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Relocation of Trondheim's port

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Submission date: June 2014
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June 24, 2014

Dedicado a
mi familia

Preface

This master thesis is the product of work carried out during the spring semester 2014 from January to June and represents the last element of my Civil Engineering degree; concluding my Civil and Transport Engineering studies period at the Norwegian University of Science and Technology (NTNU). The thesis was performed at the Department of civil and Transport Engineering.

In the first place, I would like to thank my supervisor, associate professor Edward McCormack for his support, excellent guidance and valuable comments as I developed and finished my ideas throughout the work period in my thesis resarch; Additionally I would like to thanks proffesor Trude Tørset for the time spent teaching me how to use the software, and to Christian Steinsland, of "tansportøkonomisk institutt", for providing me the data needed.

Finally, this thesis could not be carried out without the special support of my family, specially my parents, Francisco Javier Cienfuegos and Marina Delgado, who have been absolutely essential, not only to finish this thesis, but also to get up here, without their continued support I would never have done it. Additionally, thanks to a very important person, Laura Chico, always encouraging me in my worst moments and rejoicing in my bests. Her good advices have been decisive in the development of this thesis, without them, this tesis would not be what it is.

Summary

The city of Trondheim, located in the middle part of Norway, is the third most populated city in Norway. From mid-century, the population has experienced significant increase, and the city is expanding to the rural areas outside, due to the lack of room in the historical center.

The economy in Trondheim, since the very begining, has been very influenced by the trade. The excellent location of the city, has been decisive in this aspect, guaranteeing to the port a safe place to perform its activities. Due to the good conditions offered by the port, the trade became more and more important for the city, and so, the port need to expand inland. At the same time that the port needed to expand, the city also saw its population increasing, so it began to spread. After some time, the result was that the city had grown in such way that it was surrounding the port area, and when it saw that could not expand inland, it had to do that outland, towards the sea, what is more costly and difficult.

Nowadays the area occupied by the port consist in a mix of industrial , commercial, tertiary activities, services and logistics. The logistical hub of Brattøra represents 46% of all goods going in and out of Trondheim, what means a huge amount of cargo trucks traveling through the city.

The main purpose of this thesis is to study the impact of the idea of moving the port to another localization in order to allow the companies to expand in a easier way, and so, the city will colonize the area that are being free.

As will be explained, this will have several kind of impacts. The most evident will be the development of the area, which,will change the role from an industrial area, to a comercial and residential. But also some others effects, less immediate, but important if we want to know how the city works. For example the heavy vehicles driving through the city will be drastically diminished, since the moment that the logistical hub of Brattøra, the port facilities and industries are relocated.

On the other hand, this activity relocation will generate the migration of all jobs related to other areas, maybe other cities or maybe inside the same one. That will be beneficial for the cities hosting all this news companies and the activities related with them, but it does entail job losses in Trondheim.

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Chapter 1

Introduction

1.1 Current status

Trondheim is a city in Sør-Trødelag county, Norway. Is the third most populous in Norway due to its 170000 inhabitants. With a population of 182000 it is also the third largest norwegian municipallity. The excellent location of the city, inside the Trondheim fjord, has enabled the development of a important commercial activity.

Figure 1.1: Location of Trondheim fjord (Source: Google maps)

Most of this activity is located in the port area, at the north part of the city. Almost the entire coastline is occupied by buildings related with the port activity, and the idea that is being developed is to relocate all of this and change the use of the area into residential and recreational, as is possible to see in the figure 1.2. 500.000 m^2 will be released for this use. Such amount can not be approached by the city in a single step and at least 2 or 3 steps will be required.

(a) Current port (b) Developed area

Figure 1.2: Current and future situation (Source: Trondheim Havn [18])

Nowadays, Trondheim acts like the logistical hub of Mid-Norway. Shipments arrive continually from all the cardinal points, mainly by truck. It is a fact that the growth of a city generates an increase in the goods demand, usually imported, so the increased traffic is inevitable. That leads to several problems in the city, like traffic jams, faster deterioration of the access roads and contamination.

The problem is compounded if the heavy traffic of trucks, loaded with those needed goods, has to drive through the city center. The streets of downtown are not ideal to withstand heavy traffic. They are narrow, there is lack of parking, pedestrians can be a problem, and the excessive noise generated by heavy vehicles disturbs the neighbors.

That's exactly what happens nowadays in Trondheim. The port area and the commercial hub of Brattøra are located at the north part of the city, and during many years the only way to reach it has been through downtown. In 2010 the opening of Skansentunnelen (see figure 1.3), reduced the traffic going through downtown, but the continuous increase of traffic has saturated the tunnel, and threatens to repeat the previous situation. Nevertheless, insufficient capacity of the tunnel was predicted during construction as shown in the following article [12]

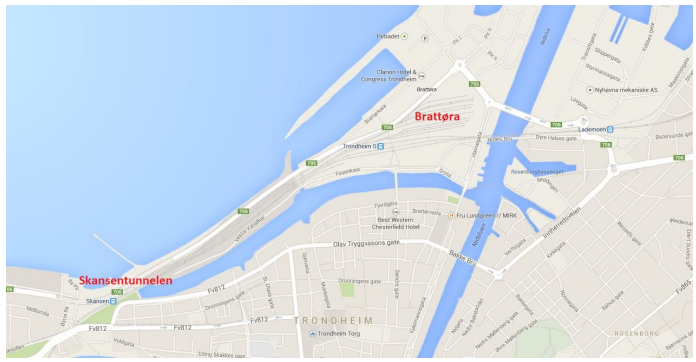


Figure 1.3: Skansentunnelen (Source: Google maps)

The importance of the tunnel was evident in 2012, when a traffic accident led to the closure of the bridge for several days, causing chaos in the city, as shown in the following article [13].

1.2 Brattøra

Brattøra is an artificial island in the city. It's located at the mouth of the river Nidelva just north of the city centre (Midtbyen), west of Nyhavna, and south of Trondheimsfjord. There is a canal that divides the mainland from what is now the island of Brattøra. In addition to some commercial offices, most of the island is used by Trondheim Central Station and Trondheim Port. The island is connected to the western parts of Trondheim by the Skansen Tunnel as seen in figure 1.3.

Since the late 1990s, there has been an urban renewal program at Brattøra, converting parts of the port to office buildings, including the swimming pool "Pirbadet" and a massive office complex housing among others Reinertsen and the Norwegian School of Management. Brattøra also houses Pirterminalen, the docks for the high-speed catamaran services to Fosen and Kristiansund as well as the corporate headquarters of Fosen Trafikklag. The Coastal Express and other cruise ships also stop at Brattøra.

But Brattøra is also the logistical hub of Trondheim and all Sør-Trødelag county. Most of the incoming or outgoing traffic, goes through Brattøra, which is located in the innermost center of Trondheim. That causes a lot of pressure on transport channels inside and outside the city, so is necessary a solution for this problem.

Brattøra could be divided in three zones, railway terminal and pier I and II, as illustrated in figure 1.4. On the other side of the river there exist another pier, called Nyhavna (New harbor), also shown in figure 1.4.

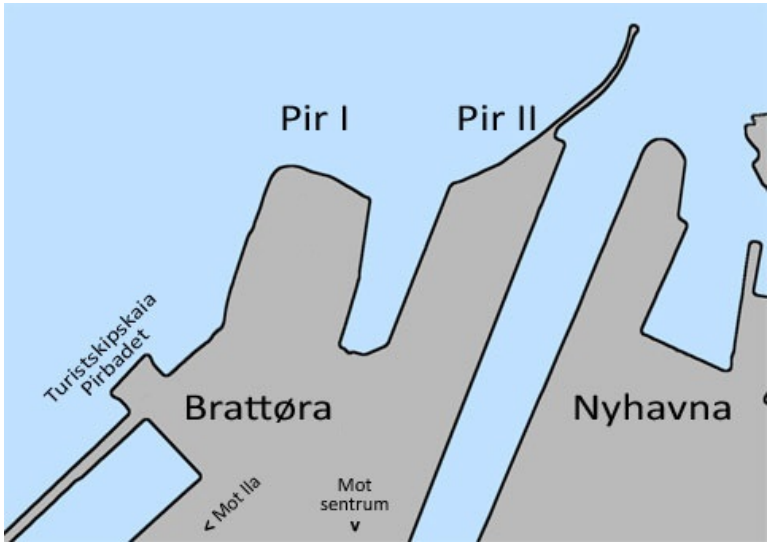


Figure 1.4: Brattøra (Source: Strinda historielag [17])

Some additional data for understanding better how Brattøra works based in studies carried out by the port authorities [2]

- Represent 46% of all the movements among the region.
- 13% of Brattøra's traffic is internal, between both piers and the railway terminal.
- 72% of Brattøra's incoming cargo is carried by trucks, meanwhile railway and boat only represent the rest 28%
- The average distance for incoming trucks to the port is 545 Km, but the leaving traffic travels only 300 km.
- In 2007, 35% of the road traffic was dedicated for local distribution (with several load and unload stops), 14% inside the city and 21% at the rest of the county.

1.3 Nyhavna

Nyhavna is the port area north east of the city centre. It's limited to the north by the river and the fjord, to the south by the railway tracks and to the east by Ladehammeren, a cliff that rises up from the fjord. The surrounding city districts are Lademoen, Nedre Elvehavn and Brattøra. The distance from the main city square to the area is approximately 1,5 km.

Figure 1.5: Nyhavna (Source: Google maps)

During the period of the city expansions from 1860s until 1930s, people in Norway moved from the periphery to the cities to get work and prevent hunger. Before this only fishermen lived along the seashore with their boats near where Strandveien (the Beach Road) is today. The area was inhabited with workers from the nearby factories. In the 1870s the fillings of the harbour areas started. In 1889 the railway was constructed, and Svartlamoen was disconnected from the city district of Lademoen. From this period onwards, the area was known as one of the poorest neighbourhoods of the city and got its nickname Svartlamoen (the dirty Lademoen).

After World War II an important part of Svartlamoen was torn down and the area regulated for port, industrial- or infrastructure purposes. By early 1980s the area was a squatter area ready for total demolition, until some younger people were interested in it and moved into the houses. They started a movement to preserve the area as a housing area and in 2001 they succeeded in their effort. The remaining houses were regulated for preservation and the area was to be developed as housing area.

Nowadays many companies are located in Nyhavna. According to the interviews made by Trondheim kommune in 2012, there exist 55 companies located there, creating 467 jobs. The activities undertaken by these companies are different, but predominates warehousing, offices and diverse production. Is interesting to highlight that most of the cargo going in and out of Nyhavna, is carried by road, but the one carried by ship is not despicable, meaning around 1750 tons each day, which leaves the carriage of goods by sea as a major mode in the transport chain in Nyhavna

One of the major restrictions that the project is encountering, is the fact that companies in the area has lease agreement with the port authorities, in some cases the agreement is for 30-40 years, so it is important to reach a negotiated solution that satisfies both parties.

1.4 Orkanger

Orkanger is a village in Sør-Trødelag county. It is located in the municipality of Orkdal, close to Trondheim's municipality, lapped by the southern arm of Trondheimsfjord as seen in figure 1.6.

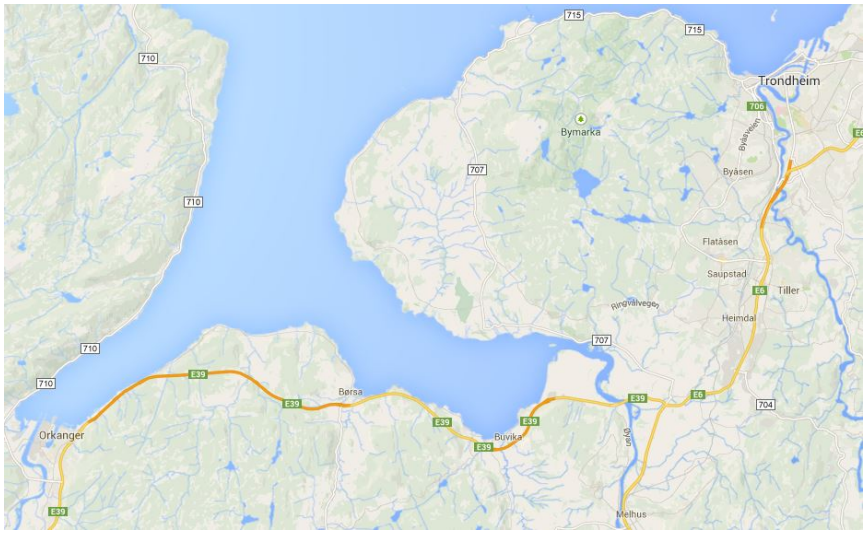


Figure 1.6: Orkanger (Source: Google maps)

It is not very populated, about 7000 inhabitants in 2009 (combined with Fannrem), but the industry plays an important role in the economy of the county, mainly in Grønøra, just west of the mouth of the river Orkla, and Tramshavn, the old harbor, now converted into a major silicon processing factory. Industrial companies on Grønøra constitutes one of the major industrial hubs in Mid-Norway.

Untill 1974 war there was a railway connection between the industry in Thamshavn (Orkanger) and the mines at Løkken, approximately 25 km down south. There also

operated a passenger line, but it lasted til 1963. In 1983 some parts of the railway were reopened as a heritage wailway. Nowadays, the city is only accesible by road (E39) or by boat.

The proximity to the most important population center in the region, Trondheim (43 km by road E39, and about 40 km by boat), and the presence of a consolidated port and industrial infrastructure, suggests that Orkanger will be a good option to move all the port facilities in Trondheim.

1.5 Transport network

Trondheim represents an important node in the comunications between the north and the southern Norway. The european road E6 cross the country from Nordlandland till Oslo, with Trondheim located halfway between them, so is an unavoidable transit city in the interconnection. Trondheim is connected with the West by the E39 road, and with Sweeden, in the East by E14, the only important road connection with the neighbouring country in many kilometres around.

By train there are two main routes. Dovre line connects Oslo with Trondheim, crossing the city by the South and connecting it with adjacent villages like Leinstrand and Melhus. Nordland Line has the starting point in Trondheim and cross the county along the coast, connecting some the municipalities like Muruvik and Stjørdal. The railway constitutes an essential way of transport, specially for Trondheim, but also for goods carried to the north.

Trondheim Havn manages ports in the region of Sør Trondelag. The port of Trondheim is the most important today, but Orkanger, located further south, has also an important traffic, specially containers. Stjørdal and Muruvik, northwest of Trondheim, are also managed by the same company, but lack the importance of the others.

Chapter 2

Similar cases

This chapter shows some examples in the nordic countries where similar developments have been carried out. All of this examples have been selected because are similars to Trondheim's future development. Should be highlated that this kind of urban development are difficult to be carried out, but when they are finish the results are outstanding for the city, due to the high quality of neirborhood created and the jobs created in the zone, much more than the jobs destroyed during the process.

2.1 Urban waterfront, Stavanger

Stavanger is the third larger urban zone and metropolitan area in Norway. The city is today considered the center of the oil industry in Norway and is one of Europe's energy capitals. Today's dependence of the coastal area is low, being used only the harbour outside the town for passenger traffic, and some piers for cargo.

Figure 2.1: Stavanger (Source: Norske arkitekters landsforbund [1])

The zone which is being developed is a former industrial area in the east of the city, which stagnated in the 80s by closures. Since then it has been considered the city's backyard. In 1998 the chamber of commerce, businesses and the comunity started the efforts to transformat the area. The area was divided into three sub-areas as show in figure 2.1, two of them regulated by the plan (75% of the area), but the third one, Badedammen, was not.

The potential utilization in the area is around 160% (much higher in Badedamen than in the other two sub-areas), with approximatelly 200000 m^2 destined to housing, 150000 m^2 of office, 25000 m^2 for services and 10000 m^2 for sport facilities. The desired distribution was to get about 50 % residential and 50 % business occupation.

2.2 Jåttåvågen, Stavanger

In Stavanger is possible to find other case of rehabilitation of an industrial area. Jåttåvågen, down south of Stavanger. It's also a former industrial area, mainlly dedicated to construct concrete substructures for oil platforms, but the industrial operation were stepped down in the late nineties. There is a semicircular park separating the area of the railway line sourronding it.

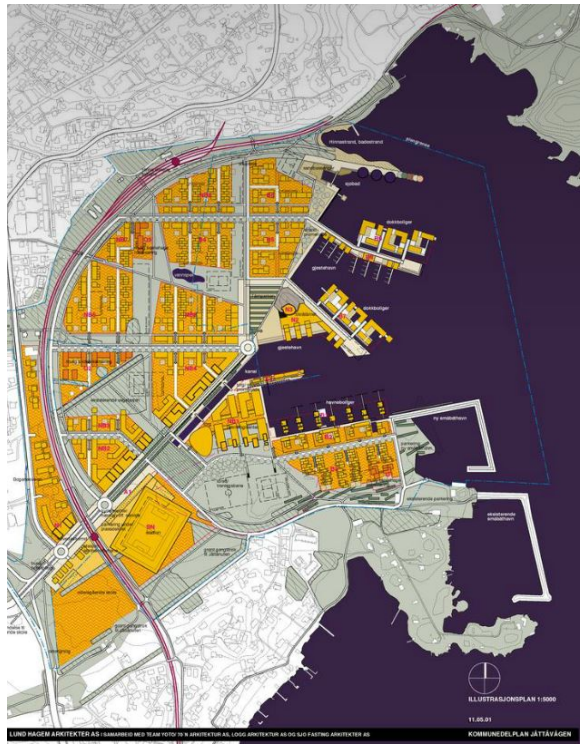


Figure 2.2: Jatavagen (Source: Lund Hagem Arkitekter AS [3])

Today the site is transformed into a local centre consisting of residential and commercial purposes. The total area is about 410000 m^2 divided in two zones, the southern one is almost developed right now, about 223000 m^2. The utilization varies from 200 % in the comercial areas till 100% in the residential area, with an overall height between 2 and 5 floors. The central area, "Scenerommet", is located on an axis with important landmarks and views in the landscape. This constitutes the main point in the plan, and has the maximum exploitation rate, mainly with commercial purposes, while the border area are meant for residence only with a lower exploitation rate. The green areas connect the neighborhood with the fjord and the green chain along it [11]

2.3 Bjorvika, Oslo

Oslo is the capital and the most populous city in Norway. It's the economic and governmental centre of Norway. The city is also a hub of Norwegian trade, banking, industry and shipping. It is an important centre for maritime industries and maritime trade in Europe. The city is home to many companies within the maritime sector, some of which are among the world's largest shipping companies, shipbrokers and maritime insurance brokers. The metropolitan area of Oslo has a population of 1,5 millon. The population currently increases at record rates, making it the fastest growing major city in Europe, 25% in the city proper.

Since the founding of the city, Bjørvika has been the main port of Oslo and, when the city grew and absorbed Bjørvika this became the logistical hub of the city, using all means of transport. But since the 2000s, Bjørvika and its surroundings has been undergoing urban redevelopment, being transformed from a container port. The neighborhood will be Oslo's cultural center, the National Opera is currently at Bjørvika,and so other cultural and recreational buildings are under construction.

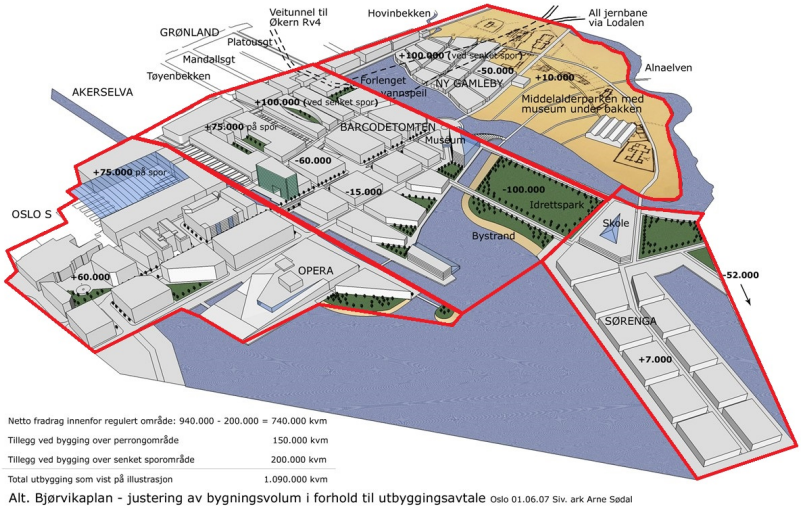


Figure 2.3: Bjorvika (Source: Allgronn [14])

The area is planned with four different sub-areas, partly as an extension of the current center of culture and employment, and partly with homes and offices. The plan can be seen in the figure 2.3. Each sub-area will have a different purpose, but in total, there will be around 7000 and 8000 people living in the developed area, and around 15-20 thousand people will have their workplace, meaning around 100000 new public transport places per day. To meet this high demand, a number of new roads are under construction and Operatunnelenl opened in May 2010.

The project has been criticized for being planned for a very high utilization, with too high buildings, and with a strong focus on profitability.

2.4 Fiskehamnen, Helsinki

With 1,3 million inhabitants, Helsinki is the capital and largest city of Finland. Situated along the Baltic Sea, the Helsinki waterfront stretches about 100 kilometers and hosts 300 islands off the mainland. Fiskehamnen, is developed on former industrial ground, property of the city, at the east of the city. The development started in 2009, after the port activities moved out. The area is planned to be completed around 2035, after several construction stages.

Figure 2.4: Helsinki (Source: Google maps

With around 1,2 km^2 the whole project can not be covered in a single step. The first one will be a subway and housing approximately 4500 inhabitants. Once fully developed the area will have 720000 m^2 housing, 535000 m^2 of office and 45000 m^2 services, what means around 18000 inhabitants and 10000 jobs

Chapter 3

Nyhavna

3.1 Nyhavna's plan

The first step in the remodeling of Trondheim's coastline, will be the conditioning of the industrial port Nyhavna. It will consist on several stages along an indeterminated number of years. The major problem that the project is encountering, is that companies in the area has lease agreements with the port authorities. According to the undertaken studies in Nyhavna [10], those agreement may reach 40 years, so a good compensation from the administration is necessary to incentivize these companies to move.

When the city began looking for a place to modernize and improve, the most immediate was Nyhavna because it's an industrial and depressed neighborhood really close to the center, what offers a high reorganization potential. If the plan succeds, Nyhavna will be a moderne commercial and residential area in an enviable location. Also, the good conection to the road network and the presence of the railway, bordering the south of Nyhavna, ensures excellent communication with the rest of the city by public transport.

The following figure, 3.1 shows the land uses in Trondheim. The area of Nyhavna is marked as industrial (blue color), while the rest of the city is represented in orange (high density buildings) or yellow (lower density). Parks and green areas are marked in green and red. The transportation network is marked in black (roads) and with dashed red lines the railway line, and can be appreciated the good road connection of Nyhavna.

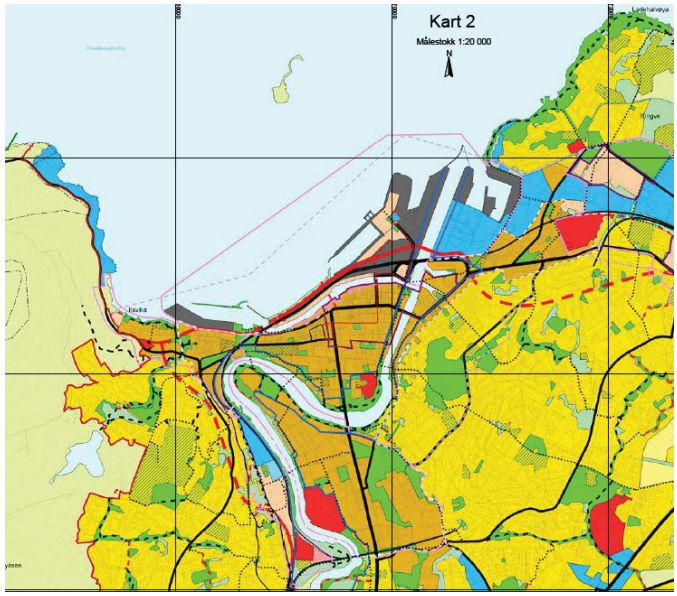


Figure 3.1: Land use (Source: Vindheimbloggen [19])

In order to improve the quality of the area, the development plan takes into account certain objectives set by Trondheim's kommune:

- Controlled localization of businesses and residences, so the kommune will determine the occupation percentage of residential and commerce, ensuring that the area does not become overly dense because of the residential development, but enough to guarantee that it's profitable and enduring in time. According to some estimation [7], Nyhavna would have capacity for 10000 new inhabitants, with approximately the same number of jobs there.

- Provision of sufficient leisure spaces, green areas, cultural activities...

- Possibility to enjoy the history of the city with relics of World War II and artistic and cultural enterprises.

- Pilot project in urban and environmental development that allows to extend this development to adjacent neighborhoods

The last point is important because other projects are underway in nearby areas. Lade All 3, "Lade teknopark", northeast of Nyhavna is a good example of other urban planning with almost 30000 m^2 . Other interesting plan is being carried out in Lilleby, where is possible to redevelop a huge industrial area, not boundaring with Nyhavna, but close enough to have impact an impact on each other. Both areas are marked on figure 3.2 (Lade teknopark in blue and Lilleby in purple), also in figure 3.1 can be seen marked in blue (industrial areas).

Figure 3.2: Lilleby and Lade (Source: Google maps)

Other small projects in Nyhavna have been already planned, anticipating the implementation of the general plan. For example, a new firehouse has been projected in Transittgata 4, at the southernmost end of the area. Also, some office buildings are already planned, like Skippergata 14 (what will offer more than 200 jobs for maritime industries) or Dora I (6100 m^2 in 6 floors fully dedicated to bureaus).

Finally, other interesting buildings are still in mind, like the new Ocean Space Center, a new flexible ocean space laboratory with complete ocean environmental modelling and deepwater facilities. But even taking into account the high expectation generated this building in the population, it is not likely to be constructed due to its high price.

The final plan is not yet decided, but could be something similar to the one appreciated in the following figure

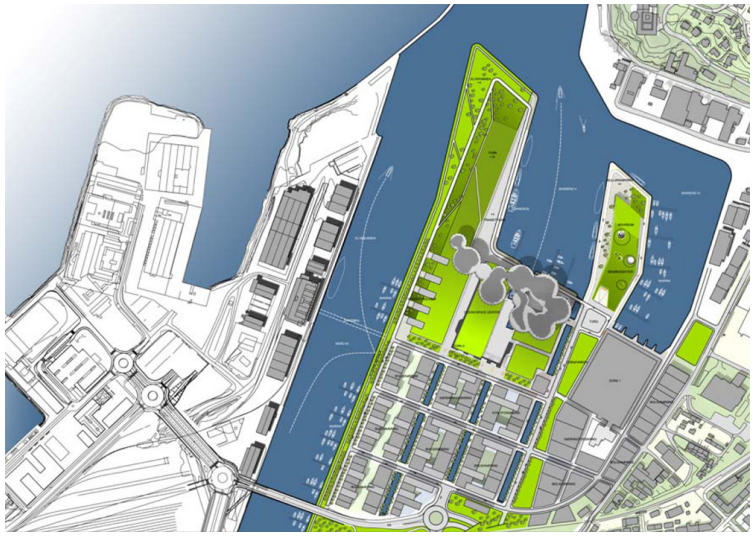


Figure 3.3: Master plan for Nyhavna (Source: Skyscrapercity.com [16])

3.2 Studies in Nyhavna

Field studies carried out [5], show that many of the firms would like to expand, but in Nyhavna there is no physical room to grow, so these companies would have to change their location in order to expand their activities. In fact, very few of them (2/56 who responded to this question) consider that the space they are occupying is excessive, but many others(12/56) consider that today they do not have adequate room to carry out their activities.

In order to a better understanding of the Nyhavna's mechanism it's important to know the kind of activities carried by the companies there:

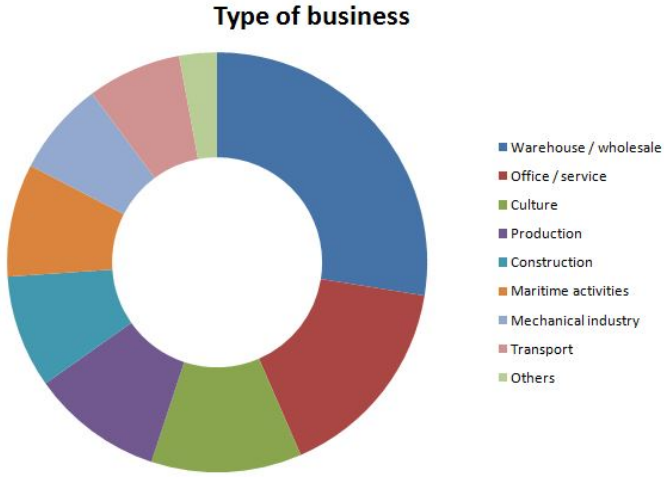


Figure 3.4: Type of business (Source: Trondheim Havn [5])

For these companies the main benefits that Nyhavna offers are:

- Proximity to the quay. Even if most of the companies import or export the goods by road, is not negligible the cargo arriving by boat, about 1750 tons per day. In Nyhavna are unloaded only industrial materials for cement and supplies companies. The remaining assets are downloaded on Høvringen or Brattøra (oil and gas).
- Proximity to potential market, due to the prime location so close to the most populated and commercial area of the city
- Reduced travel time for workers and for goods imported or exported by the same reason than the previous case.
- Lease agreements with the landowner (the port authority) very beneficial for the companies.
- Good conectiong with the main road, because Nyhavna is bounded to the south by the national road 706.

Asked about what are they looking for on the possible new location their responses were pretty similar:

- The main requirement for the new location is that the lease agreement would be beneficial for the company. That was one of the most important features of Nyhavna, but now it's clearly the most sought-after by the companies.
- Proximity to main road.
- Proximity to the market
- Proximity to the quay
- Reduced travel time for workers and goods.

Account taken of all the above, companies have developed a detailed plan for the future that is detailed in Appendix A. With that is possible to study deeper the future after Nyhavna's conversion.

There are 55 companies based nowadays in Nyhavna, with 467 workers in total. Only 7 of them have 20 or more employees, but these 7 represents almost the 50% of the working force in Nyhavna. The rest of the companies are smaller, the companies with less than 5 workers represent more than 50% of the total.

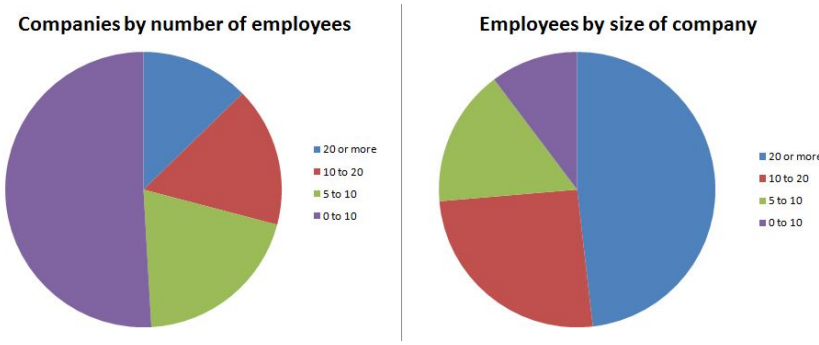


Figure 3.5: Companies in Nyhavna Source: Trondheim Havn [5])

In the future plans of Nyhavna's companies, just 30 of the 55 are thinking on staying in the city, but some of them are also considering to move out. 20 of the companies consider that the city does not offer any interesting place for them and will relocate into close villages, like Orkanger or Muruvik. Unfortunately 5 of the companies can not see a future outside Nyhavna, and they will close if they are forced to move out of Nyhavna.

In terms of employment, there will stay 244 workers inside the city, 181 will be relocated outside and 42 jobs will be lost.

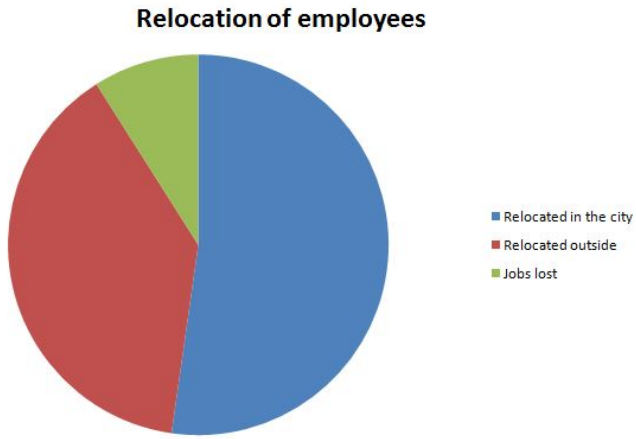


Figure 3.6: Relocation of employees Source: Trondheim Havn [5])

Chapter 4

Brattøra

The artificial island of Brattøra is today the logistical hub in Trondheim. If the internal traffic is not taken into account, Brattøra handles 46% of all goods going in and out of Trondheim, what means that all this traffic has to cross the city on each trip due to the location of Brattøra.

The figure below shows the goods traffic by road, rail and sea. Also the transit freight cargo through the city an average day in 2007 [2]. It's also indicated the direction of these flows, the tonnage and the number of vehicles needed.

	Truck/day		**Train/day**		**Ship/day**	
	tons	trucks	tons	Trains	tons	Ships
Incoming	13210	1150	1835	5	4100	5
South	8900	780	1525	4	-	-
North	3525	296	310	1	-	-
East	495	44	0	0	-	-
West	290	30	-	-	-	-
Outgoing	10615	810	1425	5	1100	2
South	3900	340	995	4	?	?
North	5900	387	430	1	?	?
East	175	23	-	-	-	-
West	640	60	-	-	-	-
North transit	5420	440	888	3	?	?
South transit	540	40	645	3	?	?
West transit	70	20	-	-	-	-

Table 4.1: Trondheim freight model (Source: Idea Consulting [2])

Most of the incoming cargo till Trondheim comes from the south, through the european road E6, representing 780 trucks per day in the city. It's interesting to note that an important part of the incoming traffic from the south continues to the north later, but it's not a transit traffic. This cargo is stored in Trondheim, and part of that is loaded again and sent to the north in other truck, what makes of Trondheim an important hub in the flow north-south.

The transit traffic to the north is not negligible, representing 30% of the north-south traffic through the city. Fortunatelly this traffic does not flow through the center, but continues on the E6 without affecting the traffic in the city center. However, the north-south traffic is negligible, representing barely a 10% compared with the south-north. Demonstrating the economic dominance of Southern Norway respect to the north.

Should also be highlighted that although the passing traffic north-south is not very representative, the incoming traffic from the north region to the city is almost 300 trucks per day. So it seems that the exported goods to the south are mainly producted in Trondheim city, while the north of Trondheim only supplies the city.

Foccusing on Brattøra the daily cargo an average day is the following:

	Truck/day		**Train/day**		**Ship/day**	
	tons	trucks	tons	TEU	tons	TEU
To Brattøra	9020	744	1835	5	760	20
From trondheim	4000	330	-	-	-	
South	3170	260	1525	4	?	?
North	730	60	310	1	?	?
East	1100	90	-	-	-	-
West	20	4	-	-	-	-
From Brattøra	9788	805	1425	5	140	4
To Trondheim	4270	350	-	-		
South	3300	270	995	4	?	?
North	1640	135	430	1	?	?
East	550	45	-	-	-	-
West	28	5	-	-	-	-
Internal	1470	200	-	-	-	-
South transit	-	-	888	3	?	?
North transit	-	-	645	3	?	?

Table 4.2: Brattøra daily cargo (Source: Idea Consulting [2])

Analyzing these data some interesting results can be obtained:

Much of the cargo exported from Trondheim leaves from Brattøra. Of 805 trucks departing each day from the logistical center, 350 were terminating the route within Trondheim, so 455 trucks were leaving the city from Brattøra, what means 56 % of all the exported goods (by road).

The importance of the logistical hub decrease when the incoming cargo is studied, just 414 trucks (not counting the 330 comming from the rest of the city) are atracted, this represent barely 36% of all the imported goods by road.

The difference between imported and exported goods is due to the fact of being considering just the road cargo. Actually, if the railway cargo is studied, the results show that Trondheim import more tonnage than what the city exports, as expected. By ship the difference is even bigger. When all the modes of transport are taken into consideration the percentages barely change, imports raise to 39%, but imports fall to 54%.

Also, should be highlighted that Brattøra handles with all the railway cargo, but very few of the maritime. The rest of the ships go mainly to Nyhavna, Ila and west of the city.

Finally, attending to the goods origin or destination:

	Imports		**Exports**	
	ton/day	**trucks/day**	**ton/day**	**trucks/day**
South	67,37%	67,83%	36,74%	41,98%
North	26,68%	25,74%	55,58%	47,78%
East	3,75%	3,83%	1,65%	2,84%
West	2,20%	2,61%	6,03%	7,41%

Table 4.3: Trondheim origin and destination (Source: Idea Consulting [2])

	Imports		**Exports**	
	ton/day	**trucks/day**	**ton/day**	**trucks/day**
South	63,15%	62,80%	59,80%	59,34%
North	14,54%	14,49%	29,72%	29,67%
East	21,91%	21,74%	9,97%	9,89%
West	0,40%	0,97%	0,51%	1,10%

Table 4.4: Brattøra origin and destination (Source: Idea Consulting [2])

Clearly, most of the cargo is coming from cities in southern Norway, for both, Trondheim and Brattøra, but when the destination of the exported goods is studied, is not so determinant the southern direction, even more, from Trondheim the main destination of goods is the northern Norway.

North is really important for the average of Trondheim, but no so significant for Brattøra, where the East direction plays a decisive rol.

In both cases the incoming or outgoing west cargo is despicable, something logic because there are not important towns there, just some small industrial companies.

Chapter 5

Traffic analysis

The traffic in the area of Trondheim has been studied using the software "CUBE" and uploading the commodities flow matrices for Norway [6][9].

The software divides the transportation network in a set of nodes and links, and allows to study the cargo flowing from each link between nodes and the cargo from one node to other. With this, is possible to know where are the goods coming and where are they going, so a deep study of the model gives to the competent authorities the opportunity to act on the conflicting points.

Nodes studied in this document are the following:

Number	**Name**
728	Orkanger
350	Orkanger
355	Skaun
367	Trondheim west
364	Trondheim north
730	Trondheim north
560	Trondheim north
363	Trondheim north
360	Trondheim east
362	Trondheim east
361	Trondheim south
365	Trondheim south
1006	Trondheim south
366	Trondheim south
356	Trondheim south
354	Melhus
357	Malvik
770	Stjordal
371	Vaernes

Table 5.1: Nodes (Source: CUBE)

A map with the location of each studied node is provided in the figure 5.1. Each link represent a freight flow, which may coincide with a road if the link is terrestial, or not if it is maritime. As the map itself could be very confusing (the evaluation version of the software doesn't allow to add a GIS background image), the screenshot has been modified, indicating the towns.

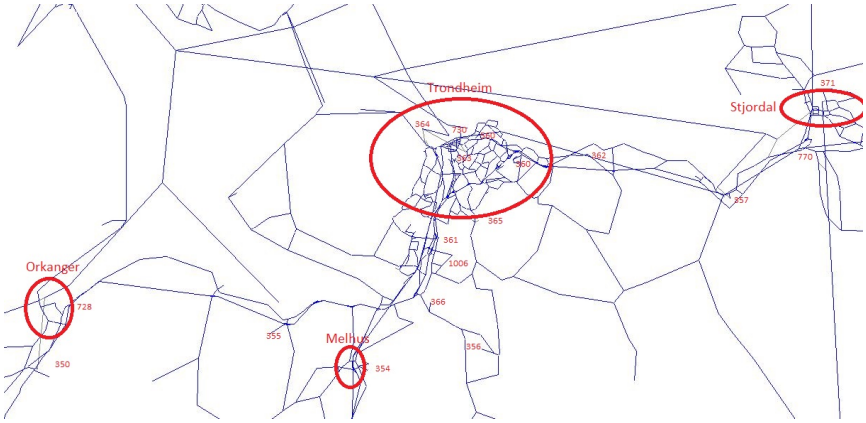


Figure 5.1: Nodes (Source: CUBE)

These nodes provide an excellent coverage of the transportation network in Trondheim and the nearby villages like Orkanger or Stjørdal.Other nodes have also been studied, but they lack of enough value to be representative and be included in this report.

The next step is to look in the flow matrices to obtain the amount of travels for imported and exported goods. The matrix differentiates each type of vehicle, dividing the traffic in 15 types of them, 2 of them not representatives for the present study (plane and ferry), and 11 for road transportation. A more detailed study is available in annex B.The following table shows the trips per year for imported goods:

Number	Name	Lorry total	Ship	Train
728	Orkanger	35854	277	0
350	Orkanger	61757	4	0
355	Skaun	5713		0
367	T.west	50	0	0
364	T.north	8653	0	0
730	T.north	12262	1021	0
560	T.north	32448	0	35000
363	T.north	16510	0	0
360	Brattøra	116475	60	34
362	T. east	61728	0	0
361	T. south	460	0	0
365	T. south	8053	0	0
1006	T. south	937	0	0
366	T. south	111244	0	0
356	T. south	705	0	0
354	Melhus	41698	0	0
357	Malvik	14335	0	0
770	Stjordal	2690	69	0
371	Vaernes	35268	0	0

Table 5.2: Incoming vehicles per year(Source: CUBE)

These data have been adjusted to show just the imported goods from outside the city, ie, the traffic between nodes in the city has been deleted to focus just in the cargo comming from outside. If the data without change are desired, are available in annex B.

There is also possible to see where are the goods being imported, for example, the railway distribution is the following:

City	Number per year
Oslo	22797
Drammen	3857
Ganddal	2231
Kristiansand	2065
Malmo	1210
Paris	606
Other	2234
Total	32766

Table 5.3: Freight wagons per year (Source: CUBE)

Brattøra is represented in the model by three differents nodes, each one representing a different mode of transportation. Node 730 represents the maritim traffic, 560 the railway, and 360 is destined to the road traffic. All together represent 44% of all the incoming road traffic to Trondheim, what doesn't fit very well with the

results taken by the port authorities in 2007, when this percentage was 38%. The difference could be due to several reasons: There could have been mistakes during the counting, inherent errors to use an statistical method, or may be just because the importance of Brattøra as logistical hub has increased at the expenses of other areas around the city.

	With internal traffic	**Without internal traffic**
Total in Trondheim	812440	370184
Total per day	2833	1291
Brattøra	355026	161185
Brattøra per day	1238	562
	43,70%	43,54%

Table 5.4: Incoming vehicles in Trondheim and Brattøra (Source: CUBE).

The same study has been done for the exported goods. In table 5.5 can be seen the number of trucks each year leaving Trondheim. Once more, the internal traffic has been deleted, but can be seen in Appendix B.

Number	**Name**	**Ship**	**Train**	**Trucks total**
728	Orkanger	292	0	34484
350	Orkanger	0	0	48969
355	Skaun	0	0	5949
367	T. west	0	0	27
364	T. north	0	0	9887
730	T. north	959	0	10377
560	T. north	0	35000	31214
363	T. north	0	0	17440
360	T. east	11	0	159034
362	T. east	0	0	2831
361	T. south	0	0	756
365	T. south	0	0	10395
1006	T. south	0	0	925
366	T. south	0	0	99037
356	T. south	0	0	560
354	Melhus	0	0	66587
357	Malvik	0	0	15225
770	Stjordal	57	0	2591
371	Vaernes	0	0	30436

Table 5.5: Outgoing vehicles (Source: CUBE)

In the light of the findings, it is clear that the city is mainly importing cargo, because the number of importing trucks is higher than the exporting ones.

In view of these results, it is possible to highlight the growth of the city in terms of products exported. In 2007 there were 810 trucks per day, but in 2013 this number has increased till 1195, ie, at a rate of 6,6% per year.

	With internal traffic	**Without internal traffic**
Total in Trondheim	750948	342456
Total per day	2619	1194
Brattøra	370073	200625
Brattøra per day	1290	700
Total	49,28%	58,58%

Table 5.6: Outgoing trucks from Brattøra and Trondheim (Source: CUBE)

	Villages nearby	**Internal traffic**	**To Trondheim**
Importations	19,6%	43,8%	36,6%
Exportations	21,4%	46,2%	32,4%

Table 5.7: Percentages (Source: Own table)

When comparing the results for the exported goods from Brattøra the upward trend is confirmed. The traffic has increased from 455 trucks per day in 2007 to 700 in 2013, that means an average increase of 7,4% each year, 0,8% more than the city average.

	Imports		**Exports**	
	Trondheim	**Brattøra**	**Trondheim**	**Brattøra**
2007	1150	414	810	455
2008	1172	436	864	489
2009	1195	458	922	525
2010	1218	482	983	564
2011	1242	508	1049	606
2012	1266	534	1119	652
2013	1291	562	1194	700
Average change	1,90%	5,20%	6,60%	7,40%

Table 5.8: Annual growth (Source: Own table)

There is another way to study the traffic in Trondheim, wich consist in study the aproximation roads (E6 and 715) to Trondheim and see the number of heavy vehicles going through each one. This study will also reveal the transit traffic through Trondheim. The roads that has been studied to do that, are marked in red in figure 5.2. The rest of the links marked have no information, so is necesary just to study those four.

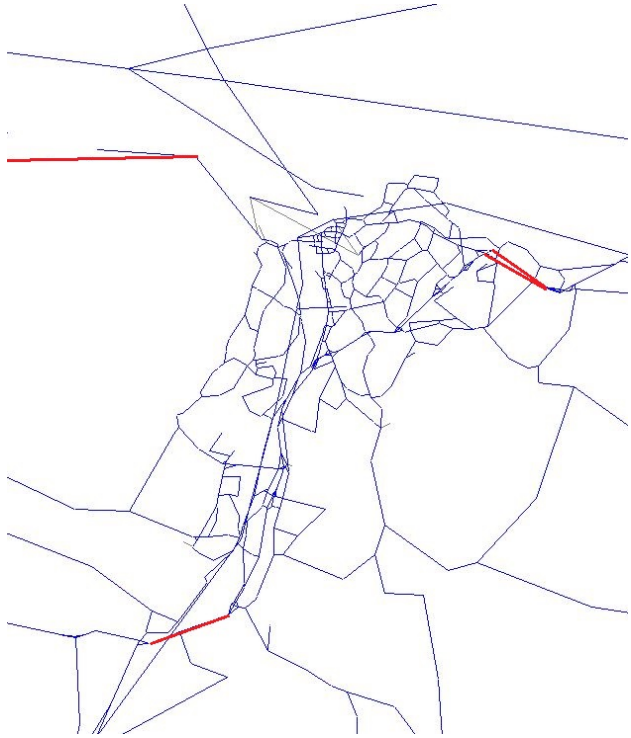


Figure 5.2: Roads entrance to Trondheim (Source: CUBE)

The number of vehicles from each road is represented in table 5.9. There are two links in the East side, they have been unified into just one because one of them had very few traffic.

	South		**Link 1 and 2 East**		**North**	
	Import	**Export**	**Import**	**Export**	**Import**	**Export**
Annual	331105	348813	209905	204781	15569	14838
Daily	1155	1216	732	714	54	52

Table 5.9: Traffic total (Source: CUBE)

Finally the following table 5.10 shows the passing traffic through Trondheim, which is the result of subtracting the incoming/ outgoing traffic in the nodes within the city to the total traffic in Trondheim, and then divide it by two, because if not it would be counted twice.

	Traffic total
With passing traffic	1125011
Without passing traffic	711981
Passing traffic	413030
Passing traffic per day	720

Table 5.10: Passing traffic (Source: Own table)

The results fits correctly with the data taken by the port authorities in 2007. In this year the passing traffic through Trondheim was 500 trucks per day, in 2013 this number has increase till 720, what means an increase of 6% each year, a value very similar to the yearly increase of traffic already studied.

The distribution of this traffic is the following:

	Passing traffic
Northbound transit	634
Southbound transit	58
Westbound transit	28

Table 5.11: Distribution of passing traffic (Source: Own table)

Chapter 6

Relocation of the logistical hub

6.1 Alternatives

Nowadays is not clear where should be moved the logistic hub located in Brattøra. There are three good locations near Trondheim that could receive it.

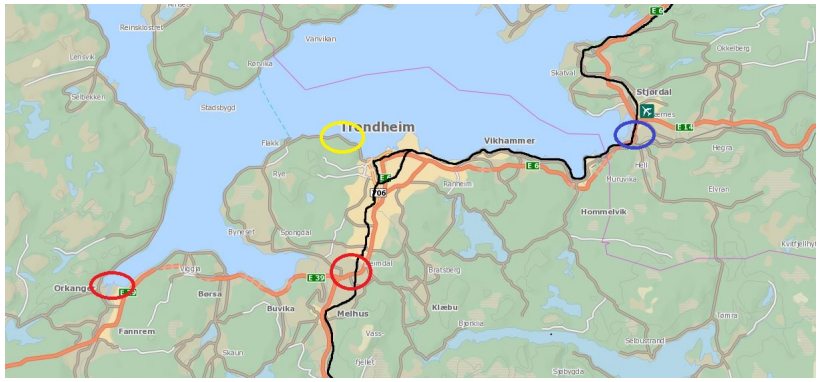


Figure 6.1: Alternate location for logistics hubs (Source: Google maps).

The first alternative, marked in red in the figure 6.1, would be a combination between Orkanger and Leinstrand. Orkanger would receive the port facilities and probably the dependant companies on the activities carried out in there. But the logistical hub would be located a few distance to the south of Trondheim, close to the former municipality of Leinstrand, taking advantage of the presence of the railway line and the road E6 as seen in the figure 6.1. This alternative has the advantage that Orkanger is an already consolidated port, so the investment needed there would not be very high. Orkanger is well known also because of the industry located there, what could helps to other companies to move here to the detriment of other nearby villages.

Other possible location would be in Hell (marked in blue in the picture 6.1), few kilometers to the east of Trondheim. There, the new logistical hub, and the area for the new ports facilities would be together, so at first it can be assumed that the number of trucks needed would decrease. This alternative would take advantage of the presence of the north railway line and the road E6 as the previous one, but also of the airport.

Trolla, east of Trondheim would be the last alternative (marked in yellow). This option could be seen as a mix of the previous ones. As Leinstrand, it exploits the proximity to Trondheim but, as opposed to this one, Trolla would have all the facilities together. The most important disadvantages of this alternatives are the low level of infrastructures in the area and the insufficient communication with the main roads, what would force to improve the road connection and create a new railway line, both developments would require the construction of a tunnel, so the price would raise.

In order to choose the optimal alternative, there will be carried out a a multi-criteria analysis. Both alternatives will receive a grade in the topics exposed ahead, and then will be ponderated in function of the importance of this topic for the project.

The multicriteria analysis will include the following issues.

- Economy: The economic aspect is the most important part of a project, that's why this topic will receive the utmost importance when assessing the project. But to evaluate the cost of the project is not the main purpose of this document, so when evaluating this topic wil be used aymond Siiri's study [15]. Some results of the report will be extrapolated to the alternatives chosen in the present.

- Traffic impact.When evaluating large projects, it is necessary to study properly the influence in the traffic that they will have in the zone. The case is even more important in the present project because one of the objectives pursued is to reduce the traffic within the city. So this study is almost as important as the economic impact, so the final valuation will be high.

- Environmental impact: Usually, other of the important issues to be studied is the environmental assessment. In this case, the importance of this study will be low, due to the location of the alternatives, close to areas already altered by the hand of man, and so, with a low environmental importance.

- Construction difficulty This study will be focused in the topography and the required materials for the works. If the topography is flat and the work does not need too much materials, it will be constructed easily and fast. But a hilly terrain will make the work more costly. With the modern materials and machines used in nowadays constructions, the difficulty is not a big deal, but still is important to study it.

- Finally, one of the major purpose of the new hub will be to serve as much people as possible. It could be an important issue, but if considered the population of Trondheim and of the other villages, there will be understood the low importance given to this assessment, because Trondheim holds around 75% of the population in the area.

Criterion	Issues considered	Percent
Economy	Construction cost	45%
Traffic impact	Trips generated across Trondheim	35%
Environmental impact	Environmental assessment	10%
Construction difficulty	Topography and construction needs	5%
Functionality	Population it serves	5%

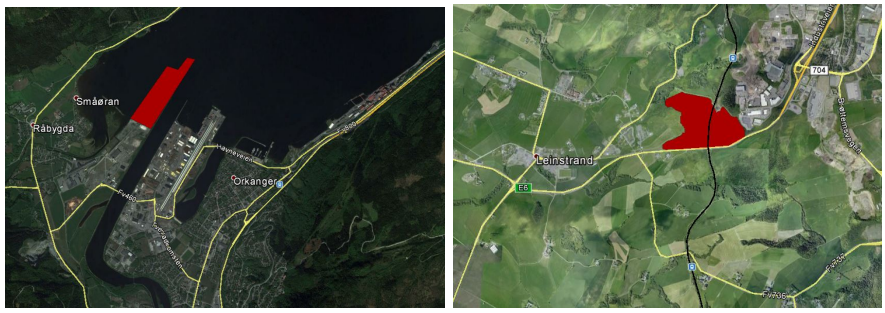
Table 6.1: Analyzed factors (Source: Own table)

6.2 Economic analysis

The economic perspective has been always an important issue, but following the financial crisis, is playing a predominant role in the decision-making. That is why the profitability is so important in the multi-criteria analysis, where it has a 45% of the final score. That means that if an alternative is not acceptable from an economic perspective it won't be taken into account.

To evaluate the cost of each alternative, this paragraph has been based on Raymond Siiri's study [15]. Some economic results of the report has been extrapolated to the alternatives chosen in the present.

6.2.1 Orkanger and Leinstrand



(a) Orkanger new area (b) Leinstrand area

Figure 6.2: Alternative 1 (Source: Google maps)

The possibility of locate the port in Orkanger was not considered in Sirii's report, so some assumptions were made in this case based in other similar cases studied. The needed of Orkanger are quite similar to Skogn's because it is also a consolidated port that needs to be expanded. That is why construction costs can be likened to those of Skogn, but not the cost related with the rail, because is not planned any new railway line between Orkanger and the storage area.

Orkanger and Leinstrand	
Description	New combined terminal in Leinstrand supported by the port of Orkdal that would be enlarged
Topography	Flat
Land use	Agricultural and residential in Leinstrand, industrial uses in Orkdal
Road connection	Connection needed to E6 (1km)
Train connection	New connection with railway (about 1km)
Port and storage	Separated
Needed material	1 million m^3 of rocks are required in Orkanger

Table 6.2: Leinstrand detailed (Source: Raymond Siiri's study [15])

	Torgard	**Orkanger**	**Total**
Combi Terminal (Reloading with crane)	325	421	746
Container and general cargo port (pier, wharf, filling, dredging, equipment, buildings)	0	491	491
Access to land (acquisition)	264	491	755
Road connections	80	0	80
Railway Connection	100	0	100
Railway Capacity Measures	552	0	552
Total	1321	1403	2724

Table 6.3: Leinstrand and Orkanger cost. Prices in million Kr. (Source: Raymond Siiri's study [15])

As seen, this alternative is not very expensive cause it is using the existing port of Orkanger, it just need to be enlarged in order to be able to handle all the new cargo received nowaday by Trondheim's port. The construction of the storage area close to Leinstrand, in a flat area, well communicated with the railway and the road networks, avoids the need to make huge expenses in the creation of the logistical hub.

6.2.2 Hell

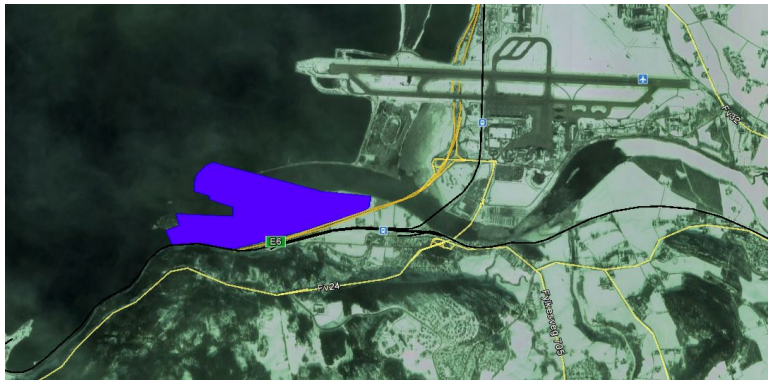


Figure 6.3: Hell new port (Source: Google maps)

Hell	
Description	New terminal for containers and general cargo in Hell
Topography	Flat
Land use	Agriculture, cultural and residential buildings
Road connection	Connection needed to E6 (1km)
Train connection	New connection with railway (about 1km)
Port and storage	Integrated
Needed material	2 million m^3 of rocks are required at sea

Table 6.4: Hell detailed (Source: Raymond Siiri's study [15])

Hell	
Combi Terminal (Reloading with crane)	325
Container and general cargo port (pier, wharf, filling dredging, equipment, buildings)	878
Access to land (acquisition)	425
Road connections	160
Railway Connection	145
Railway Capacity Measures	811
Total	2744

Table 6.5: Hell's cost. Prices in million Kr. (Source: Raymond Siiri's study [15])

This alternative has an estimated price similar than the previous one, but in this case everithing would be constructed at the same place. The needed infrastructures to join the place with the road/railway network is minimized due to the location of the site.

6.2.3 Trolla

Figure 6.4: Trolla new port (Source: Google maps)

Trolla	
Description	New terminal for containers and general cargo between Trolla and Trondheim
Topography	Flat in the terminal area, but very mountainous around
Land use	Wastewater treatment plants located in the mountains. Also some residential buildings and Bimarka natural park in the mountains. Some industry along the coast.
Road connection	New tunnel needed from Ila to Trolla (2,5 km)
Train connection	New tunnel needed from Marienborg to Trolla (2,5 km)
Port and storage	Integrated
Needed material	4.6 million m^3 of rock to be blasted out of the mountain. Around 1-2 million m^3 of rocks are required at sea.

Table 6.6: Trolla detailed (Source: Raymond Siiri's study [15])

Trolla	
Combi Terminal (Reloading with crane)	325
Container and general cargo port (pier, wharf, filling dredging, equipment, buildings)	1619
Access to land (acquisition)	3110
Road connections	300
Railway Connection	146
Railway Capacity Measures	582
Total	6082

Table 6.7: Trolla's cost. Prices in million Kr. (Source: Raymond Siiri's study [15])

This alternative is the most expensive one. That's because there's not currently an adequate infrastructure to hold the port facilities, and most of the lands that has to be expropriated are industrial, so the price would increase in comparison with the others alternatives where the land is mainly dedicated to agriculture. The construction of the port infrastructure and the connection to the road and railway network would also increase the final price of this alternative as seen in the table 6.7.

6.3 Traffic impact

The affectation to the traffic withing the city is one of the most important issues to be taken in mind when evaluating the location of a project. One of the objetives of the project is to reduce the ammount of traffic in Trondheim. Actually, the three alternatives have been designed to be constructed outside the city.

As seen in the previous chapter, the traffic has been studied with the software "CUBE", and with it is possible to know the origin and destination of all the goods for each node in the city.

As the idea is to study the relocation of the port area, the nodes there, are the ones that should be studied. The program defines 3 nodes for Brattøra, identified with the numbers 360, 560 and 730. Those nodes can be seen in the following scheme of Trondheim:

The combination of these three nodes represents Brattøra, so they have to be studied all together. The procedure that has to be followed consist in, using the destination-origin matrix, determine which nodes send or receive the cargo imported or exported by Brattøra. Once determine that, those nodes have to been located in a map, in order to know which is the direction taken by the cargo, and the know which road are they using to enter/leaving Trondheim.

Finally, based in the location of the goods, shall be determine the ammount of vehicles using each road (for trucks traffic). Trondheim has three main access (From the South E6, East E6 and 715 from the West) as the following figure shows:

Figure 6.5: Access to Trondheim (Source: Google maps)

So, the route followed by the goods could be summarized in just three: East, West and South, and then, the provenance or destination of the cargo could be studied in the following tables for Brattøra (The complete analysis is detailed in annex C):

	Exported			Imported		
730	Yearly	Daily	Percent	Yearly	Daily	Percent
South	8543	30	82,42%	9951	35	81,15%
North	1637	6	15,79%	1910	7	15,58%
East	85	0	0,82%	401	1	3,27%

Table 6.8: Trucks in node 730 (Source: CUBE)

	Exported			Imported		
360	Yearly	Daily	Percent	Yearly	Daily	Percent
South	85958	300	68,38%	80804	282	69,37%
North	7854	27	6,25%	6099	21	5,24%
East	31886	111	25,37%	29572	103	25,39%

Table 6.9: Trucks in node 360 (Source: CUBE)

	Exported			Imported		
560	Yearly	Daily	Percent	Yearly	Daily	Percent
South	3331	12	10,67%	5578	19	17,19%
North	4571	16	14,64%	6560	23	20,22%
East	23312	81	74,68%	20310	71	62,59%

Table 6.10: Trucks in node 560 (Source: CUBE)

Joining the three nodes is possible to obtain a good image of Brattøra, represented in the table 6.11.

	Exported			Imported		
	Yearly	Daily	Percent	Yearly	Daily	Percent
South	97832	341	58,49%	96333	336	59,77%
North	14062	49	8,41%	14569	51	9,04%
East	55283	193	33,05%	49967	174	31,00%

Table 6.11: Trucks in Brattøra (Source: CUBE)

When studying the south direction these results fit fine with the ones obtained by the port authorities in 2007. The rest of data can not be compared because in the present report, what is being studied is the road taken by the trucks in the nearby of Trondheim, not the provenance of them. Thus, the cargo defined as "north" in the Port Authorities report of 2007 [2], comes from the North towns, but it enters in Trondheim through the eastern road E6, so most of this is detailed here as East. In the same way, the freight defined by them as "west" is defined here as North (because uses the road 715) or South.

If the node changes it location, the transit within the city will change.

6.3.1 Orkanger and Leinstrand

For the first alternative, the one with the port in Orkanger and the storage area in Leinstrand, the working area would be the following:

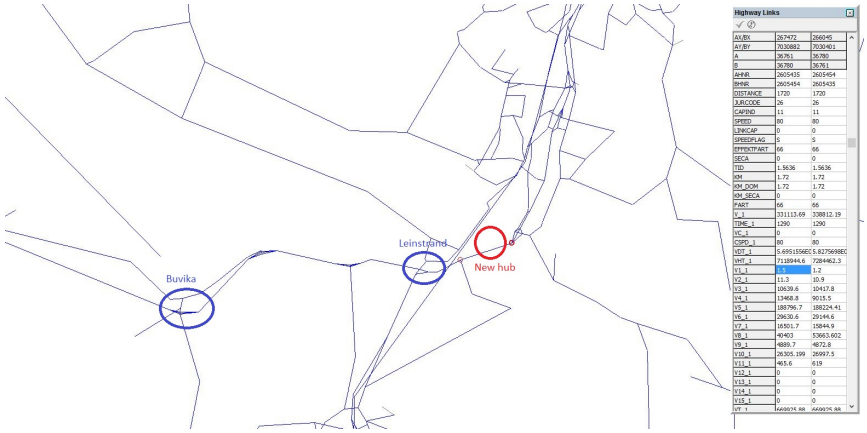


Figure 6.6: Traffic in South Trondheim (Source: CUBE)

As there is only one access road from the south to Trondheim (besides the railway), and the logistical hub would be located just there, it can be assumed that most of the incoming cargo through this road would be diverted to this node instead of going into town.

The traffic through this link is shown in table 6.12. For a more detailed study this table is expanded in table B.8

	Incoming	**Outgoing**
Annual	331105	348813
Daily	1155	1216

Table 6.12: Trucks through E6 South (Source: Own table)

This is the potential attraction capacity of the node for the incoming cargo into the city, it could handle untill 331105 trucks per year, ie, 1155 per day, twice the cargo handled today.

But there should be taken into acount the fact that the port facilities are moving into Orkanger, so all the cargo ships that nowadays are going to Brattøra, now would go to Orkanger, and that means that those goods should be redirected to the new logistical hub once unloaded. Approximatelly 2 millions of tons were moved last year by ship, if the average capacity of a truck is 12 tons, there would be needed 581 trucks per day to handle that (459 importing goods and 122 exporting), and all of those trucks would arrive till Trondheim from E6 road (South), so it should be added to the cargo handled by the logistical hub. Now the total cargo would be up to 1613 trucks per day.

Finally, Brattøra is receiving nowadays 51 trucks from road 715 and 174 from the East. The path followed by these trucks is much shorter than the followed by vehicles coming from the South. and it is not probably that this cargo would go to the southern new node, so probably would go to other places within the city, closer to the origin.

The first alternative could be summarized in table 6.13

	Traffic E6	**Transit**	**Port**	**Trains**	**Trucks total**
Incoming	1155	663	459	205	1156
Outgoing	1216	58	122	159	1439

Table 6.13: Potential traffic, alternative 1 (Source: Own table)

Previous table reflects that every day 951 trucks would arrive from outside Trondheim (without transit traffic), and 1280 would leave the logistical hub for going abroad. Also, has to be taken in mind the rail cargo. It may arrive by rail, but has to be distribuited through the city with trucks or vans, that means that the incoming and outgoing cargo by train should be translated into trucks per day. In 2013 around 2450 tons arrived till Trondheim by train, that means 205 aditional trucks each day that has to go into the city, what means a total of 1156 trucks each day going from the storage area to Trondheim. Also, 1900 tons left Trondheim by train in 2013, so around 159 trucks have to be sent to the new node with all this cargo.So adding all would be 1439 trucks from Trondheim to the storage area.

Finally, it is possible to create a table with distance and number of trucks in order to evaluate both features at the same time. The incoming/outgoing cargo of Orkanger would need 28,7 km to arrive to the storage area, and then, all goods would have to go into Trondheim, 12,4 km away (it has been taken the central square as the ending point to evaluate the length of the trip). Also, the trips from the rest of the nodes in the system has to be taken in mind to evaluate the everything. If the imported and exported goods from road 715 and E6 (East) are multiplied by a distance, it could be added to the results already obtained for doing that in the new hub of Leinstrand. To the East traffic, there has been assigned a value corresponding to the distance between the hub in the alternative 2 and the center of Trondheim. To the North traffic the value is the distance between Trolla and the center of Trondheim. Thus, the alternatives can be compared among themselves.

The results can be seen in table 6.14

	Incoming	Outgoing	Total
Port	459	122	581
Distance	28,7	28,7	29
Daily traffic	1156	1439	2596
Distance	12,4	12,4	12,4
East traffic	661	90	751
Distance	29	29	29
North traffic	103	94	197
Distance	4	4	4
Total kilometers	47098	24340	**71438**

Table 6.14: Needed distance (Source: Own table)

6.3.2 Hell

As seen in the following figure, the second alternative matches with three links in the transportation network map.

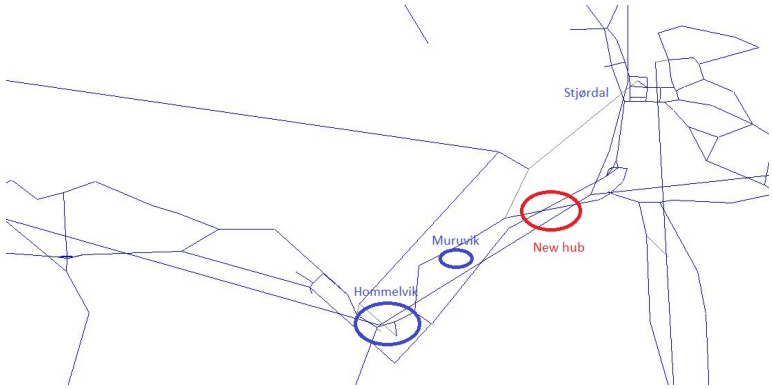


Figure 6.7: Traffic in Hell (Source: CUBE)

One of the links corresponds to the railway line, which has a very low traffic (around 150 wagons per year). The other two links are roads wich have the following traffic:

	Import	Export	Import	Export	Total import	Total export
Annual	209561	202096	344	2685	209905	204781
Daily	731	705	1	9	731	714

Table 6.15: Traffic through Hell, to and from Trondheim (Source: Own table)

The transportation by ship must be added to these results, but in this case the port and the storage area would be in the same place, so no additional traffic would

be generated in the connection of harbour and hub. Anyway, this cargo has to be sent to Trondheim, so in any case an additional traffic would be generated.

Other issue that should be considered is the rail transport. Nowadays the ending of both lines (the one going South and the one going North) is located in Brattøra, but if the terminal moves, this would affect the traffic. Now the train will have a longer way, but since most of the load comes from Oslo, a few kilometers do not matter much.

Most of trucks that nowadays are going to Brattøra from South, probably would keep going to this node because of the same reason explained for the rail cargo, if it comes from Oslo a few more kilometers do not matter much. But can not be said the same for the cargo coming through road 715, because most of it is coming from nearby villages, so the increased travel time would be not despicable.

So,the incoming and outgoing cargo could be summarized in the following table 6.16

Traffic E6	**Transit**	**Port**	**South**	**Train**	**Total**
747	58	459	336	205	1689
724	634	122	0	159	371

Table 6.16: Potential traffic alternative 2 (Source: Own table)

Finally, to evaluate this alternative, as was done with the previous one, it is necesary to measure distance and numbers of trucks. That is what table 6.17 shows:

	Incoming	**Outgoing**	**Total**
Traffic E6	1674	361	2035
Distance	29	29	29,0
South to the hub	336	0,0	336
Distance	39,0	0,0	39,0
South not to the hub	157	1158	1315
Distance	12,4	12,4	12,4
North not to the hub	103	94	197
Distance	4,0	4,0	4,0
Total	63995	25217	**89212**

Table 6.17: Needed distance, Hell (Source: Own table)

This table shows that in this alternative there are trips coming from the South crosing the city to go to the hub, and then go back again to the city, but it also shows the traffic just going into the city and not to the hub.

6.3.3 Trolla

The last alternative is the closer one to Trondheim's city center, just 5 km. The road network is presented in the following picture:

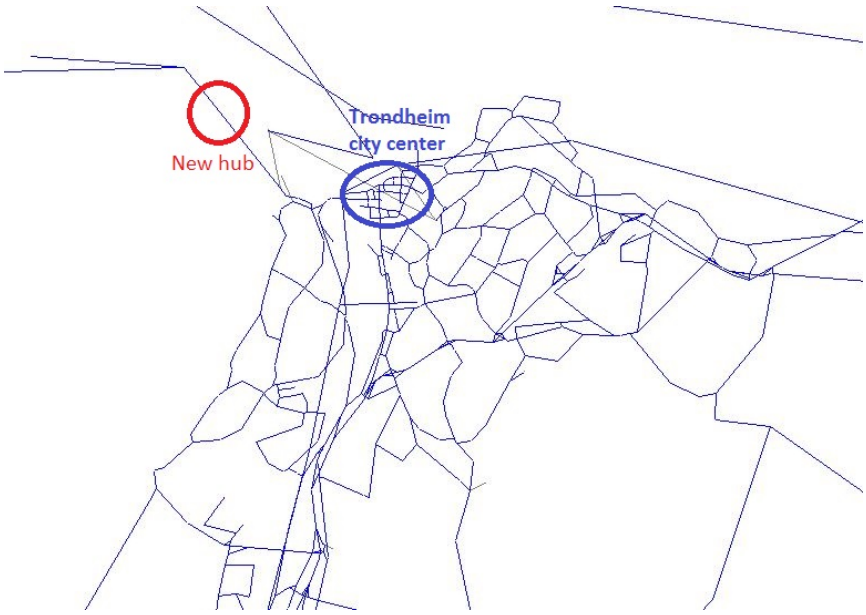


Figure 6.8: Traffic in north Trondheim (Source: CUBE)

The traffic in the link is the following:

715	**To Trondheim**	**From Trondheim**
Annual	15569	14838
Daily	54	52

Table 6.18: Traffic trough 715 (Source: Own table)

That is the pottential attraction that the new hub would have there due to the traffic in this road. Also, there should be counted the traffic arriving nowadays to Brattøra from East and South because the current node is not so far from this new one, so it is expected that this traffic continue choosing this node. But the export traffic would not choose this new node when going East or South, because it has no sense to go northwest and then, go through the opposite way.

As in the previous alternatives, there should be taken into account the incoming and outgoing cargo by train and ship. All together are represented in the following table:

	Traffic 715	**Port**	**Train**	**South**	**East**	**Transit**	**Total**
Incoming	54	459	205	336	174	0	1228
Outgoing	52	122	159	0	0	28	305

Table 6.19: Potential traffic Trolla (Source: Own table)

And finally it is necesary to measure distance and number of trucks needed, as in the previous alternatives, the following table shows that:

	Incoming	**Outgoing**	**Total**
Traffic	1228	305	1533
Distance	4	4	4
South to the hub	336	0	336
Distance	14	14	14
East to the hub	174	0	174
Distance	33	33	33
South not to the hub	157	1158	1315
Distance	12,4	12,4	12,4
East not to the hub	500	80	580
Distance	29	29	29
Total	31799	17904	**39251**

Table 6.20: Needed distance Trolla (Source: Own table)

This alternative is the one that requires less kilometers to send the cargo to Trondheim. That is because of the distance needed that is just 4 km, but also because this alternative is receiving very few traffic due to the location, up in the north of the city, where there is almost no traffic.

6.4 Environmental impact

The fjord of Trondheim and all the coastline has a huge importance due to the flora and fauna on it. There are several protected areas along the coastline and, some of these areas are the habitats where various endangered species lives. The river Gaula for example is well known because of the large colony of salmon that hosts [8]. At the mouth of river otters and many species coexist like ringed plover, gulls, pink-footed geese etc. In fishing season, many fishermen come to Gaula. Therefore, preserve this area is not only an environmental issue, but also cultural.

The purpose of the present report is not to carried out an extensive study of the environmental affections. There will be studied just the information provided by the Norwegian environment agency in their webpage [4].

6.4.1 Orkanger and Leinstrand

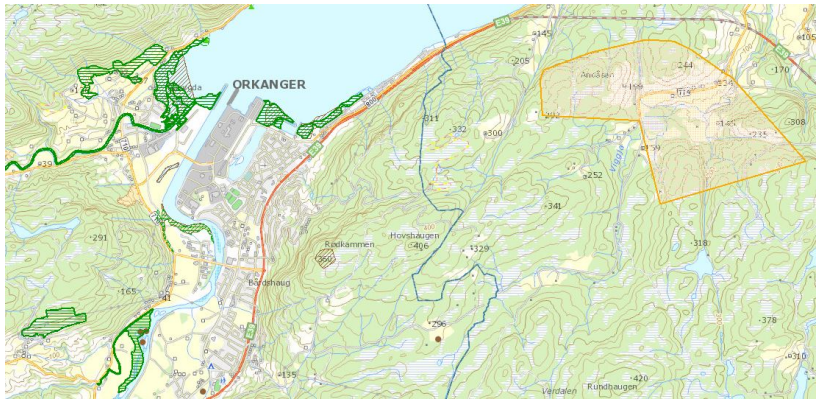


Figure 6.9: Protected zones, Orkanger (Source: Norwegian environment agency)

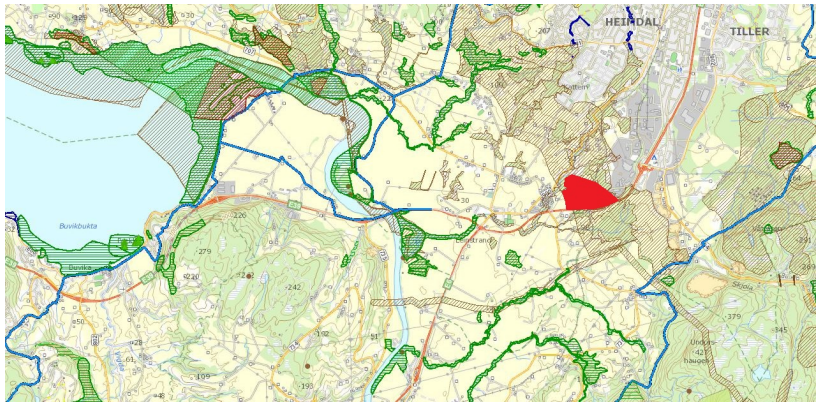


Figure 6.10: Protected zones, Leinstrand (Source: Norwegian environment agency)

As seen in the previous figures, there is a large ecosystem distributed along the coastline of Orkanger. This ecosystem has already been degraded due to the construction of the current port. If the operation area is enlarged, the affectation to the environment would increase. Anyway, this ecosystem has survived to the activities carried in the port during the last decades, so the increase of the activity may not have a huge impact.

The new storage area would cover a zone with some environmental importance.The place hosts an habitat defined as second degree, i.e, with a relative importance, but no so high as the ones marked in green at the map, which are defined as first degree habitats by the norwegian environment agency standards.

6.4.2 Hell

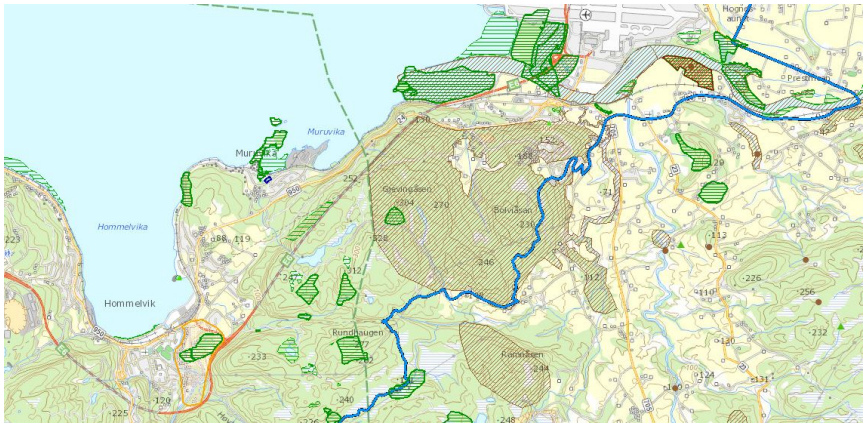


Figure 6.11: Protected zones near Hell (Source: Norwegian environment agency)

This alternative is the worst one in terms of effects on the environment. The new port area would require to be filled with stones and concrete, what would destroy completely the current habitat in the coastal area. Also, the presence of other habitats nearby, at the mouth of the river Stjørdal, makes this alternative very aggressive with the environment. The river is one of the most important fishing rivers in Norway, specially known because of the salmons going up the stream during the summer. So the opposition to this alternative by environmental activists and politicians is important.

6.4.3 Trolla

Figure 6.12: Protected zones near Trolla (Source: Norwegian environment agency)

Finally Trolla is the alternative with less environmental impact on the area. There are no outstanding habitats in the place that would host the harbour facilities. It is close to the protected areas in Bimarka, but the construction should not affect them. There should be taken in mind that is required the construction of a tunnel for railway and road, but the impact of a tunnel is not supposed to be high, because it would pass through the protected area underneath it

6.5 Construction difficulty

The topography of the area is mainly flat. Something quite logical since the construction areas are very close to the coast. The only alternative that could have some problems on this point is the third one, located between Trolla and Trondheim. There, the coastline is surrounded by mountains and, in some places, the coast is very steep, so the construction would be affected by that.

The first alternative takes advantage of the already consolidated port in Orkanger, so the needed infrastructure would be less than the required for the other two alternatives. The storage area would be constructed inland, so that would be easily constructed.

Hell and Trolla would be constructed on the coast, so, in order to construct the platform, there would be necesary to fill a large area in the fiord with stones and concrete, what is not only more expensive to build, but it also means that it would be more difficult to be constructed.

6.6 Functionallity

The objective of this section is to evaluate the number of people involved by the influence area of the hub. The more people supplied, the better alternative.

There has been defined a sphere of influence with a radius of 25 kilometers. The population covered by this sphere would be easily covered by the hub, and very probably all the goods needed would be supplied by it. All the spheres are represented in the following figure

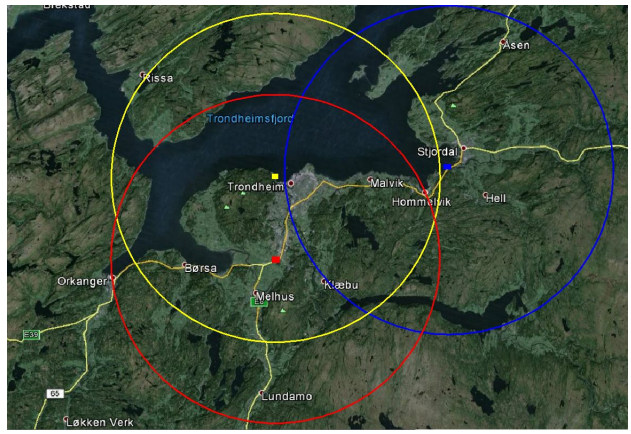


Figure 6.13: Sphere of influence (Source: Google maps)

Looking at figure 6.13 it is possible to determine which villages are covered by the spheres. The following table, 6.21, shows the number of inhabitants of each one:

Village	**Population**
Orkanger	6982
Børsa	1213
Melhus	14457
Klæbu	5801
Lundamu	1125
Hommelvik	4260
Malvik	12550
Stjørdal	21459
Hell	1418
Asen	480
Trondheim	235758

Table 6.21: Population per village (Source: Own table)

Finally, it is only necessary to sum all the villages covered by each spheres, without counting Trondheim because is covered by all the alternatives and it is too huge compared with the villages, so the results would not be easily compared. Table 6.22 shows the results of this. As seen, Leinstrand is the alternative that is covering more population, and Trolla, not well communicated in the North, is the one covering less.

	Leinstrand	Hell	Trolla
Population	46388	40167	38281

Table 6.22: Population covered (Source: Own table)

6.7 Final decision

The last step is to decide which is the optimal alternative. To do that, each one has to receive a grade in each of the different analysis carried out in the previous pages. Then, multiplying each grade by the importance of the factor, there will be obtained a single grade for each alternative. Based on this grade, the final decision will be taken.

6.7.1 Leinstrand and Orkanger

With a total cost of 2724 millions Kr, Leinstrand is the cheapest alternative of the three. That is why Leinstrand receives the highest score in the economic section.

The traffic study is also good for this alternative. A total of 71438 km per day are needed to transport all the needed good. That distance makes Leninstrand as the second best alternative, just behind of Trolla.

Regarding the environmental study, the alternative is not a good one, but not the worst. The storage area would be located in the middle of an area with some environmental importance, and the development of Orkanger port could have some impact in the nearby habitats.

About the constructive difficult and the needed materials, it has a good mark because of the flat topography and the low and scarce materials needed to expand the port.

Finally, this alternative is the one that serves more population.

6.7.2 Hell

Hell is a bit more expensive than the previous alternative, but not too much, so the grade in this point is not different from Leinstrand's alternative.

Regarding the traffic study, Hell is the alternative that requires more kilometers to transport all the needed goods. it requires almost 90000 km per day, 26% more than Leinstrand. That is because is the furthest option from the center of the city.

Also, it is the worst one in terms of environment. Located just in the middle of an important maritime habitat, this alternative will not recive a good grade in this study.

The alternative is located in a flat area with good communications, and there is not needed a lot of materials to create the harbour area.

Finally, the location of this alternative allows to serve to a huge population, not so much as the previous one, but still a good amount.

6.7.3 Trolla

Trolla is the most expensive alternative, more than 6000 M nok, so this alternative is the worst of the studied, and the importance of the economic study makes it unfeasible.

Although, the traffic study places this as the best alternative in this issue, 50% less than the second.

Regarding the environmental impact, it is also a good alternative, because there are no important habitats affected in the area. It is true that is really close to Bimarka, a place with a great environmental importance, but the construction of a tunnel won't be a problem.

The last two studies are not so kind with this alternative. The area is not flat, and the access are not good, so the constructive difficulty is high. Also, the place is not close to other village besides Trondheim, so it is serving to less population than the previous alternatives.

	Ponderation	**Leinstrand**	**Hell**	**Trolla**
Economy	45,00%	8	8	2
Traffic impact	35,00%	7	4	10
Environmental impact	10,00%	7	2	8
Construction difficulty	5,00%	10	9	4
Functionality	5,00%	10	9	5
Total		7,75	6,10	5,65

Table 6.23: Final score (Source: Own table)

Chapter 7

Conclusions

The relocation of Brattøra and the neighborhood of Nyhavna will result in several benefits for the city of Trondheim

The first is the possibility provided to Trondheim to expand through an area so close to the city center. The new neighborhood will be a modern zone, with a prime location close to the center and to the main roads. The plan for Nyhavna contemplates the creation of around 10000 new jobs in the area, the same number as new inhabitants there.

Not only the city would benefit with the relocation, also the port would have a good place to expand. Nowadays is very constricted, and a new location with more space would allow to increase the efficiency of the activities carried out in there.

Others of the concerned parties in this issue are the companies located nowadays in the area. Studies carried out by the port authorities show that many of them are willing to expand, but they have not enough space in the area. The problem is that some of the companies are not so interested in moving their offices, and they have a leasing agreement, so they could stay in the area until the end of the contract ,which can be up to 40 years in some cases.

The relocation will also affect to the traffic within the city. There has been carried some studies in this aspect. One made by the port authorities in 2007, and other made in the present report with data from 2013, and can be seen in tables 7.1 and 7.2

	Exports	**Imports**	**Total**
Trondheim	232296	329804	562100
Trondheim per day	810	1150	1960
Brattøra	130488	118729	249217
Brattøra per day	455	414	869
Total	56,17%	36,00%	44,34%

Table 7.1: Traffic in Trondheim and Brattøra, 2007 (Source: Idea Consulting)

	Exports	**Imports**	**Total**
Trondheim	342456	369525	711981
Trondheim per day	1194	1289	2482
Brattøra	200625	161185	361810
Brattøra per day	700	562	1261
Total	58,58%	43,62%	50,82%

Table 7.2: Traffic in Trondheim and Brattøra, 2013 (Source: CUBE)

In view of this findings it is possible to appreciate the increase of traffic in Trondheim and Brattøra in 6 years.

	Average change
Imported Trondheim	1,90%
Imported Brattøra	5,20%
Exported Trondheim	6,60%
Exported Brattøra	7,40%

Table 7.3: Annual growth (Source: Own table)

Finally, there has also been done an analysis of different possible location for the new harbour and the storage area. Based in a multicriteria analysis, there has been decided that the best alternative would consist in a develop of the harbour in Orkanger, and place the new storage area closer to Trondheim, in the former municipality of Leinstrand, taking advantage of the already consolidated port infrastructure in Orkanger and the proximity to Trondheim of Leinstrand.

	Ponderation	**Leinstrand**	**Hell**	**Trolla**
Economy	45%	8	8	2
Traffic impact	35%	7	4	10
Environmental impact	10%	7	2	8
Construction difficulty	5%	10	9	4
Functionality	5%	10	9	5
Total		7,75	6,10	5,65

Table 7.4: Final score (Source: Own table)

The strengths of this alternative are in first place the low cost of the project (which is very important in the final mark), and the scarce traffic generated. Also, the alternative is great when evaluating the construction difficulty and the number of people that it serves.

Appendix A

Companies in Nyhavna

According to the interviews made by the municipality of Trondheim [10], the intention of the different companies in Nyhavna regarding to the relocation would be:

Name	Jobs	Stay	Leaving	Stay	Leaving	Lost
Celsa Steelservice	8	x	x	8	0	
DSV Road		x		0	0	
K. kaffebrenneri	13	Will close				13
NORCEM	6		x	0	6	
Norsk Gjenvinning	30	x		30	0	
Norsk Stl	25		x	0	25	
Ruukki Norge	25	x	x	25	0	
Per T. Lykke AS	6		x	0	6	
Unicon AS	9	-	-	0	9	
Fugro Seabed SS	11			0	11	
GeoSI AS	3			0	3	
K Stokke Transport	5	x		5	0	
Linjebygg Offshore	6	-	-	0	6	
Midt-Norsk Fr	9		x	0	9	
Norbit Group	20	x	x	20	0	
Nyhavna Mekaniske	18	Will close				18
Saltimport AS	3		x	0	3	
Selfa Arctic	10	-		0	10	
StillCom AS	35	x		35	0	
Trnder Partne	2	x		2	0	
Trnderfrakt	12	x		12	0	
Verkstedservice	6	x		6	0	
Weatherford Labs	40	x		40	0	
Weber Leca	19		x	0	19	
AB Rr & Varme AS	3	x		3	0	
Anleggspartner 1 e	12	x		12	0	

Atea AS		-		0	0	
Atelier Dora	8			0	8	
Boa Offshore	50			0	50	
Dora 1 Bowling AS	12		x	0	12	
Erlend Leirdal	1			0	1	
Fellows Motorklubb	0			0	0	
Fiskarlaget M-Norge	1			0	1	
GeoProbing Tec	1	x		1	0	
GOBAD AS	4	x		4	0	
Gro Lager AS	1	x		1	0	
Gulosten AS	0			0	0	
Hytrykkservice AS	1	Will close				1
Ingeniørfirma P. J	6	x		6	0	
ISS Facility Services	12	x		12	0	
Johan Brobakke AS	1	x		1	0	
Jomar Utnes AS	1	x		1	0	
Kobbesgt. 10 AS		x		0	0	
Krangnes Motor	3	x		3	0	
Lade Teknopark AS	2			0	2	
N.A. EIE AS	4	x		4	0	
No Life Orchestra	4	x		4	0	
Norsk Caravan Club	0	x		0	0	
Norsk FSt Trondheim	0	x		0	0	
Proff Regnskap	4	x		4	0	
SINTEF Byggforsk	0	x		0	0	
Teateratelier, UDP	4	x		4	0	
Titek Btsenteret AS	6	Will close				6
Topp Design Broderi	1	x		1	0	
Triosphere DA	4	Will close				4
Total	**467**			**244**	**181**	**42**
				52%	39%	9%

Table A.1: Companies in Nyhavna (Source:Trondheim Kommune [10])

Appendix B

Traffic analysis

Number	Bil1	Bil2	Bil3	Bil4	Bil5	Bil6	Bil7	Bil8	Bil9	Bil10	BilA	Ship	Train	Trucks
728	1	2	0	2	696	843	5227	27739	5	1339	0	277	0	35854
350	1	1	253	6374	4774	3600	9818	30040	6382	48	466	4	0	61757
355	0	0	235	1095	857	449	270	1425	1285	97	0	0	0	5713
367	0	0	0	0	6	18	26	0	0	0	0	0	0	50
364	1	2	125	1441	1379	510	9274	336	14	68	0	0	0	13150
Internal	0	0	0	4	109	504	3582	298	0	0	0	0	0	4497
Importation	1	2	125	1437	1270	6	5692	38	14	68	0	0	0	8653
730	0	9	0	22	4336	33067	2845	30476	3655	1856	0	1021	0	762667
Internal	0	0	0	0	4209	27988	1312	25888	3655	952	0	0	0	64004
Importation	0	9	0	22	127	5079	1533	4588	0	904	0	1021	0	12262
560	0	0	0	10	340	54988	0	0	0	2237	0	0	35000	57575
Internal	0	0	0	0	55	24420	0	0	0	652	0	0	0	25127
Importation	0	0	0	10	285	30568	0	0	0	1585	0	0	35000	32448
363	2	2	5	23425	10715	3652	1857	6378	2235	356	0	0	0	48627
Internal	0	0	5	22292	452	2755	1312	2929	2116	256	0	0	0	32117
Importation	2	2	0	1133	10263	897	545	3449	119	100	0	0	0	16510
360	0	9	875	42543	77274	22319	12386	55799	936	7929	0	60	34	220070
Internal	0	2	875	35599	4030	20907	3652	36669	77	1784	0	0	0	103595
Importation	0	7	0	6944	73244	1412	8734	19130	859	6145	0	60	34	116569
362	0	2	43	65570	1846	1107	564	323	12	6	241	0	0	69714
Internal	0	0	10	6294	85	1044	331	0	0	2	220	0	0	7986
Importation	0	2	33	59276	1761	63	233	323	12	4	21	0	0	61728
361	1	0	5	3911	443	808	284	85	184	0	0	0	0	5721
Internal	0	0	1	3909	10	808	273	85	175	0	0	0	0	5261
Importation	1	0	4	2	433	0	11	0	9	0	0	0	0	460
365	0	2	48	11565	4626	982	2349	251	212	1332	0	0	0	21367
Internal	0	0	26	9571	74	870	1960	215	118	480	0	0	0	13314
Importation	0	2	22	1994	4552	112	389	36	94	852	0	0	0	8053

Table B.1: Importations (Source: CUBE)

Number	Bil1	Bil2	Bil3	Bil4	Bil5	Bil6	Bil7	Bil8	Bil9	Bil10	BilA	Ship	Train	Trucks
1006	0	0	0	0	555	0	0	0	0	0	389	0	0	944
Internal	0	0	0	0	7	0	0	0	0	0	0	0	0	7
Importation	0	0	0	0	548	0	0	0	0	0	389	0	0	937
366	1	3	377	42570	50278	41785	3153	71876	176	13633	3975	0	0	227827
Internal	0	0	377	34078	300	40844	2276	34934	10	1975	1789	0	0	116583
Importation	1	3	0	8492	49978	941	877	36942	166	11658	2186	0	0	111244
356	0	4	9	821	403	270	113	68339	19	36	0	0	0	70014
Internal	0	0	0	759	27	89	102	68300		32	0	0	0	69309
Importation	0	4	9	62	376	181	11	39	19	4	0	0	0	705
354	0	8	918	5641	1091	737	724	29763	237	2579	0	0	0	41698
357	0	22	173	5820	870	1558	3444	2282	76	90	0	0	0	14335
770	0	2	0	0	909	897	37	797	48	0	0	69	0	2690
371	0	1	544	7701	4445	6082	3090	11063	1349	268	725	0	0	35268

Table B.2: Importations (continuation) (Source: CUBE)

Number	Bil1	Bil2	Bil3	Bil4	Bil5	Bil6	Bil7	Bil8	Bil9	Bil10	BilA	Ship	Train	Trucks
728	1	1	0	4	803	1057	3453	27808	5	1352	0	292	0	34484
350	0	1	689	4435	4655	2974	11288	19470	4805	33	619	0	0	48969
355	0	0	414	615	855	849	139	1167	1725	185	0	0	0	5949
367	0	0	0	0	5	9	13	0	0	0	0	0	0	27
364	1	1	221	1368	1331	311	10811	623	14	132	0	0	0	14813
Internal	0	0	2	1184	40	171	2816	581		132	0	0	0	4926
Exportation	1	1	219	184	1291	140	7995	42	14	0	0	0	0	9887
730	8	13	0	156	2932	46700	3760	38504	2215	1643	0	959	0	95931
Internal	0	0	0	56	2800	40985	3757	35053	2214	689	0	0	0	85554
Exportation	8	13	0	100	132	5715	3	3451	1	954	0	959	0	10377
560	0	0	0	15	418	56245	0	0	0	2742	0	0	35000	59420
Internal	0	0	0	0	75	27038				1093	0	0	0	28206
Exportation	0	0	0	15	343	29207	0	0	0	1649	0	0	35000	31214
363	1	1	3	20975	10565	3646	1462	5238	3651	238	0	0	0	45780
Internal	0	0	0	18891	301	2750	895	1819	3532	152	0	0	0	28340
Exportation	1	1	3	2084	10264	896	567	3419	119	86	0	0	0	17440
360	3	8	1895	34837	79359	18865	14169	56377	978	8231	0	11	0	214722
Internal	0	0	1293	26405	4481	17452	4675	33465	0	1253	0	0	0	89024
Exportation	3	8	602	8432	74878	1413	9494	22912	978	6978	0	11	0	125698
362	1	2	77	3881	1795	586	397	642	6	5	157	0	0	7549
Internal	0	0	3	3581	11	175	172	639			137	0	0	4718
Exportation	1	2	74	300	1784	411	225	3	6	5	20	0	0	2831
361	1	1	21	1956	438	405	148	167	0	102	0	0	0	3239
Internal	0	0	1	1956	0	123	137	164	0	102	0	0	0	2483
Exportation	1	1	20	0	438	282	11	3	0	0	0	0	0	756
365	1	2	97	22488	4582	1011	1280	361	212	1863	2475	0	0	34372
Internal	0	0	13	18801	11	898	981	326		955	1992	0	0	23977
Exportation	1	2	84	3687	4571	113	299	35	212	908	483	0	0	10395

Table B.3: Exportations (Source: CUBE)

Number	Bil1	Bil2	Bil3	Bil4	Bil5	Bil6	Bil7	Bil8	Bil9	Bil10	BilA	Ship	Train	Trucks
1006	0	0	0	0	539	0	0	0	0	0	390	0	0	929
Internal	0	0	0	0	4	0	0	0	0	0	0	0	0	4
Exportation	0	0	0	0	535	0	0	0	0	0	390	0	0	925
366	1	2	237	56962	50243	30827	2015	38137	173	11613	2640	0	0	192850
Internal	0	0	189	41847		29886	1141	18712	5	1121	912	0	0	93813
Exportation	1	2	48	15115	50243	941	874	19425	168	10492	1728	0	0	99037
356	1	7	19	411	391	165	62	80161	31	67	0	0	0	81315
Internal	0	0	0	379	14	163	50	80085	0	64	0	0	0	80755
Exportation	1	7	19	32	377	2	12	76	31	3	0	0	0	560
354	1	8	3386	3684	1062	466	401	54460	449	2670	0	0	0	66587
357	1	15	568	4249	827	2391	2729	4228	75	142	0	0	0	15225
770	1	2	0	0	646	1172	37	684	49	0	0	57	0	2591
371	1	1	1897	4869	4406	4001	2472	9598	2191	138	862	0	0	30436

Table B.4: Exportations(Continuation) (Source: CUBE)

The transportation system in the area could be summarized with the following tables:

	Total	**Villages nearby**	**Internal traffic**	**To Trondheim**
Importations	1008640	197315	441800	369525
Exportations	955188	204241	441800	309147

Table B.5: Traffic per year (Source: Own table)

	Total	**Villages nearby**	**Internal traffic**	**To Trondheim**
Importations	3517	688	1541	1289
Exportations	3331	712	1541	1078

Table B.6: Traffic per day (Source: CUBE)

	Villages nearby	**Internal traffic**	**To Trondheim**
Importations	19,6%	43,8%	36,6%
Exportations	21,4%	46,2%	32,4%

Table B.7: Percentages (Source: Own table)

Finally, the incoming and outgoing traffic through the three links studied in the access to Trondheim:

	South		**Link 1 and 2 East**		**North**	
	Imports	**Exports**	**Imports**	**Exports**	**Imports**	**Exports**
Bil1	2	1	0	0	0	0
Bil2	11	11	20	16	1	1
Bil3	10639	10417	10294	10409	60	72
Bil4	13469	9016	11315	7030	4031	5293
Bil5	188797	188224	100176	99829	1687	1709
Bil6	29631	29145	37212	36677	5816	4066
Bil7	16502	15845	12241	11863	676	918
Bil8	40403	53664	16702	16953	786	646
Bil9	4890	4873	5991	5991	0	0
Bil10	26305	36998	13460	13382	2512	2133
BilA	456	619	2494	2631	0	0
Total	331105	348813	209905	204781	15569	14838

Table B.8: Traffic total (Source: CUBE)

Appendix C

Brattøra traffic

The traffic handled by the logistical hub of Brattøra will be studied in the present appendix. In the model, Brattøra is defined as three different nodes, to understand it properly is necessary to unify them into one, and also to know the destination and origin of all the cargo.

	Bil1	**Bil2**	**Bil3**	**Bil4**	**Bil5**	**Bil6**	**Bil7**	**Bil8**	**Bil9**	**Bil10**	**BilA**	**Ship**	**Train**	**Trucks**
Total	8	13	0	156	2932	46700	3760	38504	2214	1643	0	959	0	95930
Inside		8		56	2800	40985	3760	35053	2214	689				85565
South	8	5		100	132	4740		3366		292				8543
North						975				662				1637
East								85						85

Table C.1: Exportations Node 730 (Source: CUBE)

	Bil1	**Bil2**	**Bil3**	**Bil4**	**Bil5**	**Bil6**	**Bil7**	**Bil8**	**Bil9**	**Bil10**	**BilA**	**Ship**	**Train**	**Trucks**
Total	0	9	0	22	4336	33067	2845	30476	3655	1856	0	1021	0	76266
Inside	0	0	0	0	4209	27988	1312	25888	3655	952				64004
South		4		14	127	3914	1281	4545		66				9951
North				8		1165	50	16		671				1910
East		5					202	27		167				401

Table C.2: Importations Node 730 (Source: CUBE)

	Bil1	**Bil2**	**Bil3**	**Bil4**	**Bil5**	**Bil6**	**Bil7**	**Bil8**	**Bil9**	**Bil10**	**BilA**	**Ship**	**Train**	**Trucks**
Total	3	8	1895	34837	79359	18865	14169	56377	978	8231	0	11	0	214722
Inside	0	0	1293	26405	4481	17452	4675	33465	0	1253	0	0	0	89024
South	3	3	291	4308	61874	1039	3042	9154	248	5996				85958
North				1196	3396		910	2352						7854
East		5	311	2928	9608	374	5542	11406	730	982				31886

Table C.3: Exportation Node 360 (Source: CUBE)

	Bil1	**Bil2**	**Bil3**	**Bil4**	**Bil5**	**Bil6**	**Bil7**	**Bil8**	**Bil9**	**Bil10**	**BilA**	**Ship**	**Train**	**Trucks**
Total	0	9	875	42543	77274	22319	12386	55799	936	7929		60	34	220070
Inside	0	2	875	35599	4030	20907	3652	36669	77	1784				103595
South		5		3200	60430	1412	4914	5406	96	5341				80804
North				615	2297		831	2356						6099
East		2		3129	10517		2989	11368	763	804				29572

Table C.4: Importations Node 360 (Source: CUBE)

	Bil1	**Bil2**	**Bil3**	**Bil4**	**Bil5**	**Bil6**	**Bil7**	**Bil8**	**Bil9**	**Bil10**	**BilA**	**Ship**	**Train**	**Trucks**
Total	0	0	0	15	418	56245	0	0	0	2742			35000	59420
Inside	0	0	0	0	75	27038				1093				28206
South					57	1805				1469				3331
North					17	4546				8				4571
East				15	269	22856				172				23312

Table C.5: Exportation Node 560 (Source: CUBE)

	Bil1	**Bil2**	**Bil3**	**Bil4**	**Bil5**	**Bil6**	**Bil7**	**Bil8**	**Bil9**	**Bil10**	**BilA**	**Ship**	**Train**	**Trucks**
Total				10	340	54988				2237			35000	57575
Inside				0	55	24420				652			0	25127
South					33	4120				1425				5578
North					18	6506				36				6560
East				10	234	19942				124				20310

Table C.6: Importations Node 560 (Source: CUBE)

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