NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CIVIL AND TRANSPORT ENGINEERING

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| Report Title:<br>"*Timetable alternatives for Trønderbanen"* | Date:17-12-2012 |
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Abstract:

The purpose of the specialization project is to find alternative timetables for Trønderbanen. The limitations during the calculation process are more or less the limitation that the inputs of the program set. The scope of the current project also puts another limitation to the project itself. Calculating and comparing timetables that run a clock face procedure with hourly intervals sets another constraint. The other parameters of the system are considered to be the same as today. The analyzed line consists of the single line parts from Søberg to Trondheim S and Stjørdal to Steinkjer and the future infrastructure that includes a double track from Trondheim S to Stjørdal and the electrification of the whole examined line. The method used is the timetable theory and Viriato, a powerful integrated tool for timetable scheduling, made by SMA. NSB and JBV supplied all the necessary infrastructure and data needed in order to make these calculations. The background is Traffic Theory that helped to evaluate the produced Railway Timetables. The examined line is the one between Steinkjer-Søberg. The results are four timetables (A,B,C,D). After assessing a number of factors, the best alternative is scenario C. A recommendation for further study would be to examine half –hour services between the major stops that have the biggest demand and to intergrade this in a general transportation map that will include other means of transportation. The full timetable, including freight and long distance trains should be incuded in expanded evaluations and possible simulations of robustness.

Keywords: NSB, JBV, Viriato , traffic Theory, future line electricication, hourly services, clock-face timetables, evaluation, Søberg- Steinkjer

## DEDICATION OF THE REPORT

This specialization project is dedicated to Nils Olsson and Halvor S.Hansen, without whose support it would not have been possible to make it, and also to my professor Konstantinos Liberis that inspired me the love for railways.

**PREFACE**

A good time scheduling is an essential factor for making a railway network attractive. With a misfortune of a weak scheduling process, the railway may lose ground over other means of transportation. Ultimately, neglecting to give significant importance to this field is equal to deriving the railway network from evolving, thus reducing the demand. That is the reason why it is important to make the network more attractive. The first step is the planned electrification of the line between Steinkjer-Søberg so as to use a specific type of trains (Flirt) that can achieve a maximum velocity of 160 km/h.

The scope of the project has been defined in a meeting that took place in the 4th of September 2012 with the supervisor of this report, Nils Olsson, NSB and the writer of this report. By having a constant contact with NSB the scope was stated more clearly through an email. The initial version of it was to examine a future-maximum scenario (after the electrification of the line and the double line between Stjørdal and Trondheim) and a minimum one about the enhanced crossing capacity between Trondheim and Stjørdal. Two in person meetings took place in Oslo at the 26th of October and at the 7th of December respectively and it has been decided to examine the line from Steinkjer to Søberg as described above.

The tool used to produce the timetables is Viriato and has been provided to me after the financing of NSB, through SINTEF. The main content of the present report is a comparison of four different timetables alternatives that have been produced by taking some parameters into account and at the same time making a number of essential and logical assumptions.

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**SUMMARY**

Due to the wished electrification of the examined line a re-scheduling of routes is essential. The procedure of producing timetables for the specific line (Steinkjer-Søberg) has been conducted by using Viriato, a specialized software.

The evaluation criteria /factors that have been chosen in order to evaluate the scenarios are the following: The achieved crossings, the driving times, the number of train sets that need to be used. To get the number of train sets printing of the graph has been chosen because of its simplicity.

Some other factors have been examined also and these are: the demand based on the population, the timetable times around zero, the stability of the timetable, the historical value of each station, the number of crossings, Recovery times, the employees point of view and comparison with the current timetable have also been examined.

The worst scenario is that with the larger duration and the most required alterations in the specific line (scenario D).

The rest of the scenarios have some positives and negatives aspects that are being discussed in section “discussion” with the best one to be scenario C.

To evaluate thoroughly the rest of the scenarios it would be interesting to have an evaluation of the demand in every potential stop so as to cover it and to make scheduling by setting this important priority.

The procedure has been traced by the planning department of NSB and with the use of data provided by JBV.

# 1. **INTRODUCTION**

Traffic management in railway networks and timetables are two linked elements when it comes to railway operation. Even though the planning procedure deviates from its execution because of unforeseen factors, the scheduling remains a very important part for the operation of the transportation system. Timetabling is a very important tool that can be used in this sense from the level of planning until the level of communicating information to the customers.

This can be implemented in two ways: manually and with IT –tools. To achieve the continuous improvement in the planning procedure an updating is required regularly. It is difficult to make a material plan without a timetable and it is difficult to schedule maintenance and running without both personnel and without plans (Olsson, N. O. E. and M. Veiseth , 2011). For over than 150 years the scheduling was being implemented manually. It was the typical way of planning until the 1990s when computer-based methods were introduced (Pachl, 2008). Advanced tools for construction design have been introduced over the past decades. However, judging from the punctuality levels that they are not the highest ones, (apart from Japan), one can say that this tool has shortened the procedure of planning but has advanced its performance. The low degree of robustness and exactness is the main cause for this disappointing measurement (Pachl, 2008).

The method used in this project to calculate train diagrams is based on the use of Viriato, a powerful IT-tool. The aim of this project is to produce and to evaluate alternative timetables for Trønderbanen. The specialization project will also set the framework to write the master thesis the following semester. The current line operates with diesel-engined trains. The planned electrification of the Steinkjer-Søberg is a need to look at different route concepts Trønderbanen. Electric trains have better acceleration performance than today's diesel trains, which will lead to theoretical travel time savings of 7-10 min for the line from Trondheim to Steinkjer. The current path model locked at the existing crossing points, and there is little room to achieve real savings when it comes to running times, it is necessary to look for new route models so that travel time savings can be utilized. The analyzed line consists of parts of the current infrastructure (meaning the geometrical feautures of the line). These are the parts from Søberg to Trondheim S (single track) and Stjørdal to Steinkjer (single track). Trondheim S- Stjørdal is wished to be converted from a single line track to a double line track.

The limitations during the calculation process are more or less the limitation that the inputs of the program have. The infrastructure, the rolling stock and the available materials to be used are some of those. The scope of the current project also puts another limitation to the project itself. Calculating and comparing timetables that run a clock face procedure with hourly intervals may seem a logical approach from an initiation of a planning procedure but also set borders to more complicated scenarios.

The purpose of the report is to choose through a detailed examination of various factors which scenario is the optimal one for the line Søberg to Trondheim S, Trondheim S- Stjørdal and Stjørdal to Steinkjer after its electrification, the use of certain type of trains (FLIRT) and the replacement of the single track between Trondheim S and Stjørdal with a double one. By making several other assumptions and taking a number of parameters for granted, while creating timetables for a specific future version of an already existing line (Steinkjer-Søberg) the optimum alternative is intended to be found. The task is, therefore, to develop and compare different routing concepts to provide an indication of the improvement that can be achieved (like travel time, frequency, structure) and to identify other appropriate action (like construction of double track / crossing) that must done to achieve this. This is being made by the use of several criteria that are used during the evaluation.

The evaluation procedure can lead to important conclusions that can improve the current or enhance the performance of the future railway network. The above procedure has been done in cooperation with NSB. The planning department of NSB is committed to reducing the incidence of planning inadequate elements in order to achieve high and consistent standards of everyday performance.

The accuracy of the given data that has been used in order to produce the timetables is checked. NSB provided the data at 04-09-2012. All the calculations have been made with this version of database. A few months later, at 26-11-2012, JBV provided the database also for the specific line. A comparison of these two databases ensured the accuracy of the used input.

Each chapter describes the procedure that has been followed. The structure of the report is the following.

In chapter two the materials and methods that have been used are being described. These include the background that is based on the timetable theory, its basic terms and how to make a successful planning procedure. In the second part of this chapter the network and the available trains are being introduced, while in the third and final part, an analytical step-by –step procedure using VIriato is being demonstrated from the scope of NSB. This part also includes the inputs-assumptions that have been made. In chapter three an overview of the 4 produced results is presented while in the following chapter (chapter 4) the discussion is being conducted. The discussion is based on the methods presented at the chapter 2) and to other logical sequence of thinking. The final chapter is about concluding the results of the report (chapter 5).

# 2. THEORY AND METHODS

## 2.1 Timetable Theory

### *2.1.1 Planning Procedure*

To understand the purpose of the planning procedure one has to be aware of its several functions. It coordinates train times for proper utilization of infrastructure while it ensures predictability in rail traffic and produces information to the travelers and forms the basis to infrastructure management and control (Pachl, 2008). Three types of different formats exist when it comes to the produced results of planning.

- Tables for customers
- graphic tables
- tables for the personnel

The basic tool that most railways use to depict the planning is train diagrams. They depict a relation between time and distance in a time axis and in a station axis. Train movements are drawn as train paths, with train number written on them. ‘A train path describes the usage of the infrastructure for a train movement on a track and in time. They can also be modeled as a sum of blocking times that have no dependency with the type of signaling used on the line and on the train (traction and braking characteristics).In Norway the line is being depicted in the Y-axis. Stations and stops are being depicted here. In other countries the depiction takes place in the X-axis.

A timetable should at least be able to comply with safety regulations while at the same time being able to be theoretically executable (and that is it being without internal conflicts between trains) and practical and executable that is it facilitate punctual trains under normal conditions for rollback capability in the event of irregularities. In addition it has to comply with the market's demands. Unlike all the other means of transportation, railways have one degree of freedom .There are a number of factors that have to been taken into account while contacting the scheduling. The infrastructure and the laws regarding the personnel are some of them. (Olsson, N. O. E. and M. Veiseth 2011).The strategic planning is usually top-down. This type of planning is linked to a long term perspective and is linked to the strategic planning of the whole organization. On the other hand a more detailed planning requires a bottom-up approach. This kind of planning is about maintenance, materials and personnel but in a more short -term perspective.

#### *2.1.2. Blocking time and interlockings*

Interlocking is the way the signals are connected electrically in a way that movements are being contacted in a safe way. The types of interlocking are 1) interlocking without consecutive signals or 2) interlocking with consecutive signals.

Lines consist of block sections to ensure safety. A train is not permitted to enter the block section ahead it if this is occupied by another train. This time of occupation is called block time(Pachl,2008). Blocking times is an essential part of scheduling since they set an important restriction to the planning process.

#### *2.1.3. Scheduled Running Time*

The scheduled running time includes the following sub-times: the pure running time between the stops that are in the schedule, the dwell time in the stops, the recovery time and the scheduled waiting time.

The pure recovery time is the minimum possible running time between two stops while the recovery time can be divided to the regular recovery time and to the special recovery time. The first one is 3-7 % in Europe. There are some occasions when the recovering time is included to the dwell time and not to the running time( Pachl ,2008). This is being implemented in large stations.

#### *2.1.4. Headways and buffer times*

To create a sufficient headway is a crucial element of successful planning. The headways can either be assigned to the stations or to the sections in between (Pachl, 2008). There are four types of headways .The cases are:

- Two trains depart in the same line (depart-depart headway),

- Two trains arrive in the same line (arrive-arrive headway),

- Two opposing trains with the one arriving and the other one departing in the same line (arrive-depart headway)

- Two opposing trains with the one departing and the other one arriving in the same line (depart-arrive headway)

The buffer time is the smallest slot between the blocking time stairways of two trains and it depends on several factors. When the second train has a priority, the buffer time is larger (Pachl,2008).

### *2.1.5. Train separation*

Two vehicles can follow each other in a minimum distance which is equal to the difference of their braking distances plus a safety distance. The separation by sight is only applicable in low velocities. The main principles to be followed for safe train separation are the following ones:

-the section ahead must be clear.

-the overlap behind the next signal must be clear.

-stop signals must ensure that the train ahead is going to be protected from the following train and opposing movements.

What is really important is to examine the way movement is being transmitted from track to train and how the line behind the train is released (Pachl, 2008).

### *2.1.6. Capacity*

The capacity in railway infrastructure is defined as the total number of possible paths in a specific time window, considering the actual path mix or known developments respectively and the infrastructure management's own assumptions, in nodes, individual lines or part of the network and with market-oriented quality (UIC Fiche 405 OR, 2004). Practically it defines the maximum number of trains which may run on a railway section part in a certain time period, with a certain level of service. It is dependent on technical parameters. Those can be the geometry of the infrastructure, the speed limits,the type of the signaling system and prioritization of the train traffic.

From the timetabling point of view capacity has certain requirements that are obvious in the figure.

| **Timetable planning** |
|---|
| requested number of train paths |
| requested mix of traffic and speed |
| existing conditions of infrastructure |
| time supplements for expected disruptions |
| time supplements for maintenance |
| connecting services in stations |
| requests out of regular interval timetables (system times, train stops, ...) |

Figure 1-Capacity from the timetable planning point of view(UIC Fiche 405 OR, 2004)

The dynamic relationship between the main parameters that define capacity is depicted in the "Capacity Balance" (UIC Fiche 405 OR, 2004)

These parameters are the number of trains, the average speed, heterogeneity and stability.

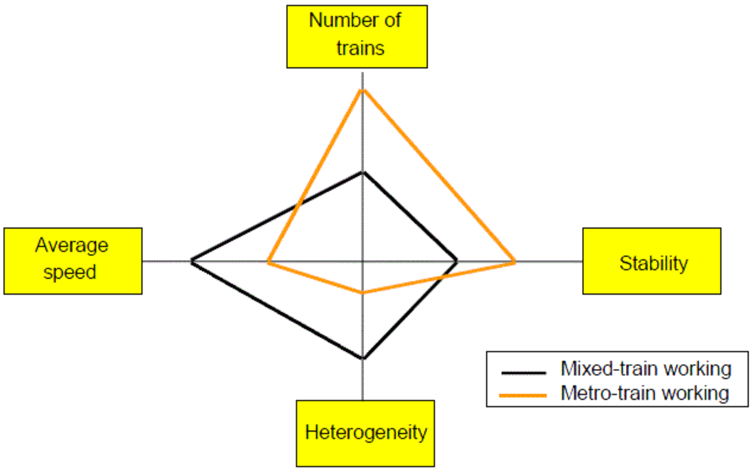



Figure 2-Capacity balance (UIC Fiche 405 OR, 2004)

The important side-conclusions that can be excluded from this diagram are:
The level of service lowers as the number of trains increases when the average speed increases, the breaking distance increases also, causing a reduction in capacity

From reliability and timetable's stability point of view, recovery times must be taken into account as well as buffer times. Consequently, this causes a reduction to capacity of the network.

When different types of train use the network heterogeneity increases unlike practical capacity that decreases.

The theoretical capacity of a line can be calculated by the following formula:

$$K=T/t \quad (1)$$

where:

K (number of sets) is the maximum capacity in the time period T (min) and the frequency.

The theoretical maximum capacity refers to the capacity of trains of the same performance when they take full advantage of their abilities.

While the theoretical capacity is the one when the actual planning is taking into account and the practical capacity is the one that is practically achieved.

### *2.1.7. Stability and Robustness in timetable planning*

Stability is the capacity of the system to make restitution for delays and, in general disturbances in the system and to go back to the initial condition. Robustness is the ability of the system to battle the parameter and the operational alterations (Hansen and Pachl,2008).

A recommended approach on finding robustness (Fischetti, 2008) comprises of two steps (1) finding an optimum timetable and (2) finding a robust schedule by the assumption of fixed train orders in passing the block sections. Another approach (Babar Khan and Zhou ,2010) in a double-track comprises of the following stages. Departure/arrival times from/to stations and deviation from the initial plan is being calculated. The sim in this particular occasion is have smaller total travel times and deviations with the assumption of high-speed trains' over the medium-speed ones. An approach that involves a stochastic model to assign time supplements to block section travelling times, considering only one train was issued by (Fischetti and Monaci,2009) that they evolved the model to periodic train schedule.

From the managerial point of view (Vansteenwegen and Oudheusden ,2006), (D'Angelo,2009) and (Odijk,2006) bring out a new definition of timetable robustness. The main concept is based on the fact that for every timetable there is one and only sequence. Thus, a timetable class contains many different timetables, the timetables are called robust. This type of timetable classes has the property that slight disturbances to the input data can be dealt with by modifying the timetable within its class. A new probability distribution has been defined that gives higher probability to robust timetable classes. (Shafia,2010) made an application of this approach to the train timetabling problem and (Shafia,2011) to the job shop scheduling problem.

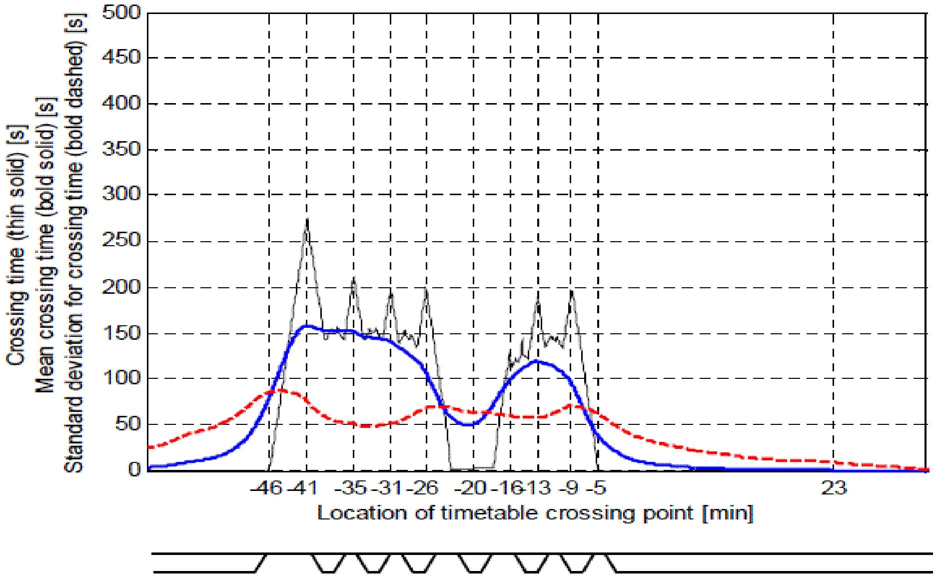



Figure 3-Location of crossings in relation to crossing time (Lindfeldt,2010)

Lindfeldt (2010) introduced a diagram ( fig 3) that gives the crossing time and the standard deviation from it in dependence on the point that the crossings are being made. Crossings at the beginning of a double line give larger deviations from planned times and as a result affect the stability of the produced timetable.

### *2.1.8. Reliability in timetables*

Reliability in timetabling procedure is dependent on several factors; the most crucial one is the quality of the timetable itself. This level of quality can be measured by defining the maximum values either for the total delay or those of the waiting times. Assessing reliability is relevant to assessing stability and robustness (Hansen and Pachl, 2008). Railway system is prone to stochastic effects on operation (e.g. running and dwell times), which reduce the theoretical capacity. To balance it, recovery times and buffer times may be added to reduce stochastic effects on traffic: the higher these times are, the lower the capacity and the higher the reliability will be. A comparison between maximum capacity and reliability is necessary to obtain a trade-off value for the user (who prefers maximum reliability with frequent services) and the railway infrastructure manager (who is interested in maximizing the number of available train paths). To measure reliability someone can measure average delay of the trains like in the following figure shows (Abril, 2008).

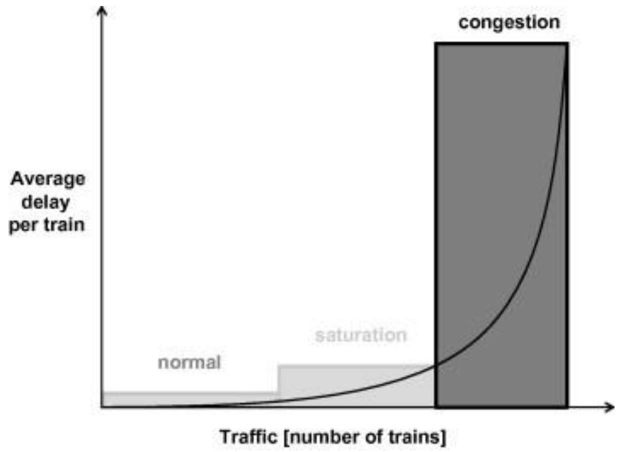



Figure 4- measurement of reliability (Abril,2008).

Reliability and punctuality are linked when it comes to the planning procedure. Train delays affect those two factors.

### *2.1.9. Scheduling Methods*

This can be implemented in two ways: manually and with IT –tools. To achieve the continuous improvement in the planning procedure an updating is required regularly. It is difficult to make a material plan without a timetable and it is difficult to schedule maintenance and running without both personnel and without plans (Olsson, N. O. E. and M. Veiseth ,2011).

For over than 150 years the scheduling was being implemented manually. It was the typical way of planning until the 1990s when computer-based methods were introduced (Pachl, 2008).

In manual scheduling the procedure that is being followed consists of the following steps:

1) The train path is being constructed as a polygon from station to station.

2) The times (running times which contain regular recovery times) are taken from tables. Special recovery times are being added. This step because of the complicated calculation includes the use of computers. Otherwise ride checks are being used.

3) The minimum line headways are being determined. A supplementary time is added to the running time. In Europe this is 1 min. A buffer time is also added which is 3 min.

The principles that are being used in this case is that the signaling type defines the dwell time. At a station with a signal at the exit of it the dwell time is attributed to the block section in approach while at a station with signaling in the entrance and the exit it can also attributed to the section beyond. While waiting at a signal the train cannot use this time for leaving and boarding passengers.

In computer based methods the principles are either the same as those used in manual scheduling or pre-defined matrices with line headways are being used.

The negative with this is that in same complicated occasions some conflicts may not be detected by the system. On the other hand, due to the significant reduction of effort in comparison to manual scheduling, this kind of planning is very successful. It requires experience to detect any flaws of the computer results.

The main principle behind scheduling with the use of computers is the calculation of blocking time stairways. Capacity research and scheduling are really similar when it comes to calculations. The only difference is that the detection of the conflictions is complicated. Where it happens buffer times have to be added. Most of the supplies of IT tools of simulation have placed an add-on to make this possible and attractive to the market.

To use the computer based planning a very detailed version of the infrastructure is necessary. This has to contain the track layout and all the restrictions that come together with it including speed limits. Up to this point, the infrastructure manager is able to solve scheduling conflicts by moving the curves. In the near future multiple suggestions for solving these conflicts are going to be available based on the background theory probably as an add-on to the already existing soft-wares (Pachl, 2008).

For creating and testing the timetable, planners can use simulation tools, like RailSys and OpenTrack or Viriato by SMA.

### *2.1.10. Clock-face Timetables*

A periodic or fixed (regular) interval or clock-face timetable has the following principle: it contains even intervals between the trains. This is widely used in Europe for commercial reasons.

On a single line in this case the running time from one meeting point to another is the half of the fixed scheduled meeting point. The constraint in this case is if two stations have a close distance, the running or dwell time has to be extended to this amount. Another major constrain is the number of the meeting points. The number of train sets is calculated by a simply dividing the cycle time to the fixed interval that is scheduled between the trains. There are three strategies using in scheduling in the case of clock-face schedules: 1) non symmetrical clock-face timetables, symmetrical and integrated ones (Pachl, 2008).

Trains from opposite directions meet twice into the time interval that has been fixed. As a consequence the timetable is always symmetrical from the one direction. If all the routes have the same symmetry time this is called a symmetric timetable.

### *2.1.11. Timetable Variant Evaluation Model*

TVEM (Timetable Variant Evaluation Model) was issued to evaluate the impact of the input parameters to capacity, Lindfeldt(2010)

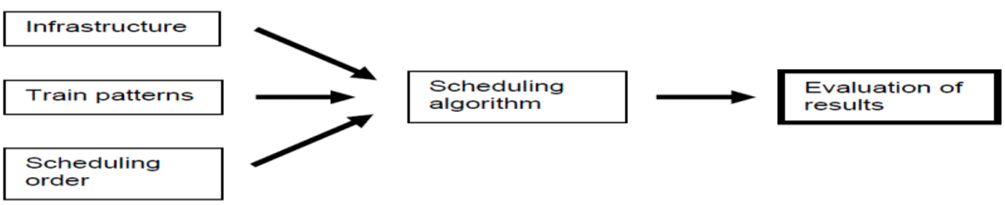



Figure 5-The structure of TVEM (Lindfeldt,2010)

Different timetable variants have an effect in capacity, scheduled delays and to the produced result. The infrastructure that is being used together with the train data and the aim of the scheduling are the inputs in the scheduling procedure. The outputs to be evaluated are the produced diagrams.

### *2.1.12. Successful planning procedure*

Some decisions have to be taken in order to begin the procedure of scheduling. Setting priorities and goals is essential for a successful result. An important decision is the frequency (in this report taken to be an hourly one). In order to simplify marketing and information given to the customers the basic pattern should operate from start to close of service. A half-hour service is oriented to serve urban areas.

The interface between the two types of line has to taken into account. The planned double line gives the freedom to the system to increase capacity. This automatically will have an effect to the single part of the line. Increasing capacity in the double line, and with the assumption that the circle of the train (from one point A to another point B and afterwards back to point A), will increase the number of crossings in the single line. As a result priorities have to be set in the planning procedure.

Appropriate recovery gaps between the times during scheduling are important. A very fancy schedule that it is not feasible in praxis can harm the image of the operator. Thus, punctuality is essential. The passenger when he is about to use a transportation mean with a fixed travelling time, he is willing to spend this time. Any positive deviation from the plan is regarded as an unwanted one.

In addition, a total transportation plan that combines other means also is essential to optimize the procedure.

To evaluate results and proceed to decision making the following factors can be evaluated. Those include income, costs, description of output (frequency, materials and manpower, quality of rolling stock, service etc). A description of the expected market impacts linked to the overall goals and plans and the risk profile and uncertainty is essential also.

The basic elements are:.

- The most important nodes of the network have to be known
- Timetables should be consistent throughout the day and every day.
- Investment should be directed at bringing key

What has to be kept in mind is that perfection cannot be achieved in a real railway network. The task of infrastructure managements and engineers is to improve on the best compromise, often under multiple constraints.

According to Pachl and Hansen (2008) in order to make a good planning the following success factors should be met:

- good overview of all aspects of infrastructure (tracks, stations etc)
- detailed overview of the design and function of signaling systems
- overview of the capacity of the network based on modern methods
- good runtime calculations

- established standards for energy-efficient power trains
- active use of robustness with special focus on crossings and bottlenecks
- use of unlike types of simulation
- monitoring and analysis of punctuality information and other traffic information

## 2.2 Network

### *2.2.1 About Trønderbanen*

Trønderbanen was NSB's project name on the coordination of passenger services on railway lines between Oppdal, Røros, Trondheim and Steinkjer. It occurred as a concept when rail services in the two counties of Trøndelag was reorganized in the 1990s.

The term Trønderbanen was created by Gunhild Myren from Sandvollan in Inderøy, when she won a naming contest in 1993.

Trønder Railway was one of the truly successful rail initiatives in Norway, with departures at fixed times almost every hour throughout the day between Trondheim and Steinkjer. In 2003 brought about the path. 1.1 million passengers. By counting point Storen were six per cent more passengers in Levanger as many passengers as compared with the year before.

From the 1st of January 2004 joined NSB using the name Trønder line of rail services north and south of Trondheim. The reason was that the business unit in Trondheim was dissolved and decisions centralized in Oslo. It is now called the local trains. The name is still Trønder path colloquially.( wikipedia)

Trønderbanen uses the following lines:

Dovrebanen, Meråkerbanen, Nordlandsbanen, Rørosbanen and sidelines Stavne Railway


Figure 6-Trondheim-Steinkjer

Currently the line is single track but there is a plan to electrify it. Between Trondheim and Stjørdal the plan is to make a double track. With this way to capacity is going to be increased on the congested corridor. The timetabling will be made operationally complex by the link with the classic line. The objectives for electrifying the line include also economic and social benefits.

The examined line includes: Søberg to Trondheim S (single track) Trondheim S- Stjørdal ( double track)and Stjørdal  to Steinkjer ( single track).

### *2.2.2 Trains*

The trains that have been used in this report are the Electric Low-floor Multiple-unit FLIRT that will provide a high-speed service.

Currently the trains that they are being used are diesel train sets (BM93) but this is to be altered.


Figure 7-4part electical train of the FLIRT family

For this purpose NSB has purchased 50 5-part electrical trains of the FLIRT family from Stadler.(NSB site)26 of these have been equipped as Long Local version for the S-Bahn traffic in the Oslo area, with travelling times of up to 90 minutes. The other 24 trains are equipped as Short Regional, and will be used in the area of Southern Norway for connections with travelling times of up to 3 hours. The trains that have been ordered are a development of the well-proven FLIRT family, with a special focus on customer friendliness for families, the elderly and the disabled. They are also characterized by an advanced thermal and acoustic insulation and fulfill the high requirements needed for winter operation in Norway.


Figure 8-types of FLIRT

## 2.3. Viriato

Due to the wished electrification of the examined line a re-scheduling of routes is essential. The procedure of producing timetables for the specific line (Steinkjer-Søberg) has been conducted by using Viriato, a specialized software.

Viriato is a powerful integrated timetable planning tool introduced by SMA ( 1996) that allows users to produce the optimal timetables. It serves the following purposes:

Strategic – Using detailed data to develop initial travel time estimates, rough timetables and rostering plans that optimize vehicle use. It helps planners identify optimal timetables by allowing them to easily compare alternatives.

Capacity – As timetable implementation approaches, Viriato can work with detailed data to refine and share timetables between stakeholders.

Operations – Daily timetables can be prepared for use by train operators and infrastructure managers. The Viriato consists of the graphic timetable, travel time analysis, conflict detection, network diagrams, platform occupation charts and customer timetables.

Large amounts of detailed data can be used to prepare precise plans to make the network's capacity maximum. Viriato is a complete timetable planning application that helps timetable planners quickly, accurately and transparently develop optimal timetables for all levels of operations. (SMA website).

### *2.3.1. Constructing the timetable in Viriato*

The initial step to be taken during the planning procedure is to decide on a specific arrival or departure time, e.g. the first train is going to leave from the stop at 6.00am and the last one at 22.00pm from a specific direction. The procedure repeats itself from the opposite direction. The path of that train would be the first one to create and it would be fixed. In Viriato there is a possibility to calculate timetables for a family of trains, meaning trains that have same characteristics and leave in regular times (clock face diagrams). The next step would be to define the headway (or interval) between trains. Taking into account the demand the infrastructure manager take some important decisions that have to do with the frequency, the number of the crossings and other important characteristics of the timetable. Timings sometimes have to be adjusted to achieve the desired crossings in the single line.

### *2.3.2. How NSB uses Viriato*

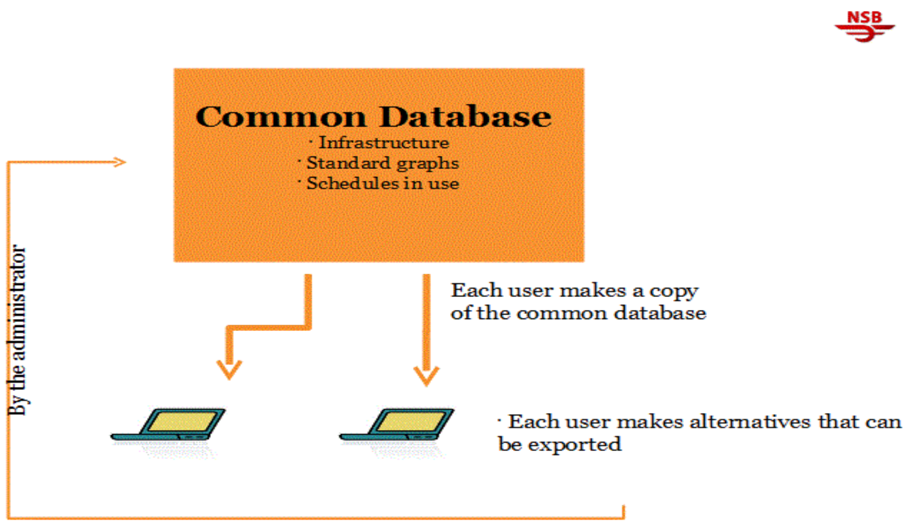
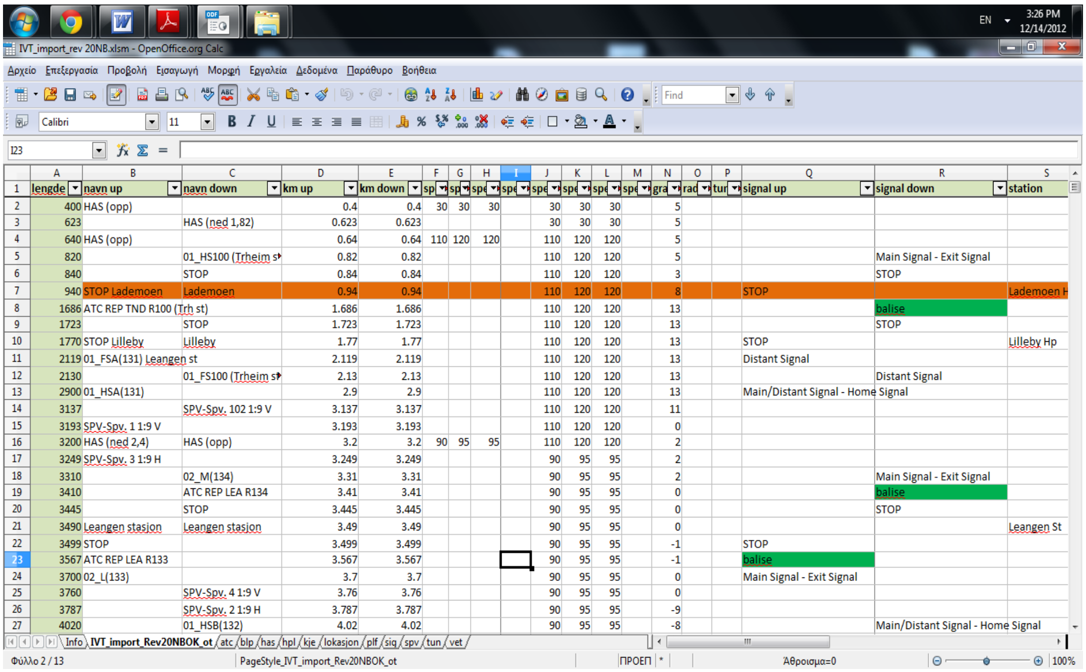



Figure 9 - flow of information in the internal network of NSB while scheduling

NSB has a common database. Each user has to make an individual copy of this database and to create alternatives. When this procedure is completed the administrator can export these alterations to the common database. The initial input during the alteration procedure is the infrastructure to be examined. The infrastructure management has to keep pace of the changes that have been made in the infrastructure data. For this reason JBV (November 2012) provided the infrastructure also that happens to be the same with the one that NSB had provided earlier this year.



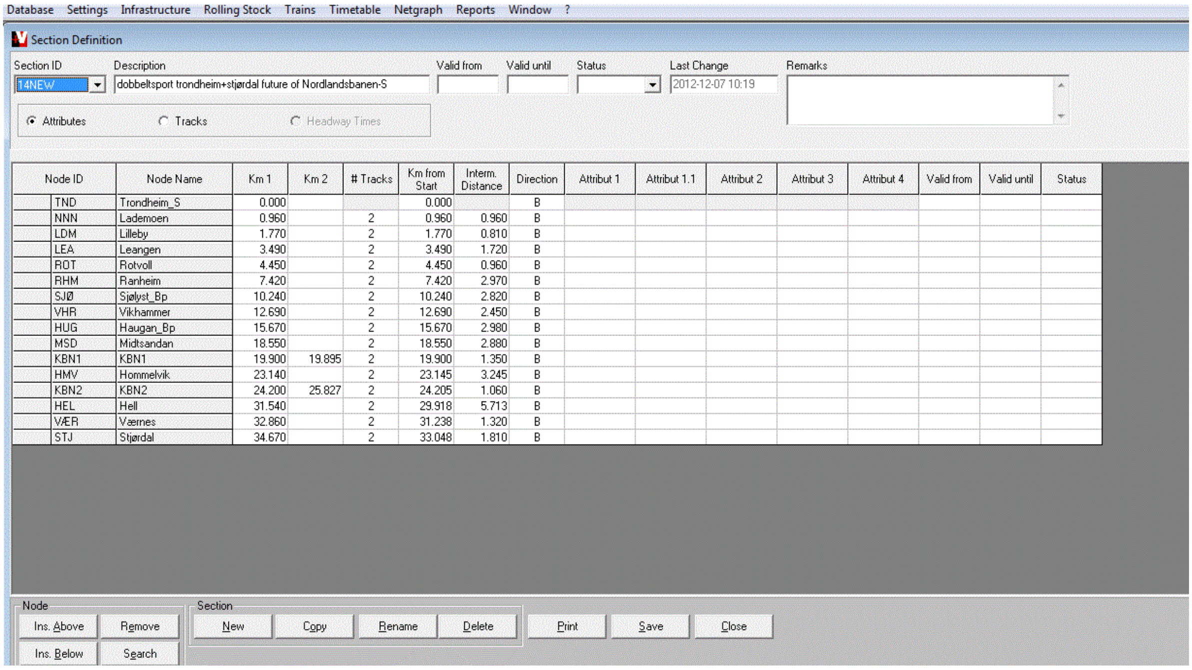
| lengde | navn up | navn down | km up | km down | sp | sp | spe | spe | spe | spe | spe | spe | gra | rad | tur | signal up | signal down | station |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 | HAS (opp) | | 0.4 | 0.4 | 30 | 30 | 30 | | 30 | 30 | 30 | | 5 | | | | | |
| 623 | | HAS (ned 1,82) | 0.623 | 0.623 | | | | | 30 | 30 | 30 | | 5 | | | | | |
| 640 | HAS (opp) | | 0.64 | 0.64 | 110 | 120 | 120 | | 110 | 120 | 120 | | 5 | | | | | |
| 820 | | 01_HS100 (Trheim s | 0.82 | 0.82 | | | | | 110 | 120 | 120 | | 5 | | | | Main Signal - Exit Signal | |
| 840 | | STOP | 0.84 | 0.84 | | | | | 110 | 120 | 120 | | 3 | | | | STOP | |
| 940 | STOP Lademoen | Lademoen | 0.94 | 0.94 | | | | | 110 | 120 | 120 | | 8 | | | STOP | | Lademoen H |
| 1686 | ATC REP TND R100 (Trh st) | | 1.686 | 1.686 | | | | | 110 | 120 | 120 | | 13 | | | | balise | |
| 1723 | | STOP | 1.723 | 1.723 | | | | | 110 | 120 | 120 | | 13 | | | | STOP | |
| 1770 | STOP Lilleby | Lilleby | 1.77 | 1.77 | | | | | 110 | 120 | 120 | | 13 | | | STOP | | Lilleby Hp |
| 2119 | 01_FSA(131) Leangen st | | 2.119 | 2.119 | | | | | 110 | 120 | 120 | | 13 | | | Distant Signal | | |
| 2130 | | 01_FS100 (Trheim s | 2.13 | 2.13 | | | | | 110 | 120 | 120 | | 13 | | | | Distant Signal | |
| 2900 | 01_HSA(131) | | 2.9 | 2.9 | | | | | 110 | 120 | 120 | | 13 | | | Main/Distant Signal - Home Signal | | |
| 3137 | | SPV-Spv. 102 1:9 V | 3.137 | 3.137 | | | | | 110 | 120 | 120 | | 11 | | | | | |
| 3193 | SPV-Spv. 1 1:9 V | | 3.193 | 3.193 | | | | | 110 | 120 | 120 | | 0 | | | | | |
| 3200 | HAS (ned 2,4) | HAS (opp) | 3.2 | 3.2 | 90 | 95 | 95 | | 110 | 120 | 120 | | 2 | | | | | |
| 3249 | SPV-Spv. 3 1:9 H | | 3.249 | 3.249 | | | | | 90 | 95 | 95 | | 2 | | | | | |
| 3310 | | 02_M(134) | 3.31 | 3.31 | | | | | 90 | 95 | 95 | | 2 | | | | Main Signal - Exit Signal | |
| 3410 | | ATC REP LEA R134 | 3.41 | 3.41 | | | | | 90 | 95 | 95 | | 0 | | | | balise | |
| 3445 | | STOP | 3.445 | 3.445 | | | | | 90 | 95 | 95 | | 0 | | | | STOP | |
| 3490 | Leangen stasjon | Leangen stasjon | 3.49 | 3.49 | | | | | 90 | 95 | 95 | | 0 | | | | | Leangen St |
| 3499 | STOP | | 3.499 | 3.499 | | | | | 90 | 95 | 95 | | -1 | | | STOP | | |
| 3567 | ATC REP LEA R133 | | 3.567 | 3.567 | | | | | 90 | 95 | 95 | | -1 | | | balise | | |
| 3700 | 02_L(133) | | 3.7 | 3.7 | | | | | 90 | 95 | 95 | | 0 | | | Main Signal - Exit Signal | | |
| 3760 | | SPV-Spv. 4 1:9 V | 3.76 | 3.76 | | | | | 90 | 95 | 95 | | 0 | | | | | |
| 3787 | | SPV-Spv. 2 1:9 H | 3.787 | 3.787 | | | | | 90 | 95 | 95 | | -9 | | | | | |
| 4020 | | 01_HSB(132) | 4.02 | 4.02 | | | | | 90 | 95 | 95 | | -8 | | | | Main/Distant Signal - Home Signal | |

Figure 10- Infrastructure data

The symbols that are being used in Viriato from NSB are those that are included in the following table.

Table 1- symbols used by NSB

| Code | Description | Example | Depiction |
|---|---|---|---|
| STA | Station | Oslo S | Solid line in graphs, large font |
| HP | Stop | Jørnevik | Dashed line graphs, medium font |
| BP | Blockpost | Ulriken bp | Dashed line graphs, small font |
| P | Important infrastructure spots | KBB1: Kjedebrudd nr 1 Bergensbanen | Does not appear in the routing tables or graphs |
| BUSS | Bus stopp | Ålesund | Thin solid line in the graphs, medium font |




| Node ID | Node Name | Km 1 | Km 2 | # Tracks | Km from Start | Interm. Distance | Direction | Attribut 1 | Attribut 1.1 | Attribut 2 | Attribut 3 | Attribut 4 | Valid from | Valid until | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TND | Trondheim_S | 0.000 | | | 0.000 | | B | | | | | | | | |
| NNN | Lademoen | 0.960 | | 2 | 0.960 | 0.960 | B | | | | | | | | |
| LDM | Lilleby | 1.770 | | 2 | 1.770 | 0.810 | B | | | | | | | | |
| LEA | Leangen | 3.490 | | 2 | 3.490 | 1.720 | B | | | | | | | | |
| ROT | Rotvoll | 4.450 | | 2 | 4.450 | 0.960 | B | | | | | | | | |
| RHM | Ranheim | 7.420 | | 2 | 7.420 | 2.970 | B | | | | | | | | |
| SJØ | Sjølyst_Bp | 10.240 | | 2 | 10.240 | 2.820 | B | | | | | | | | |
| VHR | Vikhammer | 12.690 | | 2 | 12.690 | 2.450 | B | | | | | | | | |
| HUG | Haugan_Bp | 15.670 | | 2 | 15.670 | 2.980 | B | | | | | | | | |
| MSD | Midtsandan | 18.550 | | 2 | 18.550 | 2.880 | B | | | | | | | | |
| KBN1 | KBN1 | 19.900 | 19.895 | 2 | 19.900 | 1.350 | B | | | | | | | | |
| HMV | Hommelvik | 23.140 | | 2 | 23.145 | 3.245 | B | | | | | | | | |
| KBN2 | KBN2 | 24.200 | 25.827 | 2 | 24.205 | 1.060 | B | | | | | | | | |
| HEL | Hell | 31.540 | | 2 | 29.918 | 5.713 | B | | | | | | | | |
| VÆR | Værnes | 32.860 | | 2 | 31.238 | 1.320 | B | | | | | | | | |
| STJ | Stjørdal | 34.670 | | 2 | 33.048 | 1.810 | B | | | | | | | | |

Figure 11-Definition of infrastructure

To define infrastructure one have to define the relevant sections.

The examined line includes: Søberg to Trondheim S (single track) Trondheim S- Stjørdal ( double track)and Stjørdal  to Steinkjer ( single track).

The section between Steinkjer and Trondheim has and particular ID in the general common data base. The number of this ID is 14.

Currently, the line is single track line. There is a plan to make this line a double track so someone can copy the old node and create a new one with the name 14NEW (Trondheim S- Stjørdal) . There, the alteration that has to be made is to put 2 instead of 1 in the column called # Tracks. The new part replaces a percentage of the part with ID 14.

The infrastructure also has the part with ID 10N (Trondheim to Søberg) intergrated.

To make the speed calculations Viriato uses the Strachl Formula:

$$R_{(r+a)\,vehicle} = 2.5 + \frac{(V + \Delta V)^2}{K} \qquad (kg/ton) \qquad (2)$$

Where:

V= speed (km/h)

ΔV= additional coefficient

K= constant coefficient dependent on the type of the train

Where the additional coefficient can take the following values:

=zero (horizontal line and quit weather)

=12 at (lateral wind, medium intensity)

=20 at (lateral wind, strong intensity)

=30 at (strong wind, high intensity, long duration)

And the constant coefficient can be:

= 4000 (high speed and goods train, homogeneous complete)

= 3000 (medium speed, non-homogeneous train)

= 2000 (different types of vehicles)

= 1000 (empty vehicles)

To make the calculations more accurate the curves, tunnels, the velocity profile and the vertical profile are taken into account.

Table 2- velocity categories

| Code | Category |
| --- | --- |
| H | Maximum velocity |
| P | Plus velocity |
| K | Speed titling trains |
| T | "tourist velocity" |

When making the running time calculation Viriato has to know which type of velocity is being used during this procedure. There are several alternatives as showed in the above table.


Figure 12-Depiction of the three types of velocities

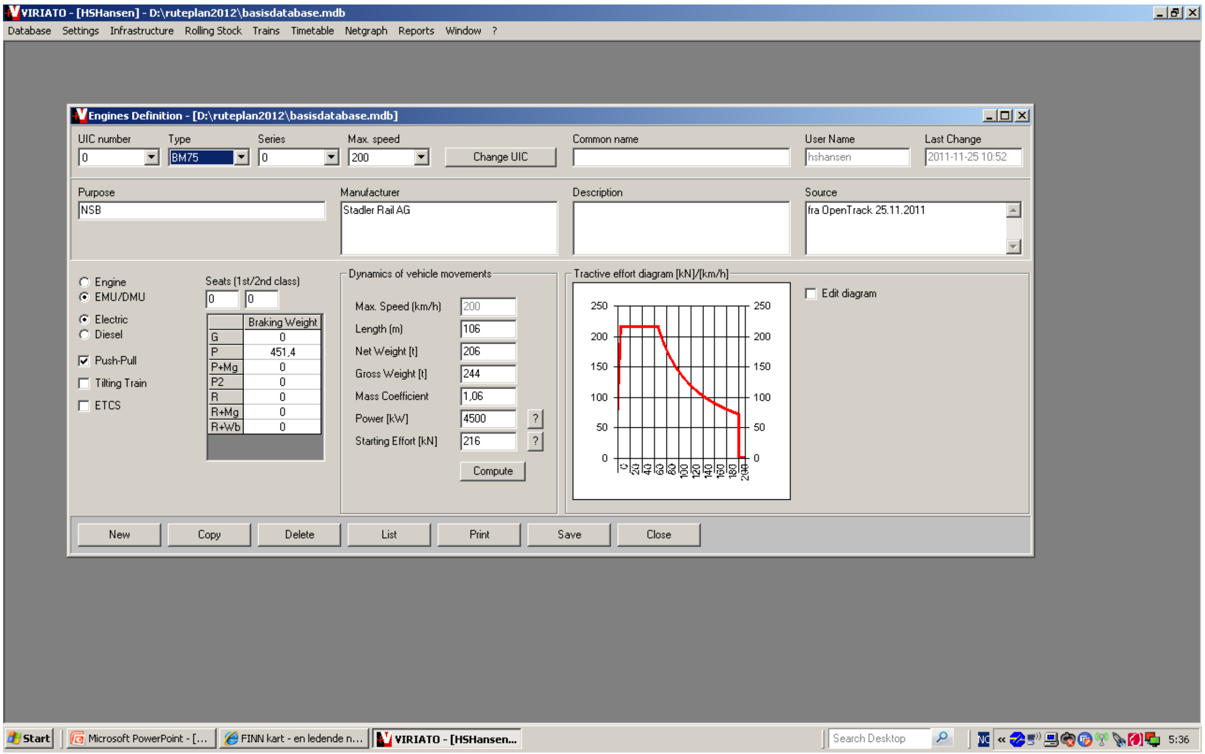



Figure 13- Generation of the traction diagram by Viriato

Viriato calculates the traction diagram by only knowing the type of the train that we use in the planning procedure. In this case this is FLIRT 4-wagon train.

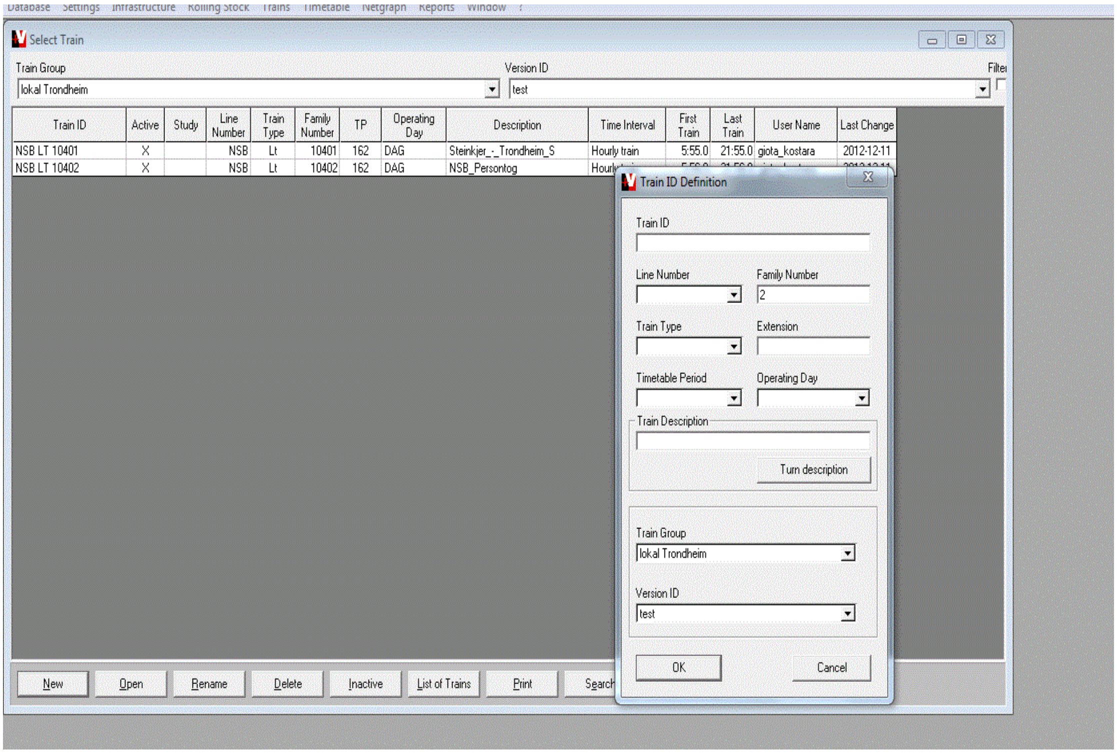


Figure 14-Definition of trains

To issue a new family of trains for each direction the fields that appear in the above diagram have to be filled in. The procedure has to be repeated for both directions.

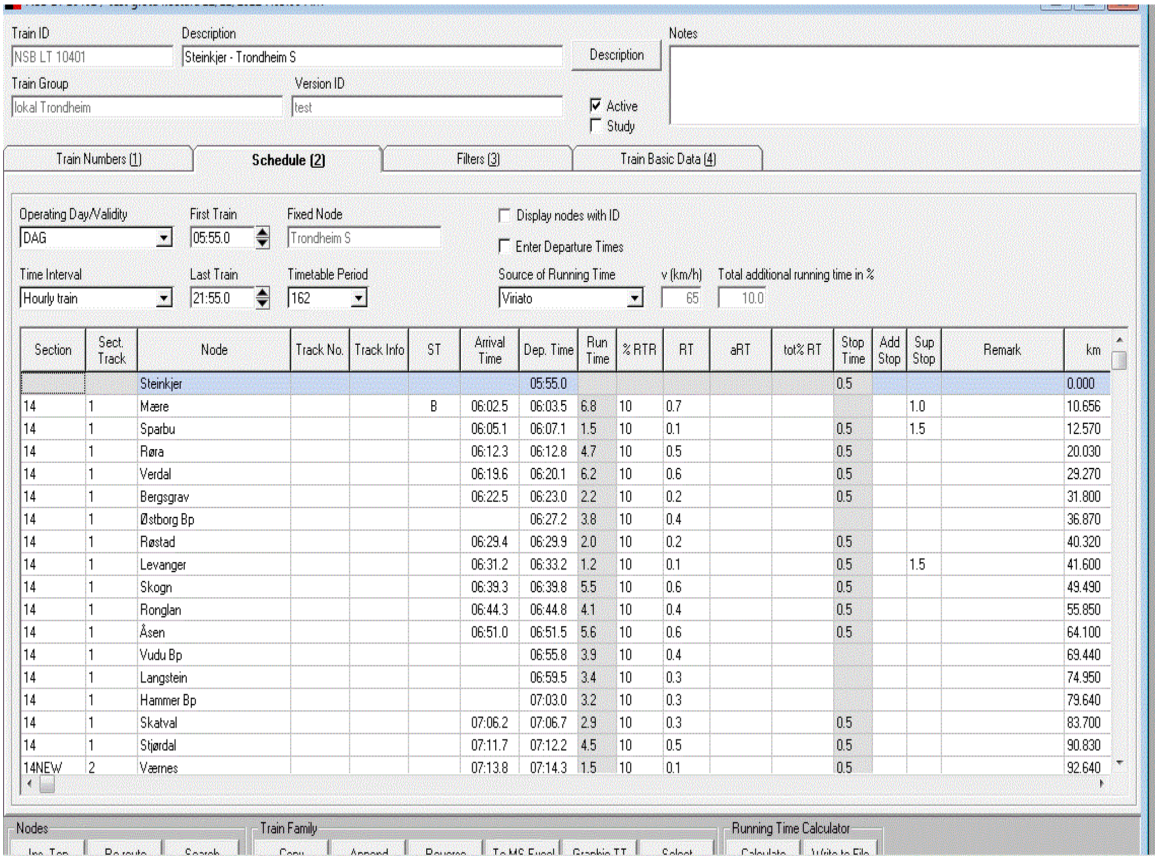


Figure 15-Putting the schedule parameters

The next phase of the planning has to do with the definition of schedule parameters. Here the first train and the last train have to be decided At the beginning the stop times are being put. To achieve favorable crossings supplementary stop times have to be added in the special column and lines in the diagram (yellow lines).

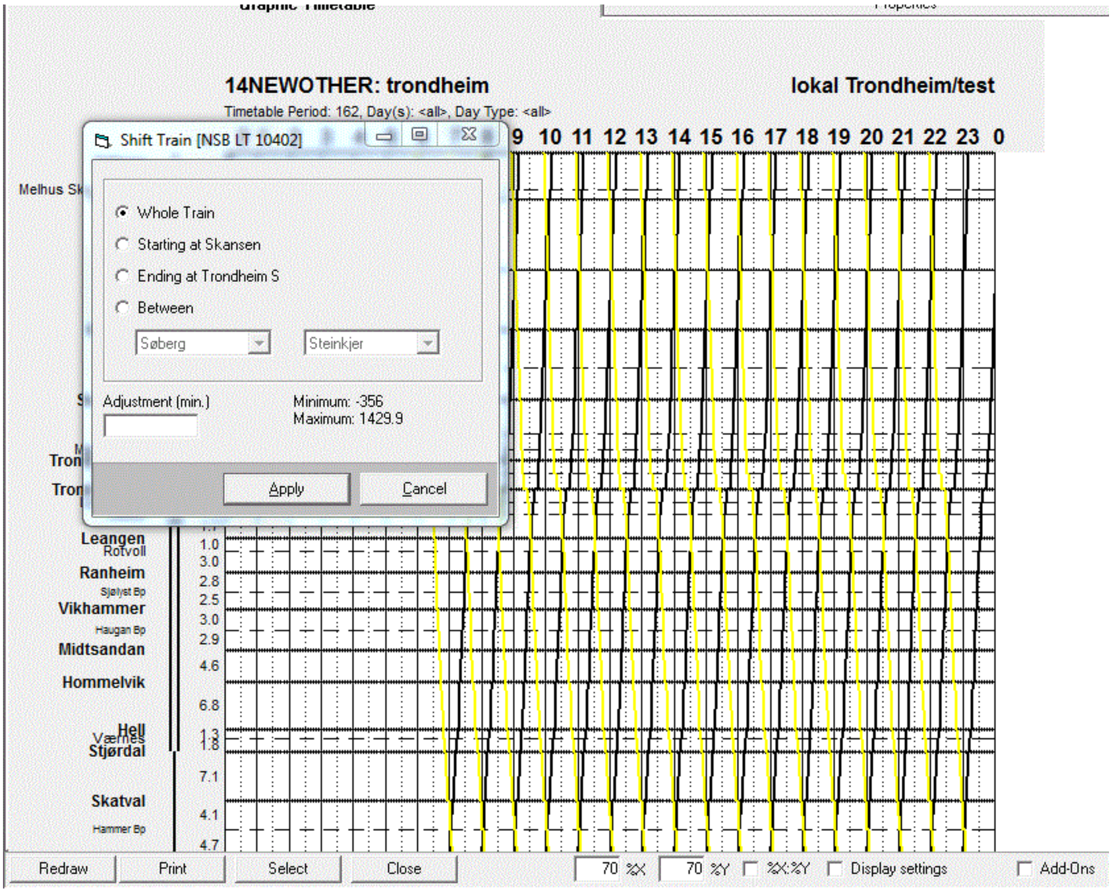



Figure 16-Adjusting the lines

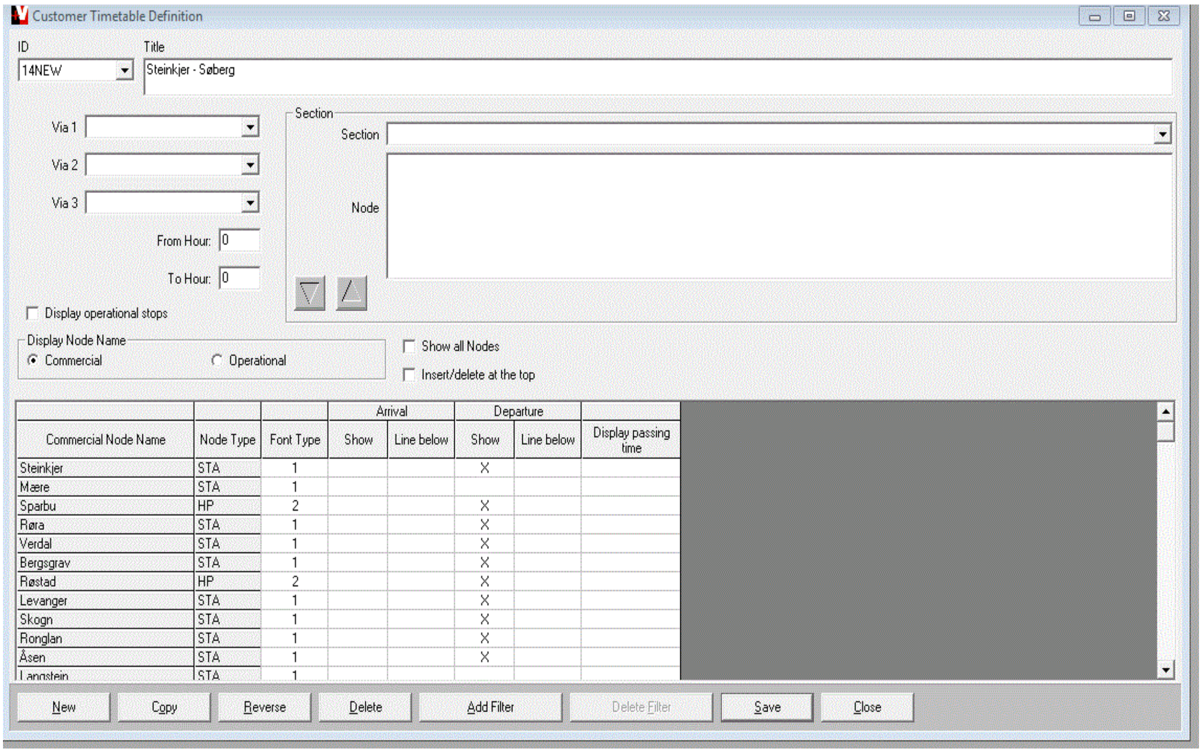



Figure 17-definition of customers timetable

To get the number of train sets there are different possibilities NSB proposes the following methods:

1.Draw the path of one train set. Continue with different color /line types for each train set until all the services have been covered. Count the number of colors/line types to get the number of train sets. The above method is easily explained by the following figure.

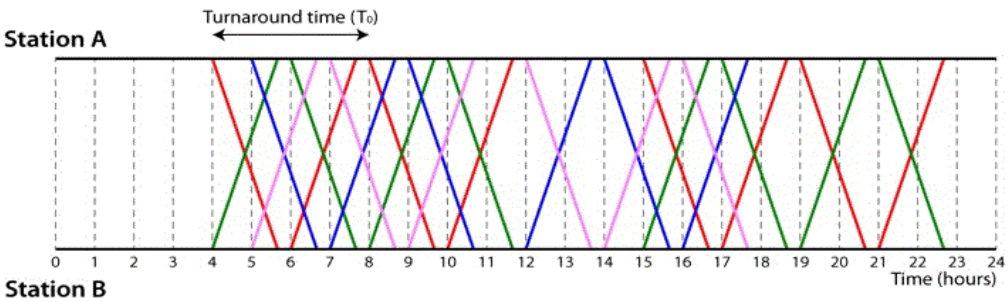



Figure 18-Calculation of the train sets for each scenario

2.Make a sum of travel time A to B turnaround time at B + Travel time B to A + Turnaround time A. Divide this number by the time between each service and get the number of train sets necessary.

3. Count the number of internal crossings. If the turnaround time is ok (above minimum) the number of necessary train sets would be the number of crossings + 1.

Table 3-Inputs of the program

| Assumption | Comment | Decision |
|---|---|---|
| Number of tracks | The future infrastructure between Trondheim and Stjørdal is going to double line track. | -double track Trondheim-Stjørdal ( future infrastructure) -single line in the rest track ( existing infrastructure) |
| Tunnel | During the calculations is not taken into account. Theoretically a tunnel will increase the resistance because of the air flow so it will reduce the remaining force for acceleration. | To simplify the model ,tunnels are not taken into account |
| Inclination | | The line is considered to be more or less without inclination. |
| Length of line | The future infrastructure is going to have the length same length as the current one. | Trondheim-Stjørdal 33.048m |
| Distances Between stops | distances between the stops and location of the stops is the same as the current infrastructure | The same as now |
| Type of V | | H=P |
| Max V | The max V that this type of trains can have. Assumption: it can maintain it min for 10 seconds and after that it is going to start push the brake | 160 Km/h |
| Speed profile | | 2P |
| V near stops | The max V that can be reached near a stop | 30km/h |
| Train type | | Flirt 4 wagon |
| Family number | | 10400/10401 |
| Timetable period | | 162 |
| Min stop time (retention times) | In big stations is minimum 2min. For suburban residence time should be 30 s at small stations and 1 min at larger stations. In Trondheim area, all stations except Trondheim S that has 30 s station stay. In Trondheim S will likely be a need for time off for personal change of at least 2 min drive stays. | 0.5 min |

| | | |
|---|---|---|
| Turn around time | For turning of trains at the station requires a minimum of about 10 min, time should be 15 minutes or more. | Min 10 min |
| Frequency | | Hourly |
| RTR% | Most train sets can run in plus speed. As a basis for sketching 10% slack has been used. | 8-10 |
| Symmetry Axis | It is xx: 00 that the symmetry axis, ie the train arriving to station X minutes before the hour will be departing X minutes after the hour. This provides symmetry xx: 00 This is a principle that is being followed as much as possible, including uses the new routing model in Eastern symmetry axis xx: 00 for the so-called 10-min system. | |
| Crossings | Crossings must be done at stations and one of the trains must always arrive first. This must be left at the station and wait for a certain number of minutes before the next train can run into the station. The scheduled time for the crossing are generally longer than the actual crossing locking time (determined by the signaling system) and are usually for 3 minutes. | 1 -2 min is also acceptable |

## 3. RESULTS-OUTPUTS

Why four alternatives? The scenarios that can be produced as a result of the above procedure seem to be numerous. A simple adjustment of the family of trains that run in each direction, followed by a modification of waiting times in certain stops where the crossing is being done can produce many scenarios. However there are some restrictions that have to be taken into account and these are the inputs that are being showed in the previous table. To make the comparison the four following scenarios are being used:

### 3.1 Scenario A

In this scenario the crossings have been made in Røra ,Ronglan and Stjørdal. From Stjørdal the line starts to be double line. As a result the examined crossings are planned to be made in Røra and Ronglan.

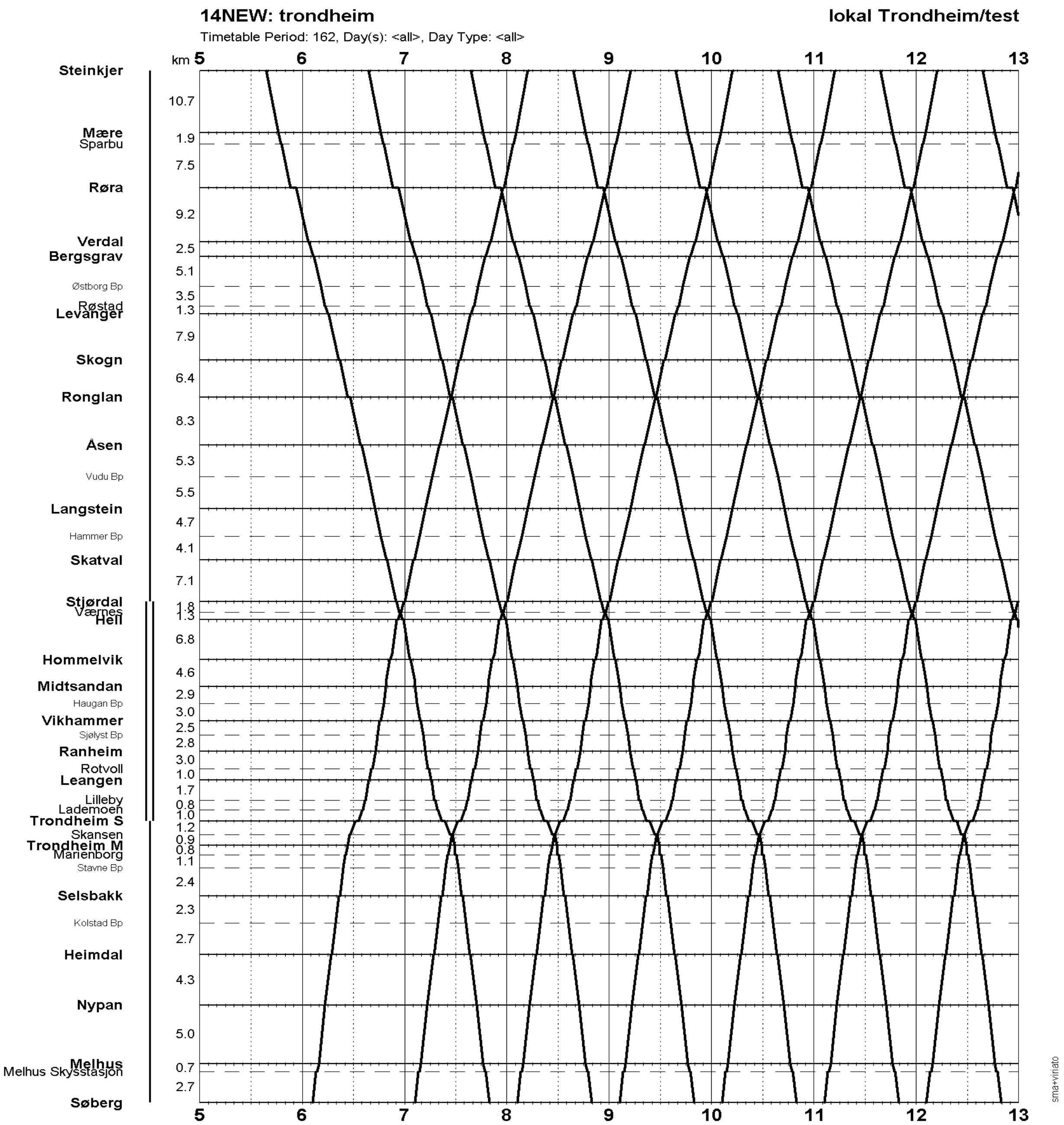



Figure 19- Scenario A

### 3.2 Scenario B

In this scenario the crossings are planned in Bergsgrav-Åsen-Selsbakk.

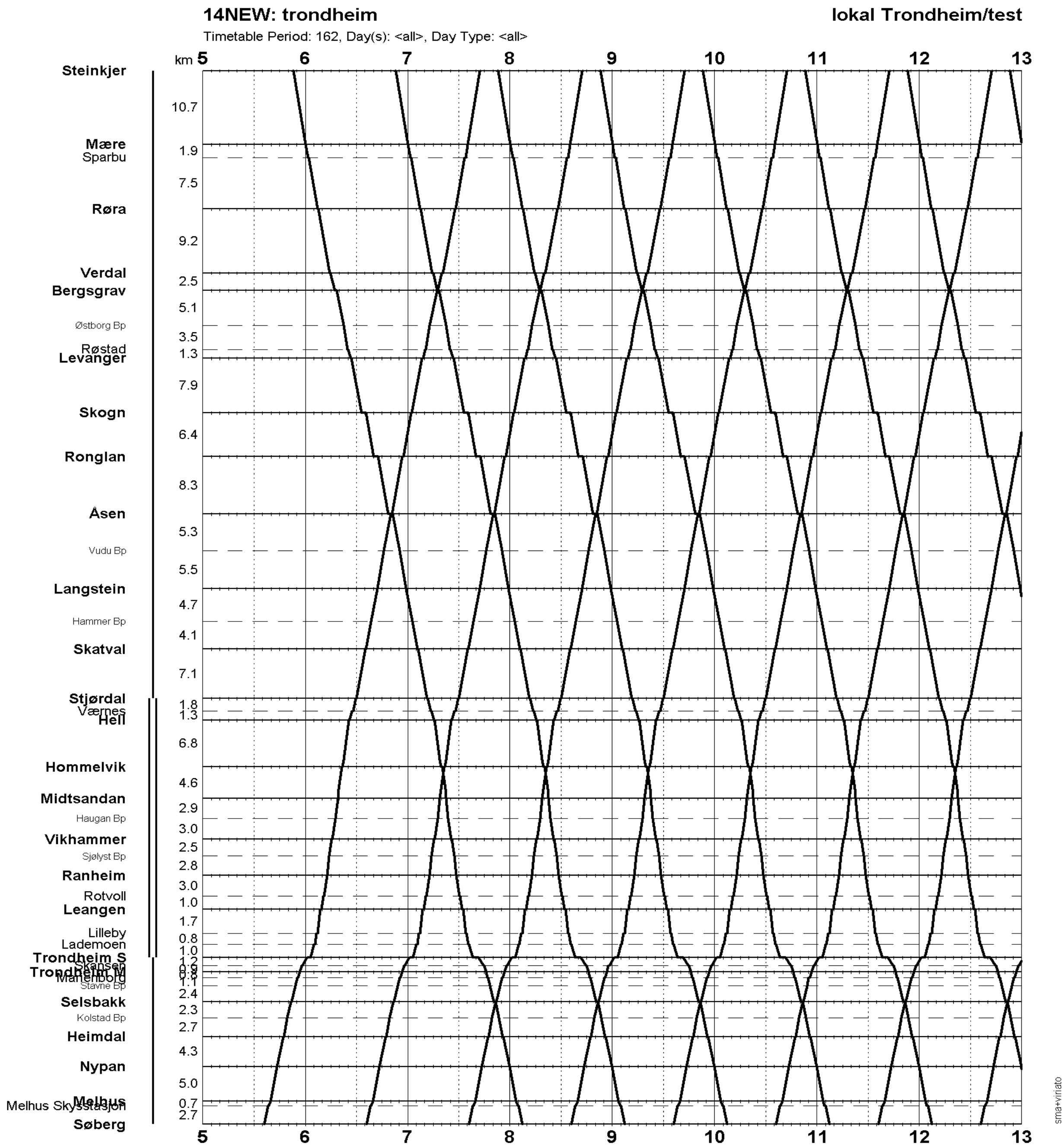



Figure 20-scenario B

### 3.3 Scenario C

Here the crossings are planned in Verdal-Åsen-Selsbakk.

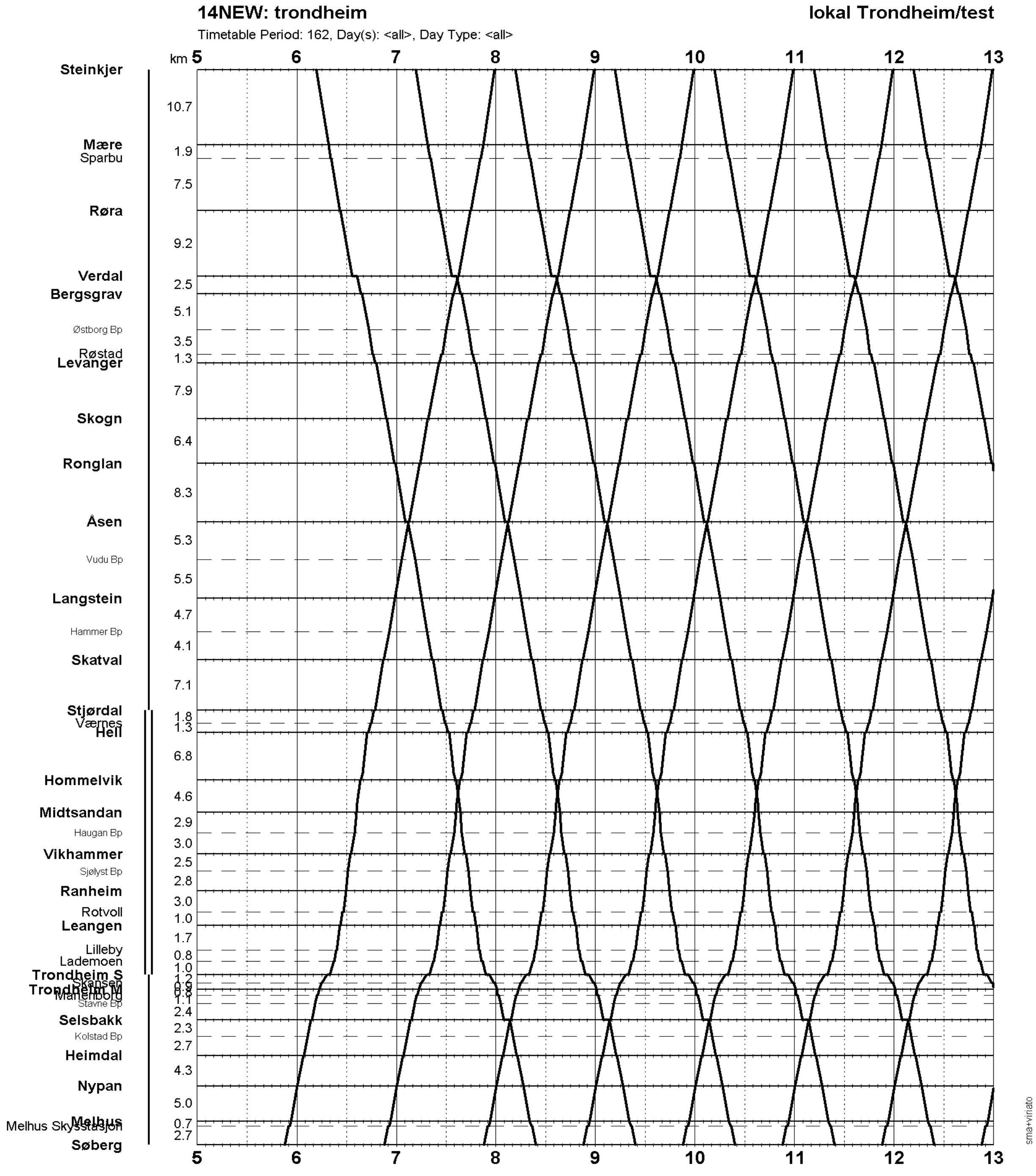



Figure 21- Scenario C

## 3.4 Scenario D

The crossings in this scenario are planned in Mære-Levanger-Hammer Bp-Nypan.

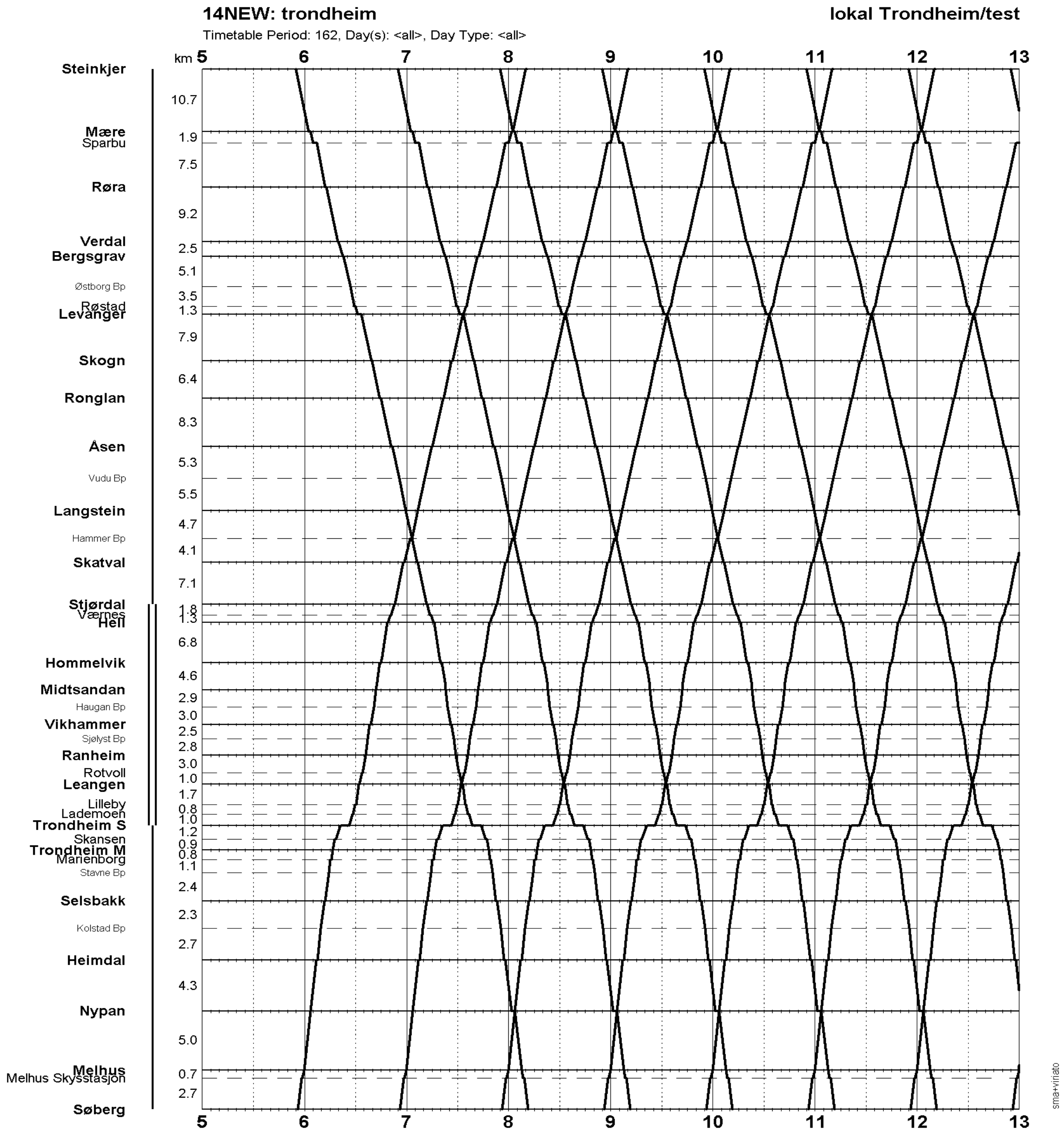



Figure 22- Scenario D

## 4. ANALYSIS AND DISCUSSION

The methodology for designing a timetable starts with analysis and of all the involved factors the factors. It is obvious from the theory part that the following have to be carefully examined:

- The need to make any alterations that are going to cost a lot of money, in a line where is not "needed". The optimal transportation system in any case is the so-called "door-to-door". It is every passenger's wish to be transferred from his starting point to his destination point. This has to be examined from the demand aspect. Taking for granted that the infrastructure manager cannot fulfill everyone's wish the aspect from which the alterations are going to be made has to be defined. This will also give an answer to the question: "Do we need to make alterations in this line?"
- The optimal use of track capacity. This is relevant as other factors have to be taken into account. For example, you may have an alternative plan A and an alternative B, and the second one to give increase capacity to the network but to the degree that is impossible (due to other limitations that have not be taken into account). To compare two alternative plans, one has to be aware not only of the scope that this comparison is being made but also of the constraints of the line that sometimes are not obvious from the first glance.
- Defining the frequencies for each route. To do that someone has to be aware of the demand. The demand is also relevant to the number of the population. This demand is also a criterion to evaluate alternative timetables. A crossing made in a station with a great demand, from example Trondheim , is more attractive that a crossing made in a stop with low demand or a block post.
- How the transportation means are being connected is also important. A highway parallel to a train track can be a competitor. While designing and evaluating it is important to have a clear image of the transportation map. This is also relevant to the demand. On the other hand is a challenge to make the railway more "attractive" to the user by various means with the help of marketing and the proper use of infrastructure.
- Each line has a specific number of trains to be used. Putting more in planning, even for the sake of increasing the capacity leads to utopia. It is obvious that the optimal situation is this one that every train is being used in the line. The capacity in this case is increased and the stability of the network (Figure 2) is increased especially when homogeneity is big (same type of trains in the line). In this case, as a family of trains has been used in scheduling, the stability and heterogeneity are increased.
- Operational issues that have to do with the shifts are also important if not crucial. The infrastructure manager cannot design and evaluate factors without taking into account the laws of the employees and the shifts.
- The railway policy from a social or economic aspect. That is defined from the government, the relevant departments and the operators.

It is easier to quantify all the essential points that can make clear which is the optimum scenario.

In this case, the scope is not defined. The demand that each station or stop has is going to be assumed as the population living nearby can be a simplified but still an important indication.

The evaluation criteria /factors that have been chosen in order to evaluate the scenarios are the following: The achieved crossings, the driving times, the number of train sets that need to be used. To get the number of train sets printing of the graph has been chosen because of its simplicity.

Table 4 comparison of results

| **Concept** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| Frequency | Hourly trains | Hourly trains | Hourly trains | Hourly trains |
| First train/direction<br><br>last train/direction | 5.39/6.06<br><br>21.39/22.06 | 5.37/5.52<br><br>21.37/21.52 | 6.11/5.52<br><br>22.11/21.52 | 5.55/5.56<br><br>21.55/21.56 |
| Crossings at: | Røra-Ronglan-Stjørdal | Bergsgrav-Åsen-Selsbakk | Verdal-Åsen-Selsbakk | Mære-Levanger-Hammer Bp-Nypan |
| Driving times | 102.1min-101.6min | 102.1min-101.6min | 102.1min-101.6min | 103.3min-<br><br>103min |
| Number of sets | 5 | 5 | 5 | 6 |
| Train kms per period (162) | 918,079train kms | 918,079train kms | 918,079train kms | 918,079train kms |
| Departures per period (162) | 322,660 dep | 322,660 dep | 322,660 dep | 322,660 dep |
| evaluation | Demand in<br><br>Røra-Ronglan-Stjørdal has to evaluated. | Demand in Bergsgrav-Åsen-Selsbakk has to evaluated. | Good departure times from the employees perspective. | Worst scenario (requires a new crossing loop in Hammer Bp, has the largest traveling time and needs one more set of trains) |

It is obvious from the comparison of the three scenarios that the worst one is the scenario D. It requires a new crossing loop in Hammer Bp, has the largest traveling time and needs one more set of trains. The positive about this scenario is the departure time of the first and the last train. It is near 6.00am which is the time when the drivers start working.

From the cost point of view is also the worst scenario. One more set of trains requires more personnel and the alteration in the line also costs.

The scenarios A,B,C are very similar scenarios. The number of departures, the train kms and the number of train sets are the same in the first three scenarios. The driving times are also the same.

The evaluation criteria that has been left to be examined in order to decide which timetable is the optimal between these three alternatives are the departure times of the first and the last train in each timetable and the place of the crossings.

To evaluate them we have to know the demand, the number of the passengers /stop that they need to get out /in of the train so as to decide where it is better to put the crossing.

In that case we have to evaluate the demand in Røra, Ronglan, Stjørdal, Bergsgrav, Åsen, Selsbakk, Verdal that are the places were the crossing has been planed in the three first scenarios.

Røra has a population of less than 500 people (Statistisk sentralbyrå, 1. januar 2012) while Ronglan is a small village that The European route E6 highway goes through it. This is a very important element to be taken into account during planning. From the social and financial point of view. On the other hand, almost 22.000 people live in Stjørdal. A crossing that would increase probably the waiting time at this station is balanced from the great demand in comparison to the other alternatives. Bergsgrav serves Vinne which is a village and Åsen has a very small population also. Selsbakk and Verdal have 900 and 15000 people respectively. From this point of view the best alternatives are those that include a crossing in Verdal and ofcourse Stjørdal. This alternatives are A and C.

From the stability and robustness point of view (Lindfeldt, 2010) the crossings are better to be made inside the double line and not where it starts. From this point of view if someone decides to put a crossing in Stjørdal that belongs at the beginning of the double track this is going to increase considerably the probability to have unexpected delays. In this case the worse scenario is scenario A. A robust time table could have the following characteristics: crossing at the stations where trains have the longest station stop times( time waiting for crossing is "utilised" because the train would stop anyway to get people on and off), crossings on the double track. The biggest station is Trondheim and the second one is Stjørdal. crossing at one end of double track is less preferred from this point of view than crossing on the double track.

From the historical point of view it is important to examine the stations-stops that have the least demand, the ones with the less population to be served. The reason behind that is that a crossing in a station with a great demand is always in the plan. Preserving stations that have a historical sense can be attractive to the user. Maintenance cost is another factor that has to be evaluated also. In Bergsgrav there has been a station since 1938 and Selsbakk station is there from 1919. Åsen station was built in 1902 by architect Paul Due and was built with a surrounding park. The current building is from 1944, but it is no longer used by the railway and it is now an art gallery (JBV). Paul Due also built the same year (1902) the station in Ronglan. From this point of view the crossings are better in Ronglan and Åsen. A,B and C alternatives include this crossings. Alternatives B and C that include a crossing in Åsen that can be an attraction because of the gallery and the track is the optimal ones from this point of view.

The departure times of the first /last train in each scenario is also an important evaluation criterion. In that case, from the employees' point of view the best scenario is C. Again to define thoroughly this criterion a more inside knowledge of the demand is required. From the managerial point of view is important to know what time the majority of the passengers want to arrive to their destination. This cannot be determined by the population. The passenger may want to move from one point of the network to the other but to belong to the departure point. This parameter is also going to define the frequency of the service which in the present study was considered to be an hourly one.

From the number of crossings point of view the best scenario is Scenario A that requires two crossings in the single line (Stjørdal is in the future double line) while Scenario B on the other hand has three crossings. This does not affect the traveling time but it is better to reduce crossings in the single line. So, in that sense scenario A is the best one.

Comparing to the current timetable one can easily identify some hidden factors that maybe have not been taken into account. It is interesting to see where the planned stops have been planned. Røra, Ronglan, Bergsgrav, Åsen, Selsbakk, Verdal are the stops that the train does not stops some specific hours. From this point of view and taking into account the fact that the current project refers only to hourly services in the entire line someone cannot make a safe conclusion out of this. Only the assumption that the future plan is going to use the same stops as the current one.

Another important aspect is the times. For example a high-speed train that arrives at 10.32 and leaves at 10.33 is not the favorable case. The times should be around the zero point. From this point of you the best scenarios are A and C.

Recovery or turn around times are another important aspect. No obvious conclusion can be made according to this. Recovery times in every scenario is obvious from the produced diagrams that are more than 10 min which is the minimum.

Table 5 – further comparison of scenarios A,B,C,D

| | **A** | **B** | **C** |
|---|---|---|---|
| Demand based on the population | Best scenario | | Best scenario |
| Times around zero | Best scenario | | Best scenario |
| Stability | Worst scenario | | |
| Historical point of view | | Best scenario | Best scenario |
| Employee's point of view | | | Best scenario |
| Number of crossings | Best scenario | | |
| Recovery times | No obvious conclusion can be made according to this. | | |
| Comparison with the current timetable | No conclusion to be made apart from the obvious one (planning has been conducted according to the demand) | | |

In the above table the scenario D has been excluded because from the very beginning it was obvious that it was the worse one. By the examined factors the best scenario is scenario C.

## 5. CONCLUSIONS

What is really important is to trace the need to make any alterations in the line. The optimal transportation system in any case is the so-called “door-to-door”. It is every passenger’s wish to be transferred from his starting point to his destination point. This has to be examined from the demand aspect. Taking for granted that the infrastructure manager cannot fulfill everyone’s wish the aspect from which the alterations are going to be made has to be defined. This will also give an answer to the question: “Do we need to make alterations in this line?”

What has to be kept in mind is that perfection cannot be achieved in a real railway network. The task of infrastructure managements and engineers is to improve on the best compromise, often under multiple constraints. The constraints set limitations to the produced result. A combined set of criteria have to be examined after setting the goal of the planning procedure.

After examining a specific set of criteria that are stated in the previous chapter (chapter 4) it is obvious that the worst scenario is that with the larger duration and the most required alterations in the specific line (scenario D). It also the one with the most expected cost. The rest of the scenarios have some positives and negatives aspects

In scenario A the crossings have been made in Røra ,Ronglan and Stjørdal. From Stjørdal the line starts to be double line. As a result the examined crossings are planned to be made in Røra and Ronglan. This is the best scenario from the number of crossing point of view, but this is balanced by the fact that its third crossing is made in the beginning of the double line which is negative from the robustness’ point of view.

In scenario B the crossings are planned in Bergsgrav-Åsen-Selsbakk. From the historical point of view a crossing here would be the best choice. The station is of great historical value since it was built by the architect Paul Due at the beginning of the last century.

In scenario C crossings are planned in Verdal-Åsen-Selsbakk. From the employees point of view scenario C is the best one (later departure time).To evaluate thoroughly the rest of the scenarios it would be interesting if not necessary to have an evaluation of the demand in every potential stop so as to cover it and to make scheduling by setting this important priority.

Scenario C gathers the most positive aspects when it comes to the examined criteria and the scenario D the most negative ones.

From the clarification of the examined factors and criteria and the understanding of their effects the interactions that each of them has to each is the second element that has to be clarified. This automatically broadens the procedure of the planning. The merit of hourly timetables is taken as a given (and is very widely in Europe). Practically this may not always be feasible because of geographic and unforeseen factors, but the focus helps to identify good solutions and may highlight areas that could enable a specific improvement to be made. The full timetable, including freight and long distance trains should be incuded in expanded evaluations and possible simulations of robustness.

The improvement that can be suggested in that sense, it is to adopt a plan that has waiting times in Verdal, Åsen and Selsbakk. With the assumption that this can in the near future be a part of a big-scale transportation map in the area it can enhance its attractiveness and make the railway network earn ground towards the other means of transportation.

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**LIST OF SYMBOLS**

BP= Blockpost

H= maximum velocity (km\h)

HP= stop

JBV= Jernbaneverket is the Norwegian government's agency for railway services.

K= constant coefficient dependent on the type of the train

K= (number of sets) is the maximum capacity in the time period

K= velocity for titling trains (km/h)

NSB= Norwegian State Railways

P = important infrastructure points

P= Plus velocity (km/h)

SMA= SMA und Partner AG is an independent company specialized in transportation

STA= station

T =(min) the frequency

T= tourist velocity (km/h)

V= speed (km/h)

ΔV= additional coefficient

**APPENDICES**

**Appendix A:**

*A1 Appendix :vehicle data*

| Vehicle data | Long Local | Short Regional |
|---|---|---|
| Customer | Norwegian State Railways (NSB) | |
| Lines operated | S-Bahn Oslo | Southern Norway |
| Gauge | 1435 mm | " |
| Catenary supply voltage | 15 kV, 16.7 Hz | " |
| Axle arrangement | Bo'2'2'Bo'+2'2'Bo' | " |
| Number of vehicles | 26 | 24 |
| Service start-up | 2012–2013 | 2011–2012 |
| Seating capacity (comfort) | 235 | 216 (44) |
| Resting seat | 36 | 30 |
| Fold up seats | 24 | 18 |
| Floor height | | |
| Low floor | 800 mm | " |
| High floor | 1180 mm | " |
| Door width | 1300 mm | " |
| Longitudinal strength | 1500 kN | " |
| Overall lenght | 105.5 m | " |
| Vehicle width | 3200 mm | " |
| Vehicle height | 4380 mm | " |
| Tare weight | 216.3 t | 218.1 t |
| Bogie wheelbase | | |
| Power bogie | 2500 mm | " |
| Trailer bogie | 2750 mm | " |
| Powered wheel diameter | 920 mm | " |
| Trailer wheel diameter | 920 mm | " |
| Maximum output at wheel | 4500 kW | " |
| Starting tractive power | 240 kN | " |
| Maximum speed | 200 kph | " |

*A2 Appendix: Technical features*

## Technical features

- Bright, passenger-friendly interior with customized design
- Air-conditioned passenger and driver compartments
- Vacuum toilet system, also suitable for the disabled
- Low floor section 69 %
- Spacious multipurpose area in entrance section
- Air-suspended bogies
- Ergonomically designed driver's cab
- 3 redundant traction chains with water-cooled IGBT power converters
- Vehicle control system with train bus and diagnostic computer
- Crashworthiness according the actual EN-standard
- Train concept prepared for long distance design

*A3 Appendix: Map of the line*

# Appendix B: Calculated tables for each scenario

## *Scenario A*

**Customer Timetable**

Timetable Period: 162, Day(s): <all>, Day Type: <all>

| | Train Type | | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Train Number | | 10401 | 10403 | 10405 | 10407 | 10409 | 10411 | 10413 | 10415 | 10417 | 10419 | 10421 | 10423 | 10425 | 10427 | 10429 | 10431 | 10433 |
| | Operating Day | | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG |
| km | | From: | | | | | | | | | | | | | | | | | |
| 0 | **Steinkjer** | | 5:39 | 6:39 | 7:39 | 8:39 | 9:39 | 10:39 | 11:39 | 12:39 | 13:39 | 14:39 | 15:39 | 16:39 | 17:39 | 18:39 | 19:39 | 20:39 | 21:39 |
| 13 | Sparbu | | 5:48 | 6:48 | 7:48 | 8:48 | 9:48 | 10:48 | 11:48 | 12:48 | 13:48 | 14:48 | 15:48 | 16:48 | 17:48 | 18:48 | 19:48 | 20:48 | 21:48 |
| 20 | **Røra** | | 5:56 | 6:56 | 7:56 | 8:56 | 9:56 | 10:56 | 11:56 | 12:56 | 13:56 | 14:56 | 15:56 | 16:56 | 17:56 | 18:56 | 19:56 | 20:56 | 21:56 |
| 29 | **Verdal** | | 6:03 | 7:03 | 8:03 | 9:03 | 10:03 | 11:03 | 12:03 | 13:03 | 14:03 | 15:03 | 16:03 | 17:03 | 18:03 | 19:03 | 20:03 | 21:03 | 22:03 |
| 32 | **Bergsgrav** | | 6:06 | 7:06 | 8:06 | 9:06 | 10:06 | 11:06 | 12:06 | 13:06 | 14:06 | 15:06 | 16:06 | 17:06 | 18:06 | 19:06 | 20:06 | 21:06 | 22:06 |
| 40 | Røstad | | 6:13 | 7:13 | 8:13 | 9:13 | 10:13 | 11:13 | 12:13 | 13:13 | 14:13 | 15:13 | 16:13 | 17:13 | 18:13 | 19:13 | 20:13 | 21:13 | 22:13 |
| 42 | **Levanger** | | 6:15 | 7:15 | 8:15 | 9:15 | 10:15 | 11:15 | 12:15 | 13:15 | 14:15 | 15:15 | 16:15 | 17:15 | 18:15 | 19:15 | 20:15 | 21:15 | 22:15 |
| 49 | **Skogn** | | 6:22 | 7:22 | 8:22 | 9:22 | 10:22 | 11:22 | 12:22 | 13:22 | 14:22 | 15:22 | 16:22 | 17:22 | 18:22 | 19:22 | 20:22 | 21:22 | 22:22 |
| 56 | **Ronglan** | | 6:28 | 7:28 | 8:28 | 9:28 | 10:28 | 11:28 | 12:28 | 13:28 | 14:28 | 15:28 | 16:28 | 17:28 | 18:28 | 19:28 | 20:28 | 21:28 | 22:28 |
| 64 | **Åsen** | | 6:34 | 7:34 | 8:34 | 9:34 | 10:34 | 11:34 | 12:34 | 13:34 | 14:34 | 15:34 | 16:34 | 17:34 | 18:34 | 19:34 | 20:34 | 21:34 | 22:34 |
| 84 | **Skatval** | | 6:49 | 7:49 | 8:49 | 9:49 | 10:49 | 11:49 | 12:49 | 13:49 | 14:49 | 15:49 | 16:49 | 17:49 | 18:49 | 19:49 | 20:49 | 21:49 | 22:49 |
| 91 | **Stjørdal** | | 6:55 | 7:55 | 8:55 | 9:55 | 10:55 | 11:55 | 12:55 | 13:55 | 14:55 | 15:55 | 16:55 | 17:55 | 18:55 | 19:55 | 20:55 | 21:55 | 22:55 |
| 93 | Værnes | | 6:57 | 7:57 | 8:57 | 9:57 | 10:57 | 11:57 | 12:57 | 13:57 | 14:57 | 15:57 | 16:57 | 17:57 | 18:57 | 19:57 | 20:57 | 21:57 | 22:57 |
| 94 | **Hell** | | 6:59 | 7:59 | 8:59 | 9:59 | 10:59 | 11:59 | 12:59 | 13:59 | 14:59 | 15:59 | 16:59 | 17:59 | 18:59 | 19:59 | 20:59 | 21:59 | 22:59 |
| 101 | **Hommelvik** | | 7:03 | 8:03 | 9:03 | 10:03 | 11:03 | 12:03 | 13:03 | 14:03 | 15:03 | 16:03 | 17:03 | 18:03 | 19:03 | 20:03 | 21:03 | 22:03 | 23:03 |
| 111 | **Vikhammer** | | 7:09 | 8:09 | 9:09 | 10:09 | 11:09 | 12:09 | 13:09 | 14:09 | 15:09 | 16:09 | 17:09 | 18:09 | 19:09 | 20:09 | 21:09 | 22:09 | 23:09 |
| 119 | Rotvoll | | 7:14 | 8:14 | 9:14 | 10:14 | 11:14 | 12:14 | 13:14 | 14:14 | 15:14 | 16:14 | 17:14 | 18:14 | 19:14 | 20:14 | 21:14 | 22:14 | 23:14 |
| 120 | **Leangen** | | 7:16 | 8:16 | 9:16 | 10:16 | 11:16 | 12:16 | 13:16 | 14:16 | 15:16 | 16:16 | 17:16 | 18:16 | 19:16 | 20:16 | 21:16 | 22:16 | 23:16 |
| 122 | Lilleby | | 7:18 | 8:18 | 9:18 | 10:18 | 11:18 | 12:18 | 13:18 | 14:18 | 15:18 | 16:18 | 17:18 | 18:18 | 19:18 | 20:18 | 21:18 | 22:18 | 23:18 |
| 123 | Lademoen | | 7:19 | 8:19 | 9:19 | 10:19 | 11:19 | 12:19 | 13:19 | 14:19 | 15:19 | 16:19 | 17:19 | 18:19 | 19:19 | 20:19 | 21:19 | 22:19 | 23:19 |
| 124 | **Trondheim S** | o | 7:21 | 8:21 | 9:21 | 10:21 | 11:21 | 12:21 | 13:21 | 14:21 | 15:21 | 16:21 | 17:21 | 18:21 | 19:21 | 20:21 | 21:21 | 22:21 | 23:21 |
| | **Trondheim S** | | 7:23 | 8:23 | 9:23 | 10:23 | 11:23 | 12:23 | 13:23 | 14:23 | 15:23 | 16:23 | 17:23 | 18:23 | 19:23 | 20:23 | 21:23 | 22:23 | 23:23 |
| 125 | Skansen | | 7:28 | 8:28 | 9:28 | 10:28 | 11:28 | 12:28 | 13:28 | 14:28 | 15:28 | 16:28 | 17:28 | 18:28 | 19:28 | 20:28 | 21:28 | 22:28 | 23:28 |
| 127 | Marienborg | | 7:30 | 8:30 | 9:30 | 10:30 | 11:30 | 12:30 | 13:30 | 14:30 | 15:30 | 16:30 | 17:30 | 18:30 | 19:30 | 20:30 | 21:30 | 22:30 | 23:30 |
| 130 | **Selsbakk** | | 7:34 | 8:34 | 9:34 | 10:34 | 11:34 | 12:34 | 13:34 | 14:34 | 15:34 | 16:34 | 17:34 | 18:34 | 19:34 | 20:34 | 21:34 | 22:34 | 23:34 |
| 135 | **Heimdal** | | 7:38 | 8:38 | 9:38 | 10:38 | 11:38 | 12:38 | 13:38 | 14:38 | 15:38 | 16:38 | 17:38 | 18:38 | 19:38 | 20:38 | 21:38 | 22:38 | 23:38 |
| 145 | Melhus Skysstasjon | | 7:47 | 8:47 | 9:47 | 10:47 | 11:47 | 12:47 | 13:47 | 14:47 | 15:47 | 16:47 | 17:47 | 18:47 | 19:47 | 20:47 | 21:47 | 22:47 | 23:47 |
| 148 | **Søberg** | o | 7:49 | 8:49 | 9:49 | 10:49 | 11:49 | 12:49 | 13:49 | 14:49 | 15:49 | 16:49 | 17:49 | 18:49 | 19:49 | 20:49 | 21:49 | 22:49 | 23:49 |
| | | To: | | | | | | | | | | | | | | | | | |

| | |
|---|---|
| *Train Group:* | lokal Trondheim |
| *Version ID:* | test |
| *Timetable Period:* | Ruteendring 162 (des 2012) |

| | *Departures* |
|---|---|
| -- | 322,660 |
| ***Tot.*** | **322,660** |

| *Train ID* | *Description* | *TT Period* | *Operating Day* | *Time Interval* | *Train-Kms* |
|---|---|---|---|---|---|
| NSB LT 10401 | Steinkjer - Trondheim S | 162 | | 1 h | 918,079 |
| NSB LT 10402 | NSB Persontog | 162 | | 1 h | 918,079 |
| ***Tot.*** | | | | | **1,836,159** |

*Scenario B*

Timetable Period: 162, Day(s): <all>, Day Type: <all>

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Train Type | | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt |
| | Train Number | | 10433 | 10401 | 10403 | 10405 | 10407 | 10409 | 10411 | 10413 | 10415 | 10417 | 10419 | 10421 | 10423 | 10425 | 10427 | 10429 | 10431 | 10433 |
| | Operating Day | | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG |
| km | | From: | | | | | | | | | | | | | | | | | | |
| 0 | **Steinkjer** | | 21:53 | 5:53 | 6:53 | 7:53 | 8:53 | 9:53 | 10:53 | 11:53 | 12:53 | 13:53 | 14:53 | 15:53 | 16:53 | 17:53 | 18:53 | 19:53 | 20:53 | 21:53 |
| 13 | Sparbu | | 22:02 | 6:02 | 7:02 | 8:02 | 9:02 | 10:02 | 11:02 | 12:02 | 13:02 | 14:02 | 15:02 | 16:02 | 17:02 | 18:02 | 19:02 | 20:02 | 21:02 | 22:02 |
| 20 | **Røra** | | 22:07 | 6:07 | 7:07 | 8:07 | 9:07 | 10:07 | 11:07 | 12:07 | 13:07 | 14:07 | 15:07 | 16:07 | 17:07 | 18:07 | 19:07 | 20:07 | 21:07 | 22:07 |
| 29 | **Verdal** | | 22:14 | 6:14 | 7:14 | 8:14 | 9:14 | 10:14 | 11:14 | 12:14 | 13:14 | 14:14 | 15:14 | 16:14 | 17:14 | 18:14 | 19:14 | 20:14 | 21:14 | 22:14 |
| 32 | **Bergsgrav** | | 22:18 | 6:18 | 7:18 | 8:18 | 9:18 | 10:18 | 11:18 | 12:18 | 13:18 | 14:18 | 15:18 | 16:18 | 17:18 | 18:18 | 19:18 | 20:18 | 21:18 | 22:18 |
| 40 | Røstad | | 22:25 | 6:25 | 7:25 | 8:25 | 9:25 | 10:25 | 11:25 | 12:25 | 13:25 | 14:25 | 15:25 | 16:25 | 17:25 | 18:25 | 19:25 | 20:25 | 21:25 | 22:25 |
| 42 | **Levanger** | | 22:27 | 6:27 | 7:27 | 8:27 | 9:27 | 10:27 | 11:27 | 12:27 | 13:27 | 14:27 | 15:27 | 16:27 | 17:27 | 18:27 | 19:27 | 20:27 | 21:27 | 22:27 |
| 49 | **Skogn** | | 22:35 | 6:35 | 7:35 | 8:35 | 9:35 | 10:35 | 11:35 | 12:35 | 13:35 | 14:35 | 15:35 | 16:35 | 17:35 | 18:35 | 19:35 | 20:35 | 21:35 | 22:35 |
| 56 | **Ronglan** | | 22:42 | 6:42 | 7:42 | 8:42 | 9:42 | 10:42 | 11:42 | 12:42 | 13:42 | 14:42 | 15:42 | 16:42 | 17:42 | 18:42 | 19:42 | 20:42 | 21:42 | 22:42 |
| 64 | **Åsen** | | 22:51 | 6:51 | 7:51 | 8:51 | 9:51 | 10:51 | 11:51 | 12:51 | 13:51 | 14:51 | 15:51 | 16:51 | 17:51 | 18:51 | 19:51 | 20:51 | 21:51 | 22:51 |
| 84 | **Skatval** | | 23:06 | 7:06 | 8:06 | 9:06 | 10:06 | 11:06 | 12:06 | 13:06 | 14:06 | 15:06 | 16:06 | 17:06 | 18:06 | 19:06 | 20:06 | 21:06 | 22:06 | 23:06 |
| 91 | **Stjørdal** | | 23:11 | 7:11 | 8:11 | 9:11 | 10:11 | 11:11 | 12:11 | 13:11 | 14:11 | 15:11 | 16:11 | 17:11 | 18:11 | 19:11 | 20:11 | 21:11 | 22:11 | 23:11 |
| 93 | Værnes | | 23:14 | 7:14 | 8:14 | 9:14 | 10:14 | 11:14 | 12:14 | 13:14 | 14:14 | 15:14 | 16:14 | 17:14 | 18:14 | 19:14 | 20:14 | 21:14 | 22:14 | 23:14 |
| 94 | **Hell** | | 23:15 | 7:15 | 8:15 | 9:15 | 10:15 | 11:15 | 12:15 | 13:15 | 14:15 | 15:15 | 16:15 | 17:15 | 18:15 | 19:15 | 20:15 | 21:15 | 22:15 | 23:15 |
| 101 | **Hommelvik** | | 23:20 | 7:20 | 8:20 | 9:20 | 10:20 | 11:20 | 12:20 | 13:20 | 14:20 | 15:20 | 16:20 | 17:20 | 18:20 | 19:20 | 20:20 | 21:20 | 22:20 | 23:20 |
| 111 | **Vikhammer** | | 23:26 | 7:26 | 8:26 | 9:26 | 10:26 | 11:26 | 12:26 | 13:26 | 14:26 | 15:26 | 16:26 | 17:26 | 18:26 | 19:26 | 20:26 | 21:26 | 22:26 | 23:26 |
| 119 | Rotvoll | | 23:30 | 7:30 | 8:30 | 9:30 | 10:30 | 11:30 | 12:30 | 13:30 | 14:30 | 15:30 | 16:30 | 17:30 | 18:30 | 19:30 | 20:30 | 21:30 | 22:30 | 23:30 |
| 120 | **Leangen** | | 23:32 | 7:32 | 8:32 | 9:32 | 10:32 | 11:32 | 12:32 | 13:32 | 14:32 | 15:32 | 16:32 | 17:32 | 18:32 | 19:32 | 20:32 | 21:32 | 22:32 | 23:32 |
| 122 | Lilleby | | 23:34 | 7:34 | 8:34 | 9:34 | 10:34 | 11:34 | 12:34 | 13:34 | 14:34 | 15:34 | 16:34 | 17:34 | 18:34 | 19:34 | 20:34 | 21:34 | 22:34 | 23:34 |
| 123 | Lademoen | | 23:36 | 7:36 | 8:36 | 9:36 | 10:36 | 11:36 | 12:36 | 13:36 | 14:36 | 15:36 | 16:36 | 17:36 | 18:36 | 19:36 | 20:36 | 21:36 | 22:36 | 23:36 |
| 124 | **Trondheim S** | o | 23:38 | 7:38 | 8:38 | 9:38 | 10:38 | 11:38 | 12:38 | 13:38 | 14:38 | 15:38 | 16:38 | 17:38 | 18:38 | 19:38 | 20:38 | 21:38 | 22:38 | 23:38 |
| | **Trondheim S** | | 23:41 | 7:41 | 8:41 | 9:41 | 10:41 | 11:41 | 12:41 | 13:41 | 14:41 | 15:41 | 16:41 | 17:41 | 18:41 | 19:41 | 20:41 | 21:41 | 22:41 | 23:41 |
| 125 | Skansen | | 23:45 | 7:45 | 8:45 | 9:45 | 10:45 | 11:45 | 12:45 | 13:45 | 14:45 | 15:45 | 16:45 | 17:45 | 18:45 | 19:45 | 20:45 | 21:45 | 22:45 | 23:45 |
| 127 | Marienborg | | 23:47 | 7:47 | 8:47 | 9:47 | 10:47 | 11:47 | 12:47 | 13:47 | 14:47 | 15:47 | 16:47 | 17:47 | 18:47 | 19:47 | 20:47 | 21:47 | 22:47 | 23:47 |
| 130 | **Selsbakk** | | 23:51 | 7:51 | 8:51 | 9:51 | 10:51 | 11:51 | 12:51 | 13:51 | 14:51 | 15:51 | 16:51 | 17:51 | 18:51 | 19:51 | 20:51 | 21:51 | 22:51 | 23:51 |
| 135 | **Heimdal** | | 23:56 | 7:56 | 8:56 | 9:56 | 10:56 | 11:56 | 12:56 | 13:56 | 14:56 | 15:56 | 16:56 | 17:56 | 18:56 | 19:56 | 20:56 | 21:56 | 22:56 | 23:56 |
| 145 | Melhus Skysstasjon | | 0:05 | 8:05 | 9:05 | 10:05 | 11:05 | 12:05 | 13:05 | 14:05 | 15:05 | 16:05 | 17:05 | 18:05 | 19:05 | 20:05 | 21:05 | 22:05 | 23:05 | 0:05 |
| 148 | **Søberg** | o | 0:07 | 8:07 | 9:07 | 10:07 | 11:07 | 12:07 | 13:07 | 14:07 | 15:07 | 16:07 | 17:07 | 18:07 | 19:07 | 20:07 | 21:07 | 22:07 | 23:07 | 0:07 |
| | | To: | | | | | | | | | | | | | | | | | | |

*Train Group:* lokal Trondheim

*Version ID:* test

*Timetable Period:* Ruteendring 162 (des 2012)

| | *Departures* |
|---|---|
| – | 322,660 |
| ***Tot.*** | **322,660** |

| *Train ID* | *Description* | *TT Period* | *Operating Day* | *Time Interval* | *Train-Kms* |
|---|---|---|---|---|---|
| NSB LT 10401 | Steinkjer - Trondheim S | 162 | | 1 h | 918,079 |
| NSB LT 10402 | NSB Persontog | 162 | | 1 h | 918,079 |
| ***Tot.*** | | | | | **1,836,159** |

*Scenario C*

**Customer Timetable**

Timetable Period: 162, Day(s): <all>, Day Type: <all>

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Train Type | | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt |
| | Train Number | | 10433 | 10401 | 10403 | 10405 | 10407 | 10409 | 10411 | 10413 | 10415 | 10417 | 10419 | 10421 | 10423 | 10425 | 10427 | 10429 | 10431 | 10433 |
| | Operating Day | | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG |
| km | | From: | | | | | | | | | | | | | | | | | | |
| 0 | **Steinkjer** | | 22:11 | 6:11 | 7:11 | 8:11 | 9:11 | 10:11 | 11:11 | 12:11 | 13:11 | 14:11 | 15:11 | 16:11 | 17:11 | 18:11 | 19:11 | 20:11 | 21:11 | 22:11 |
| 13 | Sparbu | | 22:20 | 6:20 | 7:20 | 8:20 | 9:20 | 10:20 | 11:20 | 12:20 | 13:20 | 14:20 | 15:20 | 16:20 | 17:20 | 18:20 | 19:20 | 20:20 | 21:20 | 22:20 |
| 20 | **Røra** | | 22:26 | 6:26 | 7:26 | 8:26 | 9:26 | 10:26 | 11:26 | 12:26 | 13:26 | 14:26 | 15:26 | 16:26 | 17:26 | 18:26 | 19:26 | 20:26 | 21:26 | 22:26 |
| 29 | **Verdal** | | 22:36 | 6:36 | 7:36 | 8:36 | 9:36 | 10:36 | 11:36 | 12:36 | 13:36 | 14:36 | 15:36 | 16:36 | 17:36 | 18:36 | 19:36 | 20:36 | 21:36 | 22:36 |
| 32 | **Bergsgrav** | | 22:39 | 6:39 | 7:39 | 8:39 | 9:39 | 10:39 | 11:39 | 12:39 | 13:39 | 14:39 | 15:39 | 16:39 | 17:39 | 18:39 | 19:39 | 20:39 | 21:39 | 22:39 |
| 40 | Røstad | | 22:46 | 6:46 | 7:46 | 8:46 | 9:46 | 10:46 | 11:46 | 12:46 | 13:46 | 14:46 | 15:46 | 16:46 | 17:46 | 18:46 | 19:46 | 20:46 | 21:46 | 22:46 |
| 42 | **Levanger** | | 22:47 | 6:47 | 7:47 | 8:47 | 9:47 | 10:47 | 11:47 | 12:47 | 13:47 | 14:47 | 15:47 | 16:47 | 17:47 | 18:47 | 19:47 | 20:47 | 21:47 | 22:47 |
| 49 | **Skogn** | | 22:54 | 6:54 | 7:54 | 8:54 | 9:54 | 10:54 | 11:54 | 12:54 | 13:54 | 14:54 | 15:54 | 16:54 | 17:54 | 18:54 | 19:54 | 20:54 | 21:54 | 22:54 |
| 56 | **Ronglan** | | 22:59 | 6:59 | 7:59 | 8:59 | 9:59 | 10:59 | 11:59 | 12:59 | 13:59 | 14:59 | 15:59 | 16:59 | 17:59 | 18:59 | 19:59 | 20:59 | 21:59 | 22:59 |
| 64 | **Åsen** | | 23:07 | 7:07 | 8:07 | 9:07 | 10:07 | 11:07 | 12:07 | 13:07 | 14:07 | 15:07 | 16:07 | 17:07 | 18:07 | 19:07 | 20:07 | 21:07 | 22:07 | 23:07 |
| 84 | **Skatval** | | 23:22 | 7:22 | 8:22 | 9:22 | 10:22 | 11:22 | 12:22 | 13:22 | 14:22 | 15:22 | 16:22 | 17:22 | 18:22 | 19:22 | 20:22 | 21:22 | 22:22 | 23:22 |
| 91 | **Stjørdal** | | 23:27 | 7:27 | 8:27 | 9:27 | 10:27 | 11:27 | 12:27 | 13:27 | 14:27 | 15:27 | 16:27 | 17:27 | 18:27 | 19:27 | 20:27 | 21:27 | 22:27 | 23:27 |
| 93 | Værnes | | 23:29 | 7:29 | 8:29 | 9:29 | 10:29 | 11:29 | 12:29 | 13:29 | 14:29 | 15:29 | 16:29 | 17:29 | 18:29 | 19:29 | 20:29 | 21:29 | 22:29 | 23:29 |
| 94 | **Hell** | | 23:31 | 7:31 | 8:31 | 9:31 | 10:31 | 11:31 | 12:31 | 13:31 | 14:31 | 15:31 | 16:31 | 17:31 | 18:31 | 19:31 | 20:31 | 21:31 | 22:31 | 23:31 |
| 101 | **Hommelvik** | | 23:36 | 7:36 | 8:36 | 9:36 | 10:36 | 11:36 | 12:36 | 13:36 | 14:36 | 15:36 | 16:36 | 17:36 | 18:36 | 19:36 | 20:36 | 21:36 | 22:36 | 23:36 |
| 111 | **Vikhammer** | | 23:41 | 7:41 | 8:41 | 9:41 | 10:41 | 11:41 | 12:41 | 13:41 | 14:41 | 15:41 | 16:41 | 17:41 | 18:41 | 19:41 | 20:41 | 21:41 | 22:41 | 23:41 |
| 119 | Rotvoll | | 23:46 | 7:46 | 8:46 | 9:46 | 10:46 | 11:46 | 12:46 | 13:46 | 14:46 | 15:46 | 16:46 | 17:46 | 18:46 | 19:46 | 20:46 | 21:46 | 22:46 | 23:46 |
| 120 | **Leangen** | | 23:48 | 7:48 | 8:48 | 9:48 | 10:48 | 11:48 | 12:48 | 13:48 | 14:48 | 15:48 | 16:48 | 17:48 | 18:48 | 19:48 | 20:48 | 21:48 | 22:48 | 23:48 |
| 122 | Lilleby | | 23:50 | 7:50 | 8:50 | 9:50 | 10:50 | 11:50 | 12:50 | 13:50 | 14:50 | 15:50 | 16:50 | 17:50 | 18:50 | 19:50 | 20:50 | 21:50 | 22:50 | 23:50 |
| 123 | Lademoen | | 23:51 | 7:51 | 8:51 | 9:51 | 10:51 | 11:51 | 12:51 | 13:51 | 14:51 | 15:51 | 16:51 | 17:51 | 18:51 | 19:51 | 20:51 | 21:51 | 22:51 | 23:51 |
| 124 | **Trondheim S** | o | 23:54 | 7:54 | 8:54 | 9:54 | 10:54 | 11:54 | 12:54 | 13:54 | 14:54 | 15:54 | 16:54 | 17:54 | 18:54 | 19:54 | 20:54 | 21:54 | 22:54 | 23:54 |
| | **Trondheim S** | | 23:56 | 7:56 | 8:56 | 9:56 | 10:56 | 11:56 | 12:56 | 13:56 | 14:56 | 15:56 | 16:56 | 17:56 | 18:56 | 19:56 | 20:56 | 21:56 | 22:56 | 23:56 |
| 125 | Skansen | | 23:59 | 7:59 | 8:59 | 9:59 | 10:59 | 11:59 | 12:59 | 13:59 | 14:59 | 15:59 | 16:59 | 17:59 | 18:59 | 19:59 | 20:59 | 21:59 | 22:59 | 23:59 |
| 127 | Marienborg | | 0:01 | 8:01 | 9:01 | 10:01 | 11:01 | 12:01 | 13:01 | 14:01 | 15:01 | 16:01 | 17:01 | 18:01 | 19:01 | 20:01 | 21:01 | 22:01 | 23:01 | 0:01 |
| 130 | **Selsbakk** | | 0:08 | 8:08 | 9:08 | 10:08 | 11:08 | 12:08 | 13:08 | 14:08 | 15:08 | 16:08 | 17:08 | 18:08 | 19:08 | 20:08 | 21:08 | 22:08 | 23:08 | 0:08 |
| 135 | **Heimdal** | | 0:13 | 8:13 | 9:13 | 10:13 | 11:13 | 12:13 | 13:13 | 14:13 | 15:13 | 16:13 | 17:13 | 18:13 | 19:13 | 20:13 | 21:13 | 22:13 | 23:13 | 0:13 |
| 145 | Melhus Skysstasjon | | 0:21 | 8:21 | 9:21 | 10:21 | 11:21 | 12:21 | 13:21 | 14:21 | 15:21 | 16:21 | 17:21 | 18:21 | 19:21 | 20:21 | 21:21 | 22:21 | 23:21 | 0:21 |
| 148 | **Søberg** | o | 0:24 | 8:24 | 9:24 | 10:24 | 11:24 | 12:24 | 13:24 | 14:24 | 15:24 | 16:24 | 17:24 | 18:24 | 19:24 | 20:24 | 21:24 | 22:24 | 23:24 | 0:24 |
| | | To: | | | | | | | | | | | | | | | | | | |

*Train Group:* lokal Trondheim

*Version ID:* test

*Timetable Period:* Ruteendring 162 (des 2012)

| | *Departures* |
|---|---|
| -- | 322,660 |
| ***Tot.*** | **322,660** |

| *Train ID* | *Description* | *TT Period* | *Operating Day* | *Time Interval* | *Train-Kms* |
|---|---|---|---|---|---|
| NSB LT 10401 | Steinkjer - Trondheim S | 162 | | 1 h | 918,079 |
| NSB LT 10402 | NSB Persontog | 162 | | 1 h | 918,079 |
| ***Tot.*** | | | | | **1,836,159** |

*Scenario D*

**Customer Timetable**

Timetable Period: 162, Day(s): <all>, Day Type: <all>

| km | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Train Type | | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt | Lt |
| | Train Number | | 10433 | 10401 | 10403 | 10405 | 10407 | 10409 | 10411 | 10413 | 10415 | 10417 | 10419 | 10421 | 10423 | 10425 | 10427 | 10429 | 10431 | 10433 |
| | Operating Day | | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG | DAG |
| km | | From: | | | | | | | | | | | | | | | | | | |
| 0 | **Steinkjer** | | 21:55 | 5:55 | 6:55 | 7:55 | 8:55 | 9:55 | 10:55 | 11:55 | 12:55 | 13:55 | 14:55 | 15:55 | 16:55 | 17:55 | 18:55 | 19:55 | 20:55 | 21:55 |
| 13 | Sparbu | | 22:07 | 6:07 | 7:07 | 8:07 | 9:07 | 10:07 | 11:07 | 12:07 | 13:07 | 14:07 | 15:07 | 16:07 | 17:07 | 18:07 | 19:07 | 20:07 | 21:07 | 22:07 |
| 20 | **Røra** | | 22:12 | 6:12 | 7:12 | 8:12 | 9:12 | 10:12 | 11:12 | 12:12 | 13:12 | 14:12 | 15:12 | 16:12 | 17:12 | 18:12 | 19:12 | 20:12 | 21:12 | 22:12 |
| 29 | **Verdal** | | 22:20 | 6:20 | 7:20 | 8:20 | 9:20 | 10:20 | 11:20 | 12:20 | 13:20 | 14:20 | 15:20 | 16:20 | 17:20 | 18:20 | 19:20 | 20:20 | 21:20 | 22:20 |
| 32 | **Bergsgrav** | | 22:23 | 6:23 | 7:23 | 8:23 | 9:23 | 10:23 | 11:23 | 12:23 | 13:23 | 14:23 | 15:23 | 16:23 | 17:23 | 18:23 | 19:23 | 20:23 | 21:23 | 22:23 |
| 40 | Røstad | | 22:29 | 6:29 | 7:29 | 8:29 | 9:29 | 10:29 | 11:29 | 12:29 | 13:29 | 14:29 | 15:29 | 16:29 | 17:29 | 18:29 | 19:29 | 20:29 | 21:29 | 22:29 |
| 42 | **Levanger** | | 22:33 | 6:33 | 7:33 | 8:33 | 9:33 | 10:33 | 11:33 | 12:33 | 13:33 | 14:33 | 15:33 | 16:33 | 17:33 | 18:33 | 19:33 | 20:33 | 21:33 | 22:33 |
| 49 | **Skogn** | | 22:39 | 6:39 | 7:39 | 8:39 | 9:39 | 10:39 | 11:39 | 12:39 | 13:39 | 14:39 | 15:39 | 16:39 | 17:39 | 18:39 | 19:39 | 20:39 | 21:39 | 22:39 |
| 56 | **Ronglan** | | 22:44 | 6:44 | 7:44 | 8:44 | 9:44 | 10:44 | 11:44 | 12:44 | 13:44 | 14:44 | 15:44 | 16:44 | 17:44 | 18:44 | 19:44 | 20:44 | 21:44 | 22:44 |
| 64 | **Åsen** | | 22:51 | 6:51 | 7:51 | 8:51 | 9:51 | 10:51 | 11:51 | 12:51 | 13:51 | 14:51 | 15:51 | 16:51 | 17:51 | 18:51 | 19:51 | 20:51 | 21:51 | 22:51 |
| 84 | **Skatval** | | 23:06 | 7:06 | 8:06 | 9:06 | 10:06 | 11:06 | 12:06 | 13:06 | 14:06 | 15:06 | 16:06 | 17:06 | 18:06 | 19:06 | 20:06 | 21:06 | 22:06 | 23:06 |
| 91 | **Stjørdal** | | 23:12 | 7:12 | 8:12 | 9:12 | 10:12 | 11:12 | 12:12 | 13:12 | 14:12 | 15:12 | 16:12 | 17:12 | 18:12 | 19:12 | 20:12 | 21:12 | 22:12 | 23:12 |
| 93 | Værnes | | 23:14 | 7:14 | 8:14 | 9:14 | 10:14 | 11:14 | 12:14 | 13:14 | 14:14 | 15:14 | 16:14 | 17:14 | 18:14 | 19:14 | 20:14 | 21:14 | 22:14 | 23:14 |
| 94 | **Hell** | | 23:16 | 7:16 | 8:16 | 9:16 | 10:16 | 11:16 | 12:16 | 13:16 | 14:16 | 15:16 | 16:16 | 17:16 | 18:16 | 19:16 | 20:16 | 21:16 | 22:16 | 23:16 |
| 101 | **Hommelvik** | | 23:20 | 7:20 | 8:20 | 9:20 | 10:20 | 11:20 | 12:20 | 13:20 | 14:20 | 15:20 | 16:20 | 17:20 | 18:20 | 19:20 | 20:20 | 21:20 | 22:20 | 23:20 |
| 111 | **Vikhammer** | | 23:26 | 7:26 | 8:26 | 9:26 | 10:26 | 11:26 | 12:26 | 13:26 | 14:26 | 15:26 | 16:26 | 17:26 | 18:26 | 19:26 | 20:26 | 21:26 | 22:26 | 23:26 |
| 119 | Rotvoll | | 23:31 | 7:31 | 8:31 | 9:31 | 10:31 | 11:31 | 12:31 | 13:31 | 14:31 | 15:31 | 16:31 | 17:31 | 18:31 | 19:31 | 20:31 | 21:31 | 22:31 | 23:31 |
| 120 | **Leangen** | | 23:32 | 7:32 | 8:32 | 9:32 | 10:32 | 11:32 | 12:32 | 13:32 | 14:32 | 15:32 | 16:32 | 17:32 | 18:32 | 19:32 | 20:32 | 21:32 | 22:32 | 23:32 |
| 122 | Lilleby | | 23:35 | 7:35 | 8:35 | 9:35 | 10:35 | 11:35 | 12:35 | 13:35 | 14:35 | 15:35 | 16:35 | 17:35 | 18:35 | 19:35 | 20:35 | 21:35 | 22:35 | 23:35 |
| 123 | Lademoen | | 23:36 | 7:36 | 8:36 | 9:36 | 10:36 | 11:36 | 12:36 | 13:36 | 14:36 | 15:36 | 16:36 | 17:36 | 18:36 | 19:36 | 20:36 | 21:36 | 22:36 | 23:36 |
| 124 | **Trondheim S** | o | 23:38 | 7:38 | 8:38 | 9:38 | 10:38 | 11:38 | 12:38 | 13:38 | 14:38 | 15:38 | 16:38 | 17:38 | 18:38 | 19:38 | 20:38 | 21:38 | 22:38 | 23:38 |
| | **Trondheim S** | | 23:43 | 7:43 | 8:43 | 9:43 | 10:43 | 11:43 | 12:43 | 13:43 | 14:43 | 15:43 | 16:43 | 17:43 | 18:43 | 19:43 | 20:43 | 21:43 | 22:43 | 23:43 |
| 125 | Skansen | | 23:47 | 7:47 | 8:47 | 9:47 | 10:47 | 11:47 | 12:47 | 13:47 | 14:47 | 15:47 | 16:47 | 17:47 | 18:47 | 19:47 | 20:47 | 21:47 | 22:47 | 23:47 |
| 127 | Marienborg | | 23:49 | 7:49 | 8:49 | 9:49 | 10:49 | 11:49 | 12:49 | 13:49 | 14:49 | 15:49 | 16:49 | 17:49 | 18:49 | 19:49 | 20:49 | 21:49 | 22:49 | 23:49 |
| 130 | **Selsbakk** | | 23:53 | 7:53 | 8:53 | 9:53 | 10:53 | 11:53 | 12:53 | 13:53 | 14:53 | 15:53 | 16:53 | 17:53 | 18:53 | 19:53 | 20:53 | 21:53 | 22:53 | 23:53 |
| 135 | **Heimdal** | | 23:57 | 7:57 | 8:57 | 9:57 | 10:57 | 11:57 | 12:57 | 13:57 | 14:57 | 15:57 | 16:57 | 17:57 | 18:57 | 19:57 | 20:57 | 21:57 | 22:57 | 23:57 |
| 145 | Melhus Skysstasjon | | 0:09 | 8:09 | 9:09 | 10:09 | 11:09 | 12:09 | 13:09 | 14:09 | 15:09 | 16:09 | 17:09 | 18:09 | 19:09 | 20:09 | 21:09 | 22:09 | 23:09 | 0:09 |
| 148 | **Søberg** | o | 0:11 | 8:11 | 9:11 | 10:11 | 11:11 | 12:11 | 13:11 | 14:11 | 15:11 | 16:11 | 17:11 | 18:11 | 19:11 | 20:11 | 21:11 | 22:11 | 23:11 | 0:11 |
| | | To: | | | | | | | | | | | | | | | | | | |

*Train Group:* lokal Trondheim

*Version ID:* test

*Timetable Period:* Ruteendring 162 (des 2012)

| | *Departures* |
|---|---|
| -- | 322,660 |
| ***Tot.*** | **322,660** |

| *Train ID* | *Description* | *TT Period* | *Operating Day* | *Time Interval* | *Train-Kms* |
|---|---|---|---|---|---|
| NSB LT 10401 | Steinkjer - Trondheim S | 162 | | 1 h | 918,079 |
| NSB LT 10402 | NSB Persontog | 162 | | 1 h | 918,079 |
| ***Tot.*** | | | | | **1,836,159** |