Norway High Speed Rail Assessment Study: Phase III

Journey Time Analysis

Final Report

25 January 2012

Plan Design Enable

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1. Introduction

1.1. Background

Jernbaneverket (JBV) has been mandated by the Norwegian Ministry of Transport and Communications to assess the issue of High Speed Rail (HSR) lines in Norway. There is a National Transport Plan covering the period from 2010-2019 which includes relatively minor enhancements to the railway network. The ministry wishes to understand if going beyond this and implementing a step change in rail service provision in the form of higher speed concepts could “contribute to obtaining socio-economically efficient and sustainable solutions for a future transport system with increased transport capacity, efficiency and accessibility”.

Previous studies have been carried out looking into HSR in Norway and there are various conflicting views. The aim of this study is to provide a transparent, robust and evidence based assessment of the costs and benefits of HSR to support investment decisions.

The Norway HSR Assessment Study has been divided into three phases.

- In Phase I, which was completed in July 2010, the knowledge base that already existed in Norway was collated, including outputs from previous studies. This included the studies that already were conducted for the National Rail Administration and the Ministry of Transport and Communication, but also publicly available studies conducted by various stakeholders, such as Norsk Bane AS, Høyhastighetsringen AS and Coinco North.
- The objective of Phase II was to identify a common basis to be used to assess a range of possible interventions on the main rail corridors in Norway, including links to Sweden. The work in Phase II used and enhanced existing information, models and data. New tools were created where existing tools were not suitable for assessing HSR. Phase II was completed in March 2011.
- In Phase III the tools and guiding principles established in Phase II have been used to test scenarios and develop options on the different corridors.

1.2. Purpose of this Report

The purpose of this report is to detail expected passenger journey times and the methodology used to calculate them.

This report applies both to scenarios C & D, for services typically running up to 330 kph or 250 kph, and Scenario B, where a different approach was used with the journey time calculations based on upgrade proposals from the four alignment consultants.

The journey times are important because they drive significant elements within the operating cost model, for example, the utilisation of rolling stock and on-board staff, but more importantly because they are a key factor in the competitive offer of HSR in competition with other modes and therefore the level of demand, and they in turn the economic value of that demand.

A full set of the results are expressed in tables in the appendices to this report.

Please note that the journey time results reflect the constraints of the alignment, the proposed stopping pattern, the rolling stock and timetabling assumptions; therefore, they should be understood to be subject to change when associated changes are made to these elements.

1.3. Structure of this Report

The remainder of this report has the following chapters:

- Chapter 2 outlines the scope of alternatives under consideration;
- Chapter 3 describes the approach adopted to deriving journey times;
- Chapter 4 focuses on the presentation of the Scenario C/D journey time results by corridor;
- Chapter 5 presents the Scenario B journey time analysis; and
- Chapter 6 summarises and concludes the report.

In addition, Appendix A presents more detailed journey time outputs for each of the Scenario C/D detailed appraisal alternatives discussed in the report. Appendix B provides the corresponding journey time outputs for the Scenario C/D sensitivity alternatives.

2. Scope of Alternatives

2.1. Infrastructure Scenarios

During Phase II four scenarios were considered on each corridor:

- Scenario A – a continuation of the current railway policy and planned improvements, with relatively minor works undertaken (the reference case to which the other upgrades listed below are compared);
- Scenario B – a more aggressive development of the current infrastructure;
- Scenario C – major upgrades to the current infrastructure achieving high-speed concepts; and
- Scenario D – building of new separate HSR lines.

As part of the alignment work in Phase III, new scenarios were developed and existing scenarios were adapted. The scenarios have evolved to consider the following options:

- Scenario B is conceptually defined as a uniform 20% reduction in travel time, maintaining the current stopping pattern and remaining single track outside of the Inter-City (IC) area;
- Scenario D was sub-categorised into two options:
- D1: For mixed passenger and freight traffic, design speed 330kph, gradient 12.5%, double track
- D2: For passenger traffic only, design speed 330kph, relaxed gradient restrictions, double track
- Scenario 2* is a new scenario which represents an upgrade of existing lines to double track with a 250kph design speed;
- Scenario C is defined as a combination of Scenarios D1, D2 and 2*.

On the basis of the above classification, a number of specific route alternatives were specified, considered and then shortlisted to provide a manageable set of representative alternatives which have been the primary focus for technical analysis. These fall into two categories:

- HSR Alternatives reflecting one of or a combination of D1, D2 (330kph) and/or 2* (250kph); and
- Scenario B alternatives to HSR

The approach adopted for deriving options for testing for Scenarios 2*, D1 and D2 and for deriving options for testing based on Scenario B was different. A fuller explanation of the process for selecting the corridors, routes, scenarios and alternatives, in Norwegian, can be found in the following Phase III report.

- ***Høyhastighetsutredningen 2010-12: Vedlegg B - Fastsettelse av alternativer for analyse, 2012-01-22, Railconsult AS***

2.2. HSR Corridors and Route Alternatives

In Phase III of the study, these alternatives were considered with respect to four potential corridors and associated routes. The four corridors are:

- North to Trondheim;
- West to Bergen;
- South (and West) to Stavanger; and
- East to Stockholm and Gothenburg.

2.2.1. Scenario C/D Alternatives

For the derivation of the HSR alternatives the four corridors were sub-divided into a number of potential routes. Two key elements informed this process:

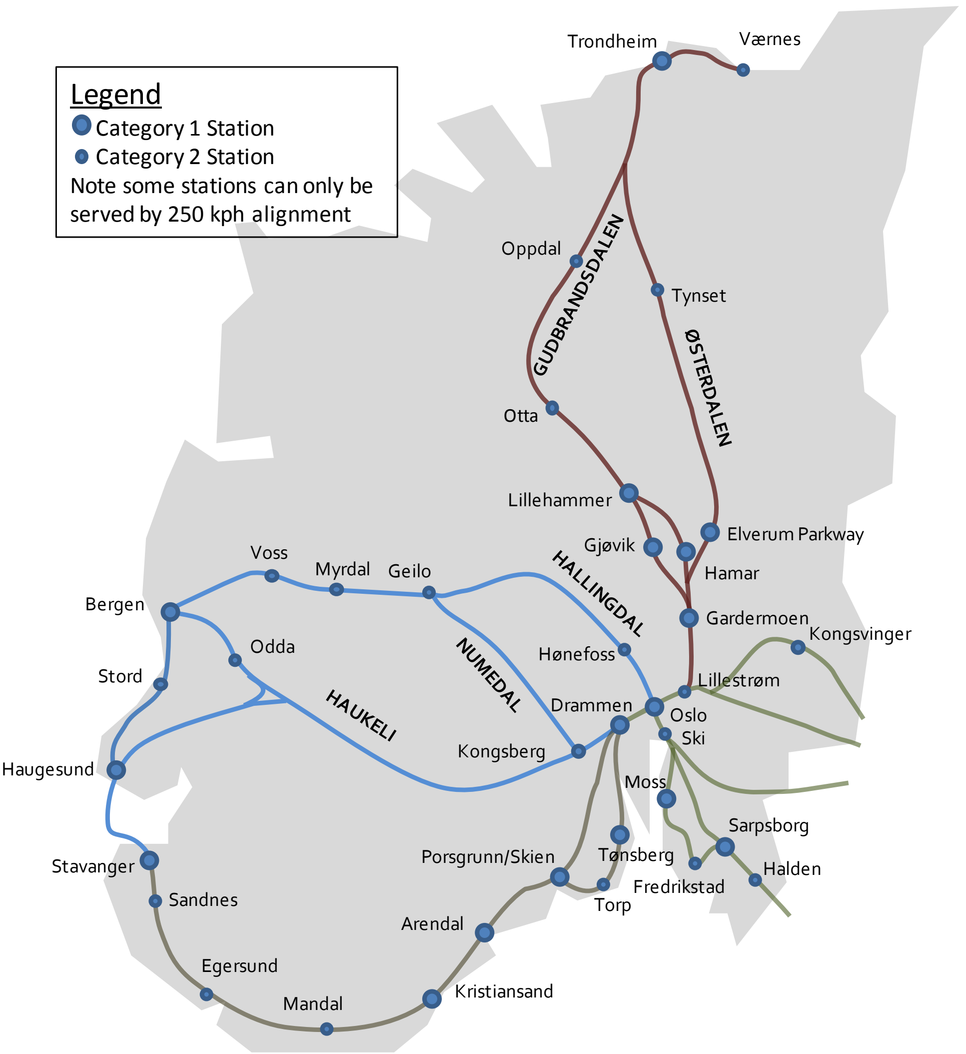
- A requirement to connect the largest cities, defined in the mandate and as Category 1 stations (see Section 3.3.1) with HSR times that would be competitive; and
- A requirement to fit with the topography to avoid prohibitively long tunnels.

For all of the corridors a number of viable routes were identified, the majority of which follow the main topographical constraints. For example, from Oslo to Bergen three different routes exist – Hallingdal (via Hønefoss), Numedal (via Drammen then north to Geilo) and Haukeli (the 'Y-shaped' network which heads more directly west from Drammen via Bø, also serving Stavanger). Similarly towards Trondheim the routes tend to follow either Østerdalen or Gubrandsdalen for the majority of their length. Some routes were identified in Phase II but not taken forward for final testing as part of an early screening process that involved all of the consultants and the client using their professional judgement, for example Oslo – Trondheim via Rondane.

For each route a range of specific alternative alignment options were considered. The purpose of these alternatives was to define the options for each route so that they could be considered and then shortlisted to provide a manageable set of representative options for the technical analysis. The definition of the alternatives included the proposed (maximum) line speeds along the main sections of the route, key connection points such as Gardermoen airport and other assumptions (for example whether it should access Oslo via Drammen or via another route).

The process for defining and short-listing the alternatives for the routes was managed by the client but involved all of the main consultants. This involvement included an extensive workshop and discussion. Care was taken to balance the needs for competitive journeys times, to reduce cost by fitting with the topography, to connect with the communities en route and with other modes of transport and to have a range of alternatives across all routes. In addition, care was taken to ensure that a range of scenarios was tested from routes that were typically 250kph with a vertical gradient that would accommodate freight (Scenario 2*), to 330kph with steeper gradients (Scenario D2).

Figure 1. HSR Corridors and Route Alternatives



In total 20 alternatives were defined and short-listed, with 12 recommended for full appraisal and 8 tested as sensitivities. The various routes and alignments are presented in Figure 1 above, as well as intermediate stops that were identified. The methodology for the identification of station stops is described in Section 3.3. The range of alternatives and sensitivities tested means that there can be sufficient certainty that no viable alternative exists that is likely to have a superior business case that would undermine the credibility of the work on this project. This does not mean, however, that in a subsequent phase of work that the alternatives cannot be optimised.

2.2.2. Scenario B Alternatives

The mandate by the Norwegian Ministry of Transport and Communications required JBV to assess an approach to delivering improvements based on solely upgrading existing lines. For Scenario B this was defined as a 20% reduction in journey times on the existing network.

For each of the four corridors to Trondheim, Bergen, Stavanger and Stockholm a single Scenario B alternative was defined by the relevant alignment engineering team, who were best placed to understand where there were incremental opportunities to upgrade the existing network.

The process for the calculation of Scenario B journey times is described in Chapter 5. It should be noted that the primary focus for technical engineering feasibility and development of options has related to Scenario C/D HSR alternatives and as a consequence, the scope to undertake a detailed analysis and assessment of those alternatives has been greater than for Scenario B.

3. Approach

3.1. Introduction

The journey time results are the product of three key tasks:

- Development of a journey time model;
- Identification of core HSR station stops and associated stopping patterns; and
- Journey time modelling refinement and adjustment.

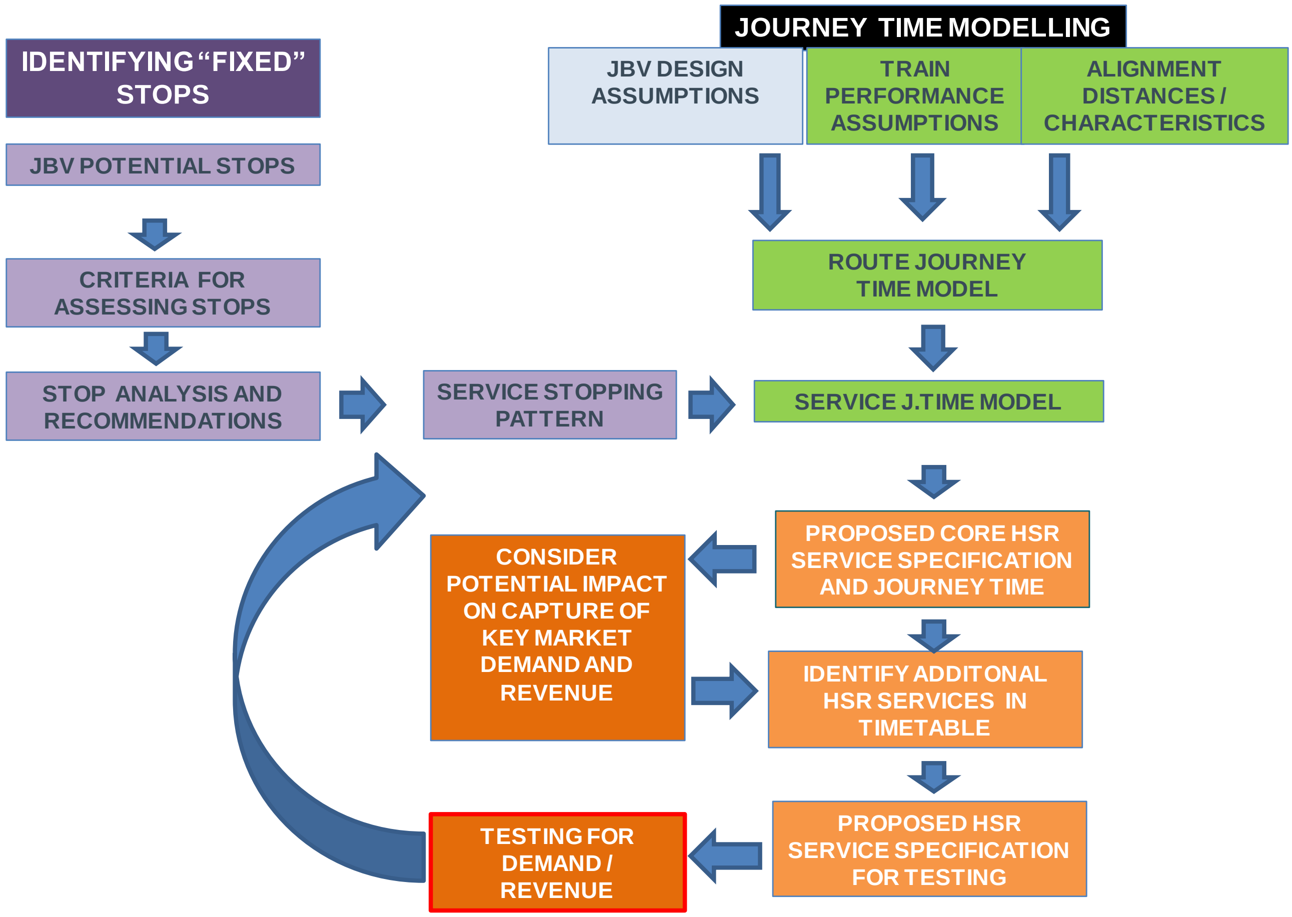
Developing the journey time model involved collating the results of the alignment work and modelling an appropriate train specification over that alignment in accordance with best practice.

The second task, undertaken in parallel with the first, was to determine appropriate station locations to serve and an initial service stopping pattern that could be fed into the route journey time model.

The third task involved modelling the specified stopping patterns to establish the associated end-to-end journey time and station to station intermediate journey times. This provided a basis for considering revision or adjustment to the inputs (such as the stopping pattern) particularly in the context of likely competitiveness of HSR against journeys by other modes, in particular air. No review was undertaken of the specification of alternatives themselves to refine and/or optimise them as part of the journey time modelling process.

In Figure 2 below the green sections relate to the journey time modelling, the purple to the determination of stops to be served and the stopping pattern, and the orange to refinement and adjustment.

Figure 2. Journey Time Methodology



3.2. Journey Time Model Development

The journey time model was developed using standard rail industry software. In this case RailSys was used, although alternatives exist.

This software takes account of the performance of the train, mainly its acceleration and deceleration during periods of normal operation. It also takes into account the performance over different gradients. The train used in this exercise was a Siemens Valero, although alternative trains exist. There may be an opportunity to optimise the gearing and other elements which could result in faster times, but this process has not been undertaken as part of this phase of work. It is recommended that should an individual corridor be selected for further work, the topographical detail produced during Phase III should be used to inform a dialogue with the rolling stock supply industry over a more optimised train set for the route.

The topographical limits of the route, where new or upgraded, were input into the model from the data provided by the alignment engineers, including the vertical alignments (gradients), horizontal alignments (the curves) and structures, including tunnels. Given the high number of tunnels, it is worth noting that the pneumatic effect within tunnels was overlaid onto the model, with longer tunnels having a progressively larger effect.

Where the alternative used existing lines or committed sections of line being designed currently, the existing line (i.e. non-stop) speeds (or the new design speeds) were used:

- Oslo – Drammen 32 minutes,
- Oslo – Ski 14 minutes (if stopping),
- Oslo – Gardermoen 22 minutes,
- Öxnered – Gothenburg 27 minutes (including 1 stop),
- Västerås – Stockholm 40 minutes.

No extra allowance was made for any capacity impact on journey times although some extra time was added for moving from existing lines to new lines (or vice versa) and for platforming. Most stops were timed at 1 minute although 2 minutes was used at the Category 1 stations (see Section 3.3 for category of stations).

In addition, 5% was added as a performance allowance. It is possible that some of this allowance will not be required or that some will be used to optimise the project with cost. At this stage it was also felt that such an allowance would limit the risk of the project promising headline times that could not be delivered in practice.

VWI, as part of their work to support environmental assessment produced some indicative journey time results using different software. These were then compared with the Atkins results. The VWI times were typically similar albeit slightly faster. On the whole the difference in journey times reflected the 5% performance assumption and the performance of the rolling stock type. Should another phase of work be commissioned and more detail be required, further analysis would be needed to optimise this allowance to ensure punctuality of services. At the moment the 5% allowance represents an appropriate balance between the fastest journey times possible and the operational requirement for consistency.

3.3. Identification of Core HSR Station Stopping Patterns

Ensuring that HSR in Norway is highly accessible to communities is an important consideration. It has been suggested that there is likely to be significant demand for HSR travel within the corridors themselves, not just to the terminus stations, which was not wholly captured in the Phase II demand forecasting. A limited number of intermediate stations were tested for each corridor in Phase II, to reflect the relatively low population density outside of the key urban areas, and the focus on abstracting from air demand on end-to-end journeys, a key objective of HSR.

In order that the proposed HSR routes serve a greater proportion of the Norwegian population, JBV proposed a revised list of stops, based on stations in the current NSB timetable where the HSR track follows existing alignments, as well as stops aimed at serving communities sited along alignments not currently served by rail. A number of these stations were not previously considered in Phase II.

3.3.1. Categorising Stations

In addition to the need to maximise the proportion of the population served by HSR, there is recognition of the need to keep end-to-end journey times at a reasonable level in order to attract demand for city-to-city flows. It was therefore decided that stations should be categorised based on a variety of factors, with the aim of securing excellent community access , while maintaining sensible stop spacing conducive to maintaining competitive journey times. This would provide a basis for selection of stations included in HSR Core service stopping pattern. Stations locations considered were required to be consistent with what was deemed feasible to serve on the basis of alignment designs.

Each station was considered against one of three categories:

- Category 1 – Major stations with expected high levels of patronage, requiring a regular service;
- Category 2 – Potential to be a well used station, especially if complemented by feeder services, but unlikely to require more than an hourly service; and
- Category 3 – Small stations, unlikely to be served by core HSR services given that category one and two stations are available.

In categorising stations the following factors were considered:

- Population in immediate surrounding area – urban settlement and municipality;
- NSB station usage in 2009, if applicable;
- Proximity to other fixed stops; and
- Transport connectivity aspects.

These criteria and how they related to station categorisation are explained more fully below.

Population served:

- Higher than 50,000 (10,000 in North, Bergen-Stavanger) Category 1;
- Between 10,000 and 50,000 (5,000 – 10,000 in North, Bergen-Stavanger) Category 2;
- Less than 10,000 (5,000 in North, Bergen-Stavanger) Category 3.

NSB station usage per year

- Higher than 500,000 (100,000 in North, Bergen-Stavanger) Category 1 ;
- Between 100,000 and 500,000 (50,000 – 100,000 in North, Bergen-Stavanger) Category 2 ;
- Less than 100,000 (50,000 in North, Bergen-Stavanger) Category 3.

Proximity to other potential fixed stops:

- Not located within 20km of an already identified higher category or graded stop
- Consideration of the need to maintain reasonable stop spacing, especially on the West and North corridors
- For example, although there are no sizable urban areas between Lillehammer and Trondheim, some stations have been given elevated priority in order to serve the villages in those intermediate areas

Transport connectivity aspects:

- Does the station serve an airport?
- Is the station near a major sea port?
- Is the station served by commuter rail services?
- Is the station near a motorway / major road / highway intersection?
- Is there a coach terminal near the station?
- Is the station well connected to serve multiple very small communities that would otherwise not be served?

As described above, the potential stops on HSR Alternative alignments were all categorised by the level of local population, and where appropriate by NSB station usage data. Stations serving populations of over 50,000 people (typically with NSB station usage of over 500,000 per year) were classified as Category 1 stations, and deemed to be stations critical to serve by HSR.

Stations within population areas between 50,000 and 10,000 (with typical NSB station usage between 100,000 and 500,000 per year) were classified as Category 2 stations, and smaller settlements (with stations with lower NSB usage) were typically classified as Category 3 stations. However, in determining final categorisation as 2 or 3, the other two aspects, namely proximity to other potential stations and transport connectivity aspects were also taken into account

3.3.2. Resulting Station Categorisation by Corridor

The process described above resulted in the categorisation of stations detailed in this section.

Corridor North

Table 1 below lists the potential stations that have been considered for the southern corridor in Norway and describes the categorisation process.

Table 1. Categorisation of stations on the North Corridor

Station	Population served	Station Usage (2009)	Proximity to key stations (< 20km)	Transport Connectivity	Category
Gardermoen	0	>100k		✓✓	1
Hamar	>10k	>100k	Gjøvik	✓	1
Gjøvik	>10k		Hamar	✓	1
Lillehammer	>10k	>100k		✓	1
Ringebu	<5k	<50k			3
Vinstra	5 – 10k	<50k	Otta		3
Otta	<5k	50 – 100k		✓	2
Dombås	<5k	<50k		✓	2
Oppdal	5 – 10k	50 – 100k			2
Berkåk	<5k	<50k			3
Støren	5 – 10k	<50k			2
Trondheim	>10k	>100k		✓✓	1
Værnes	0			✓✓	2
Elverum Parkway	>10k		Hamar	✓	1
Rena	<5k				3
Koppang	<5k				3
Alvdal	<5k		Tynset		3
Tynset	5 – 10k			✓	2

Corridor West

Table 2 below lists the potential stations that have been considered for the western corridor in Norway and describes the categorisation process.

Table 2. Categorisation of Stations on the West Corridor

Station	Population served	Station Usage (2009)	Proximity to key stations (< 20km)	Transport Connectivity	Category
Oslo – Bergen					
Hønefoss	10 – 50k	<100k			2
Nesbyen	<10k	<100k			3
Gol	<10k	<100k			3
Ål	<10k	<100k			3
Geilo	<10k	100 – 500k			2
Finse	<10k	<100k			3
Myrdal	<10k	>500k			2
Voss	10 – 50k	100 – 500k			2
Arna	<10k	<100k	Bergen	✓	3
Bergen	>50k	>500k		✓✓	1
Drammen	>50k	>500k		✓✓	1
Kongsberg	10 – 50k	100 – 500k		✓	2
Notodden	10 – 50k			✓	2
Bø	<10k	<100k			3
Seljord	<10k				3
Åmot	<10k				3
Haukeligrend	<10k				3
Bergen – Stavanger					
Haugesund	>10k			✓	1
Stord	>10k				2
Os	>10k			✓	2
Kårstø	<5k				3
Etne	<5k				3
Sauda	<5k				3
Røldal	<5k				3
Odda	5 – 10k				2
Jondal	<5k				3

Corridor South

Table 3 below lists the potential stations that have been considered for the southern corridor in Norway and describes the categorisation process.

Table 3. Categorisation of Stations on the South Corridor

Station	Population served	Station Usage (2009)	Proximity to key stations (< 20km)	Transport Connectivity	Category
Drammen	>50k	>500k		✓✓	1
Tønsberg	>50k	>500k		✓✓	1
Porsgrunn	>50k	100 – 500k		✓	1
Kragerø	<10k				3
Risør	<10k				3
Arendal	10 – 50k	<100k		✓	1
Grimstad	10 – 50k		Arendal	✓	3
Lillesand	<10k		Kristiansand	✓	3
Kristiansand	>50k	100 – 500k		✓✓	1
Mandal	10 – 50k	<100k			2
Egersund	10 – 50k	<100k			2
Sandnes	>50k		Stavanger	✓✓	2
Stavanger	>50k	100 – 500k		✓✓	1

Corridor East

For the East Corridor all station stops are assumed to be fixed and hence the station categorisation process was not undertaken on this corridor.

3.3.3. Core and Peak Stopping Patterns

Following discussion with JBV, the concept of an hourly Core HSR Service was agreed. This would operate all day and be assumed to stop at all Category 1 and 2 stops on a given route. In addition, the potential to also operate “Peak” services focused on the end-to-end market was established as discussed in 3.4 below – these would operate at peak periods to compete with air and stop at Category 1 stops only, hence delivering faster end-to-end journey times than the Core service. The Peak service would operate alongside the Core service.

3.3.4. Serving Category 3 Stations

It was noted that the potential to also serve Category 3 stations was not being precluded by this specification and that detailed development of timetables in future phases of the study could allow for these to also be served. However, for the purposes of assessing the large number of HSR alternatives at this stage, the focus would be on the Core and Peak stopping patterns described. . In order to understand the potential “maximum” impact that also serving Category 3 stations might have on end-to-end journey times, overall times were produced for a service calling at stations of all categories (1, 2 and 3).

3.4. Journey time Model Refinement and Adjustment

Following the initial results the team then looked at the stopping pattern and service specification in order suggest ways in which the journey times could be optimised. This did not involve altering the basic alternative alignment specification, but did involve consideration of the competitiveness of times relative to journey times by other modes and “indicative” target times sought for HSR.

This review process indicated that the resulting HSR times did provide a reasonable basis for forecasting, costing and appraisal in Phase III, though it was agreed to test the journey times for additional faster peak services. Following assessment of the peak profile for air services to/from Gardermoen related to the HSR corridors, it was agreed that these should be for an extra 4 peak trains per peak period per direction, with peak services only stopping at Category 1 stations to secure faster journey times.

In Phase III, the opportunity to optimise stopping patterns and journey times in the context of their influence on the demand, revenue and benefits HSR is then forecast deliver, the resulting cost of HSR to operate and the overall economic and financial performance of HSR alternatives has been very limited. It is fully recognised that there is significant opportunity to do so and it is anticipated that this would be a key consideration in further development of HSR proposals in Norway.

4. Scenario C/D Alternative Journey Times

A summary description of the detailed appraisal Scenario C/D alternatives is provided in Table 4 below. These underpinned the demand and revenue forecasting and costs that were fed into the economic and financial appraisal of C/D alternatives.

Table 4. HSR Alternatives Considered for Detailed Technical Analysis

Corridor	Option Ref	HSR Option Description
North	**G3:Y**	**250 kph Oslo – Trondheim / Vaernes via Gudsbrandsdalen** serving Gardermoen, Hamar, Lillehammer, Otta and, Oppdal
	Ø2:P	**330 kph Oslo – Trondheim / Vaernes via Østerdalen** serving Gardermoen, Elverum Parkway and Tynset
West	**N1:Q**	**250 kph Oslo – Bergen via Numedal** serving Drammen, Kongsberg, Geilo, Myrdal and Voss
	HA2:P	**330 kph Oslo – Bergen via Hallingdal** serving Hønefoss, Geilo and Voss
	H1:P	**330 kph Oslo – Bergen via Haukeli** serving Drammen, Kongsberg and Odda **330 kph Oslo – Stavanger via Haukeli** serving Drammen, Kongsberg, Odda and Haugesund **330 kph Bergen – Stavanger via Roldal** serving Haugesund and Odda
	BS1:P	**330 kph Bergen – Stavanger via coastal route** serving Haugesund and Stord
South	**S8:Q**	**250 kph Oslo – Stavanger via Vestfold** serving Drammen, Tønsberg, Torp, Porsgrunn, Arendal, Kristiansand, Mandal, Egersund and Sandnes
	S2:P	**330 kph Oslo – Stavanger via direct route** serving Drammen, Porsgrunn, Arendal, Kristiansand, Mandal, Egersund and Sandnes
East	**ST5:U**	**250 kph Oslo – Stockholm via Ski** serving Ski, Karlstad, Örebro and Västerås
	ST3:R	**330 kph Oslo – Stockholm via Lillestrøm** serving Lillestrøm, Karlstad, Örebro and Västerås
	GO3:Q	**250 kph Oslo – Gothenburg via Moss** serving Ski, Moss, Fredrikstad, Sarpsborg, Halden and Trollhättan
	GO1:S	**330 kph Oslo – Gothenburg via direct route** serving Sarpsborg and Trollhättan

The following sections present the journey times for each of the alternatives above in summary. Appendix A presents the journey time results in detail.

4.1. North Corridor

The travel time between Oslo Central and Trondheim for the all day service is expected to be around 2 hours and 11 minutes if via Østerdalen (alternative ØP:2) and around 2 hours and 59 minutes via Gudbrandsdalen.

Table 5 below shows the journey time between Oslo and Trondheim for the following services:

- Core service (standard hourly service);
- Peak service with fewer stops; and
- Stopping service, with additional time for potential calls at Category 3 (community) stops.

In addition, the average speeds for the core and peak service are presented. The extra time via Gudbrandsdalen reflects the extra 7 km before the start of the new high speed line, the 2 additional stops, the proportionally lower time spent at higher speeds because of the topography, and the fact the route is 32 km longer.

Table 5. Summary of North Corridor Journey Times

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average kph Core	Average kph Peak
G3Y (Oslo - Trondheim)	02:59	02:48	*03:25*	164	188
Ø2P (Oslo - Trondheim)	02:11	02:03	*02:26*	201	235

4.2. West Corridor

The west corridor is divided into two routes: between Oslo and Bergen and between Bergen and Stavanger.

4.2.1. Oslo – Bergen

0 summarises the journey time results for Oslo – Bergen.

The travel time between Oslo Central and Bergen for the all day service is expected to be around 2 hours and 37 minutes if via Numedal (alternative N1:Q), around 2 hours and 06 minutes via Hallingdal (HA2:P), and around 2 hours and 16 minutes via Haukeli (H1:P).

The total extra time via Numedal (N1:Q) reflects the fact that new high speed line west of Geilo is limited to 250kph, there are 6 intermediate stops, and the route is almost 20 km longer than via Hallingdal. The Hallingdal alternative (HA2:P) has only 9 km not built to 330kph, has only 3 intermediate stops and is the most geographically direct route. The Haukeli route has 42 km of the route not designed for high speed (between Drammen and Oslo Central) and is 30 km longer than via Hallingdal. It has only 3 intermediate stops and is only 3 km shorter than via Numedal.

Table 6. Summary of West Corridor Journey Times (Oslo – Bergen)

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average kph Core	Average kph Peak
N1Q (Oslo - Bergen)	02:37	02:20	*03:01*	153	171
Ha2P (Oslo - Bergen)	02:06	1:54	*2:14*	174	192
H1P (Oslo – Bergen)	02:16	02:07	*02:22*	175	187

The Haukeli route can also be used to reach Stavanger via a junction at Røldal. Stavanger is 64 km further away from Oslo than Bergen via Haukeli and has 3 intermediate stops. The final section (some 32 km) is designed for passenger traffic only and at lower speeds owing to the challenging topography. The journey time results are shown in Table 7.

Table 7. Summary of West Corridor Journey Times (Oslo – Stavanger)

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average kph Core	Average kph Peak
H1P (Oslo – Stavanger)	02:27	02:23	*02:46*	187	193

4.2.2. Bergen – Stavanger

In the far west the two alternative routes have a common section between Stavanger and Haugesund. They also both have 2 intermediate stops. However, even though the route via Røldal is 50 km longer (280 km total), the journey time takes only 7 minutes longer because of the difficult topography and steep gradients on the coastal route. Whilst there are local road and ferry connections, the construction of a new rail line would effectively build a new market for public transport rather than compete with the existing by offering faster journey times. Table 8 summarises the journey time results.

Table 8. Summary of West Corridor Journey Times (Bergen – Stavanger)

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average kph Core	Average kph Peak
H1P (Bergen – Stavanger)	01:29	01:24	*01:28*	189	200
BS1P (Bergen – Stavanger)	01:22	01:19	*n/a*	168	174

4.3. South Corridor

Table 9 summarises the journey time results for Oslo – Stavanger.

On the southern corridor, although the route west of Porsgrunn/Skien varies slightly between the alternatives to fit the rail constraints most effectively within the topography, the main difference is that S8:Q was limited to a maximum design speed of 250kph with 5 intermediate stops and S2:P was limited to 330kph with 5 intermediate stops. Despite this the 250kph alternative (S8:Q) is only 8 minutes slower over the first 373 km of the corridor, beginning from Stavanger.

East of Porsgrunn S2:P (the 330kph alternative) runs direct to Drammen. S8:Q (the 250 km alternative) runs via Vestfold on some existing and upgraded line with 2 additional intermediate stops. As a result S2:P has a faster average speed and is 29 minutes quicker.

Table 9. Summary of South Corridor Journey Times

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average kph Core	Average kph Peak
S8Q (Oslo – Stavanger)	03:31	03:18	*04:07*	153	163
S2P (Oslo – Stavanger)	03:02	02:52	*03:22*	164	174

4.4. East Corridor

The East corridor has two separate routes: Oslo – Stockholm and Oslo – Gothenburg, with two separate alternatives for each route.

4.4.1. Oslo – Stockholm

The two alternatives to Stockholm share the same alignment between Arvika and Stockholm, for 378 km of the total route (which is either 510 km via Ski (ST5:U) or 492 km via Lillestrøm (ST3:R)). Both the Stockholm alternatives have 4 intermediate stops. The majority of both routes are limited to a maximum of 250 km. 125 km of ST3:R via Lillestrøm is at existing line speeds, as is 129 km of ST5:U via Ski. Only 96 km of ST3:R via Lillestrøm is designed at 330 kph and 83 km of ST5:U via Ski. As a result the journey times are very similar. The average speeds are slightly faster via Lillestrøm and the journey times slightly quicker. The journey times are summarised in Table 10.

Table 10. Summary of East Corridor Journey Times (Oslo – Stockholm)

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average Kph Core	Average kph Peak
ST5U (Oslo – Stockholm)	02:56	02:51	*03:19*	174	179
ST3R (Oslo – Stockholm)	02:47	02:44	*02:58*	177	180

4.4.2. Oslo – Gothenburg

The two alternatives to Gothenburg are similar within Sweden with both running on 100 km of existing track. The majority of both routes are limited to a maximum of 250 km. However because GO1:S has 52 km of 330kph track taking a more direct alignment between Ski and Sarpsborg, avoiding 4 intermediate stops, it has a faster average speed of 184kph (as opposed to 146kph for GO3:Q) and is 38 minutes faster.

Table 11. Summary of East Corridor Journey Times (Oslo – Gothenburg)

Alternatives	hh:mm Core service	hh:mm Peak service	*hh:mm with Cat. 3 stops*	Average Kph Core	Average kph peak
GO3Q (Oslo – Gothenburg)	02:18	02:06	*02:24*	146	161
GO1S (Oslo – Gothenburg)	01:40	01:40	*01:49*	184	184

4.5. Scenario C/D Sensitivity Alternatives

Journey time modelling was also undertaken on the alternatives being tested as sensitivities only. The sensitivities assume different speed (and alignment requirements) across parts of the various route corridors. They proved a useful basis for cross-checking the journey time results from full appraisal alternatives. They also prove a measure of the impact different line speeds over individual routes sections might impact on the total journey time. Should further work be required on a particular route they will assist in development of more refined alignment alternatives for testing.

A summary description of the Scenario C/D Sensitivity Alternatives is provided in Table 12 below. The journey time results for these alternatives are provided in Appendix B.

Table 12. HSR Alternatives Considered for Sensitivity Testing of Demand and Revenue

Corridor	Option Ref	HSR Option Description
North	**G1:P**	**330 kph Oslo – Trondheim / Vaernes via Gudsbrandsdalen** serving Gardermoen, Gjøvik, Lillehammer, Otta and Oppdal
West	**HA1:Q**	**250 kph Oslo – Bergen via Hallingdal** serving Hønefoss, Geilo, Myrdal and Voss
	N4:P	**330 kph Oslo – Bergen via Numedal** serving Drammen, Kongsberg, Geilo and Voss
South	**S8:T**	**250 kph Oslo – Stavanger via Vestfold** serving Drammen, Tønsberg, Torp, Porsgrunn, Arendal, Kristiansand, Mandal, Egersund and Sandnes
	S3:Z	**330 kph Oslo – Stavanger via direct route** serving Drammen, Porsgrunn, Arendal, Kristiansand, Mandal, Egersund and Sandnes
	S4:P	**330 kph Oslo – Stavanger via direct route** serving Drammen, Porsgrunn, Arendal, Kristiansand, Mandal, Egersund and Sandnes
East	**ST1:Q**	**250 kph Oslo – Stockholm via Kongsvinger** serving Lillestrøm, Kongsvinger, Karlstad, Örebro and Västerås
	ST2:R	**330 kph Oslo – Stockholm via Lillestrøm** serving Lillestrøm, Karlstad, Örebro and Västerås

5. Scenario B Alternative Journey Times

5.1. Scenario B Alternatives

For the purposes of this study, Scenario B was conceptually defined by JBV as:

‘***Delivery of a uniform 20% reduction in travel time, maintaining the current stopping pattern and remaining single track outside of the Inter-City (IC) area’***

In order to undertake an analysis of the performance of Scenario B a clear specification of what this would involve. JBV’s alignment design teams each examined possible options for delivery of Scenario B and high level specifications were provided to Atkins and F+G, covering each route per corridor, and reflecting the sections of route where the journey time improvement would be secured. This is summarised in Table 13 below:

Table 13. Scenario B Summary of Specification

Corridor	Route	Section(s) of route where journey time improvement is secured	% Journey Time Assumption
North	Oslo-Trondheim	Gardermoen-Oppdal	20% reduction in total end-to-end time
West	Oslo-Bergen	Hønefoss-Bergen	
South	Oslo - Kristiansand -Stavanger	Drammen-Sandnes	
East	Oslo - Stockholm	Lillestrøm-Kongsvinger	20% reduction in Olso-Charlottenberg time: equates to a 5% reduction in Oslo-Stockholm time

The exceptional Scenario B option is clearly the East corridor option between Oslo and Stockholm where the specification aims only to achieve a 20% reduction in journey time between Oslo and Charlottenberg. Norconsult, the alignment consultants for this corridor advised that insufficient information was available to determine a specification for Scenario B improvements on Swedish sections of route and consequently specification only aimed to deliver the reduction in journey time within Norway.

5.2. Scenario B Alternative Journey Times

Atkins calculated the overall change in journey time based on the current fastest timetabled journey times for each route, as shown in Table 14 below. The alignment data for Scenario B provided by the alignment teams was used to determine where the journey time reductions are applied along each corridor. The equivalent Scenario C/D alternative journey time is also shown for comparison and highlights the significantly shorter journey times full HSR would offer, albeit for a very different type of service.

Table 14. Scenario B Journey Times

Corridor	2011 Fastest Journey Time	Scenario B Journey Time	*HSR Option Comparison Time*
Oslo-Trondheim	6:36	5:16	*2:59 (G3:Y)*
Oslo-Bergen	6:28	5:10	*2:06 (HA2:P)*
Oslo - Kristiansand –Stavanger	7:42	6:09	*3:31 (S8:Q)*
Oslo-Stockholm (Oslo-Charlottenberg)	5:55 (1:43)	5:34 (1:22)	*2:56 (ST5:U)*

6. Summary and Conclusions

All of the routes in the North and West corridors offer a competitive alternative to air travel before the addition of potential community stops. In the North, Østerdalen offers a more competitive route than Gudbrandsdalen. In the West the main difference is accounted for by the maximum design speed and whether the service has to run on the existing tracks between Drammen and Oslo.

In the South corridor there is little difference between 250kph and 330kph west of Porsgrunn. The key difference is whether the route runs via Vestfold (restricted in places to 200kph or existing line speeds) or direct to Drammen (which could be at up to 330kph) – and whether or not the extra journey time is justified in terms of access to the population in Vestfold. Both the alternatives in the South (particularly Stavanger – Oslo via Vestfold at 250kph at 3 hours 31 minutes) are beginning to struggle to be competitive compared with air and severely restrict the opportunity for business travellers to travel “out and back” in a day.

In the East on the Stockholm – Oslo route there is little difference between running via Ski or Lillestrøm in total journey time. Other issues may be more important including the connecting with the Inter-City network, cost and capacity, and critically the specification of the design speed within Sweden. The times are competitive with air between Stockholm and Oslo but limit the opportunity for business travellers to travel “out and back” in a day. Between Oslo and Gothenburg air is less of a competitive threat where the market is complicated by more intermediate journeys and connections to places such as Malmo and Copenhagen. Running via Fredrikstad at 250kph with extra stops adds 38% to the journey time. It should be noted that in the East the improvement in rail journey time compared to that provided in the reference situation is less significant than in other corridors.

Journey times have also been calculated for Scenario B based on a target level of improvement in journey time to be enabled by a specification of upgrade work to existing lines. The resulting 20% improvement in journey times end-to-end in the North, West and South corridors are in the region of twice as long as the comparative Scenario C/D journey times and do not offer a competitive time against air travel in particular in these corridors. In the East corridor, the specification of works for Scenario B means that the journey times are only improved by 20% within Norway and hence only deliver a 5% journey time improvement between Oslo and Stockholm. Consequently the improvement is journey time is minimal and cannot be compared to Scenario C/D journey times for the same route.

In Phase III, the opportunity to optimise stopping patterns and journey times in the context of their influence on the demand, revenue and benefits HSR is forecast to deliver, the resulting cost of HSR to operate, and the overall economic and financial performance of HSR alternatives, has been very limited. It is fully recognised that there is significant opportunity to do so, and it is anticipated that this would be a key area of examination in further consideration of HSR proposals in Norway.

Appendices

Appendix A. Results by Alternative

A.1. G3:Y Oslo – Trondheim (Gudbrandsdalen)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Gardermoen	1	48.000	Existing	×	×	00:21:51	00:21:51
Hamar	1	117.060	D1	×	×	00:51:59	00:51:59
Lillehammer	1	182.210	D1	×	×	01:24:00	01:24:00
Otta	2	272.530	D1	×		01:51:57	|
Oppdal	2	390.030	D1	×		02:26:05	|
Trondheim/Lerkendal	1	496.330	D1	×	×	02:59:21	02:47:32
Værnes	1	525.330	C	×		03:12:46	

A.2. Ø2:P Oslo – Trondheim (Østerdalen)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Gardermoen	1	48.000	Existing	×	×	00:21:51	00:21:51
Elverum Parkway	1	128.749	D1	×	×	00:47:23	00:47:23
Tynset	2	306.749	D1 & D2	×		01:30:01	|
Trondheim/Lerkendal	1	453.749	D1	×	×	02:10:39	02:03:20
Værnes	2	482.749	C	×		02:23:59	

A.3. N1:Q Oslo – Bergen (Numedal)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Bergen	1	0.000		×	×	00:00:00	00:00:00
Voss	2	71.000	C	×		00:27:56	|
Myrdal	2	115.000	C	×		00:47:12	|
Geilo	2	190.000	C	×		01:18:19	|
Kongsberg	2	325.074	D1	×		01:53:12	|
Drammen	1	359.074	D1	×	×	02:04:42	01:48:25
Oslo	1	399.174	Existing	×	×	02:36:42	02:20:25

A.4. HA2:P Oslo – Bergen (Hallingdal)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Bergen	1	0.000		×	×	00:00:00	00:00:00
Voss	2	72.000	D2	×		00:28:34	|
Geilo	2	175.000	D2	×		01:05:54	|
Hønefoss	2	317.000	D1	×		01:40:37	|
Oslo	1	366.710	D1 and Existing	×	×	02:06:25	01:54:29

A.5. H1:P Oslo – Bergen / Stavanger (Haukeli)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Bergen	1	0.000		×	×	00:00:00	00:00:00
Odda	2	87.000	D1	×		00:30:44	|
Kongsberg	2	320.000	D1	×		01:32:21	|
Drammen	1	354.000	D1	×	×	01:43:51	01:35:06
Oslo	1	396.353	Existing	×	×	02:15:51	02:07:06

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Stavanger	1	0.000		×	×	00:00:00	00:00:00
Haugesund	1	66.000	D2	×	×	00:24:34	00:24:34
Kongsberg	2	383.200	D1	×		01:44:01	|
Drammen	1	418.200	D1	×	×	01:55:34	01:51:08
Oslo	1	459.600	Existing	×	×	02:27:34	02:23:08

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Bergen	1	0.000		x	x	00:00:00	00:00:00
Odda	2	87.000	D1	x		00:30:44	|
Haugesund	1	214.113	D1	x	x	01:06:17	01:01:46
Stavanger	1	280.413	D2	x	x	01:28:51	01:24:20

A.6. BS1:P Bergen – Stavanger

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Bergen	1	0.000		×	×	00:00:00	00:00:00
Stord	2	110.000	D2	×		00:37:29	|
Haugesund	1	164.000	D2	×	×	00:59:43	00:56:40
Stavanger	1	230.000	D2	×	×	01:22:17	01:19:14

A.7. S8:Q Oslo – Stavanger (Vestfold)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Stavanger	1	0.000		×	×	00:00:00	00:00:00
Sandnes	2	14.400	Existing	×		00:14:08	|
Egersund	2	71.300	C	×		00:36:43	|
Mandal	2	175.400	C	×		01:08:33	|
Kristiansand	1	207.800	C	×	×	01:21:07	01:11:22
Arendal	1	264.800	C	×	×	01:39:44	01:29:59
Porsgrunn/Skien	1	377.270	C	×	×	02:13:14	02:03:29
Torp	2	421.100	C	×		02:28:40	|
Tønsberg	1	435.600	C	×	×	02:37:18	02:24:00
Drammen	1	496.100	C	×	×	02:59:21	02:46:03
Oslo	1	538.453	Existing	×	×	03:31:21	03:18:03

A.8. S2:P Oslo – Stavanger (Direct)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Stavanger	1	0.000		×	×	00:00:00	00:00:00
Sandnes	2	14.400	Existing	×		00:14:08	|
Egersund	2	67.400	D2	×		00:33:20	|
Mandal	2	173.600	D1	×		01:04:43	|
Kristiansand	1	205.900	D1	×	×	01:17:03	01:06:40
Arendal	1	262.200	D1	×	×	01:34:58	01:24:36
Porsgrunn/Skien	1	373.375	D1	×	×	02:05:52	01:55:29
Drammen	1	455.380	D2	×	×	02:30:15	02:19:52
Oslo	1	497.733	Existing	×	×	03:02:15	02:51:52

A.9. ST5:U Oslo – Stockholm (Ski)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Ski	2	22.500	Existing*	×		00:14:18	|
Karlstad	1	197.200	C	×	×	01:09:12	01:03:40
Örebro	1	305.200	C	×	×	01:45:15	01:39:43
Västerås	1	399.200	C	×	×	02:16:12	02:10:40
Stockholm	1	510.400	Existing	×	×	02:56:12	02:50:40

A.10. ST3:R Oslo – Stockholm (Lillestrøm)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Lillestrøm	2	17.960	Existing	×		00:12:25	|
Karlstad	1	179.120	C	×	×	00:59:53	00:56:36
Örebro	1	291.120	C	×	×	01:35:57	01:32:39
Västerås	1	385.120	C	×	×	02:06:53	02:03:36
Stockholm	1	492.120	Existing	×	×	02:46:53	02:43:36

A.11. GO3:Q Oslo – Gothenburg (Moss)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Ski	2	22.500	Existing	×		00:14:17	|
Moss	1	57.700	C	×		00:32:53	|
Fredrikstad	2	90.500	C	×		00:47:58	|
Sarpsborg	1	103.500	C	×	×	00:56:28	00:47:20
Halden	2	122.500	C	×		01:05:51	|
Trolhättan	1	259.700	Existing	×	×	01:49:17	01:36:30
Göteborg	1	337.000	Existing	×	×	02:18:17	02:05:30

A.12. GO1:S Oslo – Gothenburg (Direct)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Ski	2	22.500	Existing			|	|
Sarpsborg	1	74.464	D1	×	×	00:25:27	00:25:27
Trollhättan	1	230.356	C	×	×	01:11:22	01:11:22
Göteborg	1	307.656	C	×	×	01:40:22	01:40:22

Appendix B. Sensitivity Test Results

B.1. G1:P Oslo – Trondheim (Gudbrandsdalen)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Gardermoen	1	48.000	Existing	×	×	00:21:51	00:21:51
Gjøvik	1	129.500	D2	×	×	00:47:03	00:47:03
Lillehammer	1	172.000	D2	×	×	01:04:05	01:04:05
Otta	2	267.800	D1	×		01:29:53	|
Oppdal	2	385.300	D1	×		02:04:01	|
Trondheim	1	491.600	D1	×	×	02:35:27	02:23:37
Værnes	2	520.600	C	×		02:48:53	

B.2. HA1:Q Oslo – Bergen (Hallingdal)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Peak
Bergen	1	0.000		×	×	00:00:00	00:00:00
Voss	2	71.000	C	×		00:27:55	|
Myrdal	2	115.000	C	×		00:47:11	|
Geilo	2	190.000	C	×		01:18:18	|
Hønefoss	2	331.000	C	×		02:02:12	|
Oslo	1	382.710	C and Existing	×	×	02:27:50	02:13:46

B.3. N4:P Numedal

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Peak
Bergen	1	0.000		×	×	00:00:00	00:00:00
Voss	2	71.000	D1	×		00:26:26	|
Geilo	2	176.500	D1	×		00:59:26	|
Kongsberg	2	310.500	D2	×		01:31:22	|
Drammen	1	344.500	D2	×	×	01:42:47	01:26:52
Oslo	1	386.853	Existing	×	×	02:14:47	01:58:52

B.4. S8:T Oslo – Stavanger (Vestfold)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Stavanger	1	0.000		×	×	00:00:00	00:00:00
Sandnes	2	14.400	Existing	×		00:14:08	|
Egersund	2	67.400	D2	×		00:33:20	|
Mandal	2	173.600	D1	×		01:04:43	|
Kristiansand	1	205.900	D1	×	×	01:17:03	01:06:40
Arendal	1	262.900	C	×	×	01:34:57	01:25:22
Porsgrunn/Skien	1	375.370	C	×	×	02:08:37	01:59:02
Torp	2	419.200	C	×		02:24:09	|
Tønsberg	1	433.700	C	×	×	02:32:47	02:19:37
Drammen	1	494.200	C	×	×	02:54:50	02:41:41
Oslo	1	536.553	Existing	×	×	03:26:50	03:13:41

B.5. S3:Z Oslo – Stavanger (Direct)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Stavanger	1	0.000		×	×	00:00:00	00:00:00
Sandnes	2	14.400	Existing	×		00:14:08	|
Egersund	2	67.400	D2	×		00:33:20	|
Mandal	2	174.400	D2	×		01:04:54	|
Kristiansand	1	207.000	D2	×	×	01:17:16	01:06:53
Arendal	1	264.000	C	×	×	01:35:58	01:25:34
Porsgrunn/Skien	1	376.285	D1	×	×	02:08:53	01:58:30
Drammen	1	458.290	D2	×	×	02:32:16	02:21:53
Oslo	1	500.643	Existing	×	×	03:04:16	02:53:53

B.6. S4:P Oslo – Stavanger (Direct)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Stavanger	1	0.000		×	×	00:00:00	00:00:00
Sandnes	2	14.400	Existing	×		00:14:08	|
Egersund	2	67.400	D2	×		00:33:20	|
Mandal	2	174.400	D2	×		01:04:54	|
Kristiansand	1	207.000	D2	×	×	01:17:16	01:06:52
Lillesand	3	232.450	D2			|	|
Grimstad	3	247.750	D2			|	|
Arendal	1	263.200	D2	×	×	01:35:01	01:24:37
Brokelandsheia	3	312.355	D2			|	|
Tangen	3	326.400	D2			|	|
Porsgrunn/Skien	1	373.520	D2	×	×	02:04:41	01:54:17
Drammen	1	455.525	D2	×	×	02:28:05	02:17:41
Oslo	1	497.878	Existing	×	×	03:00:05	02:49:41

B.7. ST1:Q Oslo – Stockholm (Kongsvinger)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Lillestrøm	2	17.960	Existing	×		00:12:25	|
Kongsvinger	2	89.560	C	×		00:40:12	|
Karlstad	1	229.060	C	×	×	01:29:56	01:23:23
Örebro	1	337.060	C	×	×	02:11:24	02:04:51
Västerås	1	431.060	C	×	×	02:46:54	02:40:20
Stockholm	1	545.800	Existing	×	×	03:26:54	03:20:20

B.8. ST2:R Oslo – Stockholm (Lillestrøm)

Stations	Station Category	Distance [km]	Alignment	Stops Core	Stops Peak	Journey time [hrs:min:sec] Core	Journey time [hrs:min:sec] Peak
Oslo	1	0.000		×	×	00:00:00	00:00:00
Lillestrøm	2	17.960	Existing	×		00:12:25	|
Karlstad	1	181.360	C	×	×	01:03:54	01:00:31
Örebro	1	289.360	C	×	×	01:39:36	01:36:13
Västerås	1	383.360	C	×	×	02:10:33	02:07:10
Stockholm	1	498.100	Existing	×	×	02:50:33	02:47:10

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