Market Potential & Train Concept Trønderbanen

Market Potential For Train Concepts On The Trønderbanen

NTNU
Innovation and Creativity

FACULTY OF ENGINEERING SCIENCE AND TECHNOLOGY
DEPARTEMENT OF PRODUCTION AND QULITY ENGINEERING

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NTNU

Faculty of Engineering Science and Technology
Department of Production and Quality Engineering

Date 15.08.12

Our reference BAN/TØ

PROJECT ASSIGNMENT AUTUMN 2012

for

stud.techn. Ágúst Már Gröndal & Erik Smedsrød

MARKEDSPOTENSIALE FOR TOGKONSEPTER PÅ TRØNDERBANEN (Market Potential For Train Concepts On The Trønderbanen)

Norges Statsbaner AS (NSB) is one of the oldest and leading actors on the Norwegian railway system, conducting personal and goods transporting. The history of NSB begins as far back as 1854, when the first railway line was completed. NSB is a corporation under the Ministry of Transport and Communication where the Government is the only owner and contributor, playing a large role in the company's future direction of goals and structure as well as corporate strategy.

Due to the high population growth in the Trondheim area, it is essential to develop a suitable transportation system to handle the increasing need of transport. This will involve the improvement and expansion of the local existing train systems.

The current local train system consists primarily of an hourly service Trondheim-Steinkjer (with half-hourly peak services) serving the communities east and north of Trondheim, including the airport at Værnes. The less-densely populated communities south of Trondheim are served by an occasional service Trondheim-Røros, with additional peak hour trains Trondheim-Støren. The current railway infrastructure around Trondheim is of low standard and does not allow high velocities (*e.g.* the 124 km between Trondheim and Steinkjer is scheduled to 124 min, which gives an average speed of 60 km/h). In addition, the utilization of the single-track lines is close to its maximum capacity (at least for the section Trondheim-Steinkjer), and does not allow an increased frequency for the local train service. Together with the parallel improvement of the road infrastructure, this makes the current train service less and less competitive, which then leads to increased road traffic and congestion.

Considering the counties of South- and North-Trøndelag and The Norwegian National Transport Plan for this particular region, several improvements to the railway infrastructure have already been proposed, among others the electrification of the section Trondheim-Steinkjer (which will allow the use of electric units, with higher acceleration and lower travel time), the construction of the Forbordfjell tunnel and the construction of double track between Trondheim and Stjørdal. These proposed improvements have been developed by the NSB in collaboration with the JBV and Statens Vegvesen, in order to build up a more reasonable future train service in the area.

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This student project will be accomplished in cooperation with NSB. The purpose of this study is to develop concepts on behalf of NSB to describe, conceptualize and analyze the future market potential (population and industry) for the given area to serve the social development in the coming generation in best possible way. This includes determining an appropriate service level (line structure, stopping pattern and frequency of the individual lines), which will be a compromise between the benefits of the performed transport (both economical and political) and the operational costs of the service.

The scope of the project:

1. Conduct a brief study on previous train concepts for the Trondheim area.

2. Conduct a brief study on methods for market analyses and transport demand. Determine an appropriate method for the estimation of passengers demand for train-service concepts in the Trondheim area.

3. Evaluate the future market potential for various train-service concepts in the Trondheim area. This may involve:
   a. The analysis of population growth and the resulting increase in transport demand.
   b. The estimation of passenger demand.
   c. A comparison of the train service against other types of travel (bus/car).

4. Recommend one (or a few) possible future train-service concepts for the Trondheim area.

Underlying basic assumptions:

1. The section Trondheim - Steinkjer is electrified.

2. The section Trondheim - Stjørdal is running with an improved train passing capacity. Eventually with a double track.

The assignment shall be performed as a project. The student shall first do a pre-study and submit a report, which shall contain an analysis of the project objectives and a description of the tasks to be performed. The description of the tasks shall lead to an unambiguous definition of content and approach. Based on this, the student shall make an (hierarchic structured) activity plan for the work. Further the student shall prepare a complete project plan with an estimate of the workload in man-hours and a schedule with defined milestones. The plan shall be presented as a separate document.

The pre-study report shall be submitted to the supervisor within September 14, 2012.

The student shall submit a progress report per October 19, 2012. The report shall contain an ordinary progress diagram, which shows planned, actual spent and earned resources. The report shall contain a description of the work carried out within the period. All deviations shall be reported to the supervisor. The supervisor shall approve any changes in the plan.

Project planning and control of the work is a part of the assignment and will count in the final evaluation.

The pre-study report shall be included in the final project report. Subsequent progress and deviation reports will also be included. In the evaluation of the work it will be emphasized that the work is well documented.

The results of the project shall be documented in a final report. This report shall be written as a research report containing a summary, conclusion, literature list, table of contents, and a main section documenting the results of the work. In preparing the report, it should be emphasized to make the text perspicuous and well written. There should be references in the text to tables and figures in the final evaluation. It will be emphasized that the results are thoroughly prepared and discussed, and that all sources used are referred to.

Material, which is developed in connection with the project, like software, text and graphic files or physical equipment, is a part of the final report. Documentation for correct use of this shall also be enclosed in the report. Documentation, which is collected with the support from the institute during the project task, shall be handed in with the report.

If the project assignment requires contact with an enterprise and eventually work in this, the enterprise's regulations shall be adhered to. The student shall follow any orders given by the management and is not allowed to interfere with the production or other work without the management's consent. Internal information about the enterprise, which the student obtains, shall not be given to persons outside the enterprise.

The student shall pay any travel expenses, printing and telephone expenses unless other agreements exist.

The assignment text shall be enclosed and be placed immediately after the title page.

The final report shall be submitted in two bound copies and one electronic (pdf-format) by December 21, 2012.

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DEPARTMENT OF PRODUCTION AND QUALITY ENGINEERING

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Bjørn Andersen
Responsible Supervisor

PREFACE

"My ambition is a state-of-the-art network of road- and railway within 20 yeas"
former MoT, Magnhild Meltveit Kleppa 2009 – 2012.

This report sums up the result and work done in the study of the market potential for train concepts on the Trønderbanen. The project was carried out in autumn 2012, at the Department of Production and Quality Engineering at the Norwegian University of Science and Technology in collaboration with the Norwegian State Railways – NSB. The purpose of the project was to recommend one or few train service concepts based on qualitative theory, travelling statistics and projection modeling. All of the quantified materials printed are collected and reproduced from the regional transport model (RTM), SSB, KOMPAS and other sources.

Our main supervisor was researcher Hans Petter Krane at the Department of Civil and Transport Engineering, assisted by civil engineer Andreas Økland and Henning Myckland (Advisor) and Asle Nordbotten (Leader of Trønder-, Røros and Meråkerbanen) at NSB.

The report is published in English.

Trondheim
December 14, 2012

Ágúst Már Gröndal

Erik Smedsrød

ABSTRACT

This report covers the work completed in analyzing the future market potential for NSB at Trønderbanen.

The analyses expose a great potential of closing the gap of unrealized market shares and become a frontrunner of public transportation in the region. The major market is located northeast of Trondheim with specific interest of establish a frequent supply between Trondheim – Stjørdal and two new stations at Grillstad and Ranheim. An extraordinary interest of setting up a station at Bjørndalen was found due to the high traffic and the point of connection.

In view of the current railway network, the social development analysis related to critics and theory on field studied as well as elements from the case study, founds the basic platform of the following concept.

	Axis	Frequency rush [min]	Frequency low [min]	Major changes
Local	Trondheims Ekspressen	20	-	New Ranheim and Grillstad st.
	Melhus - Trondheim	30	60	New Bjørndalen station.
Regional	Trondheim - Steinkjer	30	60	Stops only at Værnes and Leangen between Trondheim and Stjørdal.

Assumptions:

1. Electrified train axis between Trondheim – Steinkjer.
2. Double lane capacity between Heimdal –Trondheim – Stjørdal.
3. Five new train tunnels.
4. Results from the Regional Transport Model conducted in 2007.

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1. INTRODUCTION

The primary objectives of this part are to give the reader an overview of the scope of the project, the problem area of origin, goals determined and buildup of the structure in the report.

1.1 *Background*

Trondheim area experiences a rapid boom in population growth and business industry. The growth of the population expected to increase with 30 % until 2040. The road and the railway infrastructure are worn and stretched to the limit of what concerns the capacity and technology.

Norwegian National Railroad Administration (NNRA) and the Norwegian Public Road Administration (NPRA) established a joint study venture to generate a strategy and concept formed report (KVU) on behalf of the Ministry of Transport and Communications (MoT). The idea of the KVU report was to highlight possible decision areas and concepts of further work presented to the Government and MoT.

NNRA is the national railway authority and responsible for executing the operations and management of the national railway network in the best interests of the MoT. The main and largest operator of freight and passenger traffic on Norwegian railroads is NSB. The Government is the only owner of NSB controlled through the department of MoT. Their work is to provide an effective, available, secure and environmental friendly transport of people and freight.

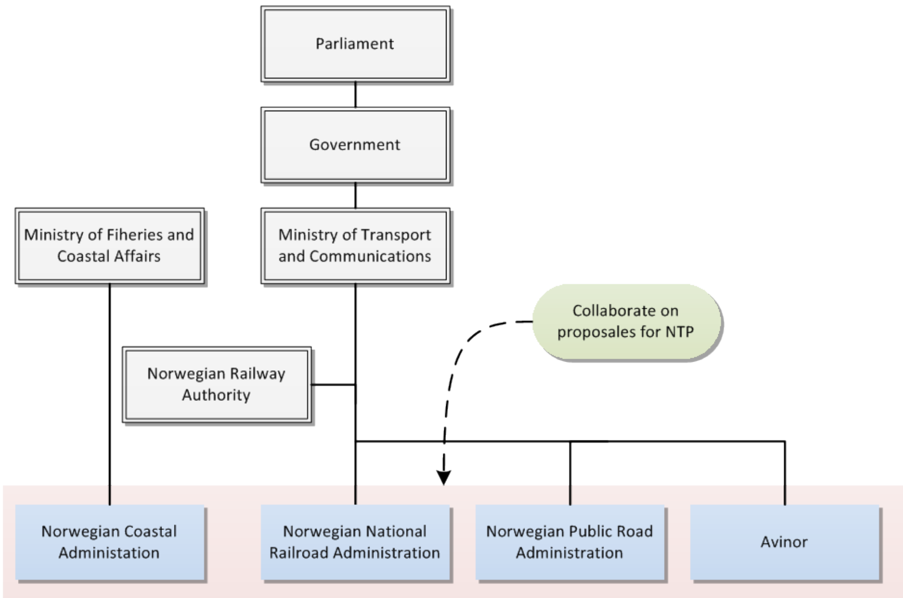

Figure 1: Organizational chart, departments of transportation
Source: (NNTP, 2012)

Based on the above-mentioned text, NSB presented a student project for 5th year students at Norwegian University of Science and Technology (NTNU). Intentionally to get the participants to come up with different route and train service concepts, based on the current and future market potential considering the already planned electrified train network of Trønderbanen.

1.2 *Thesis Question & the Objective*

The present infrastructure is overripe and the rolling stock is old and worn. Current driving pattern is characterized by rigid schedule, hourly departure and extra train sets are adopted in rush-hour, due to the annual amount of 1.2 million (NSB, 2012a) passengers and the expected increase of population growth.

It is vital to have a general understanding of how the market is and will expand, consider the amount of diverse capacity options NSB and the public transport sector will meet in the future. New hardware, technology and double track system are not synonymous with automatic problem solving. It is equally relevant to know when, where and how to initiate the new train-service capabilities.

The project objective is to highlight the possible market potential in Trondheim region, related to appropriate allocation of new stations and hub stations considering Trondheim municipality future residential and construction planning. The concept presented is founded on certain elements from the KVU report with new double railway capacity from Trondheim to Stjørdal and electrified power supply from Trondheim to Steinkjer.

To summarize:

1. Estimate passenger demand and population growth for 2012 – 2040, in the corridor of Trønderbanen.
2. Identify a new and alternative route concept(s) at Trønderbanen.

1.3 Trønderbanen

The name *Trønderbanen* has been used on the colloquially as a synonym for the entire train service axis within the region. These axes cover the area from Steinkjer in the North through Trondheim and further south to Oppdal/Røros. Figure 2, illustrate the railway road passing through some of the stations where the line drawn in-between the blue circles are defined as Trønderbanen. NNRA has defined five railway roads in the region of Trondheim:

- Nordlandsbanen
- Rørosbanen
- Dovrebanen
- Meråkerbanen
- Lerkendal-Trondheim-Steinkjer

In this report, the axis Melhus/Støren – Trondheim - Steinkjer is defined as the Trønderbanen consisting of 32 stations. Trønderbanen is functioning as a local train service supply with relative short distance between the majorities of the stations. Particular stations serve as a hub of logistics and intersection points in the regional network.

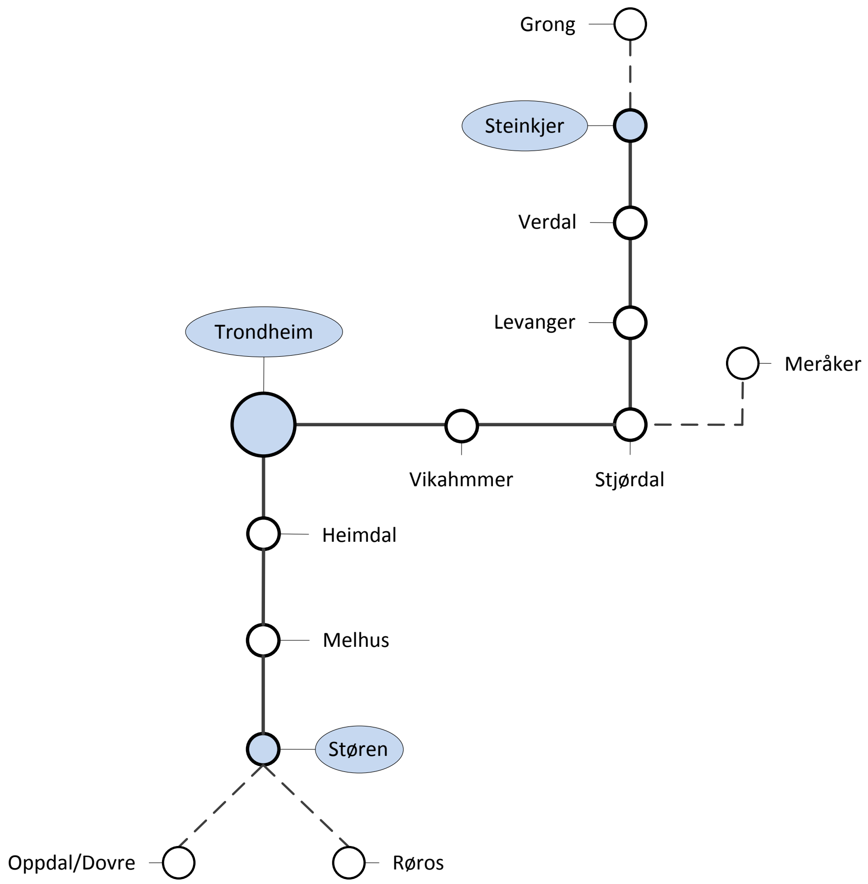

Figure 2: Overview of Trønderbanen

1.4 Motivation of Choice

Trønderbanen needs and is anticipating a modernization of the infrastructure and the rolling stock, in order to meet the demand, current political and environmental objectives. The amount of commuters into Trondheim from nearby region increases each year, and the need for a sustainable and effective transportation system is intrusive to maintain an attractive supply-and-demand situation for industries and civilians.

The project task looked more tangible and seemed to contain a natural mix of theoretical and practical work. Changing from combusting train material to new electrified and double lane capacity in our host region, is an immense and exciting project, which we was excited to study in closer details.

1.5 Limitations & Scope

Although we discovered several potential improvements during our work, the decision to focus solitary on the market potential aspect around Trondheim area and the potential impact of new stations located east and south of the city was the focus of work.

The lack of experience or ability to estimate an accurate demand-picture after radically changes in one direct supply event is to some degree known to the transport planning society, but still a hard to calculate or predict with conventional forecasting models. Moreover, upcoming major improvements in transport supply of better, faster, more accessible roads, parking areas, networks of bus etc., provide or generate the foundation of stimulus for expanding economic growth.

Other limitations of work done concern the numbers and data mentioned in the report, are estimates based on aggregate calculations done from the diverse models. The information accessible in the report, particularly input data to the RTM is dated back to the 2001 (traveling behavior), are likely expected to deviated by some means if a new survey was performed today. The uncertainty of data publicized has to be taken into account when evaluation is performed and solutions recommended.

1.6 Report Structure

Five parts divides the paper in 7 chapters. Part 1 consists of two chapters covering the basic introduction/background of this project, issues of scope, theory of methods and methods used to estimate figures and concept(s) represented in the end.

Part 2 cover some of the advanced and superior theory behind transport modeling and population projecting in the discrete choice of modeling. Chapter 3 – Transport Modeling, describes the buildup of the Norwegian regional transport model (RTM) and how it is designed to assess the best simulation of journeys in the range of 0 to 100 km and the common view on critics related to transport modeling. Chapter 4 – Population Modeling, cover the basic theory of projection analyze and the buildup of the KOMPAS model used to forecast population development in small geographical areas.

Part 3 cope with chapter 5 – Market Potential related to Trondheim region based on the data from RTM, KOMPAS and discussion of the experience report of Svealandsbanan with similar market and geographical challenges to a certain degree and the results. The market potential is based on the future social development within a horizon of 40 years.

Part 4 includes the end concept and recommendations to NSB in the choice of concept.

Part 5 covers the bibliography, appendixes and other material referred.

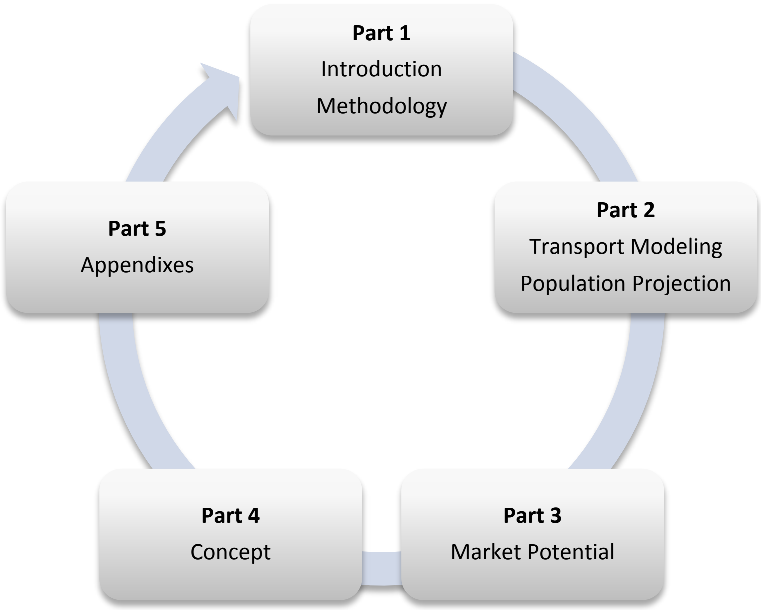

Figure 3: The report structure

2. METHODOLOGY

All means used in research assignments where the objective is to find or establish new theory can be identified as a method. Method in its own is a remarkably wide term, but it is common to define method as an approach or tool to assists researchers to solve current problems, and further establish new knowledge regarding the social world (Holme & Solvang, 1996).

Social science methodology embraces the organization and interpretation of data, which leads us to a better understanding of the society.
(Holme & Solvang, 1996, p. 14)

It is prevalent to divide method research strategies in two categories, quantitative, qualitative or a combination of these two.

Quantitative research strategy is a numerical way of handling the input of data without any influence from the researcher. All information collected is transformed in to numbers for further analyze, whether to map the pattern and find deviations from the normal distribution. Quantitative research is interested in the nature of relationships among variables, and it is a way of testing theory. Reality is objective (Bryman, 2012).

Qualitative research method is trying to see the world from the eyes of the participants, an in depth analyze. The outcome depends on the researcher's interpretation of data, through textual analyze of information through interviews and ethnography[1]. Theory emerges from data and reality can be perceived as socially constructed (Bryman, 2012).

2.1 Methods Used and Theoretical Framework

Facts of supply and demand are presented as a result of forecasts and statistics related to population growth and traveling demand in Trondheim region. The framework and the results of this report derived from theories and data both qualitative and quantitative to obtain sufficient and reliable information.

The project organization was divided into three phases, with the intention to be done in chronological order. First phase focused on collecting quantitative data and qualitative knowledge from case studies. Second phase concentrated on using the gathered data to buildup new, reliable and agile train service. The final phase intended to recommend one or few of the best concepts. On the other hand, the technical work with the report has consisted of four phases. Phases 2 and 3 integrated with each other in the content of continuous quality check of work performed (see figure 4).

[1] Describe the study of the people’s way of living (Britannica, 2012).

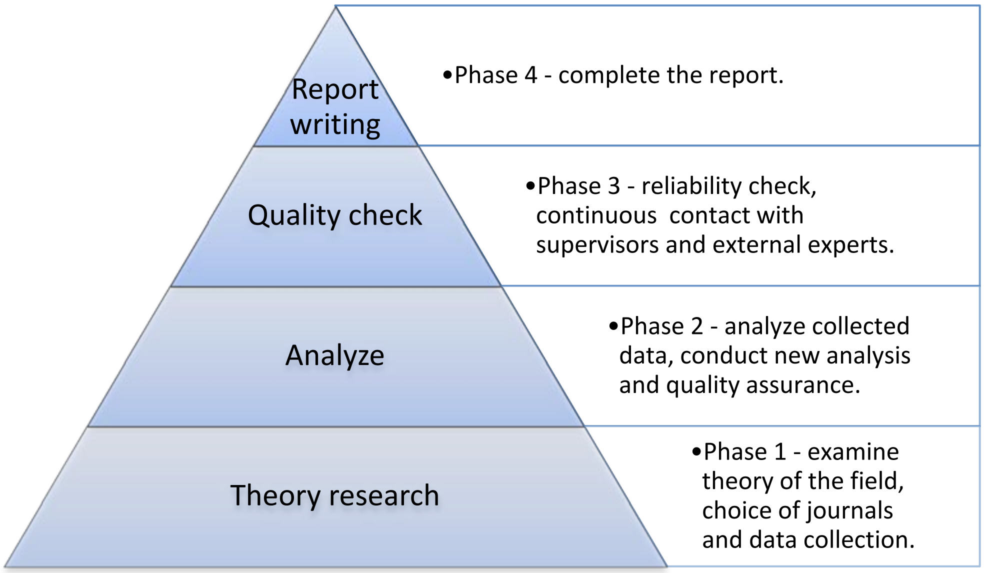

Figure 4: Technical framework

Extensive amount of time went to comprehend the train industry in lack of prior knowledge and experiences, both from the government and other stakeholder's point of view. Abroad and domestic literature and studies with similar geographical and socio-economic[2] potential is explored to consolidate a certain quality level. Such as research reports from KTH Railway Group[3], the construction of Svealandsbanan. Moreover, numerous public documentations, consultations and reports from subordinate agencies and enterprises, and Trondheim municipality have been studied to uncover and map out the current processes of development plans, projects and transport supply. In addition, comprehensive time used to obtain an adequate knowledge of how to use the geographic information system ArcGIS[4].

As a basis for assessments are key parameters for the routes and stations surveyed, such as, population forecast, travel demand, adopted strategies in municipal and county plans, capacity and travel time saving and assessment of other public transport system in the corridor.

Quantitative models of population development and geographical structure are described through the data from SSB and Trondheim municipality. The main source of statistics data comes from SSB, which the leading statistical institute in Norway. SSB produces roughly 85% of all Norwegian official statistics. Their main sources of data collection are administrative registers and survey questionnaires. One of the core registers SSB has access to, is the Population Register, maintained by the Directorate of Taxes. This

[2] Sociological classification that describes the relationship between the person's relative wealth and social status (NOU, 2010).

[3] Railway Group at the Royal Institute of Technology (KTH) in Sweden, is a multidisciplinary research center with more than 20 years' experience covering all competencies in the railway sector (KTH, 2011).

[4] ArcGIS is a complete system for designing and managing solutions through the application of geographic knowledge. It enables you to perform deep analysis, gain a greater understanding of your data, and make more informed high-level decisions (esri, 2012).

database is the basis for the population change, estimation and population projections statistics (SSB, 2012e). SSB provides annual statistics for municipalities down to the lowest geographical unit, which is the school district level. However, they do not project the population development on this level. Trondheim municipality uses a specific and developed software model for prognoses for school district level. This model is KOMPAS and uses raw statistics from SSB along with internal municipality plans. The fundamental theory behind the model is the cohort-component method, which is the most used method in population projection in our time.

The cohort-component method divides the population into birth groups (age and gender); most common cohorts are one- and five-year groups. This allows demographers to account for different mortality, fertility and migration rates for different age groups. In figure 5, an overview of the cohort-component model process presented. The starting point of this process is the *lunch-year population*, which is the population at the beginning of the projection for each birth group. The first step is to calculate the *"Survived" population*, the number of persons living in the end of the projection period. These calculations are based on the mortality rate; different rate is applied for each birth. The next step is the *projected migration*, where the in-, out- and net- migration rates of each birth group is calculated to see how the movement of people for each birth group will behave in the projection time horizon. The third step *childbearing age population* is the calculation of births in the projection lifetime; the fertility rate is applied to compute "*survived" Births* for each birth group. The total births will then be added to the rest of the population in the final stage, *projected population (Siegel & Swanson, 2004).*

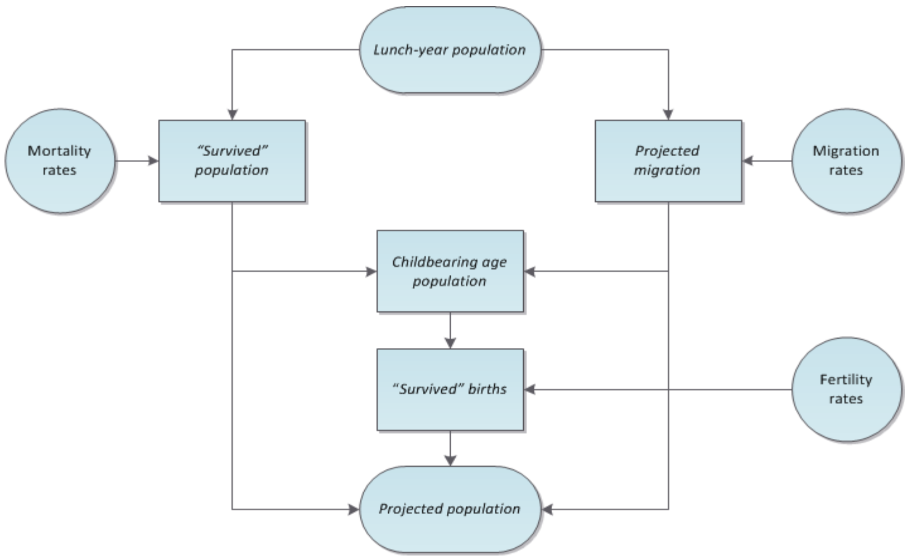

Figure 5: Overview of the cohort method
Source:(Smith, Tayman, & Swanson, 2001, p. 47)

The forecasts of passenger travel demand are obtained from its attachments to the KVU report prepared by the NNRA and NPRA. The model used is a regional transport modeling software (RTM – version 2.1.111), projected and controlled by transport agencies on behalf of the MoT.

3. TRANSPORT MODELING

The purpose of this chapter is to give an insight in the development of transport planning models, based on the four-stage model, such as the RTM and it's background, structure considering data, critics and research done, to provide a basis for understanding the figures and choice of locations accessible in this report.

3.1 Transport Planning Models

Through decades of population growth and technology evolving, the transport community (tend to) is still struggling to engineer sustainable transport systems that are built to meet current and future development. Despite the fact that financial support is the largest and last contributor in the game of deciding where, when and how a transport network should be constructed, there are a numerous and well develop mathematical models to help decision makers in the process. Ortúzar & Willumsen stated:

> *A model is a simplified representation of a part of the real world-the system of interest-which focuses on certain elements considered important from a particular point of view. Models are, therefore, problem and viewpoint specific.*
> *(Ortúzar & Willumsen, 2011, p. 2)*

With other words, the model shows us only and exactly what it is designed to show. A mathematical model does base a common ground and a reference for discussion around the critical process of decision-making. These types of models are composed of a number of equations to render relationships in the transportation market, provided by the supply and demand in the market (Tørset, 2005).

Today, nearly all transport planning models (TPM's), have their origin from the so-called classic four-stage (sequential) aggregate model described in Modelling Transport (Ortúzar & Willumsen, 2011). Theory and the structure originally developed in the United Stated in the 1950's, and it has been improved and changed ever since. The model consists of four sequential linked submodels:

1. *Trip generation*: determine the frequency associated within a zone.
2. *Distribution*: determine trips between each pair of zones in the study of area.
3. *Modal split*: the number of trips by each mode of transport.
4. *Trip assignment*: the route to allocate by origin and destination.

The data is mainly collected for zones, but the model is carried out for the city as a whole. It is adjacent to confirm that it will deviate to some extent considering the decision process (Banister, 2002).

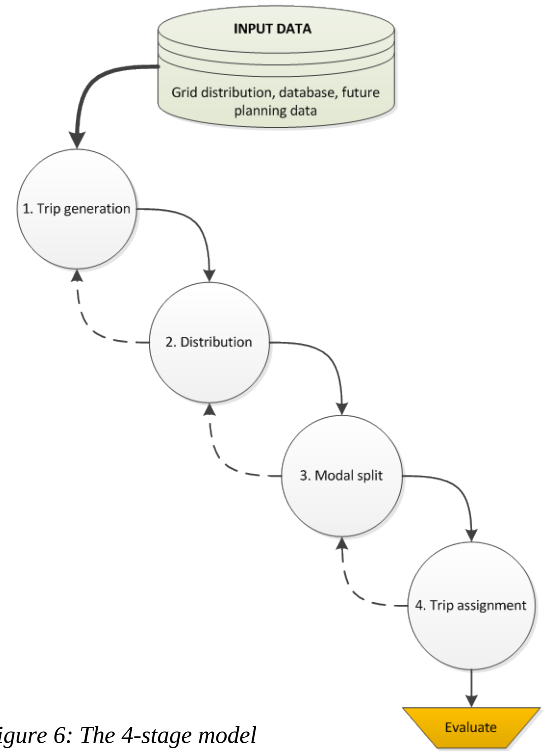

Figure 6: The 4-stage model
Source: (Ortúzar & Willumsen, 2011, p. 21)

As illustrated in figure 6, the output from one submodel is the input to the next hence the *sequential* four-stage model. All information of what concerns the input data is of course free to edit for each manager. Such input contains information about location of facilities, about transport networks for given areas, about households, future population growth and plans of area development.

Final output draws a picture of the represented transport system and provides a handful of facts for managers to use in their choice of measures. The transport network, as the world expands, becomes more and more essential as a «press release vale» in the welfare of nations. Underestimated resources and capabilities of transport handling can compared with an athlete doing exercises with less access to oxygen. The athlete will most likely experience muscle stiffening of lactic acid and eventually get cramps, not able to fulfill the whole sequence of exercises. Same issues will be the result of an inadequate transport system related to freight and public transportation delay to a major cost on behalf of the society.

The four-stage model is, without doubt, one of the most used and therefor on of the most criticized model out there, as further theories describes later on in this paper.

3.2 Regional Transport Model

The Norwegian Regional Transport Model (RTM), used to estimate travel demand in the KVU, has its origin back to 2001 through the work with the National Transport Plan (NTP) 2002-2011. It became clear that existing models were insufficient and a lack of acceptable mathematical methods for pattern and travel demand at journeys in the interval of 0-100 km. As mentioned in chapter 1.1, the transport agencies NPRA, NNRA, Norwegian Coastal Administration (NCA) and AVINOR (the Norwegian airport network operator) agreed to establish a joint project to upgrade and develop new models in content of regional transport behavior (Tørset, Malmin, Ness, Abrahamsen, & Kleven, 2008). Despite the above-mentioned facts, it is not incorrect to claim that the model builds upon older matrixes on former Norwegian models, such as the climate model and TP10 model of Norway's largest cities from late 80's early 90's (Econ, 2009). Common denominator of these models is the old and out-of-date based technology, which led to the need for modernizing.

Some of the most critical inputs in the RTM model are the intricate qualitative data collected from the survey RVU – 2001 (behavior of travel study done in 2001), a Stated Preference method[5]. RVU – 2001 was the 4th nationwide survey performed to allocate the Norwegians travel behavior in all aspects. It covers the scope of people's journeys, why journeys are performed, how it is performed and how the travelling activities may vary within divers groups of the population. All this data collected through telephone interviews was done so it is possible for researchers to state how people are behavior of travel changes through fluctuations in frameworks (Denstadli & Hjorthol, 2002).

Nevertheless, what concerns the RTM - model and its main objective, is to calculate and simulate the amount for short personal journeys under 100 km within the five defined regions of Norway. Møre and Romsdal, Sør-Trøndelag and Nord-Trøndelag are located in the middle region. In total, there are 13.500 zones within in the five regions related to SSB's statistics at low geographical level.

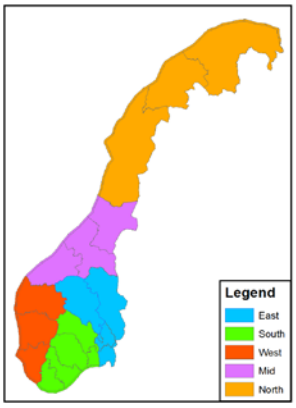

Figure 7: Regions defined in the RTM model

[5] Stated preference methods refers to a family of techniques which use individual respondents statements about their preferences in a set of transport options to estimate utility functions. The options are typically descriptions of transport situations or contexts constructed by the researcher. The methods require purpose-designed surveys for their collection of data (Kroes & Sheldon, 1988, p. 11).

As stated in chapter 3.1, the RTM likewise many others are based on the four-stage model. The calculation of traffic demand is done for one period of time (24 hours) over one working day through a year, but all calculations for each step are done simultaneously (Econ, 2009). However, not all observation was included in the mathematical matrix from the RVU - 2001, such as travelers under 13 (but students going to school are included in a separate school model), foreigners journeys in Norway, domestics journeys done by Norwegians when leaving the country and journeys with one or more nights. Figure 8 illustrate a simplified overview of the development and inputs of data.

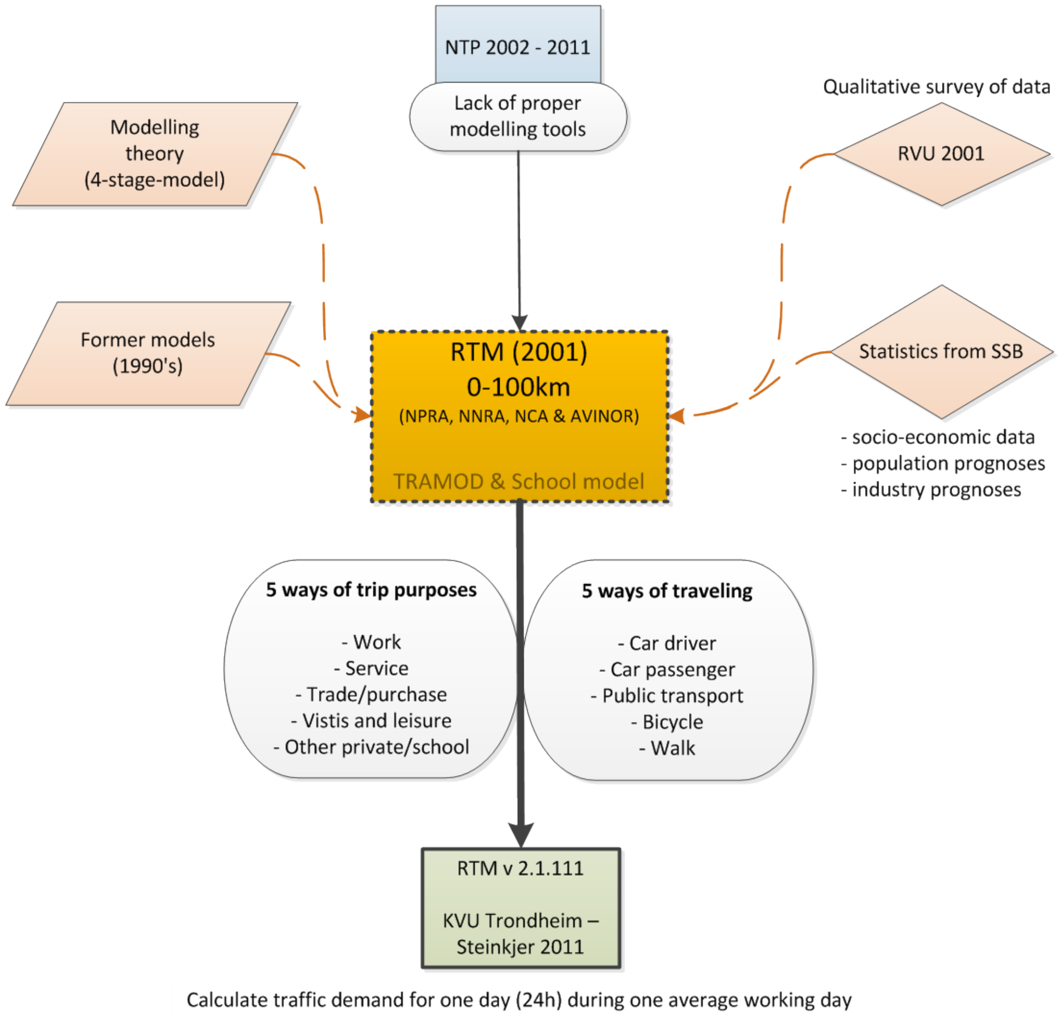

Figure 8: Overview of RTM

Three main steps of calculation in RTM
1. Transport networks and LoS data
2. Demand and rout matrices
3. Grid distribution

(NNRA & NPRA, 2011)

Integrated models in the RTM:

- The school and university travel model
- The TRAMOD demand model

(Tørset et al., 2008)

TØI/Møreforskning-Molde[6] had the responsibility of the demand model (TRAMOD) and SINTEF[7] calculated the detailed LoS[8] - data and established the language of coding into the CUBE – script and each transport agency introduced their coding of the infrastructure related to each sector of public transport such as road, sea and train (Econ, 2009).

The elemental idea of the TRAMOD model is to map out the load of average traffic (24h) on a regular workday conducted at short personal journeys across the country. Since the behavior of travel is consistently equal, at least the philosophy behind it, there is none or little geographical inequalities in how the TRAMOD model is coded considering the diverse regions. The core elements of the TRAMOD consists of two sets, each covering 5 models of travel of purpose and 5 models of transport mode as illustrated in figure 8.

As mentioned before, these models are performed simultaneously (logit-modelling[9]), not sequentially, deviating from the classic four-stage modeling principle. Another fact of significance to have in mind, is the output data generated from the RVU – 2001 considering the use of public transport, only illustrates the flow in-between the rush-hours (Larsen & Løkketangen, 2009).

[6] Corporation established in 2002 between academic institutions in Molde city.

[7] The largest multi-disciplinary and independent research organization in Scandinavia.

[8] Describe the cost and disadvantages, associated with travelling through all zones with all modes of transport. It is essential to clarify the current transport network and rules of route choice for calculation of LoS – data (Tørset et al., 2008).

[9] Multinomial logistic regression predict the probabilities of diverse possible outcomes of a categorical distributed dependent variable, based on properties related to the choice of opportunities and characteristics of the decision maker (Tørset, 2005).

3.3 *Transport Modeling Criticism*

It is well known that "modeling is modeling", and to use data as arguments in the process of discussing solutions are certainly demanding a high level of accuracy compared to actual observed data. Not only to achieve satisfactory results, but as well as making a decent reputation of the transport planning society.

Tørset (2005) discuss the lack of direct evaluations of the Norwegian transport modeling models (TPM's) and about her choice of criticisms linked to former and old model. Even though reports and case studies are conducted in the light of "analyze", the results and main critics are mainly an escapade from the work of study. An explanation could be the moderate interferer by outsiders to participating in the debate, and as a result (of many) could be the daunting impression the expertise as engineers, economists and other experts emit to the surrounding environments.

Nevertheless, it seems to be a general view in the academic cluster of transport planning worldwide, that little or nothing, of changes and optimizations took place in the 1970 - 1980 century. However, since the late 90's and to current date there have been a renaissance according to David Banister (2002), Professor of Transport Planning at University College London. He claims there has been a political and public concern, for the first time, in how transport planning has been carried out. The increasing interests of transport planning are likely to be tight connected with the indirect impact of industrial development, and the quest of increased competitiveness and rapid manufacturing. With other words, a better transportation system provides more profit and surplus of the income. Further, he provides a theory concluding that the rigid and logical approach in the four-stage model is its weakness and strength at the same time. The strength of the model seems to be linked together with the logical way of handling the data and the representations of information which decisions are based on. At the same time, it is also the weakness or limitation of the model. The framework, as it is stated in the name, will never be able to cover all sides or possibilities when the work is given within a certain frame of act. In some situations, it will be more of a restriction like a straitjacket.

> *The TPM is empirically based and designed to predict travel on the basis of establishing relationships that link travel with socio-economic and other variables. This positivistic approach is data driven and makes no attempt at understanding the behavior of people. (Banister, 2002, p. 132)*

The statement is more or less "backed up" of what concerns the structure of the TPM's if compared with the extensive field study done by Oskar Fröidh on the Svealand line in Sweden - *A study of the effects of the Svealand line on the travel market, behavior and accessibility (2003).* Regardless of the dependent variables, the amount of travelers substantial increased after the introduction of the new transport of supply with higher frequent train departures. However, it seems it is easier for motorists to change the transport of mode when the service of public transport supply has changed to the better than it is for public using the bus. Public using buses will to some degree still travel by bus if too many changes occur on the route of choice. This emphasizes the importance of locating train stations and stops in proximity to residential areas, industry and other vital destination such as airports and hospitals.

Other research projects in Sweden address the critical factor of underestimate the developments when positive major changes are conducted in the supply. The study by Fröidh proves, more or less, that giving the right picture of travelling changes has to be performed by several methods in collaboration of each other. One model or one method cannot single-handedly forecast the variable changes and their magnitude, and he suggests a combination of aggregated statistics and qualitative surveys of those who travel, to obtain the best overview when changes occur (Fröidh, 2003).

In Norway, there is apparent that uncertainty analyses and critical point of view regarding data created in the Norwegian transport models, has received little or none attention to the table. Why this occur could be explained by the size and complexity that the models generated in the term of work. With other words, the engineers and people behind the comprehensive models are in lack of capacity, using all necessary resources to validate the input of data. An additional or maybe the most vital reason could be the lack of basic and complete understanding of the purpose to the model for the end user, and the time to deliver within the deadline. Further experiences do show the difficulty to retain skilled professionals within the demand and transport-modeling cluster. If no firms continuously working with the subject, they will never be able to produce a complete and fulfilled system, covering all aspects of the real-world-model (Econ, 2009).

Considering the RTM and its lack of additional data, there is an uncertainty related to the input of data, logarithms in the choice of routes, weighting of time and cost. As above mentioned (Ch. 3.2), the RTM calculates traffic demand 24 hours in an average working day and the model is capacity – dependent. Further, it is based on older knowledge related to previous studies of behavior of travel and these elasticity coded. With other words, it does not change pattern of travel when high density of traffic occurs in rush hours. Models like the RTM do not take the individual point of view of greater public services into account when modeling the load of traffic. Such changes in individual impacts can be the results of new public transport stations, more parking places nearby the stations, improved density of incoming public transports to the main hub stations (busses and trams), new and more attractively vehicle of transport etc. Even though Raymond S. (Siiri, 2007) state in the Transport analyze (2007) that the RTM seems to be well suited for city transport modeling, it is key essential to have in mind the above mentioned factors which will come to play when large changes occur. Covering all outcomes of larges changes are hard to predict.

Regardless the underlying motivation for criticisms, Trude Tørset divided the critics into three categories as illustrated in the table below, in order to assess a framework usable in analysis of a model's ability to provide an accurate picture of the real world.

Table 1: Categories in evaluation of TPM's

Nr.	Description	Time to analyze
1	Model design. How is it built, how it is calculating and what is included and excluded.	Under constructions.
2	Underlying assumptions used in the model and what will be documented in the analysis of transport demand.	Under use.
3	How the results from the model is applied.	After calculations.

Source: (Tørset, 2005)

Further she claims that several changes in the RTM or general transportation planning models can be done without influence the main principles of the order of the calculation. Such changes of new informative subjective categories can be work, attractiveness and the supply of parking capacity related to job. What the models do not show or illustrate to this point of time is the activity-based pattern of people's daily life. Tørset clarifies through her thesis that it is possible to implement a more activity-based approach where the point of base is generated out of the framework specific correlated to each person within a household.

The outcome is a more connected and integrated management of public services through detailed analysis of the localization of diverse activities, such as management of areal allocations and transport networks to be optimized to a further distinct. However, the activity-based approach requires an enormous effort of additional work and planning to be fulfilled and ready for use.

4. POPULATION MODELING

This chapter describes the KOMPAS[10] demography model, which municipalities throughout Norway uses to project the future population in their region on a low geographical level.

4.1. Population Projection

Population *projection*, *-forecast* and *-estimation* are frequently used by demographers, referring to population growth. The differentiations of these terms are not always straightforward. The term population *estimate* is generally used when referring to known population in the past or present. On the other hand, when demographers are referring to the future population the *forecast* or *projection* is used. These two terms are often seen as a synonymous, but there is a distinguished definition between them. In this report, the projection is defined as a mathematical calculation of the future population, while the definition for the forecast is the selected projection, which is most likely to resemble the future.

Population projection is an essential tool for planning future needs in the public and the private sector. It can raise the understanding of change in population size and provide statistics for future scenarios. Population projection plays an essential role in the process of decision-making and helps users to adjust an informed choice.

There are available varieties of methods to predicting the future population both quantitative and qualitative. For decades, demographers have used the cohort-component method to develop population projections. This quantitative approach was introduced by Cannan in 1985, and since then it has been a continuously evolving in the subject. However, the basic frameworks have changed little since Whelpton revived it in 1928. As we know today, it is one of the most used methods in population projection of what concerns modeling at a national level (Siegel & Swanson, 2004).

The popularity of the cohort-component method is mainly due to its simplicity, practicality and it use of available data and pre-existing theoretical knowledge. However, the collection of data and the development of assumptions for each of the components used in the method are much more complicated.

[10] Norwegian population projection model owned and developed by COWI AS. Approximately 60 municipalities in Norway use this model to project the population in their urban areas.

4.2 KOMPAS Model

KOMPAS is an acronym for municipality planning and analysis system. It was developed in 1993 from a SINTEF mainframe solution owned by the KDØ (Kommune datasentral Øst Norge), to assist managers in a different municipality to project the future population. The KOMPAS model takes into account the population, buildings and migration on a low geographical level with the fertility, mortality and migration rate respectively of each population group. The migration uses the future level of housing divided with building types in a specific zone to define the migration rates. The user has the possibility to make own population projections to urban areas which are defined by the school districts by adjusting these rates and probabilities related to the demographic components. Accurate population prognoses are substantial vital for the municipality to provide a robust framework in the preparing of population growth within their region. Planning and constructing the infrastructure needed such as schools, kindergartens, houses, etc. can be some of the available measures to apply. (COWI, 2012)

The figure 9 illustrates the general processes of population projection in KOMPAS. The first step is to analyze the *current public service* available, then annual statistics of population, migration and buildings gather from raw statistics, plan assumption or results from previous project stage are applied to the model. The input statistics are *physical data*, the statistic of a given date, or *change data*, the statistic change between two points in a time. The next step is the *population prognosis* where KOMPAS processes the set of mathematical rules. The *results* are then analyzed and can be used, e.g. to estimate the capacity of public schools within a given area. This option provides municipalities an improved set of data considering the scope of long- and short-term decisions of *future public service* (COWI, 2012).

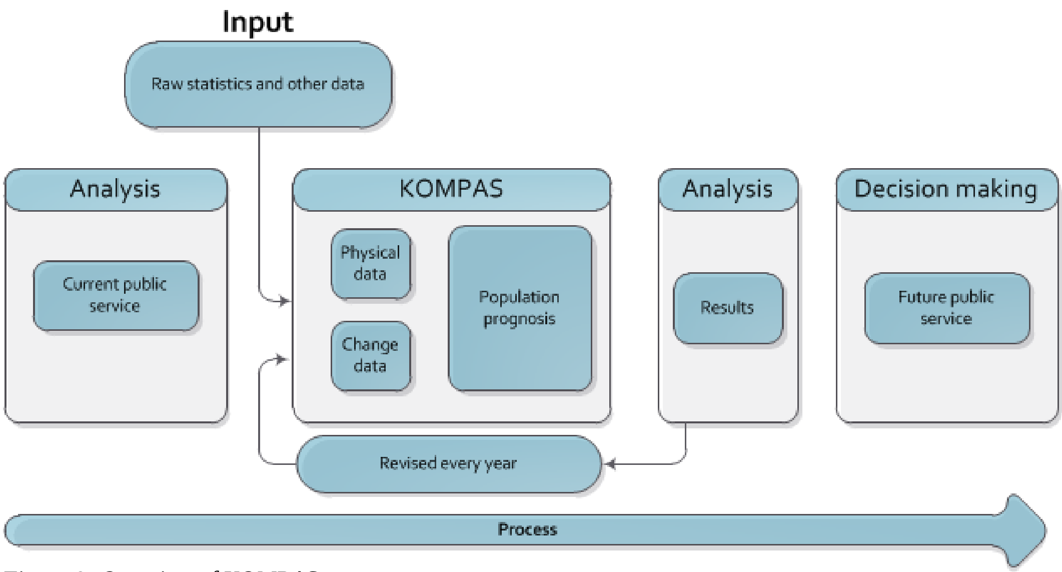

Figure 9: Overview of KOMPAS
Source: (COWI, 2012)

Prognosis results from KOMPAS are reviewed annually with the new statistics from SSB. An example of data used in a KOMPAS model for Trondheim prognoses done in 2011, is outlined in the table below.

Table 2: Data used in KOMPAS

KOMPAS 2012-2040 (MH2011)
– Residential buildings condition from June - September 2011
– Combines fertility and mortality rate for 2011 from SSB
– Net migration, adjusted to medium national growth (MMMM)[11] for population projection from SSB.
– No migration for inhabitants over 80 years old.
– Residential buildings constructions are divided after municipality to pursue the population growth from 1999-2008 for each municipality, housing budget for 2011- 2019 and the total growth in the MMMM alternative from SSB.
– The distribution of population growth is prepared according to the internal municipal area plan (IKAP), with some adjustments.

The input of data fluctuates between users based and the user owns determination of rates and probabilities linked to the demographic components. Large municipalities with high capability of resources will normally have the option to contribute with a higher density of data. The effect results in a greater precision of forecasts. The impact has led to an establishment of joint venture of population projecting between municipalities for better resource management. An example to this collaboration is the Trondheimsregionen, which is a cooperative body between following municipalities.

Table 3: Trondheimsregionen

		Municipalities		
Malvik	Stjørdal	Melhus	Skaun	Midtre Gauldal
Orkdal	Rissa	┐ ksvik	Klæbu	Trondheim[12]

The collaboration's main goal is to be the future leading region within research, education, business, culture and service provided to the public. There exist mutual objectives for land, industrial and commercial development in the region to support the common goal. These aims are developed by IKAP, the internal municipal area plan and a strategic business plan (Trondheimregionen, 2008).

[11] The alternative which assumes the medium level for fertility, life expectancy, inter-municipal migration and immigration (SSB, 2012a).

[12] Sør-Trøndelag County is a member of this collaboration.

5. MARKET POTENTIAL

The objective of this section is to provide quantitative data of the current situation and potential in the corridor of Trønderbanen. The scope of technical interest is to the circumstances concentrated around the population projection, tickets and commuter's statistics, and data from the regional transportation model. The outlook of time extends from 2012 to 2040, on an overall aspect, on the other hand the population projection for the low geographical level is 2012-2024. The structure of this chapter begins with an overview of Trønderbanen followed by detailed analysis presented for Ranheim and Bjørndalen.

5.1 *Trønderbanen*

Trønderbanen passes through nine municipalities. The population size ranges from couple of thousands to approximately 200.000 inhabitants. The prevalent is Trondheim, which is the third largest city in Norway. Trondheim is by far the largest municipality in its region compared to others in the district. It is eight times larger than Stjørdal, the second largest municipality. As illustrated in the figure below, the current dominant market is between Trondheim and Steinkjer. Meråkerbanen, which curls to east from Stjørdal/Hell to Storlien, as well as the area south of Støren and north of Steinkjer, will not be analyzed further due to the scope of the project.

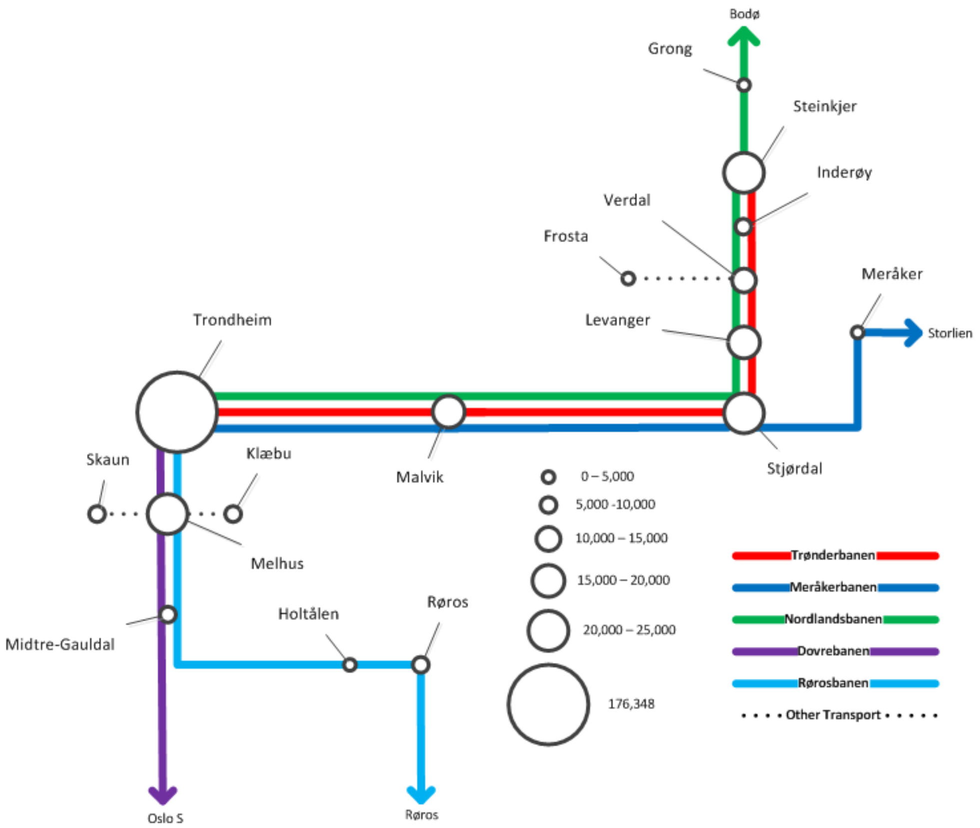

Figure 10: Overview of railway lines and population in Sør- &Nord-Trøndelag

5.1.1 *Population Estimation & Projection*

Table 4, illustrates an increase in the potential market share in the corridor of Trønderbanen. An exponential increase is anticipated to take place at Stjørdal as well as Melhus. On the other hand, Steinkjer has a relative low expected increase and positioning Levanger as the third largest municipality in 2040 measured by inhabitants.

Table 4: SSB statistics of current & projected population

Municipalities	Inhabitants $_{(2012)}$	Inhabitants $_{(2040)}$	Increase
Stjørdal	22 058	31 417	42 %
Melhus	15 392	21 142	37 %
Trondheim	176 348	227 670	29 %
Levanger	18 922	23 890	26 %
Malvik	12 785	15 931	25 %
Verdal	14 387	17 330	20 %
Steinkjer	21 303	22 959	8 %

Source: (SSB, 2012d)

The data indicates the medium/average index of increases in the most interesting municipalities. The largest are Stjørdal (42%), Melhus (37%) and Trondheim (29%) while Trondheim area expects the major growth, with an increase of 51.300 inhabitants. If assumed an equal annual distribution through 28 years, it will be a static increase of 1.800 each year in Trondheim. The table excludes Inderøy (6.700) and Midtre Gauldal (6.300) due of their trivial contribution of the total picture.

Trondheim municipality does a comprehensive, low geographical projection every year with the KOMPAS model. The model uses population estimation statistic conducted by SSB as the basis for the simulation. The table below presents the projected population for 2040.

Table 5: KOMPAS population projection

Municipalities	Inhabitants $_{(2040)}$	Increase
Stjørdal	30 629	39 %
Trondheim	239 398	36 %
Malvik	17 329	36 %
Melhus	19 415	26 %

Source: (Relling & Eiksund, 2011)

The results deviate to a certain extent from the statistics by SSB. One reason is, most likely, the more detailed information, which municipalities possess regarding plans, school areas, etc. However, these projections, undoubtedly, emphasize that a vast increase in population will occur, both in Trondheim and in municipalities nearby. Trondheim is and will probable still be the leading industrial cluster in the region for an extensive period. Consequently increase of the traffic will lead to inefficient transport infrastructure and the current structure of the network is not capable of handle this intensification.

5.1.2 Traffic Analysis

This chapter aims to describe and provide an overview of different traffic elements of current- and estimated statistics linked to Trønderbanen as a whole. Elements and data studied are, on/off flow of passengers, ticket statistics, data estimated by the regional transport model, commuter's car statistics and the roles of the trains to play in a dynamic shifting market.

Flow of Passengers

The overall travelling statistics presented in figure 11, are based on the statistical data from a report on the station structure by NNRA (Rørslett, 2012). Stations illustrated are those belonging to the definition of Trønderbanen (chapter 1.3). The on/off passenger statistics is originally expressed per day. The figures are multiplied with 300 days (NSB's definition of numbers of days in one year due to low volume in weekends) to represent the flow of one year. The aggregated sum is 3 million.

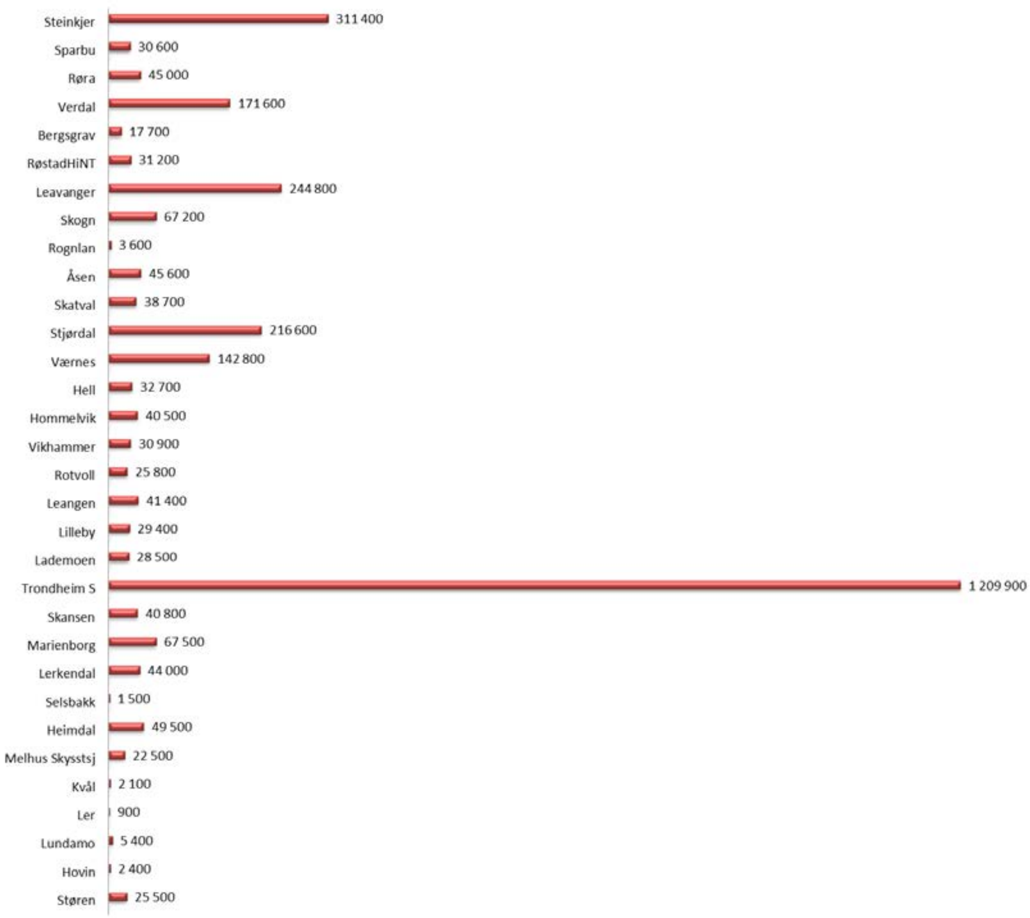

Figure 11: Aggregated statistics from on/off passenger
Source: (Rørslett, 2012)

The graph provides an overview considering the flow of goods, or people in this case associated with each station. Available data creates an accessible base of decisions needed in evaluation of further development of stations, especial for NNRA.

It is essential to emphasize that the statistics do not represents the exact amount of passengers purchasing tickets, since the possibility of counting one passenger twice is prominent. Other influencing factors are as well as present, such as transfers from regional axes (Dovrebanen and Rørosbanen in the south and Nordlandsbanen in north) and the aggregated errors conducted by those in position while observing.

Trondheim, Steinkjer, Levanger, Stjørdal, Verdal and Værnes are the stations with the highest frequency of on/off traffic. The obvious result leads to the divergent distribution between north and south of Trondheim. It can explicit be described by the proximity of larger cities and more urban areas in the northern region. However, several other external factors are contributing to the scattering and it is inevitable to forget the significant impact of trade and logistics through the maritime part compared to the inland south of Trondheim. The market density of settlements south of Støren is rather dispersed and at places quite low before Lillehammer.

Tickets Statistics

NSB transported 1.130.000 passengers on the local railway network according to their statistics of sold tickets in 2006, see table 6. As noticeable, the table withdraws the regional axes, in order to obtain a more accurate picture of the local market in region of Trondheim. Three pendulum sections are included:

- Steinkjer – Trondheim 88 % of total
- Trondheim – Støren – Røros 10 % of total
- Trondheim – Støren – Oppdal 2 % of total

NSB determined three types of travelers:

- Commuters and Students 70 % of total
- Vacation 20 % of total
- Business trips 10 % of total

If the figures of Røros, Holtålen and Oppdal are withdrawn, the total drops to 1.082.547 passengers between Steinkjer and Støren. The amount of free tickets, season tickets, kids fewer than four, etc. relates to the reliability of correct figures. However, it is recognized as one of the best measures available despite the age allowing it to be used as a reference point of further analyze.

Table 6: Passenger traffic from sold tickets

	Røros	Holt.	Oppdal	Støren	Trond-heim	Malvik	Stjørdal	Levanger	Verdal	Steinkjer	TOT from	TOT to
Røros	16	547	107	858	14 578	84	603	290	173	551	17 807	20 088
Holtålen	481	268	34	348	3 461	16	185	161	24	139	5 117	7 433
Oppdal	52	6	1 618	777	18 021	68	1 576	826	324	1 038	24 306	26 503
Støren	984	505	791	925	23 083	20	949	440	225	643	28 565	30 495
Trondheim	16 888	5 432	20 532	24 528	3 740	15 935	123 682	60 738	28 751	62 530	362 756	364 559
Malvik	54	18	68	14	15 388	281	1 542	1 613	225	601	19 804	22 159
Stjørdal	549	247	1 144	1 106	136 639	2 015	5 143	28 795	11 941	32 213	219 792	207 127
Levanger	292	171	800	754	62 120	2 119	28 127	26 117	22 851	47 760	191 111	186 864
Verdal	163	58	374	326	26 344	346	11 392	19 645	2 772	21 272	82 692	92 025
Steinkjer	609	181	1 035	859	61 185	1 275	33 928	48 239	24 739	5 777	177 827	172 524
TOT	20 088	7 433	26 503	30 495	364 559	22 159	207 127	186 864	92 025	172 524	1 129 777	1 129 777

Source: (Siiri, 2007)

SSB Statistics

Statistics Norway provides figures of domestic's transportation calculations. The statistics was collected after the companies operating at the Norwegian railway infrastructure answered forms. Any commercial rail transport including any privately owned, are included in the statistics. Tramways and suburban railways are not covered by the regulation (SSB, 2009). However, NSB is the only operator of passenger traffic at Trønderbanen. Following figures are available from the statistics.

Table 7: On/entering passenger's statistics

	2010	**2011**
Local train-Trondheim	1 079 290	1 039 075
Regional train- Nordlandsbanen	453 496	454 602

Source:(SSB, 2012f)

As illustrated from the table, there is decrease from 2010 to 2011 of 40.215 "on/entering" passengers on the local train service. While Nordlandsbanen (Trondheim – Bodø) experience an increase of 1.106 passengers from Trondheim to Bodø.

The term "on/entering" refers to one person or one unit in the terminology of statistics and as one passenger at the colloquially (Sønstebø, 2012).

Comparison

Table 8 lists the comparisons of the statistics provided by these three sources. The total figure of passengers on/off is divided by two to prevent overlap, based on assumed symmetry of transport behavior, and are named “on/passengers”. Røros, Holtålen and Oppdal are excluded from the sold tickets statistic to match the on data from NNRA and the RTM model.

Table 8: Comparisons of train passenger’s statistics

	2006	**2010**	**2011**	**2012**
NSB - Ticket statistic	1 082 547			
SSB – Local train		1 079 290	1 039 075	
SSB – Regional		453 496	454 602	
NNRA - On/passengers				1 534 000

The period is 6 years. However, the major difference can be found from the report delivered by the NNRA (Rørslett, 2012). The figures, as mentioned earlier, represent total passengers entering a train between Støren and Steinkjer. The difference can be described by no separation of passenger’s destination of goal. One passenger at Trondheim can be included in the statistics even she or he has Bodø as the final destination classified as a regional travel.

Second uncertainties are the numbers published by SSB (local train) from 2010 and 2011. Because of some administrative issues, it is uncertain if the data contain figures of Røros, Holtålen and Oppdal. However, NSB is the owner of the numbers sent to SSB and it is likely to trust the possibility that these figures matching the same axes and stations.

The differentiations of the dataset can occur by several other sources as well. It could be mathematical uncertainty related to the flattening of the distribution while counting, actual increased numbers of travelers over two years, passengers counted but did not paid for ticket, free tickets, season tickets and kids under four.

However, in the proposal to the National Transport Plan 2014 – 2023, NSB expressed that their main market of personnel traffic is located north of Trondheim with 1.200.000 passengers per year. The final conclusion may be, after all, that the figures are matching if considering the ticket statistics, elapsed time with expected increase and influencing factors that come to play when studying the high figures by the NNRA report.

RTM Modeling

At the time when the modeling took place in 2007, the RTM model did not have its own algorithm of simulate passengers back and forth between Trondheim and Værnes airport, and it did not have the behavioral algorithms for students using the train. These parameters were added to the results as "weighted" data.

Following main numbers, after calibration and weighting, were projected in 2007.

Table 9: Passenger numbers from RTM

Stretch	Basis 2006	Basis 2014	Alt. 0	Alt. 1B-el	Alt. 2B
Steinkjer-Lerkendal	880 000	1 048 000	1 087 000	1 459 000	1 195 000
Støren-Trondheim	90 000	91 000	91 000	92 000	998 000
Estimated Værnes Airport	115 000	135 000	140 000	185 000	428 000
Støren-Trondheim	90 000	91 000	91 000	92 000	998 000
Total Local Train	**1 085 000**	**1 274 000**	**1 318 000**	**1 736 000**	**2 621 000**
Index Local Train	0,82	0,97	1,00	1,32	1,99
Total Long-Distance North	190 250	239 800	242 400	218 850	218 950
Total Routes North	1 275 250	1 513 800	1 560 400	1 954 850	2 839 950

Source: (Siiri, 2007)

Matching the results with the tickets statistics 2006 and NSB's statement in the NTP 2013 – 2023, reflects, a relatively, precise reproduction of the real world after calibrating the results of *basis 2006*. On the other hand, the *basis 2014* is an independent dataset in the model, which forms the foundation of the following alternatives. The figures linked to each alternative are the result of how it would appear in 2014 with diverse properties conceder the infrastructure (Siiri, 2007). The model structure of *alternative 0* has the identical network of railway structure as the year 2006, except with the new Gjevingåstunnel which was opened in 2011. The result of "Total Local Train" in *alternative 0* is 1.318.000 passengers which correspond, more or less, with the expected future increase and the current statement of 1.200.00 passengers by NSB in 2012.

The most relevant alternatives for further concepts proposals are alternatives *1B-el* and *2B*[13].

- *Alternative 1B-el* covers the simulations and performance associated to the electrification of the corridor between Trondheim – Steinkjer, a new tunnel through Forbordsfjellet (9,5 km), establishment of Ranheim station, a new bridge over Stjørdal river and a new design of the railway structure at Hell – Værnes. Total quantity of passengers, if improvements implemented in 2014, are 1.736.000 between Støren – Trondheim – Steinkjer.

- *Alternative 2B* covers the establishment of double railway tracks from Trondheim to Stjørdal, two new stations located at Ranheim and Bjørndalen and all of the improvements as stated in *alternative 1B-el*. The total number of passengers in 2014, if improvements are implemented, is estimated to be 2.621.000 with a

[13] All the alternatives are described in Appendix I.

considerable growth of passengers to and from the airport, in addition on the southern stretch to and from Støren.

The figures of *Estimated Værnes Airport* in table 9, is founded on the Masterplan framework by AVINOR. The Masterplan contains three different scenarios of passenger growth, *high*, *reference* (medium), and *low*. Specifications in the Masterplan describe the principle of using the high volume scenario when future decisions within construction and area disposal has to be made, in order to be able to meet the market increase.

Table 10 illustrates the variation between numbers estimated (medium/reference) of total air passengers and the actual numbers from AVINOR's statistics logged in 2007, 2010 and 2012. The information includes scheduled and charter traffic, both domestic, international and transits. The projected numbers in 2007 and 2010 originally derived from a RVU conducted by Institute of Transport Economics (TØI). However, the survey took place at Gardemoen and illustrated insufficient figures, which was later on re-adjusted and weighted.

Table 10: Flight passengers after weighting

	2007	2010	2012	2015	2020	2030	2040
a) AVINOR stat	3 406 281	3 518 314	4 mill[14]				
b) Prognosis *reference*	3 392 007	3 262 010		3 630 000	4 090 000	4 700 000	5 400 000
c) Difference	-14 274	256 304					
3 % of AVINOR stat	102 188	105 549	120 000				

Source: (AVINOR, 2011; Siiri, 2007)

Castoff *b) – reference* of year 2007 appeared to be spot on compared with *a) –AVINOR* for the same period. The gap in 2010 was 256.304 more air passengers than the self-weighted statistic. The next table displays the weighted distribution by travel of mode to and from Værnes airport from various areas. Label *Cars*; include data of parked-, returned-, rental-cars and cabs.

Table 11: Weighted distribution by travel of mode separated by area

	Trondheim	N-Trøndelag	Other areas	Out of Trd	Tot
Train	23 600	69 500	1 500	6 400	101 000
Bus	1 032 600	40 900	66 400	3 000	1 142 900
Cars	1 186 200	465 400	248 100	31 00	1 930 700
Other	36 800	112 000	65 100	700	214 600
Tot	**2 279 200**	**687 800**	**381 100**	**41 100**	**3 389 200**

Source: (AVINOR, 2011; Siiri, 2007)

As noticed, only 3 % of the total uses the train while 34 % bus and 57 % by car.

[14] AVINOR passed 4 million passengers Tuesday, December 4, 2012 (Ånosen, 2012).

Work-Commuters by Car

The car traffic in and out of Trondheim municipality can be related to the commuters, which live in the municipalities in the region and work in the city, or the other way around. These municipalities have a population ranging from a couple of thousand to more than 20.000. In relation to Trønderbanen, the table below summarizes the corresponding municipalities where Trønderbanen passes. There are two tables splitting the municipalities into two groups, north and south, of Trondheim city.

Table 12: Municipalities east/north of Trondheim

Municipality	Distance [Km]	Time by Car [hh:mm]	Daily commuters 2011
Malvik	20	0:24	4466
Stjørdal	33	0:32	3270
Frosta	73	1:07	119
Levanger	79	1:09	660
Verdal	89	1:16	288
Inderøy	106	1:32	163
Steinkjer	120	1:42	508

Source: (SSB, 2012c)

Table 13: Municipalities south of Trondheim

Municipality	Distance [Km]	Time by Car [hh:mm]	Daily commuters 2011
Melhus	18	0:22	4706
Klæbu	16	0:23	2238
Skaun	24	0:33	1823
Midtre Gauldal	60	1:18	561

Source: (SSB, 2012c)

Trønderbanen path does not consist of Frosta, Inderøy, Skaun and Klæbu. However, due to the associated commuters and they are considered as a park and ride passengers they are taken into account whereas these municipalities are located in an east - west direction of the railway line. The most interesting data the table resembles are the total commuter's traffic on the road to and from Trondheim. The numbers represents a great market potential in transferring these commuters to the train service at Trønderbanen.

SSB estimates the figures of daily commuters of both traveling in to Trondheim and out of Trondheim to the specific municipalities. SSB exclude students, business trips and holidays from their definition of employed persons(Siiri, 2007). Their explicit definition for *employed persons* used in their commuter's statistics is as follows:

> *Persons performing at least one hour of income-producing work during the week or day referred to, as well as persons who have this sort of work, but who were temporarily absent due to sickness, vacation, paid leave etc. Persons in the civil service and conscripts are considered employed persons.*
>
> *(SSB, 2012b)*

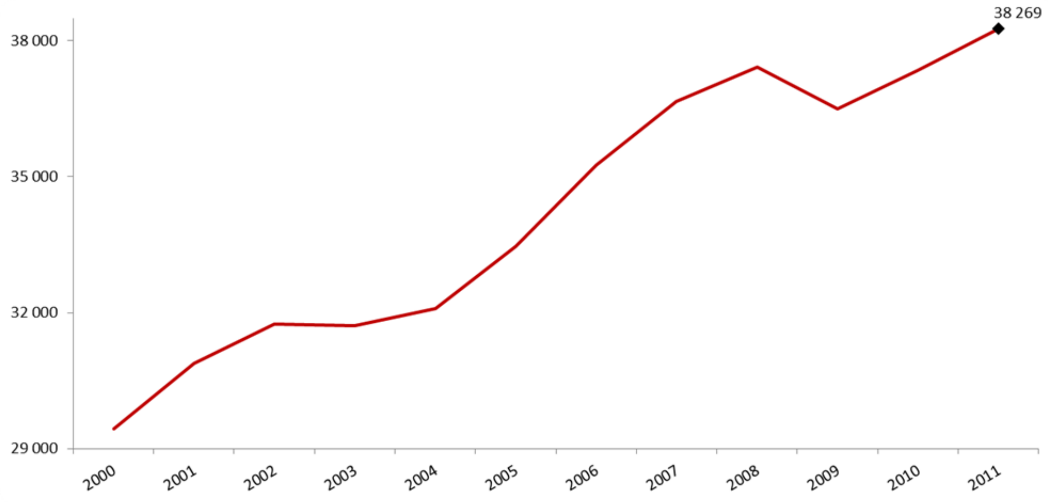

Figure 12: Commuters traffic to/from Trondheim per day
Source: (SSB, 2012c)

The statistic from SSB is a comprehensive analysis which asses all of the municipalities in Norway. The graph illustrates the growth of commuter's to and from Trondheim municipality the last 11 years.

The steep increase last decade is likely to believe continue upward for the coming years, leading to even more traffic around Trondheim in the rush hour. The future solution of commuter's traffic is not a new road infrastructure. The focus should be on changing the transportation mode by the commuters.

Capacity Expansion

An interesting element is the capacity available when a new and modern rolling stock is introduced. The current rolling stock has a capacity of 136 passengers per train set compared to 200 of the new. The results of an expected increase in daily departures combined with the 64 more seats per train set are displayed in the following table. The table assumes a 17 hours and 30 minutes operation, as today, for the new infrastructure with a 20 minutes departure interval between Trondheim and Stjørdal.

Table 14: Example of improved capacity

	Operation per day [hh:mm]	Avg. time per departure [mm:ss]	Departures per day	Capacity per train set	Tot capacity per day	Tot capacity per year*
Old	17:30	52:30	20	136	2 720	816 000
New	17:30	20:00	71	200	14 200	4 260 000

**) Multiplied with 300 due to half volume in weekends*

As noticed, the capacity expansion is up 5 times from the current situation.

Competition & Roles

The major perception of roles to play in the structure of logistic network is a synergy between train and bus. Train has the advantages of speed and comfort on long to medium-long distances linking main hubs, both personnel and freight. Bus, on the other hand, is more agile in the sense of transport in urban areas serving a network of veins to main hubs and key stations. However, new techniques of planning and technology evolution allows for fast built roads with cars and busses competing against the train in its own "backyard".

Good examples are the express buses serving the corridor between Trondheim, Heimdal and Melhus by fifteen minutes of interval in rush hour and the airbus shuttles by departures every 10 minutes from Trondheim to Værnes. In the northern corridor, Trondheim – Steinkjer (125 km), NSB provides 20 departures per day (24 h) while there is a supply of four departures by bus from Trondheim to Namsos, which is considered as an extension to the route. The competition on this axis is to some degree reduced, however, TIMEkspressen have 20 departures from Orkanger – Trondheim – Stjørdal (Midtun & Nyvold, 2012). The table below displays the time of travel between travels of mode on respective axes.

Table 15: Timetable for trains & buses

Stretch	Train [hh:mm] $_{avg}$	Bus [hh:mm] $_{avg}$
Trondheim – Steinkjer	2:06	2:20
Trondheim – Stjørdal	0:35	0:43
Trondheim – Værnes	0:33	0:50 (air bus)
Trondheim – Heimdal	0:15	0:25
Trondheim - Melhus	0:25	0:35
Trondheim - Støren	0:48	1:10

Source: (AtB, 2012; NSB, 2012b)

The current ratio of passengers using the train back and forth from Trondheim – Værnes is, as a mentioned earlier, considerable low. The potential to attain a higher market share due to the existing time of travel is well existing and with new alternatives (concepts) the time would, most likely, be reduced even more. The major challenges of today's competition are the non-corresponding departures of trains to the air traffic departures and the low frequency of trains compared to the airbus shuttles.

NSB mentioned their interest of looking into diverse options of establish new stations on three specific locations, within the city limits of Trondheim. These locations are examined with population projection on a lower geographical level. These numbers are of interest when long-term decisions have to be made. However, when projecting on a low geographical level the uncertainty becomes more significant due to the long period. Therefore, the analysis of the urban areas will be presented with the population projection in a period ranging from 2012 to 2024. The time of interval corresponds to the same period as the urban planning perspective decided by Trondheim municipality (Hansen & Harkjerr, 2012).

5.2 *Grillstad & Ranheim*

The current structure of stations at Trønderbanen has no stations between Rotvoll and Vikhammer. The length of this section is currently about 8.4 km and will be reduced to 5.9 km with the new tunnel under Hundhammeren (NNRA, 2011). Even with the new tunnel, the axis needs more or less, a new station(s) in order to serve the increasingly populated areas at Charlottenlund, Ranheim and Vikåsen. Due to the specific circumstances, this part contains a more detailed analyze of the market potential of a new station(s) in the area illustrated below.

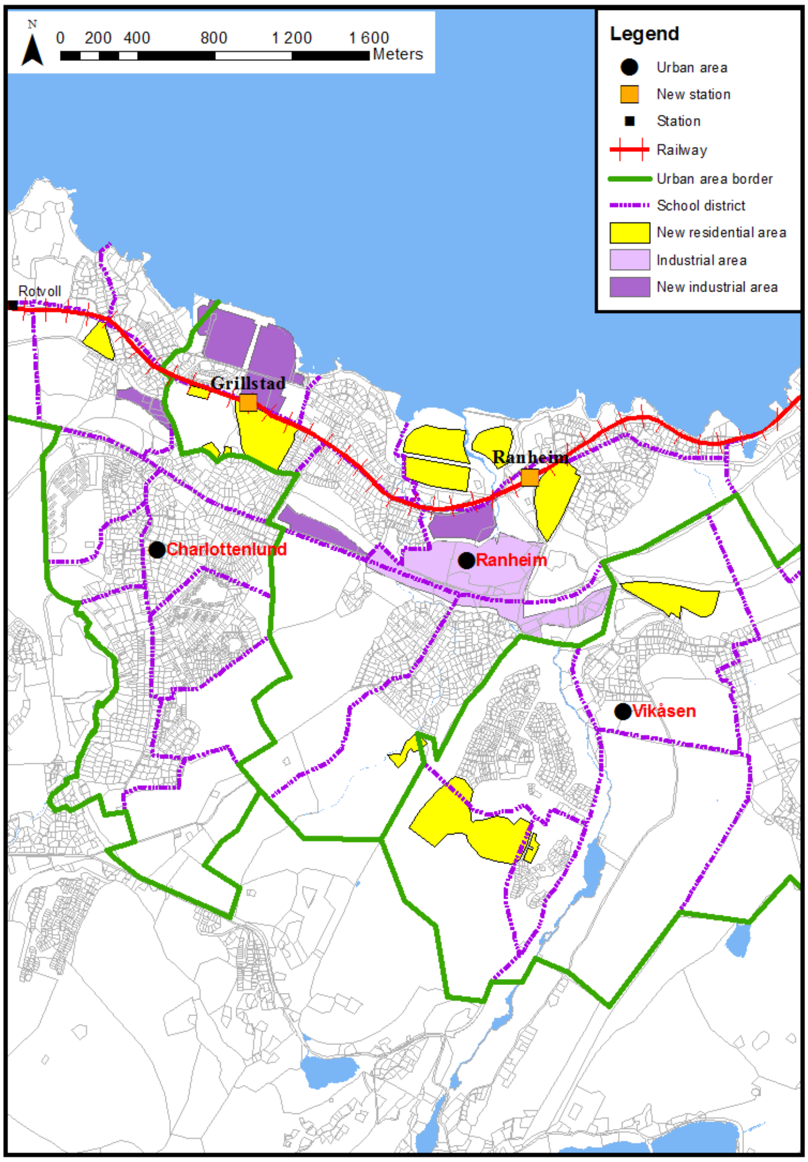

Figure 13: Overview of Ranheim & Grillstad area

5.2.1 Population Estimation & Projection

In the last decade the population increase in and around Trøndelag has been 17 %, which accounts for approximately 40.000 inhabitants and over 50 % of this increase is settled in Trondheim city (SSB, 2012d). Today, people are migrating to the outer urban areas due to the increasing residential prices. Trondheim municipality opposes to this increase by planning and regulating new residential areas further east of Trondheim, at Grillstad and Ranheim.

The City Planning Office at Trondheim municipality is responsible for planning and development of associated regions. The plans are developed over a predefined period where new residential and industrial areas are presented. The planned development in the figure above is designed on the plan for 2007 – 2012. The period is the basis of the KOMPAS model, which projects the future population of urban areas within Trondheim.

The plans related to the eastern part of Trondheim consist of a large development at Ranheim, where the population is expected to double the next 12 years. Comparing Charlottenlund and Vikåsen with Ranheim reveals a significantly lower level of future planes proposed. One of the main reasons is the maturity of the area. Charlottenlund is, more or less, fully utilized. There is expected some development in the south of Charlottenlund, at Jakobsli, but this construction is not an agenda of the current plans. The green fields around Rotvoll in the north of Charlottenlund are defined as a recreational area, corresponding to no future planned construction. However, the next stage of development, after Ranheim, is likely to believe to be Vikåsen. The following table illustrates the current population and the projected of the year 2024.

Table 16: Statistics of current & projected population at Ranheim & Grillstad area

Urban Area	Inhabitants $_{(2012)}$	Inhabitants $_{(2024)}$	Increase
Ranheim	4949	9443	91 %
Charlottenlund	6583	7136	8 %
Vikåsen	3175	3393	7 %

Source: (SSB, 2012d; Sveinung Eiksund, 2011)

With no major residential construction in Charlottenlund and Vikåsen, the increase with normal rate of migration, fertility and mortality is expected. The massive increase in Ranheim indicates the need for a better infrastructure considering public transport. A new railways station could be optimal from the market perspective. On the other hand, questions still remains whether to establish one or two stations, choice of location and the statistics of traffic.

5.2.2 Location

The overview in figure 13 shows the locations of the possible two new stations, Ranheim and Grillstad. Ranheim station is positioned where the former Ranheim station was located before it was closed for passenger trains in 1985 (Jernbaneklubb, 2007). It is reasonable to located at same spot consider the infrastructure already available. The position of Grillstad is between Rotvoll- and potential Ranheim station.

Grillstad st. is more centralized than Ranheim st. considering the total population in the area, if Charlottenlund and Jakobsli are included. However, the industrial- and sport area at Ranheim can weigh up the difference and play a key role of attracting passengers. The eventual location of Grillstad station, if established, has to be considered in parallel with the future decision-making of Rotvoll regarding the passenger traffic.

The core idea of having two stations in proximity is to serve the suburban areas south of E6, Charlottenlund, Jakobsli and Vikåsen, in order to appeal people in these areas to use the train service. The transportation infrastructure from the settlements to the stations has to be well accessible and optimized. This implies walking and bicycles paths as well as bus routes serving as a connection between the residential areas and railway stations.

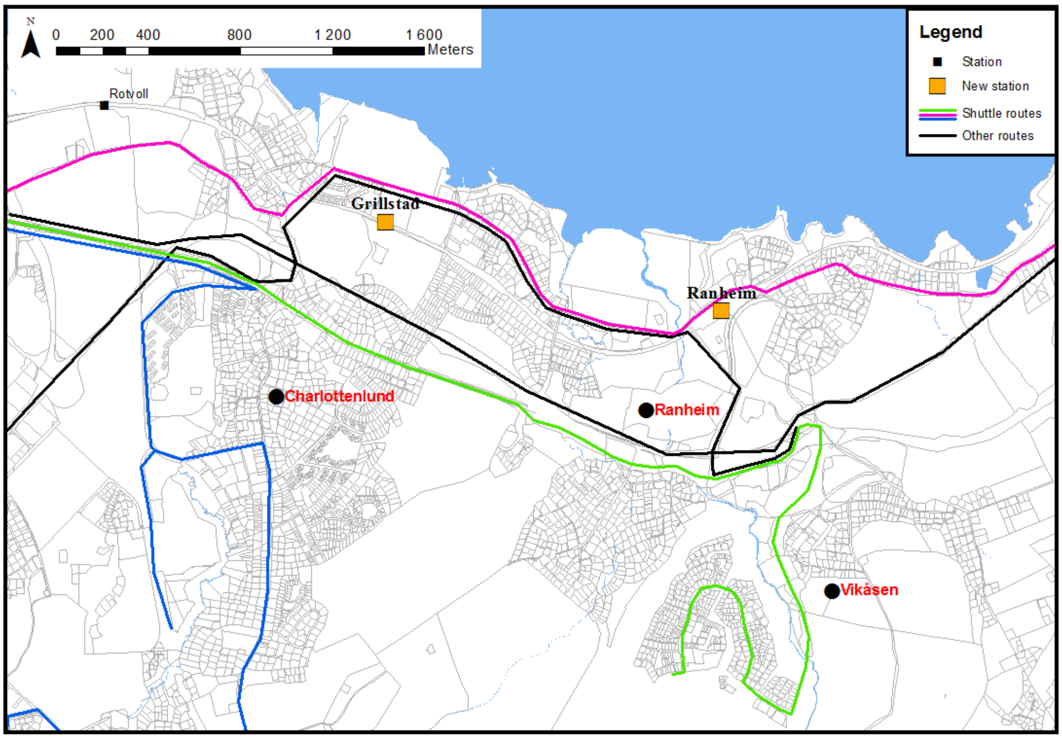

Figure 14: Overview of busses in east Trondheim

Figure 14 illustrate the current public transportation infrastructure. It shows the existing bus routes from Vikåsen and Charlottenlund, which operate on routes towards to the main road (E6) and parallel with the railway line. The only exception is *other routes*, where bus companies operates once every hour and twice during rush hours. These routes consist of few stops in order to decrease the total travelling time. The *shuttle route* has more stops and the main purpose is to transit passengers from areas drawn to the main hub, Trondheim station. The shuttle buses operate the routes with a frequency of 20 minutes and every 10 minutes throughout the rush hour. In order to grab market potential it would be essential to establish a quick and frequent structure of new shuttle routes.

5.2.3 Traffic Analysis

Currently there are eight stations operative on the axis between Trondheim – Stjørdal. The table below lists the following stations with distance from the main station, distance between stations and the passenger traffic.

Table 17: Location & traffic for stations between Trondheim & Stjørdal

	Distance from Trondheim station (km)	Distance between stations (km)	ON/OFF passengers
Trondheim S	0	-	1 209 900
Lademoen	0,94	0,94	28 500
Lilleby	1,77	0,83	29 400
Leangen	3,49	1,72	40 800
Rotvoll	4,31	0,82	25 800
Vikhammer	12,69	8,38	30 900
Hommelvik	23,14	10,45	40 500
Hell	31,54	8,4	32 700
Værnes	32,86	1,32	142 800

Source: (Rørslett, 2012)

As the table displays, the lowest figures of passengers flow on the eastern section are observed at Rotvoll. Due to the statistics, NNRA has extended the decision of closing the station. Some critics are raised due to the low figures and short distances between stations in proximity to Trondheim, even an experience of stable demand is present year to year (Midtun & Nyvold, 2012).

Raymond Siiri (Siiri, 2007) analyzed the potential passengers traffic associated to Ranheim st. for different scenarios. One of these alternatives, *2B* (see appendix I), is the basis of the KVU concept 1, which emphasize a huge market potential on the stations between Trondheim and Stjørdal. The RTM simulation concluded how important Leangen stations will be for the largest industrial area in Trondheim and Ranheim by serving the potential increase of people, due to the inner and outer urban expansions.

The RTM model simulated an expected on/off traffic for both Ranheim and Rotvoll, respectively, 78.000 and 58.000 per year. The statistics represents the possible amount of passengers in 2014, considered the reconstruction of the new railway infrastructure as finished. It indicates a strong and sustainable market in the area, capable of serving two stations, in the long-term perspective.
From the short-term point of view, *alternative 1A* is the first alternative Ranheim is taken into account. The alternative intends a 15 minutes decrease of the time between Steinkjer

and Trondheim, reducing the total travelling time from 2:09 hours to 1:51 hours. The estimated increase of passenger is 14 %, which correspond to 1.5 million passengers. The estimated on/off traffic at Ranheim was 38.000 and 22.000 at Rotvoll per year. The model predicts a decrease of passengers at Rotvoll when Ranheim is introduced.

Factors abovementioned are prerequisite for a decision-making, whether a station shall be closed or not (Rørslett, 2012). However, the additional stopping time for each station has to be taken into account as well as the cost of setting up a new station(s).

5.3 Bjørndalen

The bridge over Bjørndalen (Bjørndalsbrua) is located south of Trondheim city, it is of special interest to NSB regarding market potentials and decisions of putting up a new station or not. This bridge serves as a link between the northern part of Byåsen and Tiller. The capacity of handling increased and increasing traffic is absent, leading to large traffic bottleneck during rush hour. A new infrastructure of transport and logistics at this location can reduce the traffic jam and serve as a central sub-hub station of the urban settlements and as well for the increasing industry in the area. In the figure below, an overview of the area is illustrated.

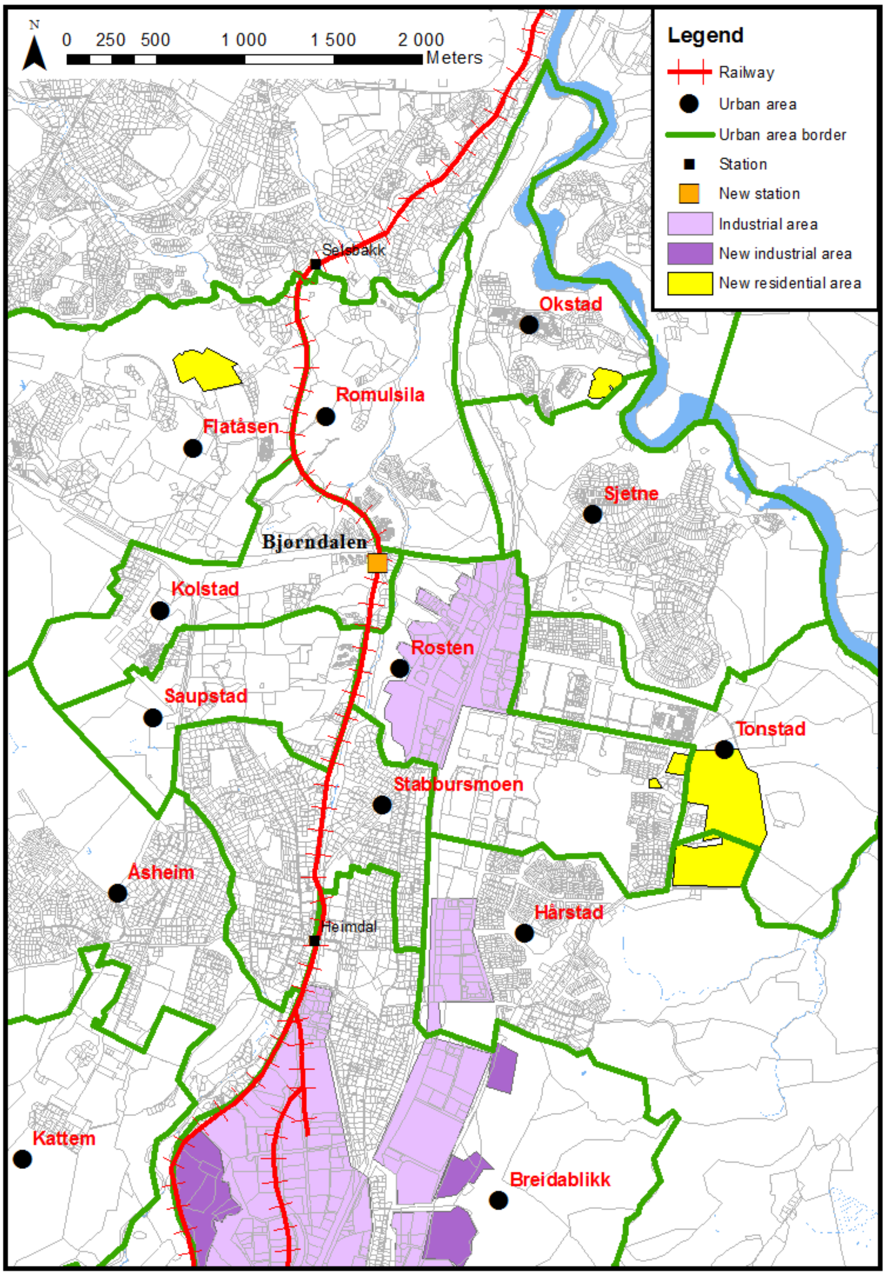

Figure 15: Overview of Bjørndalen & related areas

5.3.1 Population Estimation & Projection

The urban settlements surrounding Bjørndalen have reached 20.000 inhabitants and more, table 18 displays the current and future population estimation of the urban areas presented in figure above.

Table 18: Statistics of current & projected population of Bjørndalen & related areas

Urban Area	Inhabitants (2012)	Inhabitants (2024)	Increase
Tonstad	2480	3214	30 %
Saupstad	3021	3616	20 %
Okstad	1672	1906	14 %
Flatåsen	5524	5900	7 %
Rosten	2085	2203	6 %
Romolslia	2219	2244	1 %
Sjetne	2871	2857	0 %
Kolstad	3155	2980	-6 %

Source: (SSB, 2012d; Sveinung Eiksund, 2011)

Most of the urban areas experience an increase except Kolstad, which is projected a decrease of 6 %. The increases at Saupstad and Okstad are, apparent, related to the new planned residential regulations. The total projection predicts an increase of approximately 2.000 inhabitants, which is on the low scale of growth compared with Ranheim.

However, these particular areas have the same amount of inhabitants as the KOMPAS model predicts for Ranheim in the same period. In other words, the market potential of establishing a new station at Bjørndalen is well present, from the population point of view. In the next chapter, a further analysis of additional factors related to choice of location and assessment of traffic statistics.

5.3.2 Location

As mention before, Bjørndalsbrua serves as an important connection between Byåsen, Tiller and the main road (E6). A station in proximity to the bridge can be considered as the center point of the total area. One of the benefits already existing is the current network of buses, s*huttle routes,* which transit people over the bridge from the western part and further down town.

However, the bus network in the eastern area consist of, *other routes,* which operate in less frequency than *shuttle routes* and rarely cross the Bjørndalsbrua. The point of center for both routes is located at a hub bus station at City Syd. It is essential to reconfigure the network in order to centralize and steer the public transport services to the potential new station. The figure below illustrates the current bus network and location of the new stations.

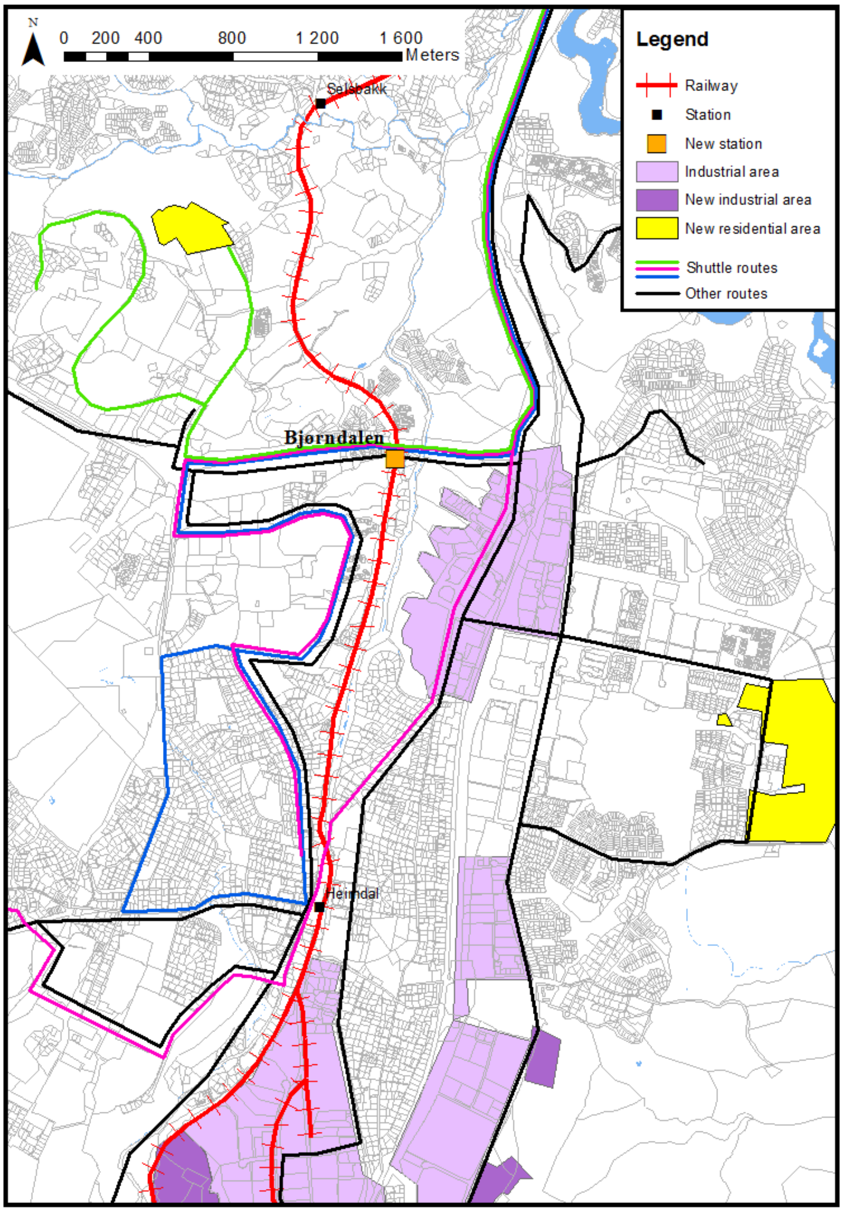

Figure 16: Overview of busses in south Trondheim

The location Bjørndalen, if decided, will be in between Heimdal and Selsbakk. These existing stations do have a large variation in passenger traffic. In 2008 it was registered 1.500 (Selsbakk) and 47.800 (Heimdal) of on/off passengers.

5.3.3 Traffic Analysis

The RTM calculated the amount of passenger in *alternative 2B* (appendix I) and expected 77.000 on/off passengers per year at Bjørndalen. The RTM takes into account the average (daily) car traffic on E6 which derives from the NPRA. The model uses the traffic statistic of cars passing Kroppanbru in order to estimate the potential train passenger traffic at Bjørndalen. The bridge crossing traffic is assumed to be the total stream of traffic between Tiller, Heimdal and Trondheim city (Siiri, 2007)

The table 19 presents the average car traffic per day at central sections (Kroppanbru and Storlersbakken) after Klett, where E6 from south joins with E39 from west.

Table 19: Average car traffic

Year	**Kroppanbru [per day]**	**Storlersbakken [per day]**
2005	46 724	20 707
2006	49 032	21 951
2007	50 366	22 676
2008	50 075	23 226
2009	49 615	23 471
2010	48 868	21 372
2011	48 783	21 246
2012/August/Sept	50 439	22 118

Source: (NPRA, 2012)

The dissimilarities in the figures between the car traffic on these two sections are the results of assumed “take offs” from E6 to Kolstadvegen in the intersection at Tiller. The figure 17 outlines these areas.

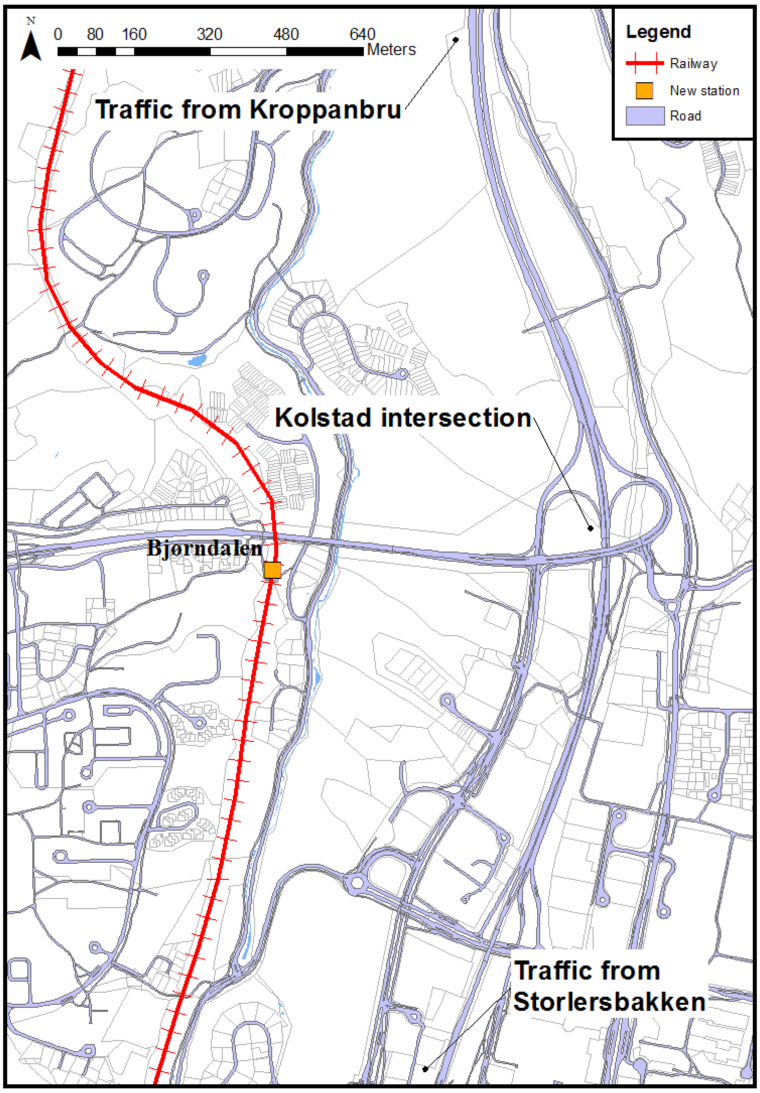

Figure 17: Major roads in & out of Bjørndalen

Detailed car traffic analysis was conducted by the NPRA to assess the traffic before and after the construction of the new four-lane E6 from Tonstad to Jaktøyen, south of Storlersbakken (Berg, 2008). The traffic from 2005 was forecasted to 2013 with two alternatives, with or without the new four-lane highway (E6). The forecast was extended to a period of 25 years with an adjusted future traffic growth. One of the areas analyzed was Bjørndalen, where the report emphasized the vital role of Bjørndalsbrua to play in the infrastructure.

Numbers of cars passing Bjørndalen are presented in the table below.

Table 20: Cars passing Bjørndalen per day

	2005	2013	2038
Bjørndalen	16.000	19.100	24.900
Bjørndalsbrua	22.400	27.200	35.400

Source: (Berg, 2008)

A station in Bjørndalen would be in the middle of a large populated area, whereas motorists connect with the highway frequently by using the Bjørndalsbrua. The market appears to be adequate to support two stations even when the short distance, 2,2 km, between Heimdal- and Bjørndalen station is considered.

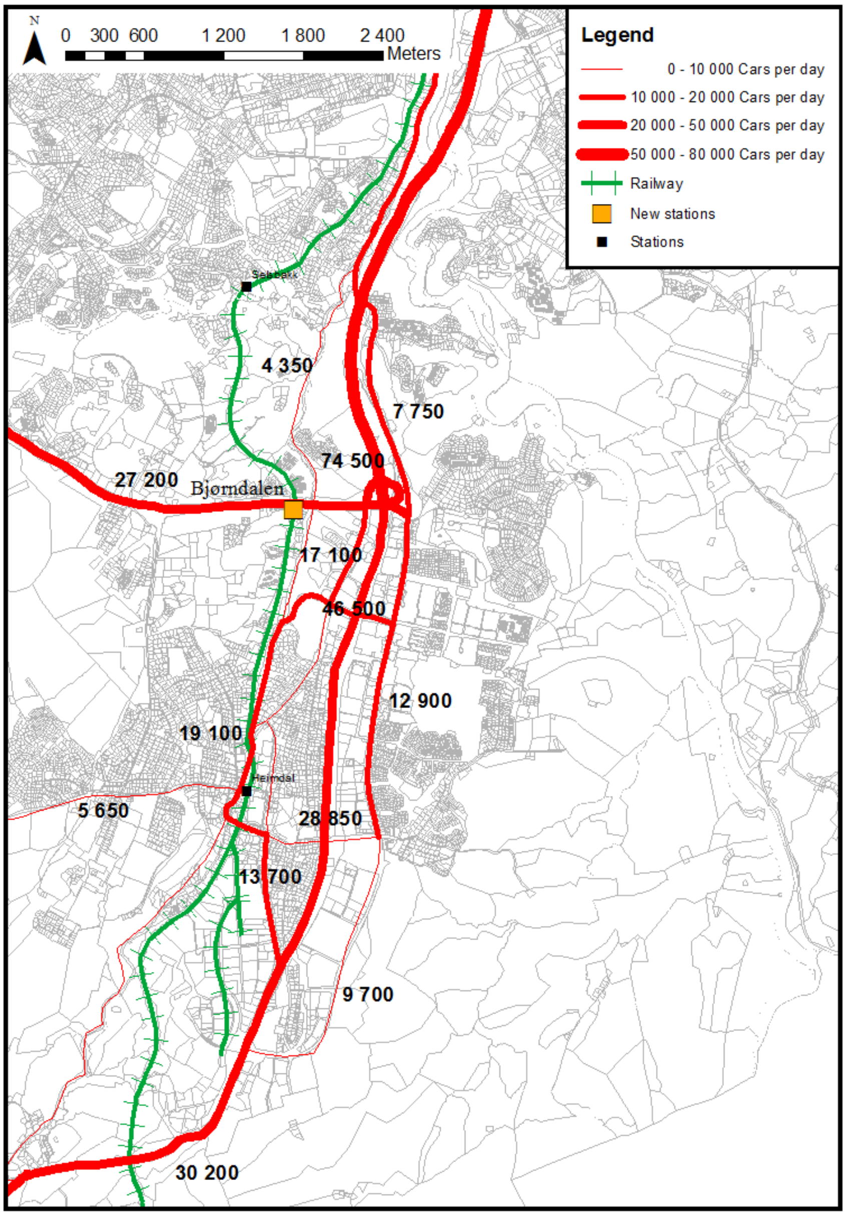

Figure 18: Car traffic projection of 2013

5.4 *Discussion of Results*

Tickets is to be considered as the most accurate measurement of passengers statistics while the observation and counting serves as tool to check and readjust expectations and future plans. The overall statistics data shows a small to medium variance of passengers and a minor stagnation appeared to have found place. An origin could be the lack of opportunities to increase either the supply or the quality offered by the rolling stock

However, as mentioned in chapter 3.3 there are critics and elements which quantitative modeling software do not take into consideration due to heavily data algorithms. Such elements are the frameworks designed to each model. A model is not, obviously, able to simulate situations not given in the frame of act. The results generated by the RTM are at the current stage of time considered to be one of the best alternatives to simulate future level of traffic. Nevertheless, the model does not cover the subjective and independent reaction when introducing a sufficient and smoother transportation system. Such impact can results in both ways, but most likely, when utilized to its maximum, as it is in Trondheim, a higher demand would occur if the infrastructure. As lesson learned and experienced in Sweden at Svealandsbanan, the market share substantial increased from 6 % to 30 % and their load of passengers increased by seven times. Moreover, motorists seemed to have a lower barrier of shifting transportation of mode than individuals using the bus. The network of busses is well developed and covers large areas holding a significant portion of the market share. Although it should prove to be challenging to transit customers from bus to train, will it more likely be easy to increase the market shares with a transition from car to train.

The population modeling in KOMPAS is based on statistics from SSB and ideas from individual municipality planning comity. The long-term projection corresponds to the SSB projection for 2012 – 2040, with 5% deviation and depends on medium rate of migration, fertility and mortality. The numbers from SSB are considered as highly reliable for the future population. As mention in chapter 4.2, the KOMPAS projects population for urban areas in view of the planned residential development. The planning period for each municipality varies, for instance, Trondheim publish their plans every 5 years. The long-term population projection is only dependent on the migration, fertility and mortality rate. The effect can lead to uncertain data output in periods were no plans have been developed. For period where plans are available, the modeling develops more accurate projections, due to additional information. On the other hand, the population projection is only valid for short period. To sum up, the long-term population projection can be assumed with high probability associated to the whole municipality. However, when modeling on lower geographical levels, the results attends to be less accurate. With other words, the future population is calculated but with decreased possibility to assess where this increase will settle within the municipality, until new plans are posted.

5.5 Comments

The quantitative analysis of various social developments related to Bjørndalen, Grillstad / Ranheim and Trønderbanen as a whole emphasis the needs of intuitive developments in near future in order to maintain or preferable increase the train's ability to compete on the shorter to medium long axis. Melhus to Trondheim is currently the pendulum with the poorest supply of train options nevertheless the potential are vast. Trondheim to Stjørdal is on the other hand the largest market, but more exposed to competition of other public transportation services.

The future growth relates to a great potential at Grillstad and Ranheim with the likelihood of majority working in town or at industrial areas surrounding. A well-functioning infrastructure supporting the inhabitants will in its true sense results in a greater market share. Second spin-acting effects are illustrated by the RTM main results, if *alternative 2B* implemented, considering the increase in table 9 (115.000 to 428.000) of air passengers using the train above the airbus shuttles. A significant portion of the increase is to believe derived from Grillstad and Ranheim due to the lack of station at current time. From an administrative point of view, it appears to be an affordable and necessary step to take.

Bjørndalsbrua serves as a traffic link between the northern Byåsen and Tiller. The bridge is already jammed during the rush hour because of the enormous flow of cars. Due to the basic assumptions of double lane further south and electrified infrastructure speaks in favor of a new station, large and well designed, to handle the traffic expected of cars, buses, bicycles etc. The stations should, if possible, work as a cross docking station where buses feed the stations with passengers from Heimdal, Byåsen and Tiller. This confirms the total market potential of an efficient and contemporary station.

Another potential option is the possibility of transfer motorist to the railway south of Heimdal. The RTM illustrate a vast increase from 90.000 to 998.000 if *alternative 2b implemented* today. Moreover is the estimated volume of cars passing Melhus in 2013 is approximately 17.650 per day including all types of transportation of mode. The figures from the SSB's car commuter statistics 2011 indicate 4.706 cars per day or 1.717.690 cars in a year. NSB tickets statistic showed 23.083 passengers per year between Støren/Melhus and Trondheim. The result shows an 314 % increase from 23.083 to 72.496 railway passengers per year, if only 3,5 % of the total car commuters where transferred to the railway.

6. ROUTE CONCEPT

In view of the current railway network, the social development analysis related to critics and theory on field studied in previous chapters as well as elements from the case study in Sweden, founds the basic platform of the following concept.

	Axis	Frequency rush [min]	Frequency low [min]	Major changes
Local	Trondheims Ekspressen	20	-	New Ranheim and Grillstad st.
	Melhus - Trondheim	30	60	New Bjørndalen
Regional	Trondheim - Steinkjer	30	60	Stops only at Værnes and Leangen between Trondheim and Stjørdal.

Assumptions:

1. Electrified train axis between Trondheim – Steinkjer.
2. Double lane capacity between Heimdal –Trondheim – Stjørdal.
3. Tunnel at Hundhammeren, Vikhammer, Sveberget, Forbordsfjellet and at Åsen.
4. Certain results from *alternative 2B* generated by the RTM simulation conducted in 2007 (appendix I).

Table 21: Interfering elements of decision

Interfering Elements of Decision	
Airport	One of the greatest potentials. The regional industry is growing, reflected by this year remarkably increase of flight passengers. International competition and new airways entering the market contributes to low-priced tickets while the prosperity of Norwegians is increasing.
Time and frequency	In order to grab market shares from the road on the northern regional axis, reducing time is essential. A solution seemed to be to eliminate stops between Værnes and Leangen saving additional 15-18 minutes. An axis with frequent departures responds to a market in short to medium short distance from town, industry and airport. Frequent departures are a key element to compete against the public bus network in the proximity of Trondheim.
Development	The new and major settlements the next 15 years will be located at Ranheim, Charlottenlund, Grillstad, Presthus, Vikhammer and Hommelvik. The development in Trondheim and Stjørdal area tends to adapt the same merging relationships as other large cities of infrastructure.
Societal	Provide an efficient reliable and flexible transportation system between Trondheim and Steinkjer of humans and goods. A natural evolution of the population increases the need for a proficient and sustainable industry.

6.1 Local Axis

As figure 19 illustrates, there are 18 stations covering the passenger and freight traffic on the intended local axis from Melhus to Stjørdal.

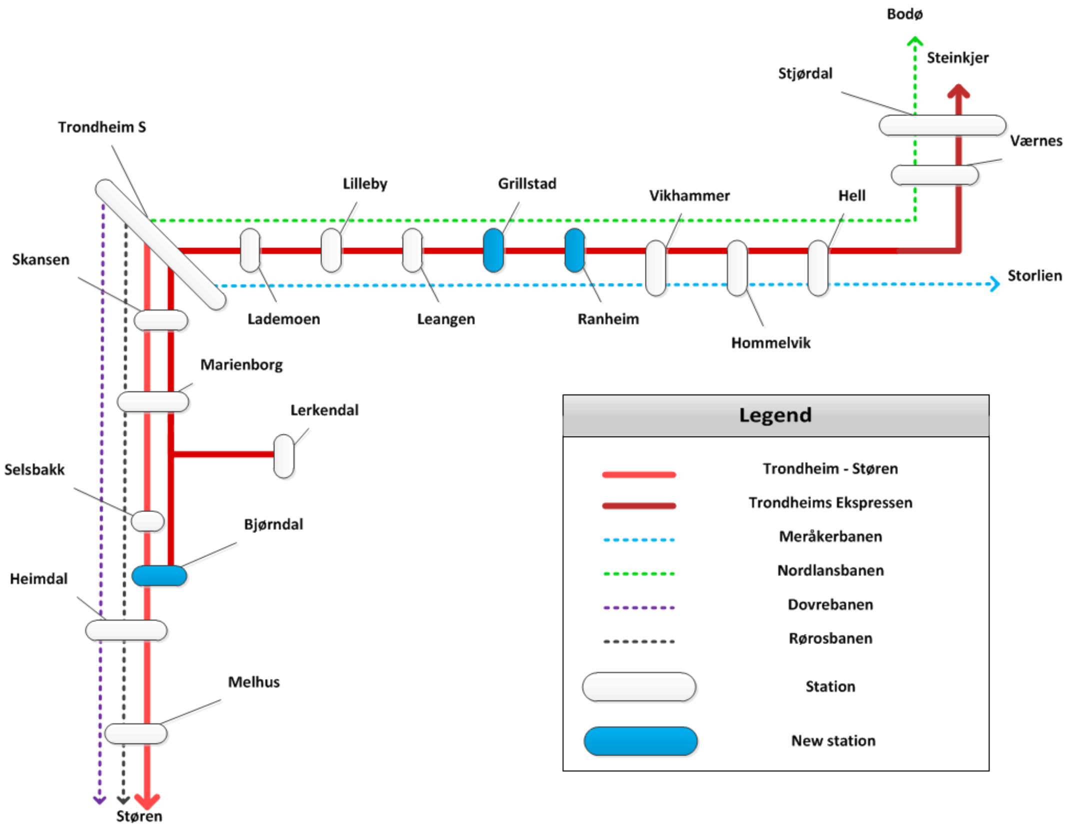

Figure 19: Proposed layout of southern part of local axis

Three new stations added and one removed (Rotvoll). The axis of *Trondheims ekspressen* is the becoming the local fast express in between Bjørndalen – Lerkendal – Trondheim – Stjørdal with departure every 20 minutes. Selsbakk is excluded from the route in order to maintain a fast supply from the hub station at Bjørndalen and down to Lerkendal. The purposed is to provide a frequent supply to the majority of daily commuters and gain a foothold in the market of air passengers. A frequent time schedule will better match the time schedule at Værnes airport.

The attention of *Melhus – Trondheim* is considered on the southern part through Bjørndalen with departures every 30 minutes in rush hour and every hour in low demand. Lerkendal station is excluded from the route plan while Selsbakk is added due to the only link between lower Byåsen and the railway and partly of the expected effect from a smoother supply, substantial increase regardless other dependent variables.

Stations role and functions can be found in appendix II

6.2 Regional Axis

As the figure 20 illustrates, there are 14 (Trondheim – Steinkjer) stations covering the passenger and freight traffic.

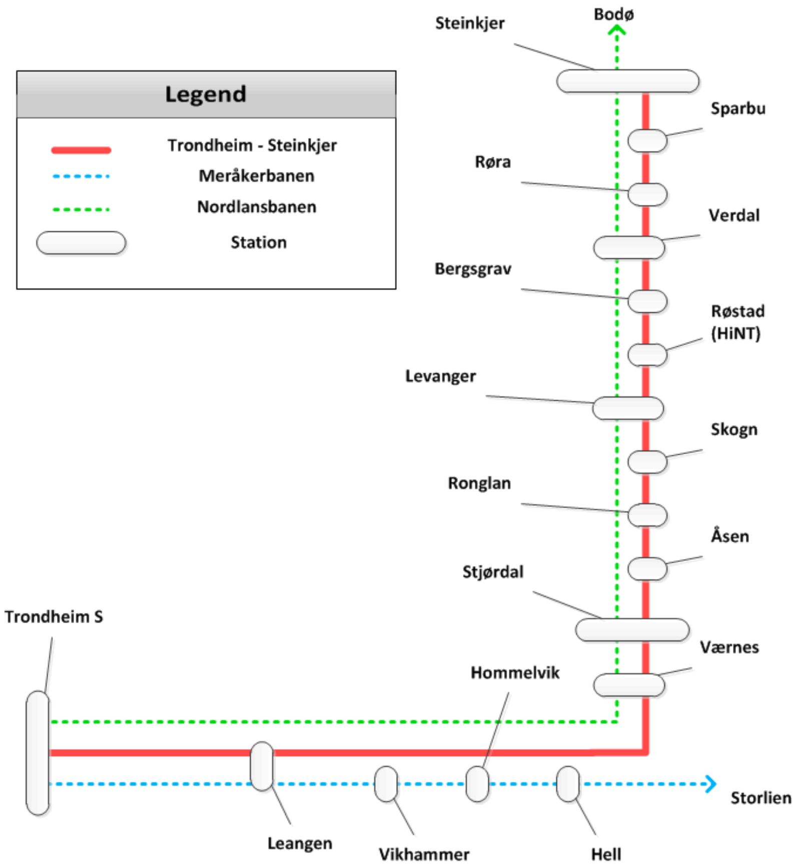

Figure 20: Proposed layout of northern part of the regional axis

Stations in between Trondheim and Værnes are excluded from the route plan except Leangen, because of the strategic position considering business and industry facilities.

The respective *Trondheim – Steinkjer* is intended to deal with the traffic north of Værnes to arrange for a fast and effective supply on the regional axis. The proposed bypass of stations between Stjørdal and Trondheim has the potential of reducing the time by approximately 15 minutes.

Stations role and functions can be found in appendix II

6.3 Measures Required

A summarize of possible measurements required of the proposed concept.

Table 22: Summarize of measures required

Measures	Remarks
Close down Rotvoll station.	Future regulated plans do not count for noteworthy social development. Rotvoll is not central compared to populated areas even when the RTM model shows 58.000 passengers on/off in *alternative 2B.* Decision of closedown is based of establishment of two new stations at Grillstad/Ranheim. Potentially reduced time: 3 minutes.
Establish new stations at Grillstad and Ranheim.	The proximity between the two stations are considered possible due to symmetry as Leangen, Lilleby and Lademoen with stable demand and electrified rolling stock. 78.000 on/off passengers estimated in *alternative 2B* for one station. The effects of a new infrastructure are, most likely, theoretical supposed to have greater impact than expected. Potentially additional time: 6 minutes.
Maintain Selsbakk station.	The currently low traffic is alleged to change with a new railway structure and lessons learned in Sweden speak for maintaining the station, even when other simulations and quantitative studies claim the contrary. RTM simulation assume Selsbakk to be closed when Bjørndalen is introduced; consequently no passenger traffic numbers are available regarding the future.
Establish a new station at Bjørndalen.	Linking high-populated areas as Heimdal, Byåsen, Tiller and nearby areas with Trondheim centrum. The potential market is considered huge if station and external strategies are well designed. 77.000 on/off passengers estimated in *alt. 2B*
Establish a new public bus network.	Collaborate with AtB and other agencies in the development and operation of hub - train/bus stations as well as new s*huttle routes,* to link and support surrounding areas to preserve a continuous flow of customers. Mutual benefits due to higher market shares. Motorist shifting from car to bus and train.
Other transportation infrastructure.	Collaborate with ruling municipalities in preparation and organization of bike and walking paths towards new and old stations. Establish easy *ticket to buy* solution through electronic devices and possibility of multiply use. Vital to ensure easy and continuous flow at all levels of transportation by mode.

7. CONCLUSION & FURTHER WORK

The quantitative and qualitative data and research done on the field, reveals great potential of practically all aspects, individual behavioral, time, passengers, frequency and societal and environmental effects. New infrastructure and modern rolling stock will add up the capacity by several times. The proposed concept emphasis the focus of attention to the three sections, south, east and north. The idea of the concept setup is to optimize the intentions of a fast and reliable supply & support in areas of focus. A specific concentration to each endpoint and their axes clarifies the goal and objectives, both upward and downward within an organization.

The decision of adding two new stations at lower Charlottenlund and at Ranheim follows an interpretation of external political will to pursue a development east of Trondheim city. However, Rotvoll is proposed closed due lack of future plans. Plans and regulations are, at all times, changeable and shifting environment can add additional supportive information to the table to maintain or reestablish Rotvoll station. The construction and buildup of a hub station at Bjørndalen is the “nitty-gritty” process with households around where possible expropriation of land is a reality. Nevertheless, the potential impact is more valuable and important to the society as a total rather than if 10 or 20 people has to be moved.

The northern part of the concept excludes Skatval of the future infrastructure due to the tunnel through Forbordsfjellet. There are currently 2.250 inhabitants at Skatval and 38.700 on/off passengers on an annual basis, which is considered as a high value of a minor district. Circumstances described emphasize the possibility of a cost-benefit analyze related to maintain the short local pendulum around Forbordsfjellet on the existing railway. Another essential note is the positive features available this pendulum adds. If a hazardous situation occurs or suddenly maintenance needed, it would be possible to route the train around if closed.

One model or one method cannot single-handedly forecast the total variable changes and their magnitude, as specified in chapter 3.3. An element to further work is to conduct a larger qualitative survey of those who travel to map the pattern of public behavior (activity based) and their view on public transport. A possible outcome can be an improved understanding of what the shifting generation requests and their valuations of the factors time vs. frequency.

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APPENDIX I

Alternative	Infrastructure	Time table	Speed [km/t]
Basis 2014	The current layout.	2:09 Trondheim – Steinkjer	58
Alt. 0	The current layout, with Gevingåsen tunnel.	2:07 Steinkjer – Trondheim	59
Alt. 1B-el	Reconstruction on track between Hell – Værnes. New bridge over Stjørndalselva. New tunnel through Forbordsfjellet. Electrified line between Trondheim – Steinkjer	1:34 Steinkjer – Trondheim	75
2A	1-2 new cross-section tracks south of Trondheim. New route Stjørdal – Støren. New stations in Ranheim & Bjørndalen	1:29 Stjørdal – Støren. 1:02 Stjørdal – Melhus. 1:34 Trondheim – Steinkjer	58
2B	Double track between Trondheim – Stjørdal. New stations at Ranheim & Bjørndalen. Reconstruction on track between Hell – Værnes. New bridge over Stjørndalselva. New tunnel through Forbordsfjellet. Electrified line between Steinkjer – Trondheim.	1:10 Stjørdal – Støren 0:51 Stjørdal – Melhus. 1:34 Trondheim – Steinkjer	73

Source: (Siiri, 2007)

APPENDIX II

Local axis:

Nr	Stations	Role
1	Melhus	Support the area. Intersection point.
2	Heimdal	Start of the double lane.
3	Bjørndalen	New hub station linking Byåsen, Tiller and areas near.
4	Selsbakk	Support lower Byåsen. Excluded from *Trondheims ekspressen.*
5	Lerkendal	Support NTNU Gløshaugen and Lerkendal area.
6	Marienborg	Support St. Hospital and NNRA offices.
7	Skansen	Linking Ila, Øya and Sverresborg.
8	Trondheim S	Main station, serves as region hub-station.
9	Lademoen	Support the business area and Lademoen.
10	Lilleby	Support the residential area at Nedre Møllenberg and Lademoen.
11	Leangen	Support the industry area at Ladedalen and the new Sirkus shopping mall.
12	Grillstad	New station. Supports Charlottenlund and Grillstad.
13	Ranheim	New station. Supports Ranheim and Vikåsen and sports area nearby.
14	Vikhammer	Support Vikhammer residential area.
15	Hommelvik	Support Hommelvik and freight logistics from sea.
16	Hell	Serves as a branching station between Nordland- and Meråkerbanen
17	Værnes	Serves the airport.
18	Stjørdal	Support the city. Several crossing lanes. End of double lane.

Regional axis:

Nr	Stations	Role
1	Trondheim	Main station, serves as region hub-station.
2	Leangen	Support the industry area at Ladedalen and the new Sirkus shopping mall.
3	Værnes	Serves the airport with passengers from and to Nord-Trøndelag.
4	Stjørdal	Support the city, several lanes.
5	Åsen	First station after tunnel through Forbordsfjellet. Intersection lanes.
6	Ronglan	Serves as an intersection point due to low demand.
7	Skogn	Support the inhabitants at Skogn and industry area at Karibukta.
8	Levanger	Support the city and the hospital in town. Several lanes.
9	Rørstad/HiNT	Support the Nord-Trøndelag University College with students.
10	Bergsgrav	Support the residential area at Bergsgrav. Intersection point.
11	Verdal	Support the city and industrial area. Several lanes.
12	Røra	Support the residential area at Røra. Intersection point.
13	Sparbu	Support the residential area at Sparbu.
14	Steinkjer	Support the city, linking shopping mall to station. Several lanes.

APPENDIX III

Following documents are listed:

- Pre-study report
- Gantt-chart
- S-diagram
- Progress report
- Meeting minutes
- Meeting invitation

NTNU – Trondheim
Norwegian University of
Science and Technology

Market Potential for Train Concepts on the Trønderbanen

Project assignment autumn 2012

stud.techn Ágúst Már Gröndal & Erik Smedsrød

TPK 4510

Department of Production and Quality Engineering

Table of Contents

1. Introduction

1.1 Purpose

NSB have presented a general wide open project, intentionally to get the participants to come up with different route (train service) concepts based on the current and future market potential considering the electrified new train network in Trondheim.

The purpose with the pre-study report is to conduct a detailed description of the tasks to be performed. It should lead to an unambiguous definition of content and approach of the work. Further, it will form the basis of a complete activity plan with descripted work packages.

The scope of the project:

1. Conduct a brief study on previous case studies for the Trondheim area.

2. Conduct a brief study on methods for market analyses and transport demand. Determine an appropriate method for the estimation of passengers demand for train-service.

3. Evaluate the future market potential for various train-service concepts in the Trondheim area. This may involve:
    a. The analysis of population growth and the resulting increase in transport demand.
    b. The estimation of passenger demand.
    c. A comparison of train service against other types of travel (bus/car).

4. Recommend one (or a few) possible future train-service concepts for the Trondheim area.

Underlying basic assumptions:

1. The section Trondheim – Steinkjer is electrified.
2. The section Trondheim – Stjørdal is running with an improved train passing capacity. Eventually with a double track.

1.2 Terms and Acronyms

- NSB
    - Norwegian biggest actor within passenger transport and it is owned by the Ministry of Transport and Communications.
- NTM – National Transport Model:
    - It is a demand control model for long distance (over 100km) travelling in Norway. The network in the model contains information about sea-, road-, railway- and flight routes, and their respective stations. The model calculates the travel purpose within four different categories (service, visits, holidays and leisure and other private travel).
- RTM – Regional Transport Model:
    - Unlike the NTM, this model calculates the demand for shorter distances (below 100km). Opposite to the NTM, the RTM is coded for long and short routes and it entails five different models of demand. Each and one of these models take into account diverse factors for each action, more detailed calculation regarding driver, passengers, collective, bike, walking etc. It covers more or less the whole transport aspect below routes of 100km.
- JBV – Jernbaneverket:
    - Norwegian state agency under Ministry of Transport and Communications with the responsibility of the infrastructure considering signals, rails, turnouts, bridges, tunnels etc. JBV does not have permission carry out transport missions.
- AtB – To get from A to B:
    - It is a collective bus operation firm fully owned by the Sør-Trøndelag County Council performing public and school bus transportation in Trondheim area.
- Network Statement:
    - Network Statement is a description of service that Norwegian National Rail Administration provides to Railway Undertakings and traffic companies.
- Pendulum:
    - The train service or the train product between two points in a network.
- Rolling Stock:
    - The train equipment available, owned by a railroad carrier.
- Railroads:
    - Trønderbanen.
        - The railway line in Trøndelag. From Oppdal and Røros in Sør-Trøndelag and all the way to Steinkjer / Grong in Nord-Trøndelag.
    - Nordlandsbanen
        - The railway line from Trondheim Central up to Bodø.
    - Meråkerbanen
        - The railway line from Trondheim Central to Storlien in Sweden.
    - Dovrebanen
        - The railway line from Oslo Central to Trondheim Central through Dovre.
    - Rørosbanen
        - The railway line from Hamar to Trondheim Central through Røros.
    - Lerkendal – Trondheim – Steinkjer
        - The railway line from Lerkendal to Trondheim Central through Værnes and up to Steinkjer.

2. Technical Aspect

2.1 Thesis Question

It is vital to have a general understanding of how the market is and will expand, considering the amount of diverse capacity options NSB and collective transport sector will face in the future. New hardware, technology and double track system is not synonymous with automatic problem solving. It is equally important to know when, where and how to initiate the new train-service capacity.

Currently, NSB and the single railway system at Trønderbanen are stretched to the limit. The infrastructure is overripe and the existing rolling stock is old and worn. Current driving pattern is characterized by rigid schedule, hourly departure and extra train sets are adopted in rush-hour, due to the annual amount of 1.2 million passengers and the expected increase of population growth.

NSB and local authority have a clear ambition to renew and expand the Trønderbanen with a double track system from Trondheim to Stjørdal and electric material on the whole network. This major restructuring and strategic procurement investment, is clearly stated in the suggestions input from NSB to National Transport plan 2014 – 2023.

2.2 Project Objectives

The following topics are the goals which are set to be completed during the project life cycle. The result oriented goals are designed to be measurable to document discrepancies or achievement. On the other hand, the process goals describe more or less what the participants want to benefit from the project. The diverse result oriented goals are developed in compliance with the Gantt – schedule and work packages.

2.2.1 Main Goal

- Complete the final project and report within 14. December 2012.

2.2.2 Effect Goal

- Highlight the future market potential with a 30 year long perspective.
- Highlight possible changes of the railway network in Trondheim area.

2.2.3 Result Oriented Goals

- Estimate passenger demand and population growth for 2012 – 2040, both regional and local before 19. October 2012.
- Identify new alternative route concepts within 30. November 2012.

2.2.4 Process Goals

- Increase the practical methodology skills related to the project management.
- Increased knowledge of how working processes related to planning and management are conducted in the business sector.
- Expect that the final product will be value adding to NSB future prospects.

2.3 Project Description

The project is divided into three phases and supposed to be done in chronological order. In the first phase it is necessary to look into current situation and similar case studies done abroad and gather the experience developed from it. Make contact with key personal, sitting on valuable information will be of interest and an important role. Further, the act of obtaining accurate data and models considering population growth and passenger demand will be the building blocks for the project.

The next phase during the project is more or less the buildup of new reliable and agile train service concepts in Trondheim area. Questions like; where should new station be located? Which pendulum should be where and when?...is expected to be addressed.

Last phase of the project entails the ending of the main report and the final recommended train service concepts presented to NSB. The technical aspects of the report are vital to understand from a research point of view where methodology and theory are well described.

2.4 Main Challenges

Problem areas that may prevent us from being successful are:

- Lack of experience with similar projects.
- Gathering insufficient data.
- To find modern theory related to the subject.

2.5 Conclusion

This assignment is fully achievable by our conclusion. The underlying basic assumption makes it more clearly in a sense that the capacities are present. The current focus on the political agenda regarding green technology and sufficient transport network for the region creates a motivation for change.

It will require flexible and well-coordinated collaboration between the students and their supervisors. There will be challenges in that neither of the students has previously worked on similar railway projects.

3. Work Packages

See appendix 1 – 6.

4. Project Organization

4.1 Project Participants

The project group consists of two students:

- Ágúst Már Gröndal
    - M.Sc. student at Global Production Management - NTNU
- Erik Smedsrød
    - M.Sc. student at Global Production Management – NTNU

4.2 Equipment and Resources

Project office is at a separate room at The Department of Production and Quality Engineering located at NTNU - Valgrinda. Two computers and necessary software is acquired.

4.3 Project Deliverables

- Pre Study report: 14. September 2012
- Progress report: 19. October 2012
- Final report: 21. December 2012

The final report shall be submitted in two bound copies and one electronic pdf.-format.

4.4 Project Management

During the project it is more or less vital to divide some responsibility between the participants regarding the project coordinator role.

Weeks	**36 - 37**	**38 - 42**	**43 – 45**
Project coordinator	Ágúst	Erik	Ágúst
Weeks	**46 - 47**	**48 – 49**	**50**
Project coordinator	Erik	Ágúst	Erik

4.5 Time Planning

See separate document (Gantt schedule).

4.6 Quality Assurance

To ensure a good quality assurance during the project, following topics are decided.

4.6.1 Project folder

The project folder will at any time be located at the office for exemption to all participants. The folder shall include:

- Work packages.
- Gantt schedule.
- Meeting minutes
- Progress report
- Theory and other scientific published journals.

4.6.2 Backup

Material backup is essential. The project group uses Microsoft SharePoint Workspace as an internal server and workstation for all documents created and shared. In addition, we use a second-level backup, called Dropbox.

4.6.3 Content- and Language Check

All written and published documents will be controlled and analyzed by the supervisor and an external resource.

4.6.4 Activity Log

All activity with context to the project will be logged in a separate S-diagram (xlsx.format).

Appendix – 1 (WP 1)

NTNU – Trondheim
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Course: TPK4510		**Date:** 14.09.2012
Project: Market Potential For Train Concepts On The Trønderbanen		
Activity: Semester Project		**Activity Nr:** 1
Start: 03.09.2012	**Finish:** 14.12.2012	
Predecessor:		
Successor:		
Goal: This activity is a summary work page for all the activities that have to be finished in order to deliver the semester project. The goal is to be on schedule with all the sub-activities .		
Description This activity runs over the whole project life cycle.		
Man Hours: 840 Hours	**Resource** Ágúst Már Gröndal: 420 Hours Erik Smedsrød: 420 Hours	
Costs: 0,-		
Resources:		
Risk: The semester project is a time consuming assignment. Continued process is needed and it is necessary to begin as soon as possible.		
Activity Owner: Ágúst Már Gröndal & Erik Smedsrød		

Appendix – 2 (WP 2)

NTNU – Trondheim
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Course: TPK4510		**Date:** 14.09.2012
Project: Market Potential For Train Concepts On The Trønderbanen		
Activity: Pre Study Project		**Activity Nr:** 1.1
Start: 03.09.2012	**Finish:** 14.09.2012	
Predecessor:		
Successor: Phase I		
Goal: Understand the objectives. Finish up the Gantt schedule planning for the project life cycle, structure all the work packages and write the pre-study report.		
Description Pre-study report shall be submitted to the supervisor within 14. September 2012, containing: analysis of project objective, description of the task, activity plan for the work and estimate workload project plan.		
Man Hours: 120 Hours	**Resource** Ágúst Már Gröndal: 60 Hours Erik Smedsrød: 60 Hours	
Costs: 0,-		
Resources:		
Risk: Pre-study report contains our understanding of the project and how the work will be proceed. The more work spend on the pre-study report reduces the risk of misunderstanding the assignment and be able to meet all the deadlines.		
Activity Owner: Ágúst Már Gröndal & Erik Smedsrød		

Appendix – 3 (WP 3)

NTNU – Trondheim
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Science and Technology

Course: TPK4510	**Date:** 14.09.2012
Project: Market Potential For Train Concepts On The Trønderbanen	
Activity: Phase I	**Activity Nr:** 1.2
Start: 17.09.2012	**Finish:** 19.10.2012
Predecessor: Pre-Study Report	
Successor: Phase II	
Goal: Estimate the population growth and passenger demand around the Trondheim area.	
Description The project consist of three phases. This work package consist of the first phase which is to collect information about the market.	
Man Hours: 180 Hours	**Resource** Ágúst Már Gröndal: 90 Hours Erik Smedsrød: 90 Hours
Costs: 0,-	
Resources:	
Risk:	
Activity Owner: Ágúst Már Gröndal & Erik Smedsrød	

Appendix – 4 (WP 4)

NTNU – Trondheim
Norwegian University of
Science and Technology

Course: TPK4510		**Date:** 14.09.2012
Project: Market Potential For Train Concepts On The Trønderbanen		
Activity: Phase II		**Activity Nr:** 1.3
Start: 22.10.2012	**Finish:** 30.11.2012	
Predecessor: Phase I		
Successor: Phase III		
Goal: Map out and analyse current route concepts in the Trondheim area. Identify alternative route concepts that can be implemented to service the growing market that was analysed in phase I.		
Description The project consist of three phases. This work package consist of the second phase which is to collect information about the current train routes in the Trondheim area.		
Man Hours: 360 Hours	**Resource** Ágúst Már Gröndal: 180 Hours Erik Smedsrød: 180 Hours	
Costs: 0,-		
Resources:		
Risk:		
Activity Owner: Ágúst Már Gröndal & Erik Smedsrød		

Appendix – 5 (WP 5)

NTNU – Trondheim
Norwegian University of
Science and Technology

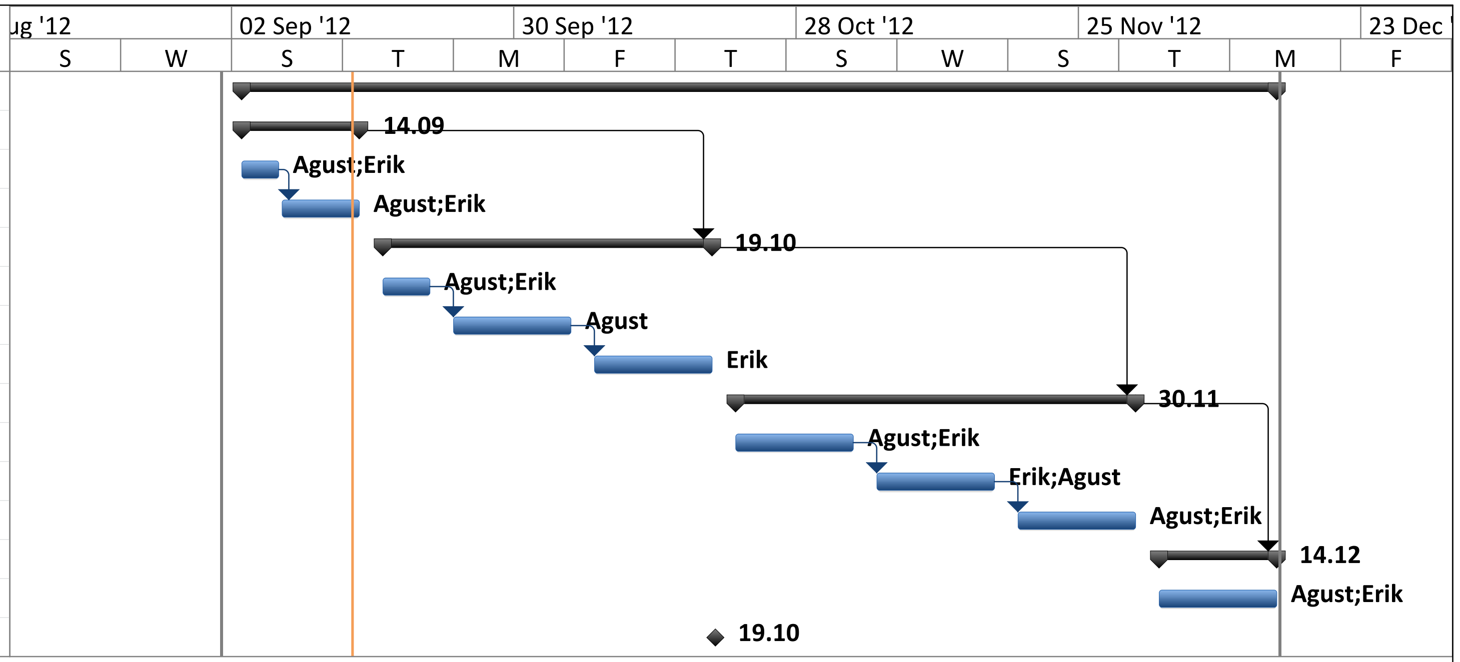
Course: TPK4510	**Date:** 14.09.2012
Project: Market Potential For Train Concepts On The Trønderbanen	
Activity: Phase III	**Activity Nr:** 1.4
Start: 03.09.2012	**Finish:** 14.12.2012
Predecessor: Phase II	
Successor:	
Goal: Recommend one or a few new train service concept, which can be implemented to service the Trondheim area and finish up the writing process.	
Description The project consist of three phases. This work package consist of the third and the last phase which is finalize the semester report.	
Man Hours: 120 Hours	**Resource** Ágúst Már Gröndal: 60 Hours Erik Smedsrød: 60 Hours
Costs: 0,-	
Resources:	
Risk:	
Activity Owner: Ágúst Már Gröndal & Erik Smedsrød	

Appendix – 6 (WP 6)

NTNU – Trondheim
Norwegian University of
Science and Technology

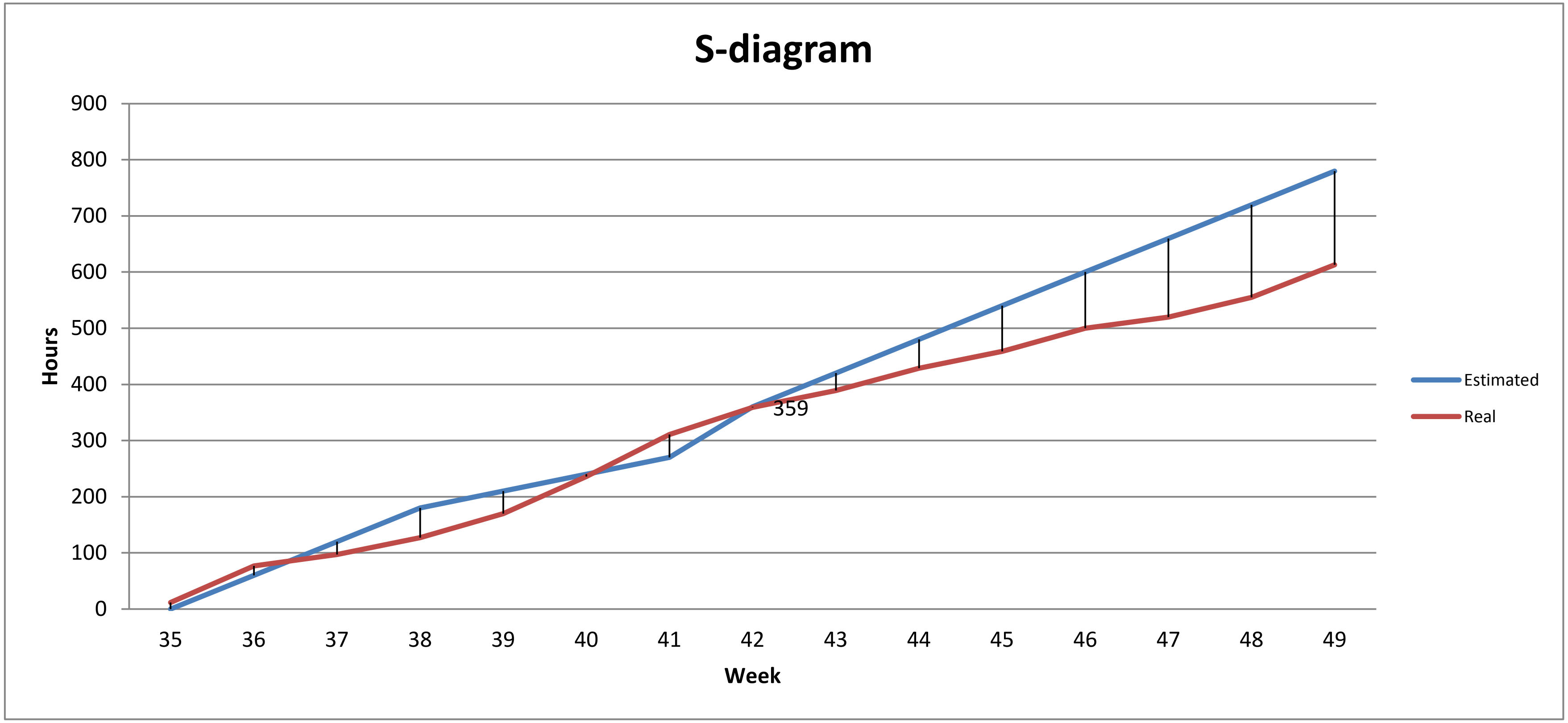
Course: TPK4510	**Date:** 14.09.2012
Project: Market Potential For Train Concepts On The Trønderbanen	
Activity: Progress Report	**Activity Nr:** 1.5
Start: 03.09.2012	**Finish:** 14.12.2012
Predecessor:	
Successor:	
Goal: Compare the writing process to the pre-study report within the time period since the pre-study report was submitted. (19. September 2012)	
Description Progress report shall be submitted to the supervisor within 19. October 2012, containing: Ordinary progress diagram, description of the work carried out within the period and all deviations from the pre-study report should be noted.	
Man Hours: 60 Hours	**Resource** Ágúst Már Gröndal: 30 Hours Erik Smedsrød: 30 Hours
Costs: 0,-	
Resources:	
Risk:	
Activity Owner: Ágúst Már Gröndal & Erik Smedsrød	

ID	WBS	Task Name	Duration	Start	Finish	Predecessors
1	**1**	**Semester Project**	**75 days**	**Mon 03.09.12**	**Fri 14.12.12**	
2	**1.1**	**Pre-Study Report**	**10 days**	**Mon 03.09.12**	**Fri 14.09.12**	
3	1.1.1	Planning The Project Lifecycle (Gantt & WP)	4 days	Mon 03.09.12	Thu 06.09.12	
4	1.1.2	Writing up the pre-study report	6 days	Fri 07.09.12	Fri 14.09.12	3
5	**1.2**	**Phase I**	**25 days**	**Mon 17.09.12**	**Fri 19.10.12**	**2**
6	1.2.1	Experience Projects	5 days	Mon 17.09.12	Fri 21.09.12	
7	1.2.2	Estimate Population Growth, Regional & Local	10 days	Mon 24.09.12	Fri 05.10.12	6
8	1.2.3	Estimate Passenger Demand	10 days	Mon 08.10.12	Fri 19.10.12	7
9	**1.3**	**Phase II**	**30 days**	**Mon 22.10.12**	**Fri 30.11.12**	**5**
10	1.3.1	Map Out Current Route Concepts	10 days	Mon 22.10.12	Fri 02.11.12	
11	1.3.2	Analyze Current Route Concepts	10 days	Mon 05.11.12	Fri 16.11.12	10
12	1.3.3	Identify New Alternative Route Concepts	10 days	Mon 19.11.12	Fri 30.11.12	11
13	**1.4**	**Phase III**	**10 days**	**Mon 03.12.12**	**Fri 14.12.12**	**9**
14	1.4.1	Finalize The Report	10 days	Mon 03.12.12	Fri 14.12.12	
15	1.5	Progress Report	5 days	Mon 15.10.12	Fri 19.10.12	



Prosjekt: msproj11
Dato: Fri 14.09.12

Aktivitet
Deling
Milepæl
Sammendrag
Prosjektsammendrag
Eksterne aktiviteter
Ekstern milepæl
Inaktiv aktivitet
Inaktiv milepæl
Inaktivt sammendrag
Manuell aktivitet
Bare varighet
Manuell sammendragsfremheving
Manuelt sammendrag
Bare start
Bare slutt
Tidsfrist
Fremdrift



S-diagram
Hours
900
800
700
600
500
400
300
200
100
0
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
Week
359
Estimated
Real

NTNU
Norwegian University of
Science and Technology

Progress report -PR 1

Week: 42	**Period**: 04.09.12 – 19.10.12	**Project group:** Ágúst Már Gröndal Erik Smedsrød
Date: 17.10.12		**Ref**: Erik Smedsrød
Receiver: Supervisor at NTNU		

Students:	**Ini.**	**Telephone**	**E-mail**
Ágúst Már Gröndal	AG	480 61 498	amgrondal@gmail.com
Erik Smedsrød	ES	414 70 104	erik.smedsrod@online.no
Contacts:			
NTNU			
Hans Petter Krane	HPK	975 15 809	hans.p.krane@ntnu.no
NSB			
Henning Myckland	HM	938 45 603	henningm@nsb.no

1. Achieved goals / milestones in the period

Goals / milestones	Responsible	Comments
Experience reports and methodology	ES	Ok
Estimate population growth, regional & local	AG	Ok
Estimate passenger demand	AG & ES	Due to late answers from experts, the exactly demand have not been presented in the text.

2. Deviation

Deviation	Comments	Responsible	New deadline
Estimate passenger demand	Due to late answers from experts, the exactly demand have not been presented. Got the answer 17.10.12	AG & ES	TBAL

3. Tasks next period

Tasks	Comments	Responsible	Deadline
Implement passenger demand data	Currently working on it.	ES	TBAL
Map out current route concepts		AG & ES	02.11.12
Analyze current route concepts		AG & ES	16.11.12
Identify new alternative route concepts		AG & ES	30.11.12

4. Time consumption in period

Name	Activity	Hours
Ágúst Már Gröndal	Estimate population growth, making excel charts, study the KOMPAS model that Trondheim municipality is using and writing on report.	95
Erik Smedsrød	Gather information about other experience reports, understand the universal four stage transport modelling theory and the Norwegian RTM model + writing on paper.	112

5. Other

Field trip along the Trønderbanen 10.10.12 with NSB.

Meeting with NSB - MM1

MINUTES 04.09.2012 09:00 – 12:00 VALGRINDA 4. FLOOR

MEETING CALLED BY	NSB
TYPE OF MEETING	Introduction of Semester Project, fall 2012
FACILITATOR	Nils Olsson
NOTE TAKER	Erik Smedsrød & Agust Mar Grøndal
TIMEKEEPER	Nils Olsson
ATTENDEES	Agust Mar Grøndal Student amgrondal@gmail.com Andreas Økland Sintef Andreas.Okland@sintef.no Asle Nordbotten NSB AsleN@nsb.no Erik Smedsrød Student erik.smedsrod@gmail.com Halvor Hansen NSB halvors@nsb.no Hans Petter Krane NTNU/Sintef hans.p.krane@ntnu.no Henning Myckland NSB HenningM@nsb.no Nils Olsson NTNU/Sintef nils.olsson@ntnu.no

Agenda topics

30 MIN INTRODUCTION EVERYBODY

DISCUSSION	Nils began by setting the outline for the meeting agenda; topics, time and etc. Then all of the attendees made a brief introduction, where they stated their name and background.
CONCLUSIONS	

ACTION ITEMS	PERSON RESPONSIBLE	DEADLINE

45 MIN NSB GOALS NORDBOTTEN & MYCKLAND

DISCUSSION	Asle and Henning started with a basic introduction to Trønderbanen. Followed with their expectation and the purpose of the project. Furthermore they talked detailed about the current train infrastructure and pointed out interesting factors that the students can focus on.
CONCLUSIONS	Agust and Erik got much clearer picture of the project and the objectives.

ACTION ITEMS	PERSON RESPONSIBLE	DEADLINE
Pre-Study Report	Agust Mar & Erik	14.09.2012

30 MIN	THESIS QUESTION	NILS OLSSON

DISCUSSION	Regarding the thesis question, Agust and Erik, asked couple of questions regarding the scope of the project to clarify it.
CONCLUSIONS	Nils, Henning and Asle provided some contacts that Agust and Erik can be in touch with regarding this matter and recommended some reading material.

ACTION ITEMS	PERSON RESPONSIBLE	DEADLINE

15 MIN	FURTHER COLLABORATION PLANS	NILS OLSSON

DISCUSSION	Brief talked about the collaboration between the two student's project and communication between students and NSB.
CONCLUSIONS	The projects are two different assignments and will not involve each other in their study. Regarding the communication with NSB, the students got all the relevant contacts and to whom they should report if they have any questions or need additional information.

ACTION ITEMS	PERSON RESPONSIBLE	DEADLINE

Meeting with NSB – MM2

MINUTES 19.10.2012 13:15 – 15:00 VALGRINDA 4. FLOOR

MEETING CALLED BY	Erik Smedsrød
TYPE OF MEETING	Feedback meeting for semester project
FACILITATOR	Hans Petter Krane
NOTE TAKER	Agust Mar Grøndal
TIMEKEEPER	Agust Mar Grøndal
ATTENDEES	Agust Mar Grøndal — Student — amgrondal@gmail.com Erik Smedsrød — Student — erik.smedsrod@gmail.com Hans Petter Krane — NTNU/Sintef — hans.p.krane@ntnu.no

Agenda topics

1 HOUR 45 MIN STATUS OF REPORT EVERYBODY

DISCUSSION	Erik and Agust started with outlining the status of the report, which lead to combine discussion of following subjects: • Extracting numbers from RTM • Extensive literature work • Potential proposals for NSB
CONCLUSIONS	Start right away with the concept proposal.

ACTION ITEMS	PERSON RESPONSIBLE	DEADLINE
Proposal for NSB	Agust & Erik	1.11.2012

NTNU – Trondheim
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Progress Report Meeting

INVITATION 19.10.2012 13:15-15:00 VALGRINDA

MEETING CALLED BY	Erik Smedsrød
TYPE OF MEETING	Feedback meeting for semester project
FACILITATOR	Hans Petter Krane
NOTE TAKER	Agust Mar Grøndal
TIMEKEEPER	Agust Mar Grøndal
ATTENDEES	Agust Mar Grøndal Student amgrondal@gmail.com Erik Smedsrød Student erik.smedsrod@gmail.com Hans Petter Krane NTNU/Sintef hans.p.krane@ntnu.no

Agenda topics

13:15 – 14:00	PRESENTATION OF THE PROGRESS REPORT	AGUST & ERIK
14:00 – 15:00	FEEDBACK FROM SUPERVISORS	HANS PETTER