer to the postal side of the terminal. During the day, when there is no freight for Jyväskylä and Seinäjoki, this grid can be utilized to price and mark the KYK-freight that arrives.

Grid 12

This area is located next to the first strip door area, and can be utilized to gather customer specific freight, such as items that have specific timetables for delivery. During peak times for letters and small shipments, such as Christmas, the small package sorting area can be moved to this area to create more room in the postal side of the terminal.

Travel distances

To analyze the effects of the changes to the re-positioning of the strip doors, the transportation distances were calculated from the current layout and the layout suggestion, and a comparison was made between the two. The comparison, as seen in figure 18 shows that the total transportation distances to regions from strip doors was reduced by 21,2%. This is a significant reduction in transportation distances. The breakdown of the calculations for the transportation distances can be seen in appendix 4 & 5.

SUM OF TRAVEL DISTANCES	
Layout suggestion 1	10 328,3
Current layout	13111,7
Difference	-21,2 %

Figure 18. Comparison of transportation distances between the current layout and the first layout proposal.

9.2 Layout proposal 2

The second layout considers the possibility of utilizing unloading zones within the terminal, having unloading zones in the terminal could increase the speed of the unloading process. In the second layout proposal, the terminal has two unloading zones and the staging areas have been divided into 18 grids. The size of these grids can be altered and the grids can also be divided if there is a need for that. The dimensions for the grids can be seen in figure 19.

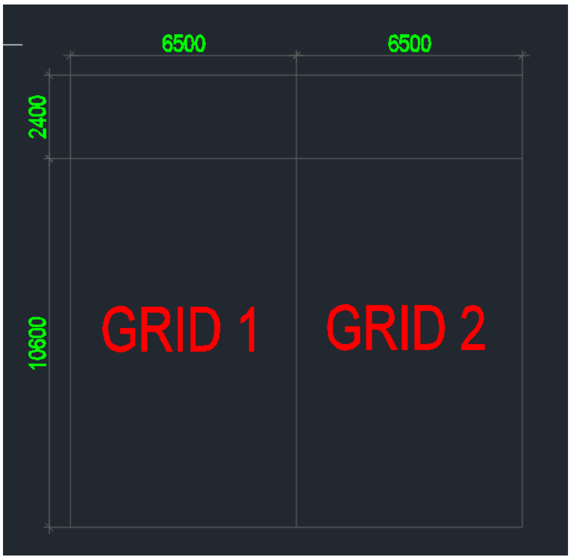

Figure 19. Dimensions of the terminal grids in layout suggestion 2.

The smaller areas on the grid are reserved to stage and store freight for Jyväskylä regions, and the bigger ones are reserved for freight that is bound to other terminals. In total, there are 10 doors in the design that are assigned as strip doors. In front of those doors, there are two areas. The smaller area is 13x13 meters, and this area would be used to collect freight that is bound to Jyväskylä. The larger area is 13x28,5 meters, and this area would be used to collect the freight that is bound for other terminals. Doors 2 – 5 should be used to unload transport units that contain freight for Jyväskylä and doors 6 – 12 should be used to unload the units that contain assorted freight or a lot of freight to other terminals. An illustration of the second layout proposal can be seen in figure 20 and the full layout proposal can be seen in appendix 8.

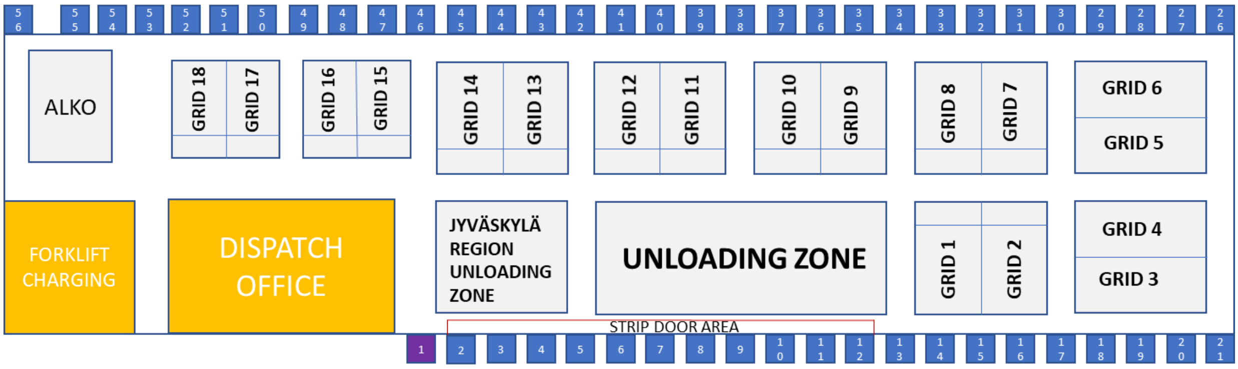

Figure 20. Illustration of the second layout proposal.

This method requires a lot of workforce for it to be successful. The basic principle is that there would be a set number of forklifts that unload the goods from the units and place them to the corresponding unloading zones, depending on whether the freight is bound to Jyväskylä or some other region. Another set of forklift drivers would have the assignment of driving those unloaded goods to the correct locations, freight could be prioritized, and the not so critical freight could be moved from the zone later. Using these unloading zones enables more possibilities to freight handling, such as registering every piece of freight that is unloaded and it gives a way to affect the material flows within the terminal through the prioritizing of freight. An illustration of the material flows from the unloading zones can be seen in figure 21.

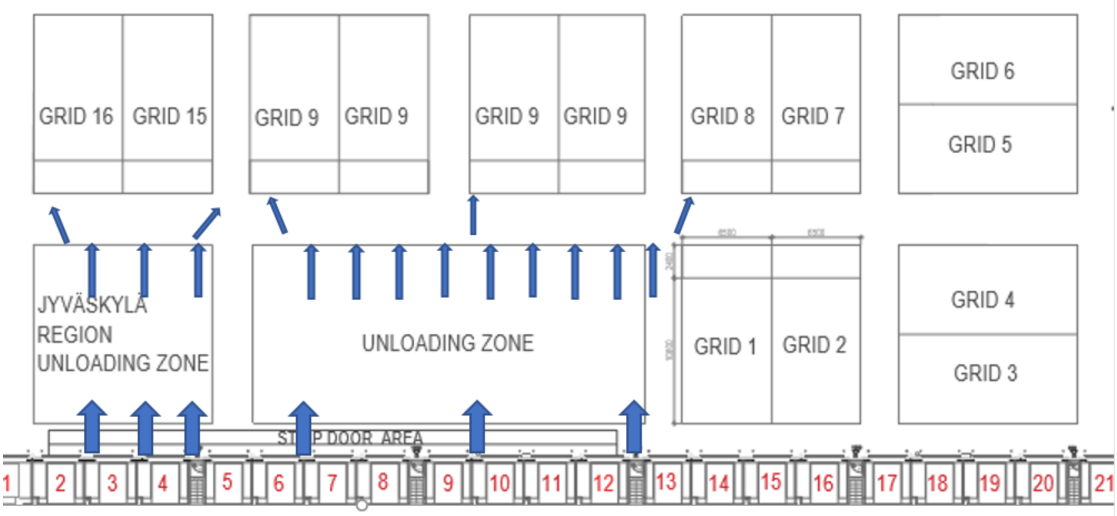

Figure 21. Material flows from unloading zones in layout proposal 2.

As the forklift drivers that are assigned to unloading the units only have to move the freight to the unloading zones, the speed of the unloading process would be increased. This enables faster rotation of the units that are unloaded at the strip doors. When assigning regions to the grids the same principle that was used in the first layout proposal should be followed, placing them with the “best door” method, where the highest flow regions are placed in the center of the terminal and the regions with the smallest flow are placer in the corners of the terminal.

Implementing this layout would require some structural changes to the terminal, as the fence surrounding the terminal is closer on the side where the strip doors are located in the design. To ensure fast rotation of the units at the strip doors, the fence should be moved further away from the doors to allow more room to maneuver the vehicles that are moving the transport units.

9.3 Chosen layout

The first layout proposal offers the solution to the problems of the current layout with minimal changes. It gives the terminal more flexibility, shortens the transportation distances and reduces congested areas. No structural changes are required for the layout, the implementation of the layout could be done in a few days, as it mostly requires new terminal lanes to be painted and moving the placards that hang above the regions to the corresponding lanes. Informing other terminals of the changes beforehand should also be done, to let the drivers know the new doors that are reserved for them.

The possibilities of combining the postal goods and freight, was researched, but to make decisions regarding the number of vehicles that transport those good requires more data regarding the material flows. Information regarding the volume of postal goods was insufficient, as in the dispatch software units containing postal goods are just marked as “posti”, with no indications of regions or amounts. Due to that insufficiency, the information is not valid enough to base decisions on. Currently, the best method to combine transports and utilize fill-rates between the two sides of the terminal is close-knit cooperation between them. The terminal has shortwave radio communicators or “walkie-talkies” in use, with these the communication between supervisors of both sides is quite easy and they can be used to determine how much space each side has in their transportation units. For example, if the freight side lacks capacity in their units to Tampere, they can ask the postal side if they have room in theirs to utilize that units properly. At the moment, the empty space in postal transports is usually filled up with empty cages or trolleys, this could be replaced with freight. Due to the relatively low amount of freight that is utilized in postal transports and vice-versa, there is no need to make drastic changes to door allocation because of this.

10 Conclusions

The goal of the thesis was to create new layout designs for Posti’s terminal. Due to process changes and new customer acquisitions the layout needed an update. Before the work started, the scope and limits of the thesis were defined. The thesis was limited to creating new layout designs for the terminal, implementation of the designs was excluded from the work. A schedule was created for the thesis with deadlines, and the schedule was kept throughout the work.

The research started with charting the current state of the terminal, and through observations and a questionnaire the problems of the layout were determined. The questionnaire pointed out the issues regarding the safety of the terminal, and with the results of the questionnaire changes were made to the layout proposals that would reduce the risk of those safety issues. The operations and processes in the terminal were observed, these observations gave more insight into the inherent problems with safety as well as the nature of the material flows.

There were some issues with acquiring the data regarding the material volumes, as the company had no specific system in place for collecting data from terminal to terminal material volumes. This came as a bit of a surprise and caused some bumps in the scheduling of the thesis. The company had a dispatch software however, that showed this data, and it even allowed viewing historical data, as that data was saved in the software. The data was manually dug up from the dispatch software, which proved to be very slow work as there was no real way to extract the data from the software, instead each line of data had to be manually typed into excel to form the data sheets. The sheer amount of work gathering and processing the data limited the amount of historical data that could be processed, it would have been possible to gather a greater amount of data, but due to the schedule of the thesis, three months of historical data was the limit. Seasonal changes in the volumes were also checked from the data, as the volumes slow down during certain times of the year. During the summer, as the holiday season is heavy in most industrial companies, and companies lower their manufacturing volumes, the material volume in the terminal drops significantly as well. The ratios between regions do not however face major changes, the regions that have the highest volume during peak times also have the biggest volume during lower volume times.

The results of the research are valid enough to recommend the implementation of the first layout proposal. The data provided by the dispatch software is reliable, and that same data is used for capacity planning by the dispatchers. The results are not based on the data regarding material flows alone, but they also take into account the author’s personal experience as having worked in the terminal for over 4 years, as well as the improvements they make to the safety of the terminal. The safety issues brought up by the questionnaire can also be considered reliable, as the answers came from people who specifically work the night-shift all year round.

The layout is designed specifically for the terminal in Jyväskylä, and its utilization in other terminals as it is, is not recommended. Terminals have different shapes, sizes and ways of operation, so simply implementing designs reviewed and displayed in this thesis would not lead to optimal designs. There are still quite a few terminals owned by Posti that have the same shape and size, as some of the terminals were built by Transpoint with the same layout principle, before Posti acquired the company. Those terminals could find the researched topics and layout suggestions useful, due to the similarity in design. The research done in the thesis may prove useful to other companies as well, when researching ways to shorten transport distances and improve material flows within terminals.

Posti is implementing a new software later in 2017, which gives them more tools to monitor and gather data regarding the material flows between terminals. There is a definite possibility, and need for further research after the software has been implemented, and enough historical data has accumulated to make predictions and calculations based on it. If the system shows more information from the postal transports, research to make more drastic changes to the cooperation between the two sides of the terminal could be done. The second layout suggestion could be used as a basis for the new research. Information regarding the material flows should monitored closely after the new software has been implemented. If major changes occur in the volume of material flows, it is a relatively fast process to implement changes in region placements within the terminal to accommodate those changes.

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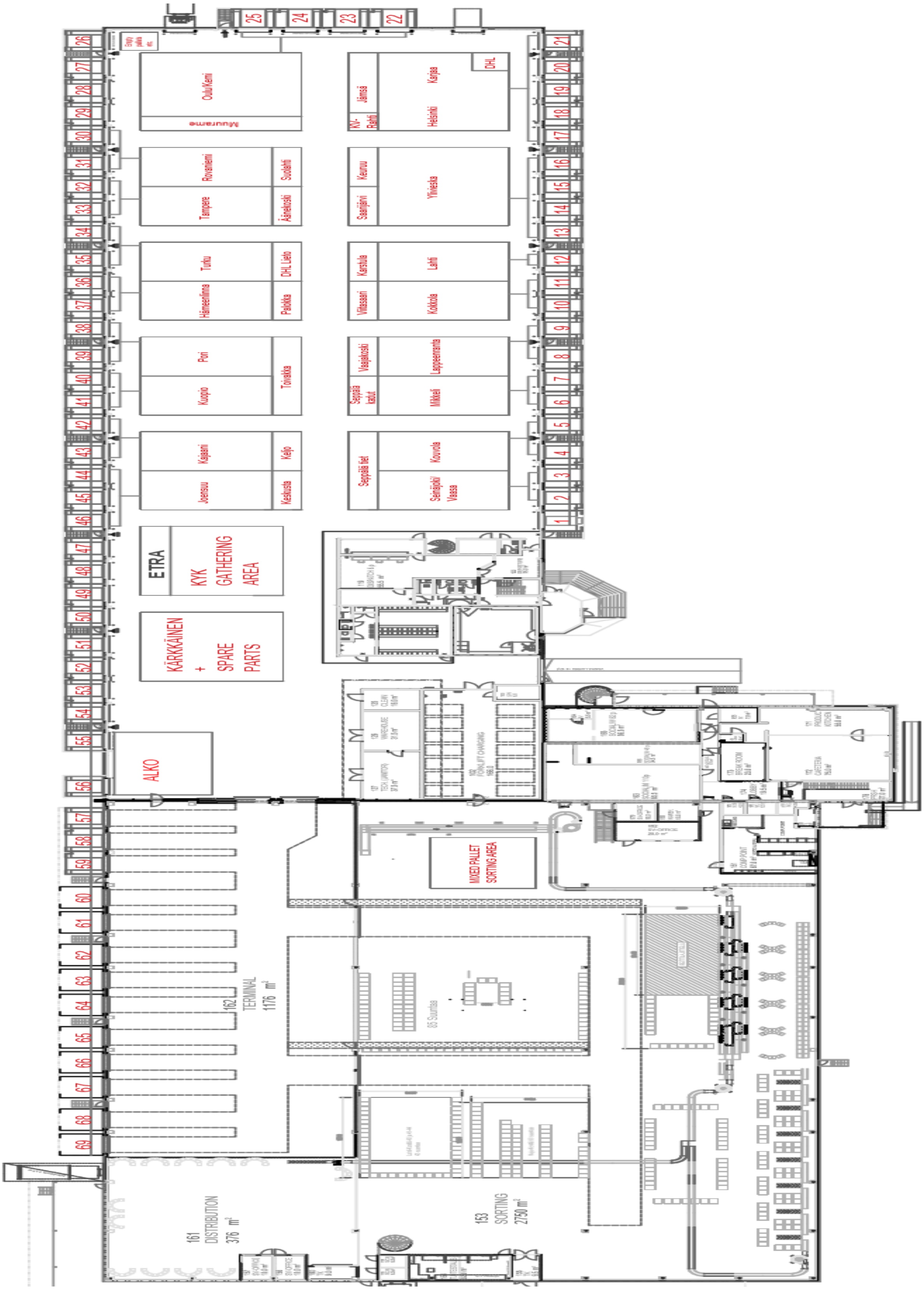
Appendices

Appendix 1. The current layout



Appendix 2. Questionnaire for terminal employees

A questionnaire about the risks and safety of Postis' terminal in Jyväskylä

1. Employer

- ☐ Posti Group
- ☐ Other, which? ______________________________

2. Job description

- ☐ Terminal worker
- ☐ Terminal supervisor

3. How long have you worked at Postis terminal in Jyväskylä?

- ☐ Less than a year
- ☐ 1 – 4 years
- ☐ 5 – 10 years
- ☐ over 10 years

4. Have you been in a work related accident or a close-call incident between the years 2016-2017? if the answer is "No", go to question 8.

- ☐ Yes; work related accident
- ☐ Yes; close call situation
- ☐ No

5. Did the situation lead to,

- ☐ Material damages
- ☐ Personnel damages
- ☐ Sick leave

6. In what area of the terminal did the incident occur?

- [ ] Sorting area
- [ ] Strip-door area
- [ ] Aisle
- [ ] A certain staging lane, which one?; ______________________
- [ ] Somewhere else, where?; ______________________

7. How did the incident happen?

____

____

____

8. What areas do you find the most dangerous in the terminal, and why?

- [ ] Sorting area
- [ ] Strip-door area
- [ ] Aisles
- [ ] A certain staging lane, which one?; ______________________
- [ ] Somewhere else, where?; ______________________

____

____

____

Appendix 3. Freight volume from strip doors

UNIT		DESTINATION																
		Jyväskylä	Helsinki	Hämeenlinna	Ylivieska	Kouvola	Pori	Kokkola	Oulu	Turku	Kuopio	Vaasa	Seinäjoki	Kajaani	Lahti	Joensuu	Tampere	Mikkeli
	M14077	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	U15119	7,5	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
	GR2311	11	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	M5853	10	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0
	M14061	1,5	1	1	2	1	1	1	2	1,5	1	0	0	0	0	0	0	0
	R1224	2	0	0,5	0	0	0,5	1	0	1	0	0,5	1,5	0,5	0	0	0	0
	M4824	7	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
	EX647	3	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	
	M14035	6	0	0	0	0	0	0	0	0	5	0	0	0	2	0	0	0
	EX01531	7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	R7569	7	0	0	0	0	0	0	0	0	2	0	0	1,5	0	2,5	0	0
	U808	2,5	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	0
	EX1512	7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	R3950	3	2	1	2		1	0,5	0	0	0	0	0	0	0	0	1,5	2
	EX1508	7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	DHL1	7,5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	KIYS182	2	0	0	1,5	0	0	0	0	0	0	0	0	4	0	0	0	0
	PYIS182	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	K43007	4,5	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
	TOTAL	116	5	3,5	9,5	6	2,5	2,5	2	2,5	8	0,5	1,5	13	2	4,5	1,5	2
		64 %	3 %	2 %	5 %	3 %	1 %	1 %	1 %	1 %	4 %	0 %	1 %	7 %	1 %	2 %	1 %	1 %

Total volume from strip doors	182,5
Total freight volume	388,5
Percentage of total volume	46,98 %

Appendix 4. Current transportation distances in meters from strip doors

STRIP DOORS	DESTINATION																
	Joensuu	Vaasa/SK	Kajaani	Kouvola	Kuopio	Mikkeli	Pori	Lappeenranta	Hämeenlinna	Kokkola	Turku	Lahti	Tampere	Ylivieska	Rovaniemi	Oulu/kemi	Helsinki
47	15,3	62,4	52,6	52,6	52,6	52,6	68,6	68,6	68,6	68,6	84,6	84,6	84,6	84,6	100,6	100,6	100,6
48	19,0	66,1	56,3	56,3	56,3	56,3	72,3	72,3	72,3	72,3	88,3	88,3	88,3	88,3	104,3	104,3	104,3
49	22,8	69,9	60,1	60,1	60,1	60,1	76,1	76,1	76,1	76,1	92,1	92,1	92,1	92,1	108,1	108,1	108,1
50	26,5	73,6	63,8	63,8	63,8	63,8	79,8	79,8	79,8	79,8	95,8	95,8	95,8	95,8	111,8	111,8	111,8
51	30,3	77,4	67,6	67,6	67,6	67,6	83,6	83,6	83,6	83,6	99,6	99,6	99,6	99,6	115,6	115,6	115,6
52	34,0	81,1	71,3	71,3	71,3	71,3	87,3	87,3	87,3	87,3	103,3	103,3	103,3	103,3	119,3	119,3	119,3
53	37,8	84,9	75,1	75,1	75,1	75,1	91,1	91,1	91,1	91,1	107,1	107,1	107,1	107,1	123,1	123,1	123,1
54	41,5	88,6	78,8	78,8	78,8	78,8	94,8	94,8	94,8	94,8	110,8	110,8	110,8	110,8	126,8	126,8	126,8
55	45,3	92,4	82,6	82,6	82,6	82,6	98,6	98,6	98,6	98,6	114,6	114,6	114,6	114,6	130,6	130,6	130,6

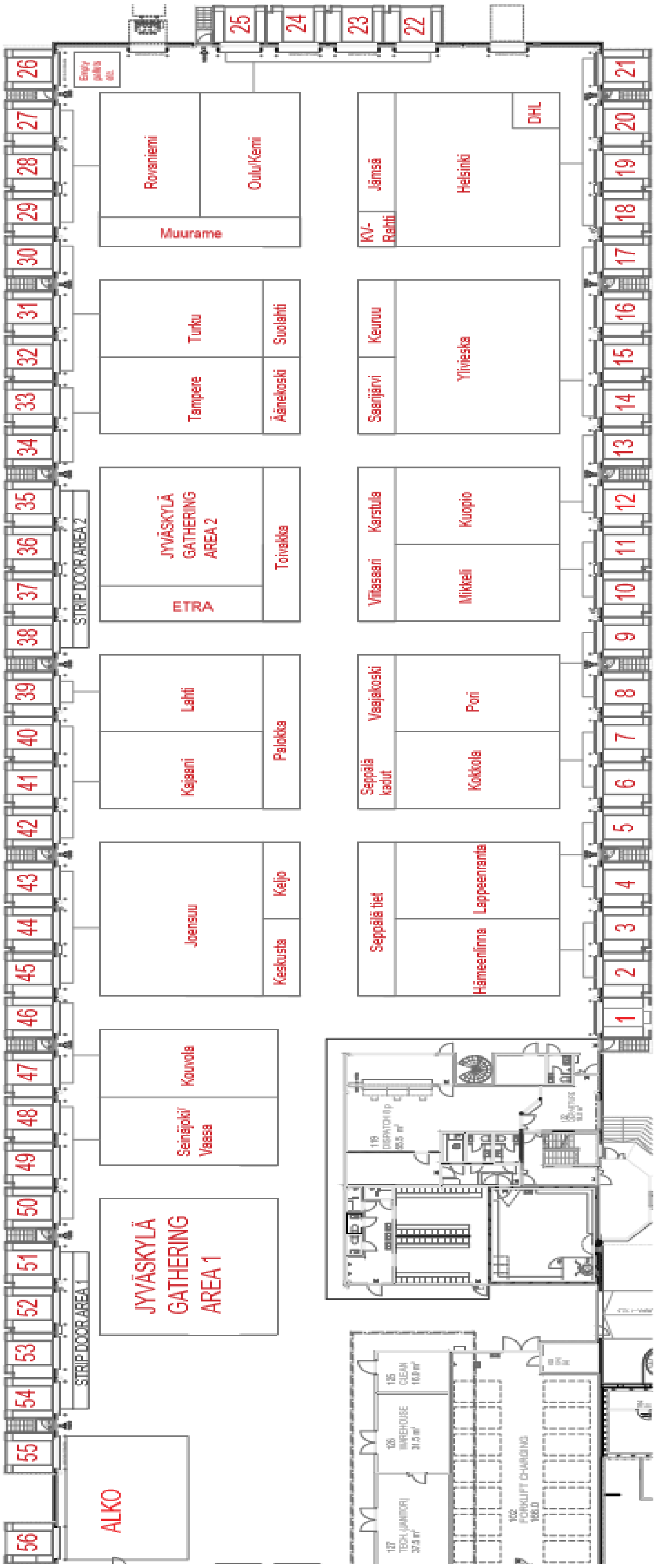
Appendix 5. Transportation distances from strip door in layout proposal 1

STRIP DOORS	DESTINATION																
	Joensuu	Vaasa/SK	Kajaani	Kouvola	Kuopio	Mikkeli	Pori	Lappeenranta	Hämeenlinna	Kokkola	Turku	Lahti	Tampere	Ylivieska	Rovaniemi	Oulu/kemi	Helsinki
35	62,0	77,8	32,3	51,5	31,0	42,3	42,3	62,0	71,8	62,0	21,0	22,3	11,0	34,8	50,8	45,8	50,8
36	54,5	74,0	28,5	55,3	34,8	38,5	38,5	54,5	64,3	54,5	24,8	18,5	14,8	38,5	54,5	49,5	54,5
37	50,8	70,3	24,8	59,0	38,5	34,8	34,8	50,8	60,6	50,8	28,5	14,8	18,5	42,3	58,3	53,3	58,3
38	47,0	66,5	21,0	62,8	42,3	31,0	31,0	47,0	56,8	47,0	32,3	11,0	22,3	46,0	62,0	57,0	62,0
51	30,3	19,8	67,6	25,3	67,6	67,6	83,6	83,6	77,4	67,6	115,6	83,6	99,6	99,6	115,6	115,6	115,6
52	34,0	23,5	71,3	29,0	71,3	71,3	87,3	87,3	81,1	71,3	119,3	87,3	103,3	103,3	119,3	119,3	119,3
53	37,8	27,3	75,1	32,8	75,1	75,1	91,1	91,1	84,9	75,1	123,1	91,1	107,1	107,1	123,1	123,1	123,1
54	41,5	31,0	78,8	36,5	78,8	78,8	94,8	94,8	88,6	78,8	126,8	94,8	110,8	110,8	126,8	126,8	126,8
55	45,3	34,8	82,6	40,3	82,6	82,6	98,6	98,6	92,4	82,6	130,6	98,6	114,6	114,6	130,6	130,6	130,6

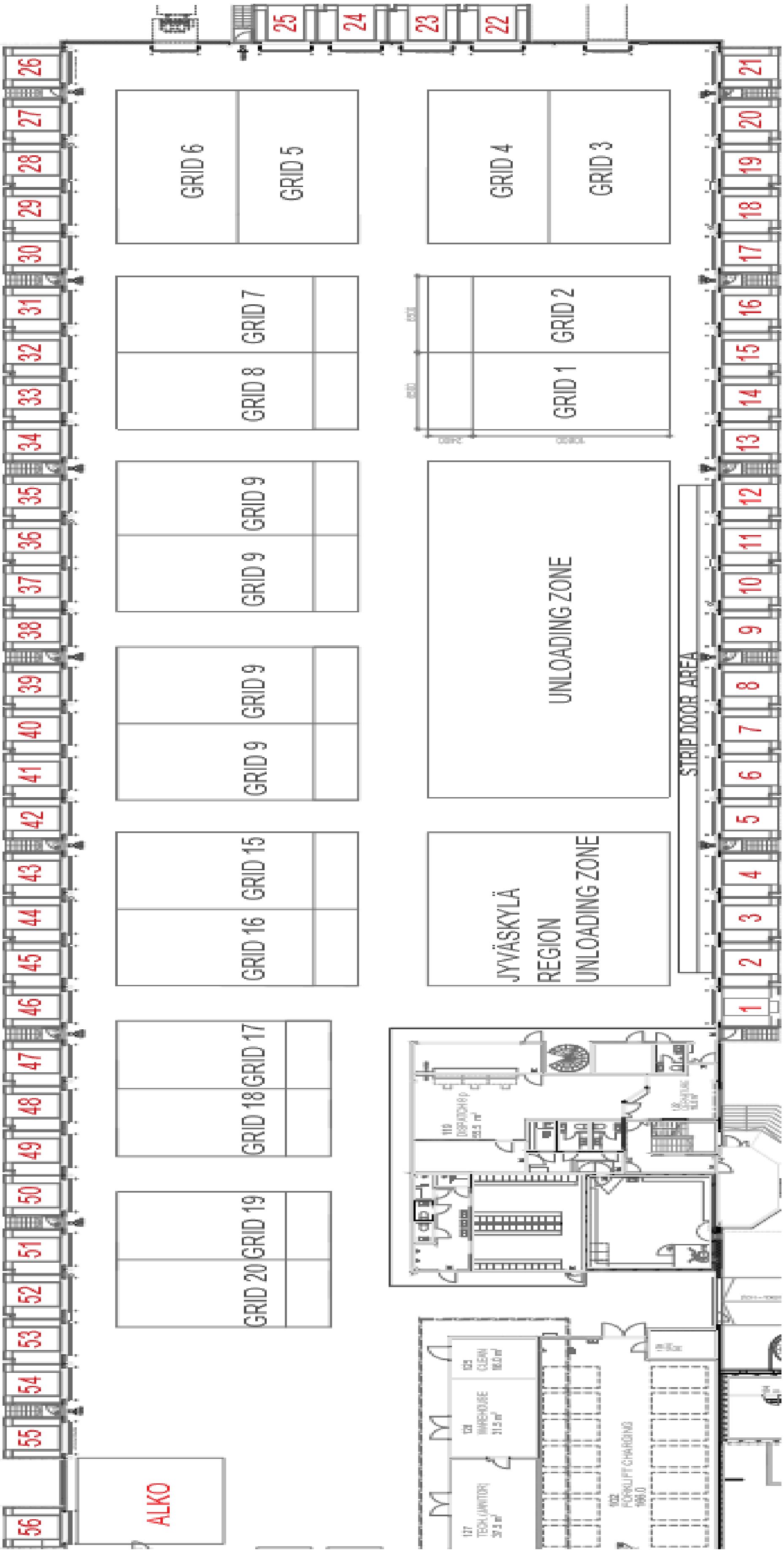
Appendix 6. Transportation distance comparison

TOTAL TRANSPORTATION DISTANCES FROM STRIP DOORS																	
Region	Joensuu	Vaasa/SK	Kajaani	Kouvola	Kuopio	Mikkeli	Pori	Lappeenranta	Hämeenlinna	Kokkola	Turku	Lahti	Tampere	Ylivieska	Rovaniemi	Oulu/kemi	Helsinki
Layout suggestion 1	403,0	424,8	481,8	392,3	521,9	521,8	601,8	669,5	677,7	589,5	721,9	521,8	601,9	696,8	840,8	820,8	840,8
Current layout	272,3	696,2	608,0	608,0	608,0	608,0	752,0	752,0	752,0	752,0	896,0	896,0	896,0	896,0	1040,0	1040,0	1040,0
Difference	48,0 %	-39,0 %	-20,8 %	-35,5 %	-14,2 %	-14,2 %	-20,0 %	-11,0 %	-9,9 %	-21,6 %	-19,4 %	-41,8 %	-32,8 %	-22,2 %	-19,2 %	-21,1 %	-19,2 %

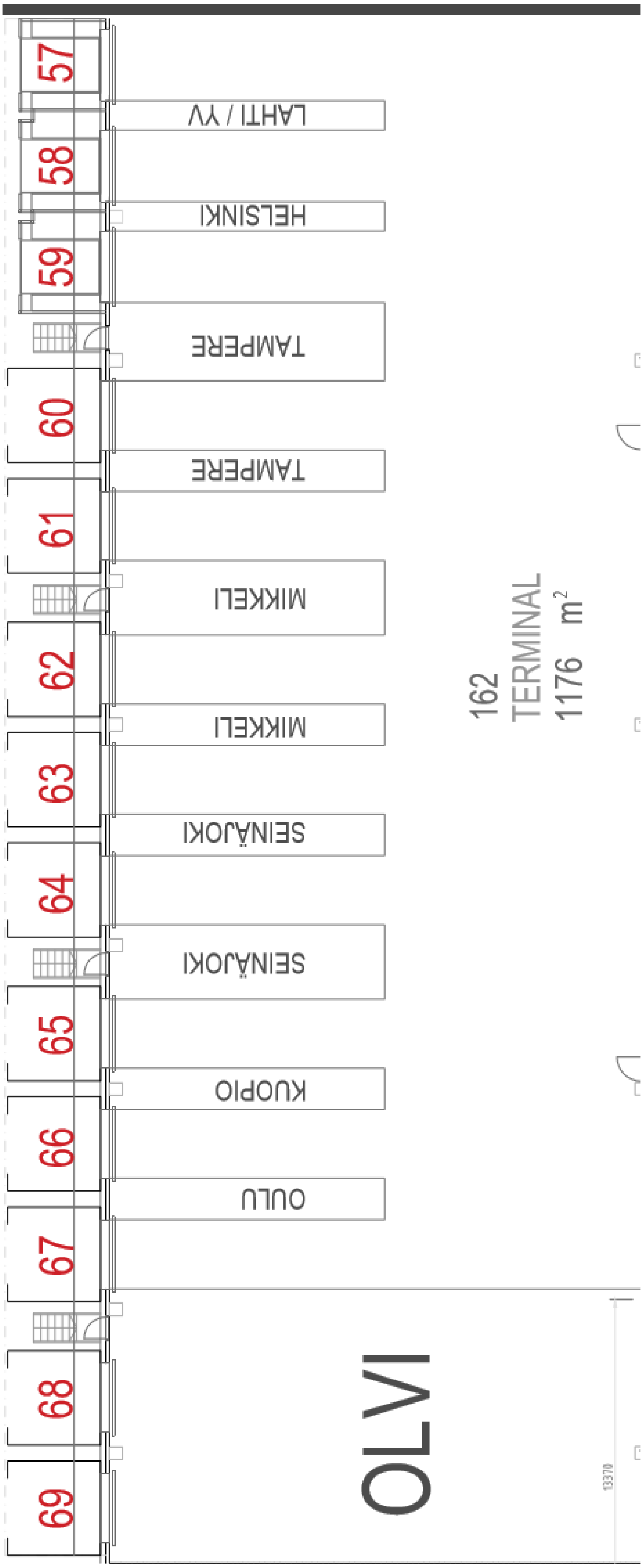
Appendix 7. Layout proposal 1, freight side of the terminal



Appendix. 8 Layout proposal 2, freight side of the terminal



Appendix 9. Layout of the postal side



Appendix 10. Door allocation postal side, night operations.

			INBOUND TRANSPORTS				OUTBOUND TRANSPORTS						
			OULU	KUOPIO	SEINÄJOKI	SEINÄJOKI	MIKKELI	MIKKELI	TAMPERE	TAMPERE	HELSINKI	HELSINKI	LAHTI/YLIVIESKA
TIME	69	68	67	66	65	64	63	62	61	60	59	58	57
19:00	OLVI	OLVI											
19:15													
19:30													
19:45													
20:00									Mon - Fri				
20:15									20:00 40R3320				
20:30													
20:45													
21:00			21:00 01R9016B								Mon - Fri	Mon - Fri	
21:15													
21:30			21:30 01R9016B								21:30 40R0021	21:30 40R0021	
21:45													21:45 84R4018
22:00							21:45 50R4020	21:45 50R4020		Mon - Fri			Mon - Fri
22:15							Mon - Fri	Mon - Fri		22:05 40R3322			
22:30					Mon - Fri 22:45								
22:45					40R6022						Mon - Fri	Mon- Fri	
23:00											23:00 40R0123	23:00 40R0123	
23:15													Sun
23:30													23:25 40R00SU
23:45				Mon - Fri 00:00								23:50 90R0119	
0:00			23:45 00R9020 Mon - Thu	40R7000		23:45 60R4021						Mon- Fri	00:15 15R4021
0:15			00:00 00R9019 Fri			Mon - Thu	Fri	Fri		00:20 33R4022A	00:20 33R4022A		Mon - Fri
0:30			00:20 00R9019 Fri	00:10 70R4022		Mon - Thu	01:00 40R5301	01:00 40R5301		Mon - Fri	Mon - Fri	Mon - Fri	
0:45			00:45 00R9020 Mon - Thu	Mon - Fri	00:25 60R4021B	00:45 40R6000	Mon - Fri	Mon - Fri	Mon - Fri			00:35 90R0119	
1:00					Mon - Thu		01:00 40R5001	01:00 40R5001	00:55 40R3300				00:50 33R4022
1:15				01:00 01R4021		Fri - Sat							Mon - Fri
1:30				Mon - Fri		01:30 40R6001							
1:45									01:50 20R4021			1:40 00R8421	
2:00									Mon - Fri			Mon - Fri	
2:15											02:10 01R4022		
2:30											Mon - Fri		
2:45			02:30 00R9022									Mon - Fri	Mon - Fri
3:00			Mon - Fri									3:00 00R8422	3:00 40R8403
3:15			03:15 00R9022									2:55 90R0122	
3:30												Mon - Fri	
3:45							3:50 00R4022		03:50 20R4023			Mon - Fri	
4:00							Mon - Fri		Sun			03:40 90R0122	
4:15													
4:30													
4:45													
5:00													
5:15								05:05 33R4002			Mon - Fri		
5:30								Mon - Fri			5:30 40A35001		
5:45													05:50 90R9000A
6:00													Mon - Thu
6:15													06:00 90R0000A
6:30													
6:45													
7:00													
7:15													
7:30													
7:45													
8:00													
8:15													
8:30													
8:45													
9:00													
9:15													
9:30													
9:45													
10:00									9:50 33R4007	9:50 33R4007			
10:15									Mon - Fri	Mon - Fri			
10:30													
10:45													
11:00													
11:15									11:10 33R4008	11:10 33R4008			
11:30									Mon - Fri	Mon - Fri			
11:45									11:50 33R4009	11:50 33R4009			
12:00									Mon - Fri	Mon - Fri			
12:15													
12:30													
12:45													
13:00													
13:15								13:00 40RVVSU1					
13:30								Sun					
13:45													
14:00													
14:15													
14:30													
14:45													
15:00													
15:15				Sun									
15:30				15:30 40R00SU1									
15:45													
16:00													
16:15										16:00 20R40SU	Mon - Fri		
16:30							16:20 60R40SU			Sun	16:30 40R0016		
16:45							Sun						
17:00													
17:15			17:00 0090SU1	17:15 78R4015	17:15 78R4015	17:00 53R40SU							
17:30			Sun	Ykköset	Ykköset	Sun							
17:45			Sun	Wed	Wed	Sun	Sun		Mon - Fri	Mon - Fri			
18:00			18:00 00R90SU1			18:00 40R60SU	18:00 40R60SU		18:15 40R3318	18:00 40R3318			
18:15										Sun			
18:30										18:30 40R20SU			
18:45													

Appendix 11. Door allocation postal side, day operations.

	Postal side of terminal													Freight side of terminal				
	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55	54	53	52
Morning 4:40 - 5:30	OLVI		40100 Jyväskylä 40101 Jyväskylä 40200 Jyväskylä	40520 Jyväskylä 40500 Jyväskylä 40530 Jyväskylä 40900 Säynätsalo 40950 Muurame	40800 Vaajakoski 40420 Jyskä 41160 Toivakka 41770 Leivonmäki	44100 Äänekoski	40270 Palokka/Kirri 40250 Palokka/Kirri 41160 Tikkakoski 41230 Uurainen	42100 Jämsä 42300 Jämsänkoski 41800 Korpilahti	42100 Jämsä 42300 Jämsänkoski 41800 Korpilahti	43100 Saarijärvi 43300 Kannonkoski 43440 Pylkönmäki 43800 Kivijärvi 43900 Kinnula	43500 Karstula 43700 Kyyjärvi	41520 Hankasalmi 41400 Lievestuore	40700 Jyväskylä 40740 Jyväskylä 40600 Jyväskylä 40630 Jyväskylä 40640 Jyväskylä 41900 Petäjävesi 41930 Kuohu/Vesanka			44200 Suolahti 44300 Konnevesi 41340 Laukaa	44500 Pihtipudas 44800 Viitasaari	42700 Keuruu 42800 Haapamäki 42600 Multia 42870 Kotala
Afternoon 10:00 - 13:00	OLVI		40100 Jyväskylä 40101 Jyväskylä 40200 Jyväskylä	40520 Jyväskylä 40530 Jyväskylä 40500 Jyväskylä 40640 Jyväskylä 40950 Muurame 40900 Säynätsalo	40800 Vaajakoski 40420 Jyskä	44100 Äänekoski	40270 Palokka/Kirri 40250 Palokka/Kirri 41160 Tikkakoski 41230 Uurainen **Jakeluposti**	42100 Jämsä 42300 Jämsänkoski		43100 Saarijärvi 43300 Kannonkoski 43440 Pylkönmäki 43800 Kivijärvi 43900 Kinnula 43500 Karstula 43700 Kyyjärvi	41160 Tikkakoski 41230 Uurainen **16.pak**	41520 Hankasalmi 41400 Lievestuore	41800 Korpilahti 13:30 41930 Kuohu/vesanka 40700 Jyväskylä 40740 Jyväskylä 40600 Jyväskylä 40630 Jyväskylä 40620 Jyväskylä **9:30 & 12:30 16.pak** 40100 Jyväskylä 40520 Jyväskylä **9:30 16.pak**	40700 Jyväskylä 40740 Jyväskylä 40600 Jyväskylä 40630 Jyväskylä 40640 Jyväskylä 40620 Jyväskylä **Jakeluposti** 41160 Toivakka 41770 Leivonmäki		44200 Suolahti 44300 Konnevesi 41340 Laukaa	44500 Pihtipudas 44800 Viitasaari	42700 Keuruu 42800 Haapamäki 42600 Multia 42870 Kotala 41900 Petäjävesi