Norway High Speed Rail Assessment Study: Phase III

Journey Time Analysis
Market, Demand & Revenue Analysis
Estimation & Assessment of Investment Costs
Economic & Financial Analysis

Summary Report

25 January 2012

Atkins in collaboration with:

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 had already been 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 high speed rail. Phase II was completed in March 2011.
- In Phase III the tools and guiding principles established in Phase II were to be used to test scenarios and alternatives on the different corridors. This will provide assessments of alternatives and enable recommendations for development and investment strategies in each corridor.

This report is a component of the Phase III work and provides a summary of a number of strands of analysis undertaken by Atkins, supported by its study partners Faithful + Gould (F+G), Ernst & Young (E&Y) and Significance. Atkins has been responsible for a number of strands of technical analysis as part of Phase III:

- Journey time analysis: derivation of representative stopping patterns and journey times for potential HSR alternatives to be considered as part of the study;
- Market, demand and revenue analysis: analysis of the market for HSR alternatives focused on forecasting of future demand and revenue potential and implications of introducing HSR services in Norway;
- HSR freight market analysis: examination of the potential market for utilising HSR infrastructure to deliver high speed freight;
- Estimation and assessment of investment costs: estimation of the capital and life-cycle costs of alternatives for implementing HSR infrastructure and maintaining its operation into the future, including assessment and allowances for risk;
- Economic and financial analysis: determining the economic and financial implications of a range of HSR alternatives, accounting for the costs, benefits and impacts to which an economic and financial value could be attributed.

The results of these strands of analysis are the subject of this report.

1.2. Structure of this report

This report provides a summary of the areas of technical analysis outlined above. It focuses on presenting the key outputs and conclusions that can be drawn from the work carried out by Atkins in Phase III. Separate stand-alone technical reports have also been prepared and these comprehensively provide the background, methods, assumptions and results associated with each area of technical analysis, and should be referenced if a greater level of detail is sought.

The remainder of this report is structured as follows:

- Chapter 2 summarises the HSR alternatives that have been the focus of the technical analysis undertaken;
- Chapter 3 summarises the Journey Time analysis of HSR alternatives considered;
- Chapter 4 summarises the Passenger Market, Demand and Revenue analysis of HSR alternatives considered;
- Chapter 5 summarises the analysis of the Freight Market Potential in the context of HSR;
- Chapter 6 summarises the Estimation and Assessment of Investment Costs associated with HSR alternatives considered;
- Chapter 7 summarises the Economic and Financial appraisal of HSR alternatives considered;
- Chapter 8 summarises the overall technical analysis of the alternative existing line upgrade alternatives considered, known as Scenario B; and
- Chapter 9 provides an overall Summary and Conclusions.

1.3. Reference documents

Underpinning the results presented in this Summary Report are a number of detailed technical reports prepared by Atkins and it’s study partners which should be viewed as reference documents in relation to the areas of analysis summarised in this document. These are:

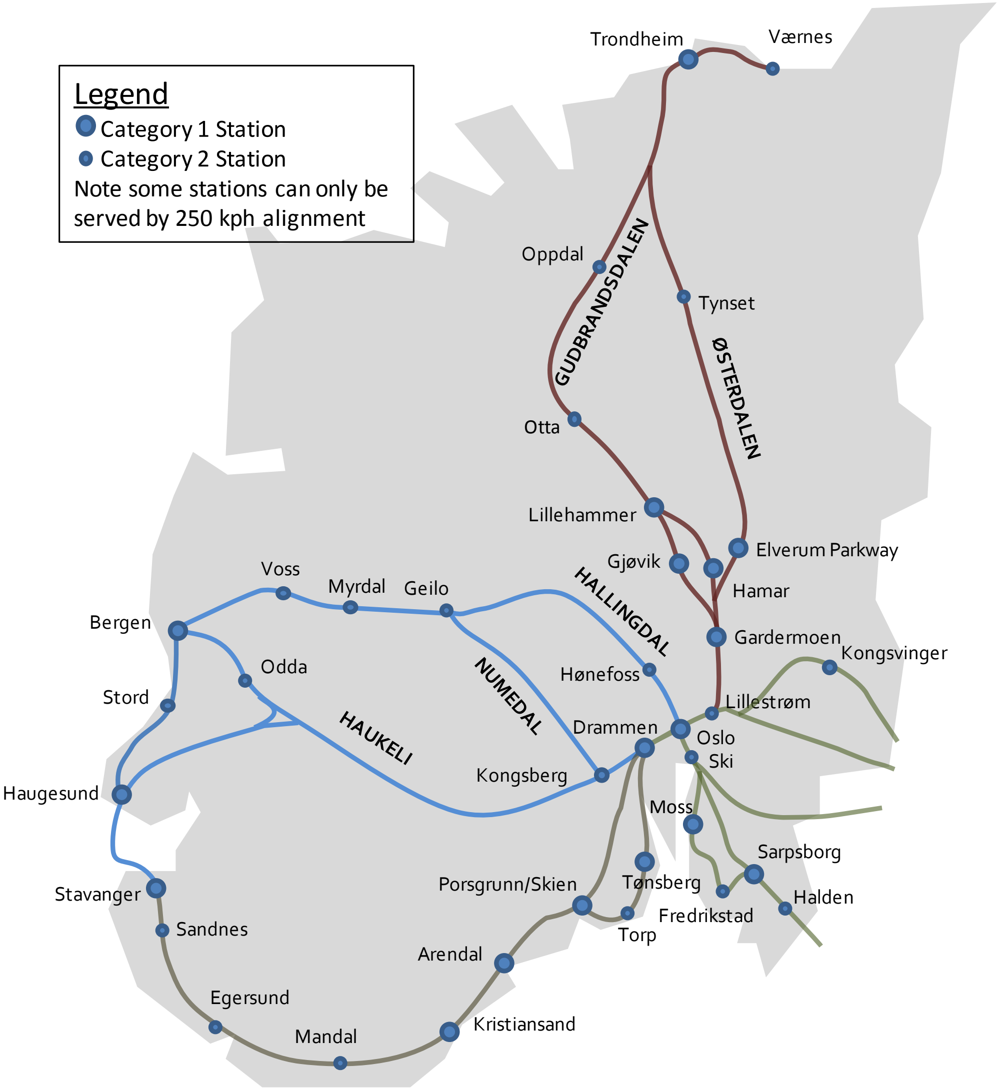
- Norway HSR Assessment Study Phase III: Journey Time Analysis, Final Report, 25 January 2012;
- Norway HSR Assessment Study Phase III: Model Development, Final Report, 25 January 2012;
- Norway HSR Assessment Study Phase III: Market, Demand and Revenue Analysis, Final Report, 25 January 2012;
- Norway HSR Assessment Study Phase III: Market, Demand and Revenue Analysis – Potential for HSR Feeder Networks, Supplementary Report, 25 January 2012
- Norway HSR Assessment Study Phase III: Freight Market Analysis, Final Report, 25 January 2012;
- Norway HSR Assessment Study Phase III: Estimation and Assessment of Investment Costs, Final Report, 25 January 2012; and
- Norway HSR Assessment Study Phase III: Economic and Financial Analysis, Final Report, 25 January 2012.

2. Alternatives considered and key assumptions

2.1. HSR Corridors and Route Alternatives

In Phase III of the study HSR has been considered with respect to a number of potential corridors and associated routes. Figure 1 below presents these corridors and routes:

Figure 1. HSR Corridors and Route Alternatives



The Phase III alignment studies are divided into four corridors and each of those corridors contains one or more 'routes' that are being considered:

- Corridor North: Oslo – Trondheim;
  - Route: Oslo – Trondheim only.
- Corridor West: Oslo – Bergen / Bergen – Stavanger;
  - Route: Bergen – Stavanger;
  - Route: Oslo – Bergen; and
  - Route: Oslo – Stavanger (not via Kristiansand).
- Corridor South: Oslo – Kristiansand – Stavanger;
  - Route: Oslo – Kristiansand – Stavanger only.

- Corridor East: Oslo – Gothenburg / Oslo – Stockholm;
    - Route: Oslo – Gothenburg; and
    - Route: Oslo – Stockholm.

As shown in Figure 1 for some corridors more than one potential alignment route might be considered. For example, from Oslo to Bergen three different alignments could be considered – the Hallingdal alignment (via Hønefoss), the Numedal alignment (via Drammen then north to Geilo) and the Haukeli alignment (the 'Y-shaped' network which heads more directly west from Drammen via Bø, also serving Stavanger). Some potential alignments could only be considered with the construction of a completely new high speed track as they are currently not served by existing railway lines.

2.2. Infrastructure Scenarios

Four scenarios were initially considered on each of the corridors for Phase II testing:

- 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 offensive 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.

- Scenario B was 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 alternatives:
    - D1: For mixed passenger and freight traffic, design speed 330kph, gradient 12.5%, double track; and
    - 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; and
- 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.

It should be noted that the primary focus for technical engineering feasibility and development of alternatives has related to HSR Alternatives and as a consequence, the scope to undertake a detailed analysis and assessment of these has been greater than for Scenario B. This is reflected in this report, where the primary focus is on the presentation of results for the HSR Alternatives, with Scenario B alternatives being summarised in all respects, including alternative specification, within Chapter 7.

2.3. Specific C/D Scenario Alternatives Considered for Technical Analysis

JBV have prepared a report that presents the HSR Alternatives to be considered for analysis:

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

This identifies alternatives for detailed appraisal and assessment and additional alternatives to be understood as a sensitivity option to the detailed appraisal alternatives. For the purposes of this report, only the detailed appraisal HSR Alternatives are reported, and a summary description of these is provided in Table 1 below.

Table 1. HSR Alternatives considered for detailed technical analysis

Corridor	Alternative Ref	HSR Alternative Description
North	**G3:Y**	**250 kph Oslo – Trondheim / Værnes via Gudbrandsdalen** serving Gardermoen, Hamar, Lillehammer, Otta and, Oppdal
	Ø2:P	**330 kph Oslo – Trondheim / Værnes 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
	BS1:P	**330 kph Bergen – Stavanger via coastal route** serving Haugesund
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 Ski** serving Ski, Moss, Fredrikstad, Sarpsborg, Halden and Trollhättan
	GO1:S	**330 kph Oslo – Gothenburg via direct route** serving Sarpsborg and Trollhättan

The identification and choice of stops per HSR Alternative is explained in Chapter 3 of this report. Details of the engineering alignments associated with the above HSR alternatives were developed and reported in detail by each of the four corridor alignment design teams in their Phase III Reports:

- ***"High Speed Rail Assessment Project, Corridor North Oslo – Trondheim: Delivery 2 – Phase 3 Alignment study", 2011-11-25, Rambøll;***
- ***"High Speed Rail Assessment 2012-2012: Phase 3 – Corridor West", 25.11.2011, SWECO;***
- ***"High Speed Rail Assessment Phase III – South Corridor: Part 1 – technical basis and proposed alignments", 2011-11-25, Multiconsult/WSP; and***
- ***"Norwegian High Speed Railway Assessment, Phase 3 corridor east: Corridor specific analysis main report", 2011-11-25, Norconsult.***

2.4. HSR Passenger Service Scenarios

Critical to the technical analysis of the implications of HSR are the assumptions made with respect to the type of HSR service that would operate.

At this early stage in project development there is inevitably a great deal of uncertainty as to the service that might be delivered and operated. Consequently it is essential to establish a reasonable basis for "testing" the impact of HSR. To this end, two HSR Passenger Service Scenarios were established, reflecting somewhat different rationales for HSR service provision:

- **HSR Passenger Service Scenario 1 (PSS1)**: In this scenario the provision of HSR services is specified with the capture of demand and market share in mind. It is assumed that an hourly core HSR service that serves all the larger and significant towns and cities on the alignment is provided (approximately 18 trains a day in each direction). This is supplemented by an additional hourly limited stop, and hence faster, morning and afternoon peak period service targeting the end-to-end market (4 trains a day in each direction in the morning and afternoon). In this scenario it is assumed that the rail fare is approximately 60% of the air fare, reflecting the current pricing of rail services compared with air services.
- **HSR Passenger Service Scenario 2 (PSS2)**: In this scenario the provision of HSR services is specified with the delivery of commercial operational performance in mind – securing revenue while keeping the associated costs for service delivery down. In this instance it is assumed that only the hourly core HSR service is provided (18 trains a day), reducing the cost of service delivery, while the rail fare is assumed to be higher than in PSS1, equivalent to the competing air fare.

It is fully recognised that each of these scenarios represents a simplification of what might be delivered as an HSR service, and the potential range of service and fare levels that might be offered in practice. However, they provide a reasonable basis and range of service offer for assessment, consistent with this stage of study and the need to undertake comparative analysis of a large number of alternatives within the study timescale and consistent with the detail at which the available tools allow for alternatives to be considered..

2.5. The Reference Situation

In order to undertake an assessment of the potential impact of introducing HSR, it is necessary to establish a "reference case" against which impacts can be assessed and quantified. The reference case is constructed through reference to the provision of transport infrastructure that would be built without HSR, the services that would be in place, the nature of the market for travel, and the way in which these are assumed to change over time. In the case of this study, the following assumptions have been adopted for the reference case:

- The provision of transport infrastructure and services across all modes reflects the current situation plus improvements into the future for which a commitment to delivery is in place. No consequential changes to the provision of infrastructure or services are assumed in response to the introduction of HSR infrastructure and services.
- The underlying demand for travel in Norway in future is as assumed to be as per the NTM5 model which adopts Norwegian Government assumptions on population growth over time. Where necessary, NTM5 has been supplemented by additional data such as information on travel in Sweden and cross border travel secured through JBV. Forecasts for inflation and GDP growth are per Norwegian Government guidance and are adopted as appropriate.

2.6. Assumed Timescales

The start date for construction, as advised by JBV, is assumed to be 2017. Indicative construction time-scales for the purposes of alternative comparison and appraisal have been derived for each of the HSR Alternatives. These assume a best-case multi-contractor delivery route allowing for concurrent programmes of construction of different sections of route – consequently these may differ from any timescales reported in alignment design reports. The indicative construction timescales and the resulting assumed start year of HSR operation is shown in Table 2 below

Table 2. Indicative Construction Timelines for HSR Alternatives analysed

Corridor	Alternative Ref	HSR Alternative Description	Indicative Construction Period	Indicative 1st Year of Operation
North	**G3:Y**	250 kph Oslo – Trondheim / Værnes via Gudbrandsdalen	10 years	2027
	Ø2:P	330 kph Oslo – Trondheim / Værnes via Østerdalen	8.5 years	2025
West	**N1:Q**	250 kph Oslo – Bergen via Numedal	7 years	2024
	HA2:P	330 kph Oslo – Bergen via Hallingdal	7 years	2024
	H1:P	330 kph Oslo – Bergen via Haukeli 330 kph Oslo – Stavanger via Haukeli 330 kph Bergen – Stavanger via Roldal	10 years	2027
	BS1:P	330 kph Bergen – Stavanger via coastal route	6 years	2023
South	**S8:Q**	250 kph Oslo – Stavanger via Vestfold	9 years	2026
	S2:P	330 kph Oslo – Stavanger via direct route	9 years	2026
East	**ST5:U**	250 kph Oslo – Stockholm via Ski	7 years	2024
	ST3:R	330 kph Oslo – Stockholm via Lillestrøm	7 years	2024
	GO3:Q	250 kph Oslo – Gothenburg via Ski	5 years	2022
	GO1:S	330 kph Oslo – Gothenburg via direct route	5 years	2022

3. Journey Time Analysis

3.1. Introduction

The purpose of this section of the summary report is to detail expected passenger journey times and the methodology used to calculate them. As part of this it also presents the choice of stops to be served by services adopted as this influences stopping patterns and journey times. 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 high speed rail in competition with other modes and therefore the level of demand and benefits HSR generates.

This chapter only addresses the HSR Alternatives under Scenario C/D - that is for services typically running up to 330kph or 250kph. A different approach was used for Scenario B and that is discussed in Chapter 8.

It should be noted that the journey time results reflect the constraints of the alignments, the proposed stopping pattern, the rolling stock and timetabling assumptions. They therefore should be understood to be subject to change with changes to these elements.

For information on the approach adopted to choice of station locations to be served, stopping patterns adopted, journey time calculation, and more detailed presentation of journey times, the reader is advised to reference the report:

- ***"Norway HSR Assessment Study, Phase III: Journey Time Analysis", Final Report, 25 January 2012.***

3.2. Choice of core stations and stopping patterns

3.2.1. Choice of core stations to be served

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, other factors were also taken into account:

- the proximity to other stops with the aim of achieving sensible stop spacing;
- the opportunity stops offered to serve multiple small communities; and
- potential for interchange with air, shipping, coach or cars.

Having taken these addition factors into account, a final choice of Category 2 and 3 stations was made, with Category 2 stops being deemed stations that should also be served by a core HSR service. The exact location was discussed with the alignment teams and in some instances had to refined to reflect the engineering limits of the alignment at given locations.

Figure 1, presented in Chapter 2, shows the resulting Category 1 and 2 stop locations identified with each corridor and route.

3.2.2. 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 – 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.

The Core and Peak services and stopping patterns provided the basis for the Passenger Service Scenarios 1 and 2 described in Chapter 2.

3.2.3. 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).

3.3. HSR Alternative Journey Times

3.3.1. Approach to calculating journey times

The journey time modelling was developed using standard rail industry software (in this case RailSys although alternatives exist). This software takes account of the performance of the train mainly its acceleration and deceleration during periods of normal operation, but also adjusts its performance to the different gradients of the programmed route. The train used in this exercise was a Siemens Valero – alternative trains exist and the opportunity to optimise the gearing and other elements could result in faster times.

The topographical limits of the route where new or upgraded were inputted into model from the data provided by the alignment engineers. These included the vertical alignments (gradients), the horizontal alignments (the curves) and structures including tunnels. Allowances were also made for operational considerations including an extra allowance for performance.

3.3.2. HSR Alternative Journey Times

3.3.2.1. 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 3 below shows the journey time between Oslo and Trondheim on a core (standard hour service), on a peak period service with fewer stops, with extra time added for potential calls at Category 3 (community stops) and the average speeds for the core and peak service. The extra time via Gudbrandsdalen reflects the extra 7 km before the start of the new high speed line, the 2 extra stops, the proportionally lower time spent at higher speeds because of the topography, and the fact the route is 32km longer.

Table 3. 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

3.3.2.2. West Corridor:

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

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). 18 minutes of the difference between running via Hallingdal and Numedal is accounted for by the route via Numedal having to run via Drammen which means longer in a non-high speed section and an extra intermediate stop.

Table 4 below shows the journey time between Oslo and Bergen on a core (standard hour service), on a peak period service with fewer stops, with extra time added for potential calls at Category 3 (community stops) and the average speeds for the core and peak service.

The total extra time via Numedal (N1:Q) reflects the fact that new high speed line west of Geilo is limited to 250 kph, there are 6 intermediate stops, and the route is almost 20km longer than via Hallingdal. The Hallingdal alternative (Ha2:P) has only 9 km not built to 330 kph, 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 4. 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

Oslo – Stavanger:

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 5.

Table 5. 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

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. 0 summarises the journey time results.

Table 6. 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

3.3.2.3. South Corridor:

Table 7 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 250 kph with 5 intermediate stops and S2:P was limited to 330 kph with 5 intermediate stops. Despite this the 250 kph alternative (S8Q) is only 8 minutes slower over the first 373 km of the corridor, beginning from Stavanger.

East of Porsgrunn S2:P (the 330 kph 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 7. South 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
S8Q (Oslo – Stavanger)	03:31	03:18	*04:07*	153	163
S2P (Oslo – Stavanger)	03:02	02:52	*03:22*	164	174

3.3.2.4. East Corridor:

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

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 8.

Table 8. 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

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 52km 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. The journey times are summarised in Table 9.

Table 9. 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

3.4. 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.

4. Passenger Market, Demand and Revenue Analysis

4.1. Summary of Approach

This section of the summary report presents results from Phase III analysis of demand and revenue forecasting related to the HSR Alternatives described in Chapter 2. It includes summary analysis of expected passenger markets and revenues for each of the alternatives related to two different service offerings – a central case with high speed rail fares assumed to be broadly level to existing rail fares, and an alternative case where high speed rail fares are closer to existing air fares, with reduced peak capacity reflecting lower expected passenger demand.

The demand forecasts displayed within this section were produced using a bespoke modelling framework developed to assess Norwegian high speed rail alternatives during Phase II, and subsequently refined during Phase III of the study. During Phase II the model forecast only trips of over 100km and included additional gaps; for instance where air travel was not an existing option. To reflect the increasing emphasis on intermediate trips Phase III developments have filled in these forecasting gaps using data relating the existing rail market and from NTM5. As a result of these modelling improvements the demand forecasts have increased relative to the previous phase.

Full details of modelling framework development, assumptions and limitations can be found in a separate model development report, which shall be issued with the final detailed reporting. Key points to take into account when interpreting results are:

- Estimates of individual station usage are limited by the zone system and representation of road and rail network access – these could be refined at a next stage of alternative development;
- Forecasts do not include origin-destination forecasts where trips are less than 20km or are part of the core inter-city market. There is a potential overlap with the market for Inter-City rail services, which we have identified in the main report; and
- Short distance trips are forecast with relation to journey time aspects only and are not related to fares. Additional survey data would improve estimates of shorter distance travel.

The following sections present the results from the key appraisal alternatives. For these scenarios the main mode share assumptions are that:

- Passenger Service Scenario 1 (PSS1) is adopted delivering an hourly HSR core service stops at Category 1 & 2 stations whilst a peak HSR service, four departures in both directions in both the morning & afternoon, stops at Category 1 stations only; and with rail fares set to 60% of the equivalent air fare;
- No change in the level of service for other modes has been assumed; and
- Journey times are as presented in Chapter 3.

Detailed reference information on the methods used to support analysis presented in this chapter and a greater depth of reporting of results is provided in the following reports:

- ***"Norway HSR Assessment Study Phase III: Model Development", Final Report, 25 January 2012***
- ***"Norway HSR Assessment Study Phase III: Market, Demand and Revenue Analysis", Final Report, 25 January 2012***
- ***"Norway HSR Assessment Study Phase III: Market, Demand and Revenue Analysis – Potential for HSR Feeder Networks", Supplementary Report, 25 January 2012***

4.2. Demand and Revenue: North Corridor

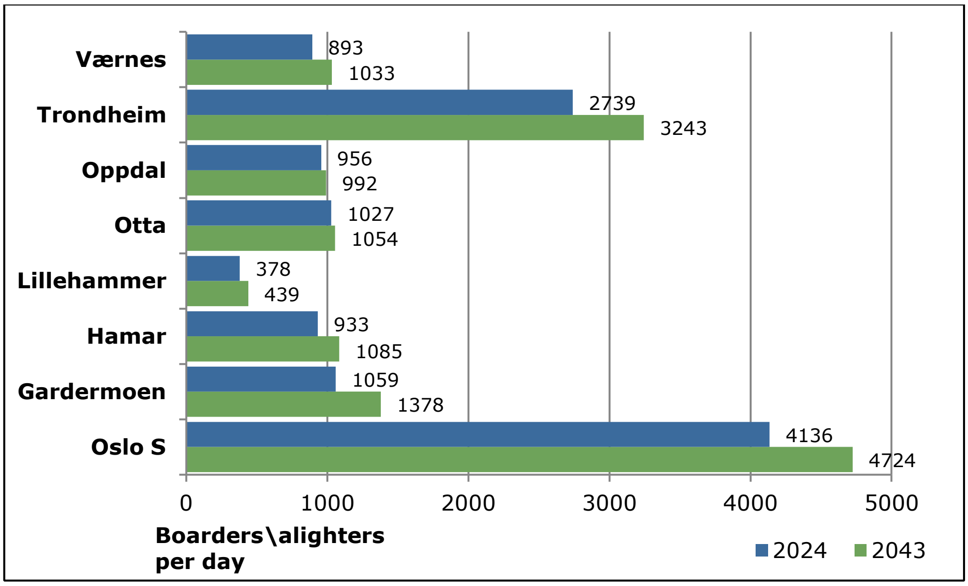
4.2.1. Alternative G3:Y

This alternative leaves the existing line just north of Gardermoen Airport and follows the existing rail corridor via Hamar and Gudbrandsdalen to Trondheim and Værnes Airport. It is designed for 330 kph rail passenger and freight traffic between Gardermoen and Trondheim.

Table 10. Summary of Demand and Revenue – Alternative G3:Y

Demand & Revenue	Annual		Per Day	
	2024	2043	2024	2043
Total HSR passengers (thousands)	4420	5090	12.1	13.9
HSR passenger km (millions)	1610	1870	4.4	5.1
HSR train km (millions)	9970	9970	27.3	27.3
Revenue (NOK millions)[1]	1480	1710		
Average train occupancy[2]	161	188		

Figure 2. HSR Daily Boardings and Alightings by Station – G3:Y



It can be seen that annual HSR journeys in 2024 are estimated at nearly 4.5 million, increasing to 5.1 million in 2043. The highest demand originates from Oslo and Trondheim, although there is also sizable demand from the intermediate stations, with the exception of Lillehammer. The lower than expected demand from Lillehammer is a function of the zoning system in the model, with some demand accessing Otta instead as it is located in a far larger zone. In reality, more passengers would be likely to use Lillehammer station than Otta station.

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[1] Revenue is given in 2009 NOK prices

[2] Average train occupancy refers to passenger km divided by train km.

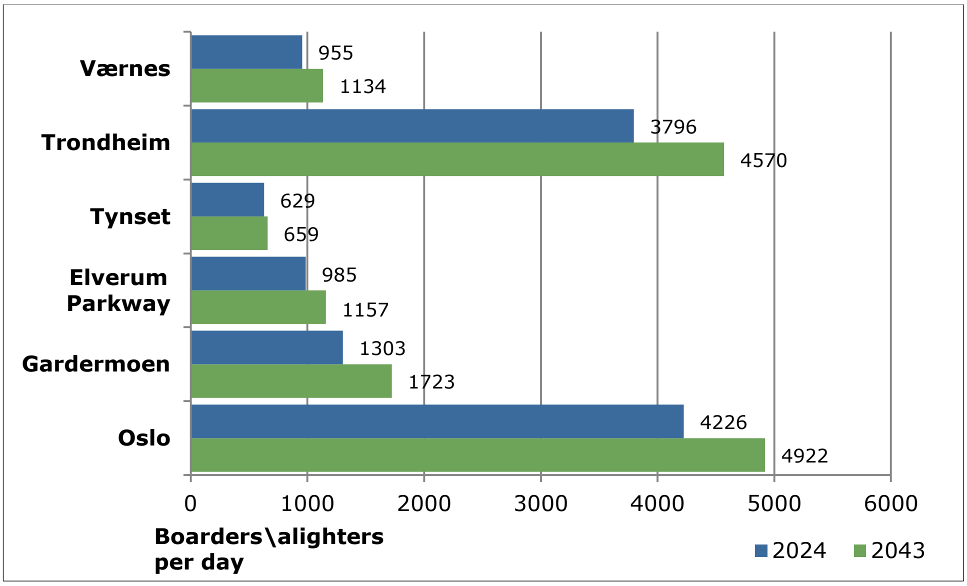
4.2.2. Alternative Ø2:P

This alternative also leaves the existing route 60km north of Gardermoen, via a new station near Elverum, before continuing along the Østerdalen to Trondheim and Værnes Airport. It is designed for 330 kph rail passenger and freight traffic for the majority of the route between Gardermoen and Trondheim.

Table 11. Summary of Demand and Revenue – Alternative Ø2:P

Demand & Revenue	Annual		Per Day	
	2024	2043	2024	2043
Total HSR passengers (thousands)	4340	5170	11.9	14.2
HSR passenger km (millions)	1660	1980	4.5	5.4
HSR train km (millions)	9160	9160	25.1	25.1
Revenue (NOK millions)	1610	1920		
Average train occupancy	181	216		

Figure 3. HSR Daily Boardings and Alightings by Station



This alternative attracts similar levels of demand to G3:Y. There are more trips made in Ø2P between Oslo and Trondheim due to the faster journey time, although this is offset by there being lower intermediate demand and fewer intermediate stations than G3:Y. However, Ø2:P has higher levels of revenue due to the longer average trip length, and hence higher average fares, on this corridor. The higher proportion of longer distance trips also contributes to a higher average train occupancy over the length of the route.

4.3. Demand and Revenue: West Corridor

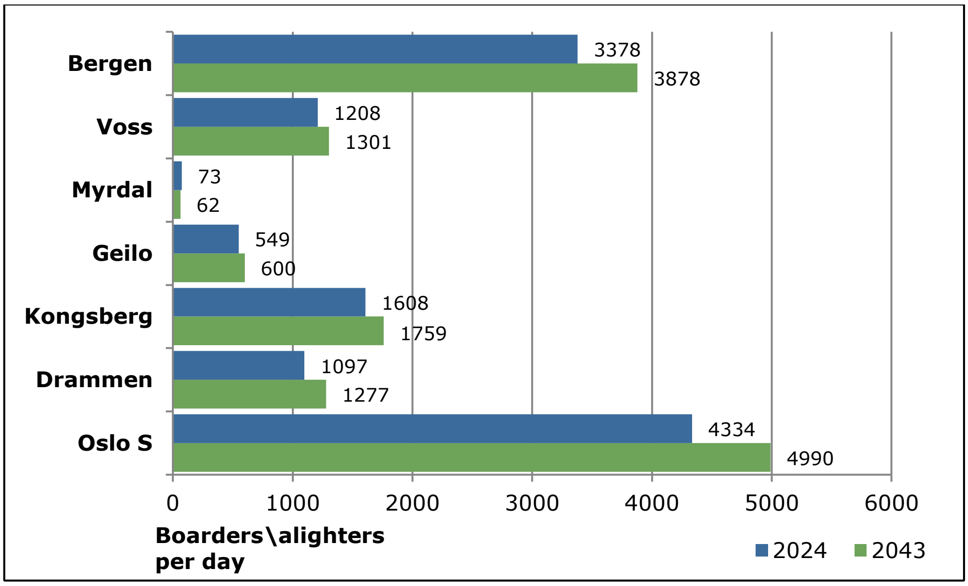
4.3.1. Alternative N1:Q

This alternative leaves the existing line at Drammen and follows the Numedal to Geilo, with this section designed for 330 kph rail passenger and freight traffic. The line from Geilo to Bergen predominantly follows the existing route and is designed for 250 kph traffic.

Table 12. Summary of Demand and Revenue – Alternative N1:Q

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	4470	5060	12.2	13.9
HSR passenger km (millions)	1250	1440	3.4	3.9
HSR train km (millions)	7580	7580	20.8	20.8
Revenue (NOK millions)	1390	1590		
Average train occupancy	165	190		

Figure 4. HSR Boardings and Alightings by Station – N1:Q



It can be seen that annual HSR journeys in 2024 are estimated at nearly 4.5 million, increasing to nearly 5.1 million in 2043. The highest demand originates from Oslo and Bergen, although there is also sizable demand from particularly Drammen, Kongsberg and Voss. There is lower demand at Geilo and Myrdal due to the low population density in these mountainous areas. In reality there is likely to be a variation in the spread of demand between the Voss, Myrdal and Geilo, as these stations are located in large zones in the model. In particular, tourist demand associated with Myrdal station may be understated in these results.

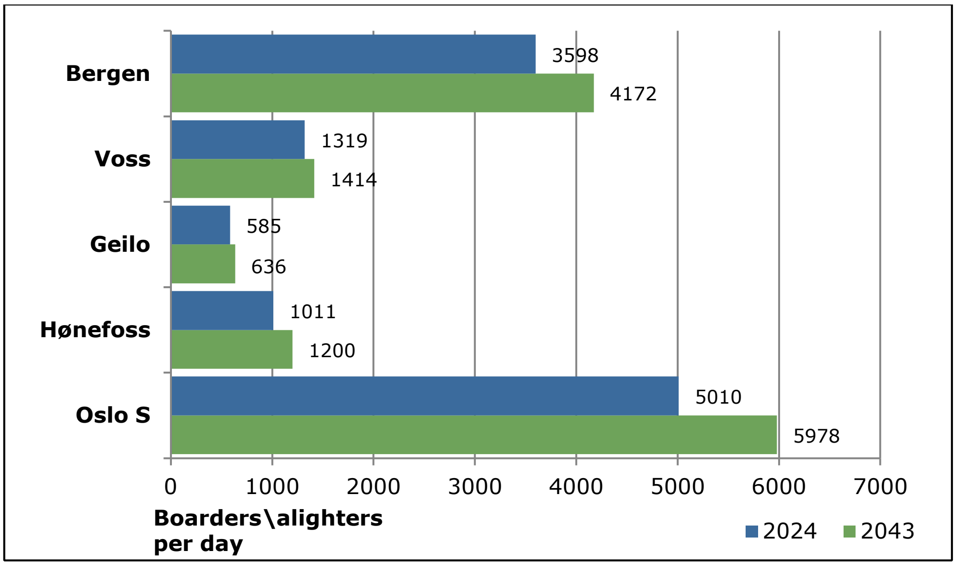
4.3.2. Alternative HA2:P

This alternative involves a new direct line between Sandvika and Hønefoss before following the existing rail corridor to Bergen. It is designed for 330 kph rail passenger and freight traffic between Oslo and Geilo, and 330 kph rail passenger traffic only from Geilo to Bergen.

Table 13. Summary of Demand and Revenue – Alternative HA2:P

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	4210	4890	11.5	13.4
HSR passenger km (millions)	1200	1400	3.3	3.8
HSR train km (millions)	6960	6960	19.1	19.1
Revenue (NOK millions)	1430	1670		
Average train occupancy	172	201		

Figure 5. HSR Boardings and Alightings by Station – HA2:P



This alternative attracts lower demand than N1:Q, but higher average train occupancy and slightly higher revenue due to the greater proportion of long distance trips, which is as a result of the lower journey times. However, the additional demand driven by the faster journey times is relatively small, when considering that the journey time between Oslo and Bergen is 30 minutes faster in HA2:P than N1:Q. The higher overall demand in the N1:Q alternative is driven by shorter distance trips between intermediate stations in larger towns, such as Drammen and Kongsberg.

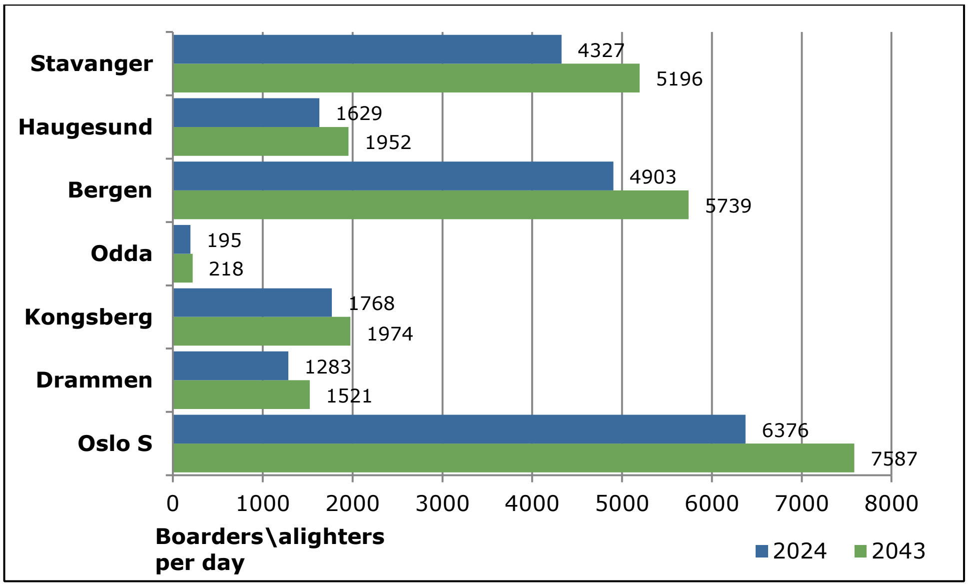
4.3.3. Alternative H1:P

This alternative involves a Y-shaped network linking Oslo with both Bergen and Stavanger with two branches joining at Røldal, enabling services between Oslo – Bergen, Oslo – Stavanger and Bergen – Stavanger. The whole network is designed for 330 kph rail passenger and freight traffic, with the exception of Haugesund – Stavanger which is for passenger traffic only.

Table 14. Summary of Demand and Revenue – Alternative H1:P

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	7470	8830	20.5	24.2
HSR passenger km (millions)	2410	2870	6.6	7.8
HSR train km (millions)	21570	21570	59.1	59.1
Revenue (NOK millions)	2720	3220		
Average train occupancy	112	133		

Figure 6. HSR Boardings and Alightings by Station – H1:P



It can be seen that annual HSR journeys in 2024 are estimated at nearly 7.5 million, increasing to over 8.8 million in 2043. The overall demand is significantly higher than with the other individual alternatives, as this alternative provides 3 separate service routes and links 3 major urban areas in Norway. This is associated with higher levels of revenue when compared with other alternatives. On the other hand there are a far greater number of vehicle kilometres due to the number of services run. The highest levels of demand are unsurprisingly from the three termini stations. There is also higher demand from intermediate stations when compared with the majority of alternatives, with the exception of Odda, which is situated in a relatively remote location.

Average train occupancy figures are lower than for other West Corridor alternatives, due to lower loading figures on Stavanger – Bergen services. Oslo – Bergen and Oslo – Stavanger services have similar loading figures to the other West Corridor alternatives.

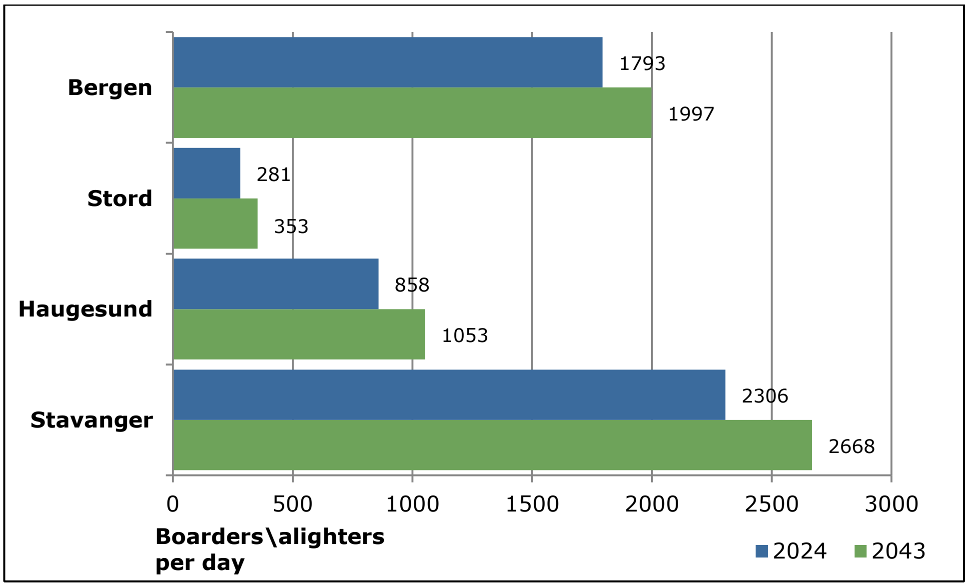
4.3.4. Alternative BS1:P

This alternative follows an alternative alignment between Stavanger and Bergen along the coast via the towns of Haugesund and Leirvik (Stord), and is designed for 330 kph rail passenger traffic.

Table 15. Summary of Demand and Revenue – Alternative BS1:P

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	1910	2220	5.2	6.1
HSR passenger km (millions)	330	370	0.9	1.0
HSR train km (millions)	4370	4370	12.0	12.0
Revenue (NOK millions)	400	450		
Average train occupancy	75	84		

Figure 7. HSR Boardings and Alightings by Station – BS1:P



Annual HSR journeys in 2024 are estimated at fewer than 2 million, increasing to over 2.2 million in 2043. Revenue is estimated to be less than 500 MnNOK. The demand and revenue is lower than for the other alternatives on the West corridor, which is to be expected, as this alternative does not serve Oslo. The highest levels of demand are again from the terminus stations, although there is intermediate demand, particularly from Haugesund. This alternative would be more effective in terms of demand generation if combined with an HSR line between Oslo – Bergen and/or Oslo – Stavanger.

4.4. Demand and Revenue: South Corridor

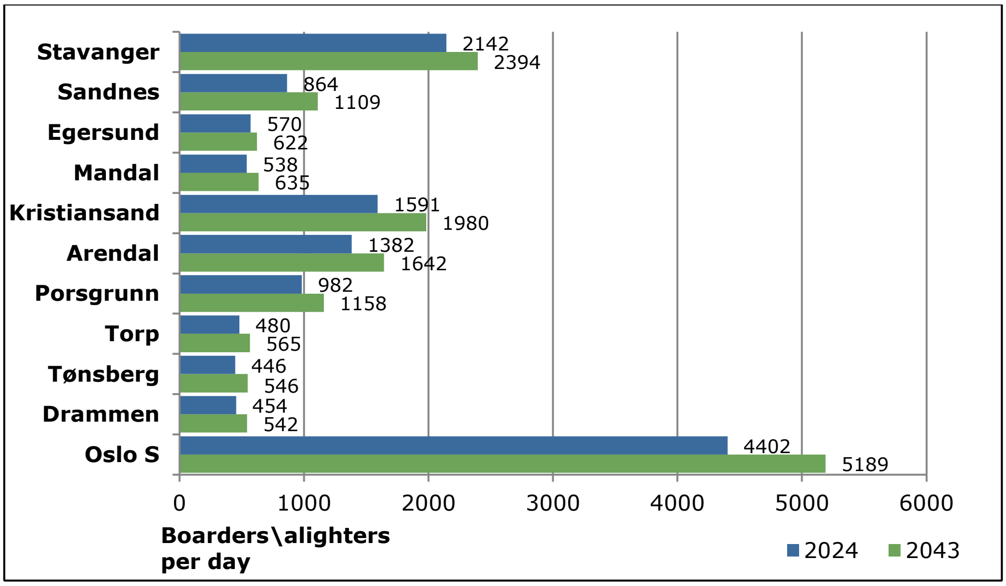
4.4.1. Alternative S8:Q

This alternative follows the alignment of the existing Vestfoldbanen between Oslo and Porsgrunn before following the south coast to Kristiansand and Stavanger. The line between Drammen and Stavanger is designed for 250 kph rail passenger and freight traffic.

Table 16. Summary of Demand and Revenue – Alternative S8:Q

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	5060	5980	13.9	16.4
HSR passenger km (millions)	1530	1810	4.2	5.0
HSR train km (millions)	10220	10220	28.0	28.0
Revenue (NOK millions)	1470	1720		
Average train occupancy	150	177		

Figure 8. HSR Boardings and Alightings by Station – S8:Q



It can be seen that annual HSR journeys in 2024 are estimated at greater than 5 million, increasing to nearly 6 million in 2043. Revenue is estimated to be 1.5 BnNOK in 2024 and 1.7 BnNOK in 2043. Train boardings are more evenly spread along the corridor than compared with the others, which is due to the greater population density in intermediate areas, particularly between Oslo and Kristiansand. The highest boardings are still at the termini stations of Oslo and Stavanger, although Kristiansand and Arendal also generate significant levels of demand.

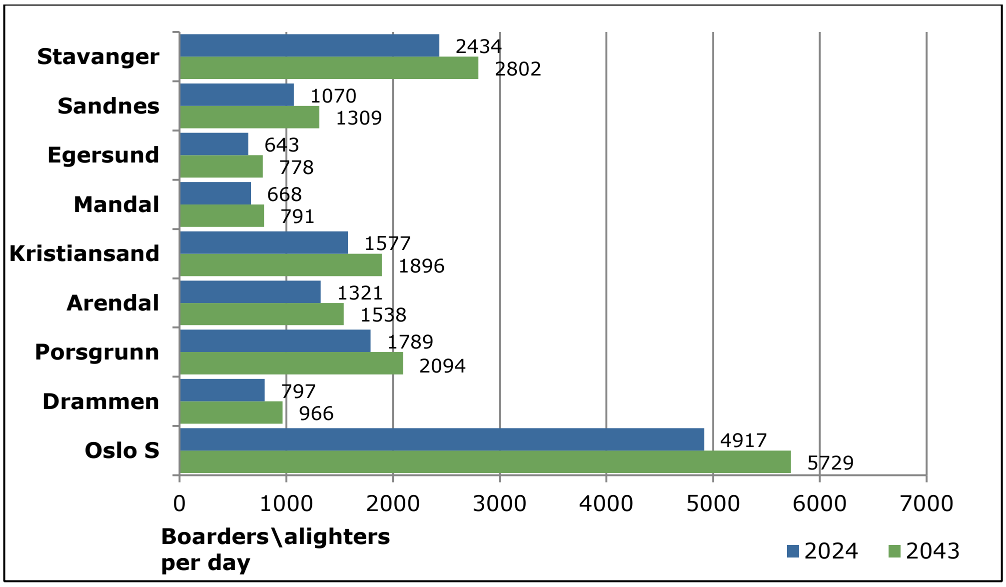
4.4.2. Alternative S2:P

This alternative follows a new direct alignment between Drammen and Porsgrunn before following the south coast to Kristiansand and Stavanger. The line between Porsgrunn and Egersund is designed for 330 kph rail passenger and freight traffic, with Drammen – Porsgrunn and Egersund – Stavanger for passenger traffic only.

Table 17. Summary of Demand and Revenue – Alternative S2:P

Demand & Revenue	Annual		Per Day	
	2024	2043	2024	2043
Total HSR passengers (thousands)	5550	6530	15.2	17.9
HSR passenger km (millions)	1620	1900	4.4	5.2
HSR train km (millions)	9450	9450	25.9	25.9
Revenue (NOK millions)	1580	1850		
Average train occupancy	172	201		

Figure 9. HSR Boardings and Alightings by Station – S2:P



This alternative attracts higher demand and revenue than S8:Q, due to the shorter journey times for long distance trips, with the journey time between Oslo and Stavanger being approximately 30 minutes quicker, although serving no intermediate centres between Porsgrunn and Drammen. Correspondingly, there is poorer community access for the Vestfold region; although passengers are still able to access the HSR network at Drammen and Porsgrunn.

4.5. Demand and Revenue: East Corridor

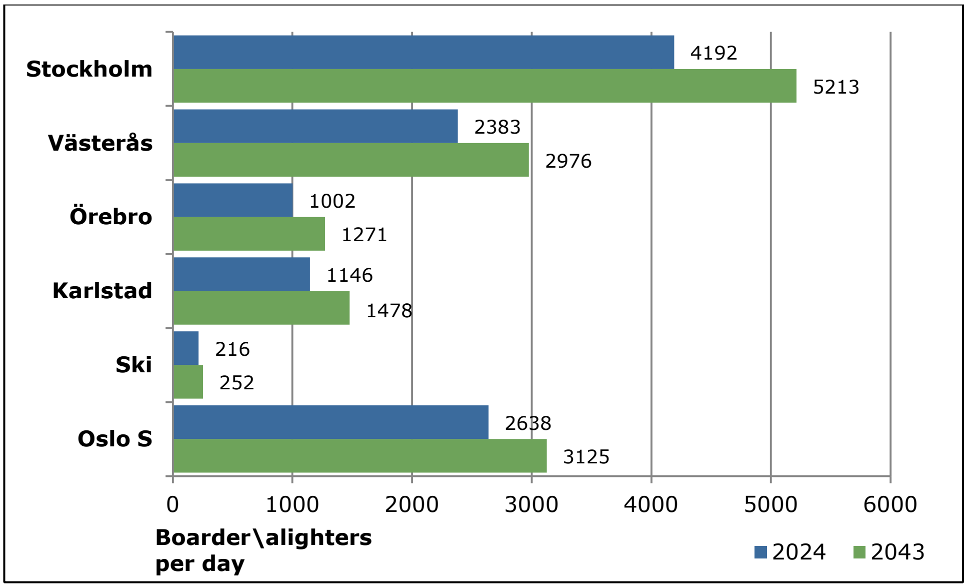
4.5.1. Alternative ST5:U

This alternative follows the existing Eastern Østfold Line via Ski and Mysen, before following a new alignment between Mysen and Arvika in Sweden. The majority of the route is designed for 250 kph rail passenger and freight traffic.

Table 18. Summary of Demand and Revenue – Alternative ST5:U

Demand & Revenue	Annual		Per Day	
	2024	2043	2024	2043
Total HSR passengers (thousands)	4230	5230	11.6	14.3
HSR passenger km (millions)	1130	1340	3.1	3.7
HSR train km (millions)	9690	9690	26.5	26.5
Revenue (NOK millions)	1150	1370		
Average train occupancy	116	139		

Figure 10. HSR Boardings and Alightings by Station – ST5:U



It can be seen that annual HSR journeys in 2024 are estimated at just over 4.2 million, increasing to over 5.2 million in 2043. Revenue is estimated to be 1.1 BnNOK in 2024 and 1.3 BnNOK in 2043. There is a large proportion of demand between Stockholm and intermediate stations in Sweden. There is also significant demand between Oslo and Stockholm. It should be noted that demand from Ski to Oslo has been excluded from these figures, as it is assumed to travel on Inter-City services instead. Average train occupancy is lower than other corridors in Norway, which demonstrates the high number of shorter distance trips within Sweden.

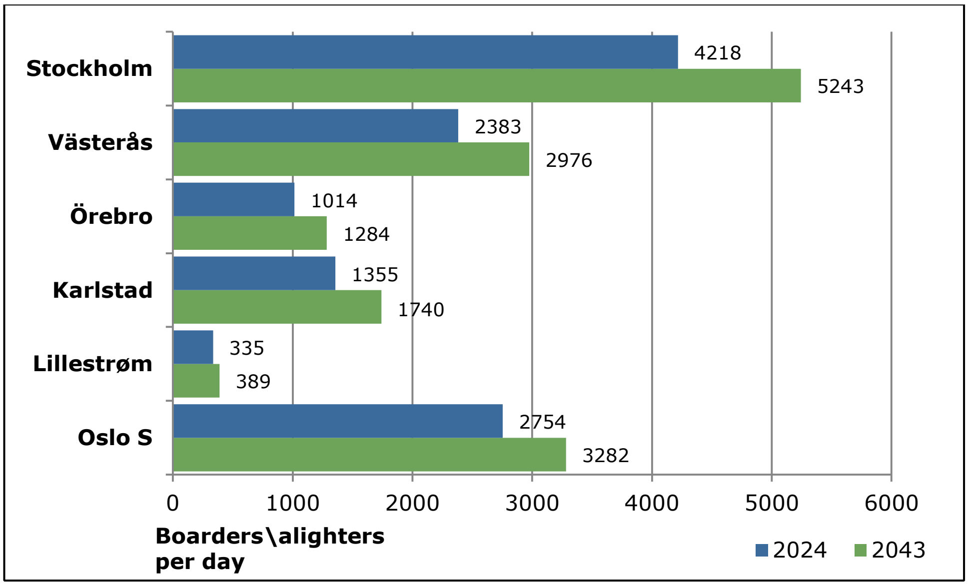
4.5.2. Alternative ST3:R

This alternative follows a new alignment between Lillestrøm and Arvika before following existing rail routes to Stockholm. The line between Lillestrøm and Arvika is designed for 330 kph rail passenger traffic, with the remainder of the route designed for 250 kph rail passenger and freight traffic.

Table 19. Summary of Demand and Revenue – Alternative ST3:R

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	4400	5440	12.1	14.9
HSR passenger km (millions)	1100	1340	3.0	3.7
HSR train km (millions)	9340	9340	25.6	25.6
Revenue (NOK millions)	1160	1400		
Average train occupancy	118	143		

Figure 11. HSR Boardings and Alightings by Station - ST3:R



This alternative attracts a slightly higher demand and revenue than ST5:U. This is partly a function of the shorter journey time between Oslo and Stockholm and the higher number of boardings at Lillestrøm towards Oslo compared with Ski (trips between Lillestrøm and Oslo are assumed to travel on Inter-City services).

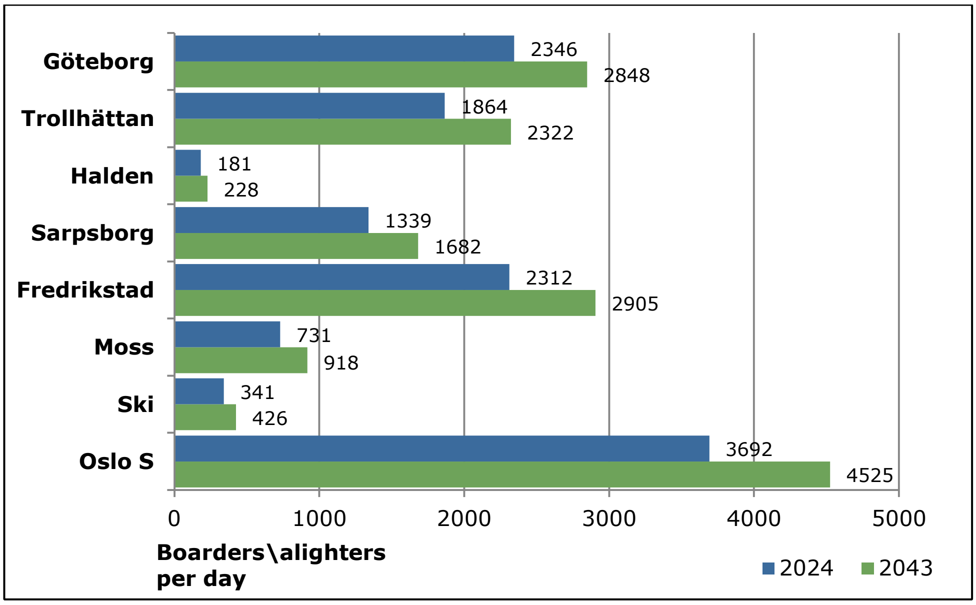
4.5.3. Alternative GO3:Q

This alternative is principally an upgrade of the existing Western Østfold Line between Oslo and Gothenburg and is designed for 250 kph rail passenger and freight traffic.

Table 20. Summary of Demand and Revenue – Alternative GO3:Q

Demand & Revenue	Annual		Per Day	
	2024	**2043**	**2024**	**2043**
Total HSR passengers (thousands)	4670	5790	12.8	15.9
HSR passenger km (millions)	560	680	1.5	1.9
HSR train km (millions)	6400	6400	17.5	17.5
Revenue (NOK millions)	830	1000		
Average train occupancy	88	106		

Figure 12. HSR Boardings and Alightings by Station – GO3:Q



Annual HSR journeys in 2024 are estimated at nearly 4.7 million, increasing to 5.8 million in 2043. Revenue is estimated to be 830 MnNOK in 2024 and 1 BnNOK in 2043. There are generally far lower levels of long distance demand on this corridor when compared with the other alternatives tested, although this is offset by higher levels of intermediate demand, especially between Oslo and Sarpsborg and Fredrikstad in Norway, and between Trollhättan and Gothenburg within Sweden. The greater proportion of short distance trips is illustrated by the lower average train occupancy and passenger kilometres compared with other alternatives.

Trips between Ski and Oslo in this alternative are not included, as they are assumed to travel on Inter-City services.

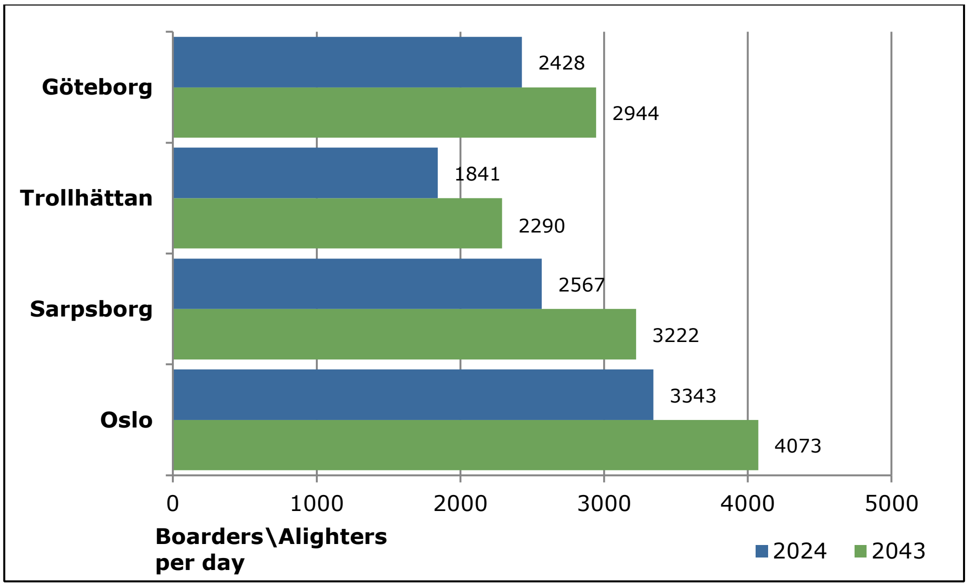
4.5.4. Alternative GO1:S

This alternative follows a new direct alignment between Ski and the Swedish border before following the existing alignment to Gothenburg. The line within Norway is designed for 330 kph rail passenger and freight traffic.

Table 21. Summary of Demand and Revenue – Alternative GO1:S

Demand & Revenue	Annual		Per Day	
	2024	2043	2024	2043
Total HSR passengers (thousands)	3720	4570	10.2	12.5
HSR passenger km (millions)	440	520	1.2	1.4
HSR train km (millions)	5840	5840	16.0	16.0
Revenue (NOK millions)	710	840		
Average train occupancy	75	89		

Figure 13. HSR Boardings and Alightings by Station – GO1:S



This alternative attracts a lower demand and revenue than GO3Q. Although there is a vastly quicker journey time between Oslo and Sarpsborg, Trollhättan and Gothenburg, there are far fewer journey opportunities in the Østfold region within Norway due to the lack of intermediate stations. Base demand for travel between Oslo and Gothenburg, where the greatest journey time savings are made in this alternative, is lower than for end-to-end travel on the other corridors examined.

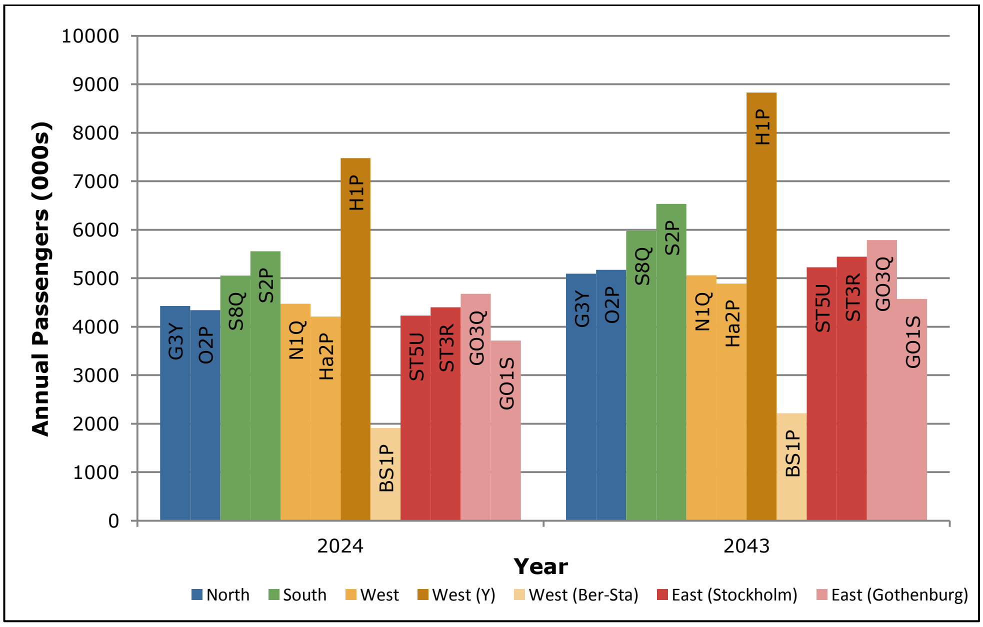
4.6. Comparison of Results

4.6.1. Comparison of corridor results

The Figures within this section compare forecasts of demand and revenue by alternative HSR routes. The colouring within the charts reflects the corridor on which the alternative sits whilst routes are labelled.

It is important to note than demand and revenue are only part of a routes assessment with non-financial benefits and costs also impacting on routes' attractiveness. A more complete picture of the relative attractiveness of each alternative is shown in the scheme appraisal.

Figure 14. Comparison of HSR passengers by alternative



The Y-shaped network linking Oslo with both Bergen and Stavanger obtains the highest demand, although this assumes the core and peak services operate to both Bergen and Stavanger. Figure 14 shows that, of the other, more comparable, single route corridors, the faster route to Stavanger (S2:P) obtains the highest demand. Demand is lowest on the Bergen-Stavanger corridor which is the only corridor excluding Oslo.

Figure 15. Comparison of HSR revenue by alternative

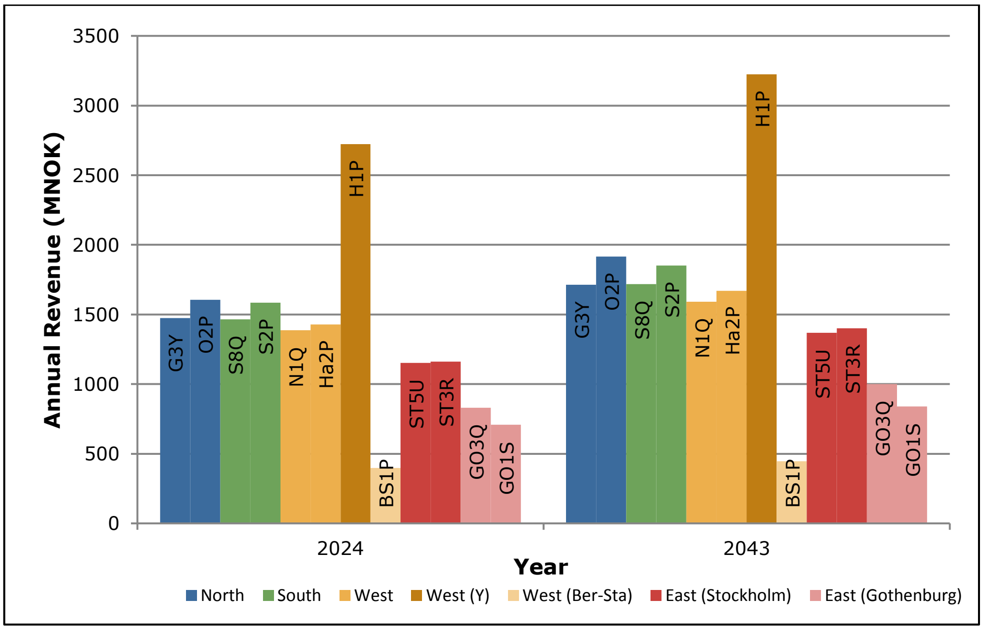


Figure 15 shows the main Norwegian corridors generating similar levels of revenue. The South corridor alternatives, which generated in the region of 20% more demand than either the North or West corridor alternatives, only generates similar revenue due to the larger proportion of short distance trips on the corridor. Although the eastern corridors delivered a similar number of passengers to the Norwegian corridors, they offer significantly less revenue; again this is due to a high proportion of short distance trips on these corridors.

Figure 16. Comparison of HSR average occupancy by alternative

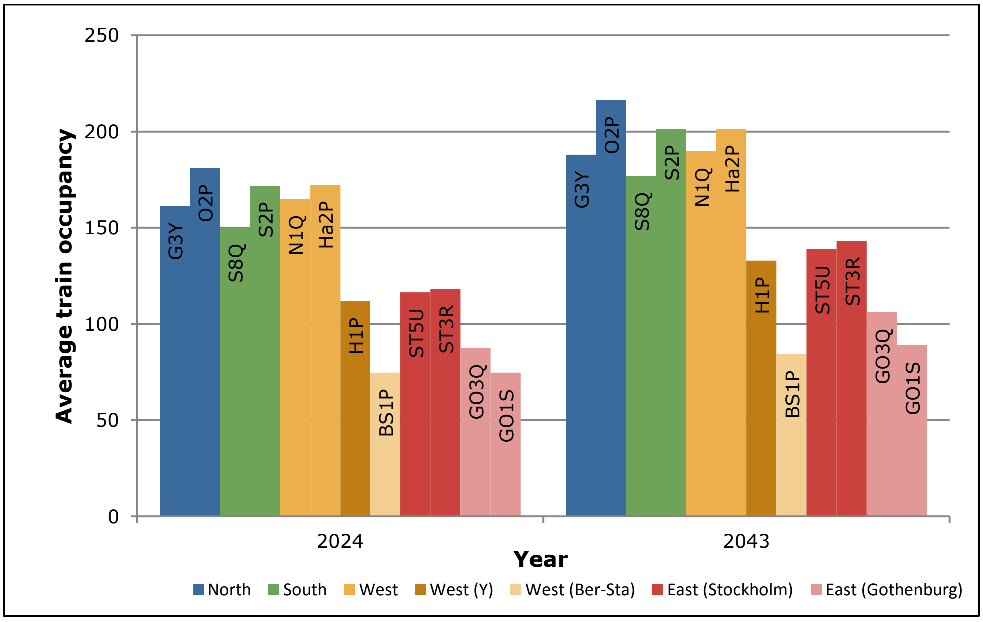


Figure 16 shows average occupancy by route alternative. In many ways this is a better indicator of demand than passenger demand as it accounts for corridor length. Average occupancy is similar across the three main Norwegian corridors with the highest occupancy being on route Ø2:P. As with revenue, occupancy is lower on the East corridors due to a large number of short distance trips.

Interestingly although the occupancy on the Bergen-Stanger corridor (BS1:P) is lower than on other routes proportionally this is not as significant as either for passengers or revenue; due to the shorter distance on this line. The average occupancy on the Y shaped corridor between Oslo and Bergen\Stavanger is brought down by relatively low occupancy on the Bergen to Stavanger services.

The graphs show that it is not clear cut whether a slower stopping service or a faster direct service would offer an optimised service on a given corridor. This highlights that optimising service provision within a single corridor would involve a significant number of tests.

4.6.2. Impact of alternative service assumptions

Presentation of HSR Alternatives, as discussed above, has been based on PSS1. In Chapter 2, an alternative passenger service scenario, PSS2, has also been established. PSS1 assumes a HSR fare equivalent to 60% of the competing air fare with combined Core and Peak services operating (26 trains a day in each direction). However, over the lengths of the corridors considered, HSR would be very competitive with air, with forecasting showing a clear preference by passengers for HSR over air. Consequently any HSR service will serve a different market to the existing long distance rail service within Norway, attracting passengers with higher values of time who are willing to pay a fare premium for faster more efficient travel. In addition, there might be scope to reduce train service related costs with some reduction in the number of services operated without significantly affecting demand.

PSS2 offers a combination of higher rail fares, being the equivalent of air fares, and a reduction in the number of trains operated, with the additional four trains in each direction identified for the peak periods removed. It should be noted however, that, because the forecasting model is an all day model, the removal of “peak” services manifests itself as a reduction in trains a day by eight to around 18 a day, and hence a reduced overall daily frequency, rather than a specific peak period impact.

The graphs below show sensitivity tests around the key appraisal test above of adopting PSS2.

The following Figures show the alterations to passenger demand, revenue and average occupancy as a percentage of the original demand from the core tests. It should be noted that the methodology for forecasting trips of under 100km in the model does not account for fare increases, therefore, these trips are unchanged in the results below. This has not had a large effect on the North, South and West corridors, although the effect is more marked on the East corridor alternatives, and hence some caution should be used for those figures.

Figure 17. Comparison of HSR passengers by alternative with PSS2

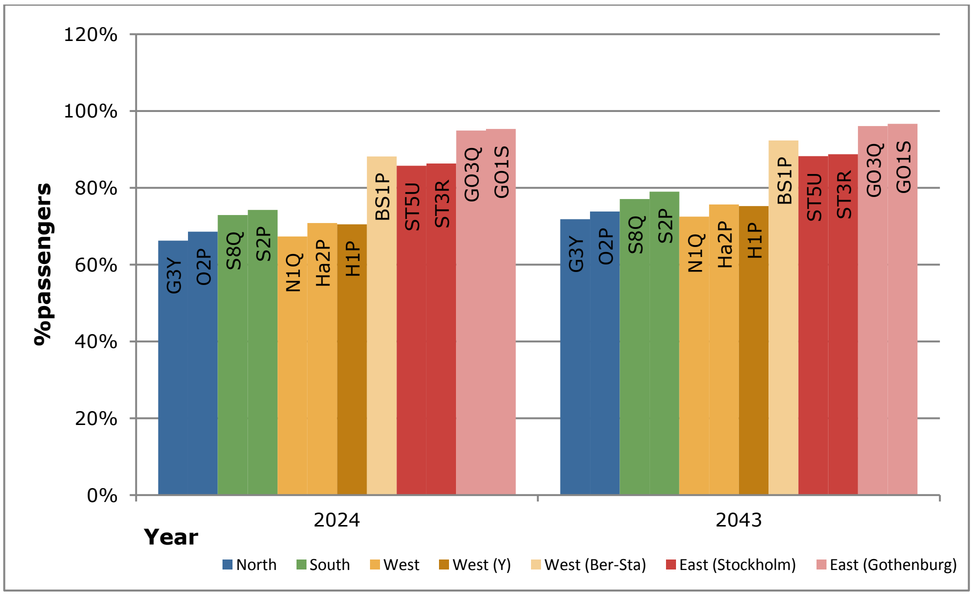


Figure 17 above shows that, despite a fare increase to the equivalent of the current air fare, and a reduction in the number of HSR services by 8 trains per day to around 18 trains per day, demand on the Norwegian corridors remains at approximately 65-70% of those forecast in the core appraisal. A slightly higher proportion of demand can be seen to remain in 2043, this is due to increasing values of time throughout the appraisal period. The Eastern corridors show over 80% of demand remaining, it is noted that this is inflated due to the shorter distance trips, which are significant on these corridors, not being influenced by the fare within the forecasting approach.

Figure 18. **Comparison of HSR revenue by alternative with PSS2**

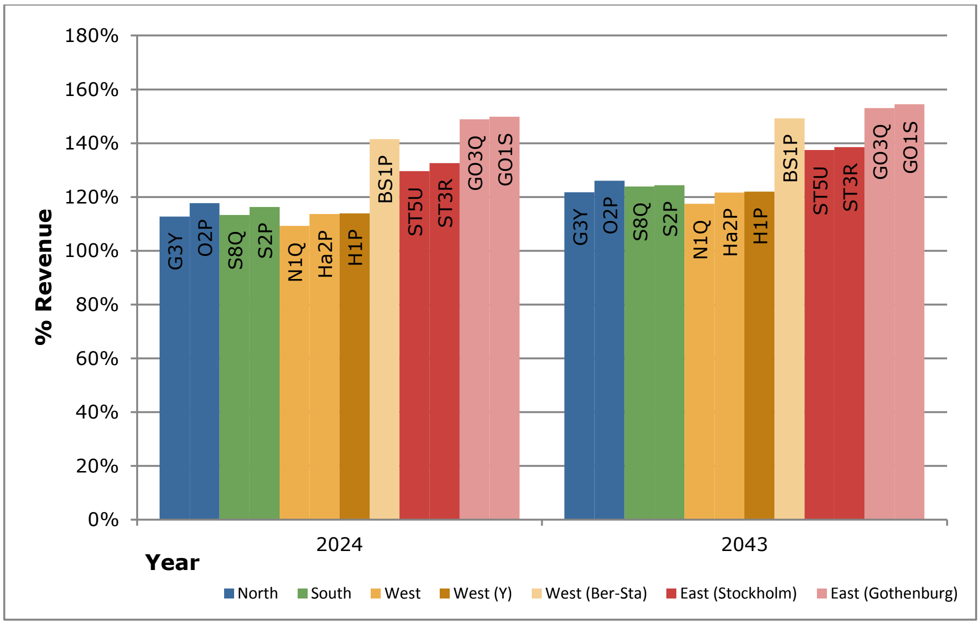


Figure 18 shows that, despite the reduction in demand and service levels, the fare increase results in larger revenue than in the core results. Revenue on the Norwegian corridors is typically more than 10% higher than in the original tests. The increase in revenue is higher in 2043, due to the higher value of time which reduce the impact of fare increases on demand. Again, revenues on the East corridors are inflated due to the forecasting not accounting for the impact of increased fare on demand over shorter distances.

Figure 19. **Comparison of HSR average occupancy by alternative with PSS2**

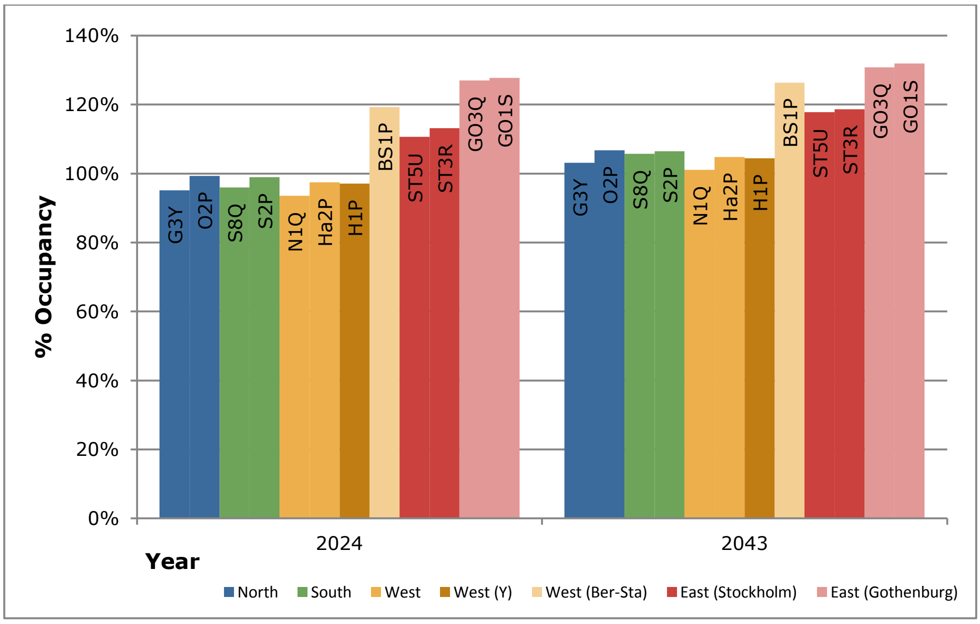


Figure 19 above shows that, although demand has fallen, occupancies are typically similar to in the original PSS1.

As noted earlier in this report the alternatives tested do not necessarily, and are extremely unlikely to, reflect an optimised service in terms of service provision or fares. For route Ø2:P (Oslo-Trondheim), Figure 20 below shows how changing the HSR fare (as a proportion of the current air fare) impacts on HSR demand and revenue.

Figure 20. Impact of HSR fare on demand and revenue (Route Ø2:P, 2024)

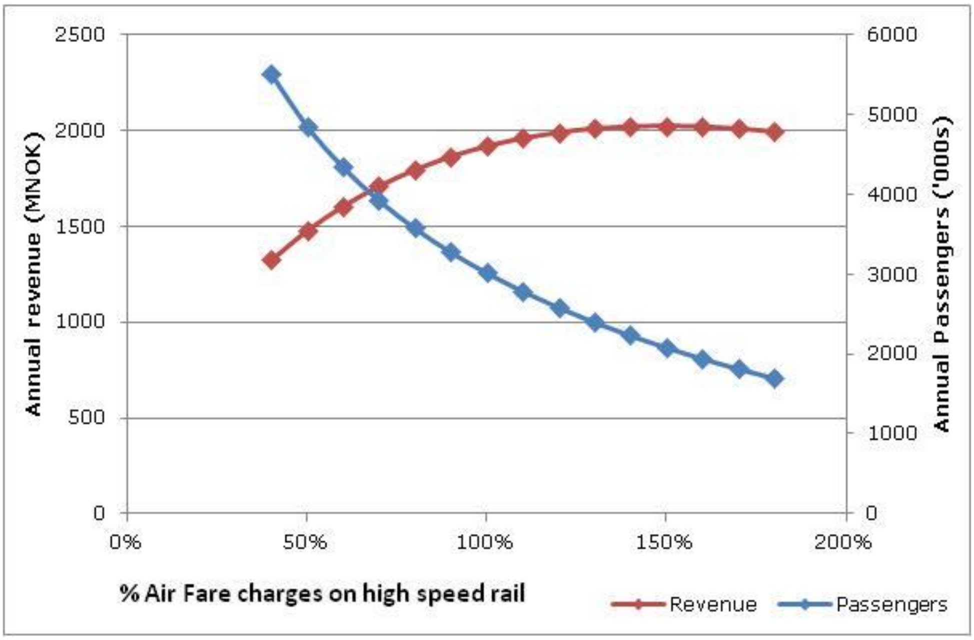


Figure 20 shows that, although the HSR appraisals alternatives in PSS1 have been assessed with a HSR fare set to 60% if the current air fare, HSR revenues are not maximised until the HSR fare reaches approximately 150% of the existing air fare. It can be seen that although a higher fare maximises revenue passenger, demand is significantly lower with higher fares. With an HSR fare of 60% of the existing air fare, HSR demand falls by 30% with an HSR fare of 100% air fare, and by over 50% with an HSR fare of 150% air fare, at which point HSR revenue is maximised.

It is noted that maximising revenues will not maximise benefits, as a lower number of passengers will receive time savings and where passengers pay a premium over their existing fare they will experience a disbenefit.

We also emphasise that the forecasting looks at average fare paid by journey purpose. With appropriate marketing and revenue management systems – similar to those used on airlines – it may be possible to increase overall revenues while maintaining passenger numbers to some extent. Further investigation would follow at a more detailed stage of scheme development.

4.7. Accessibility and Feeder Networks

4.7.1. The Need for Feeder Services

The Phase II Report: *Location of Stations and Termini*, identified the challenging balance that needs to be struck between maximal geographical coverage of the HSR network through its stations and the minimisation of journey times between termini. A greater number of station stops on the network provides social benefits to a wider range of communities, however, in order to attain competitive journey times the number of stops between the end points along each HSR corridor has to be limited.

Given this constraint to the potential reach of the HSR network, it is recognised that improving the access to proposed HSR stations by means of feeder services (connecting rail or bus services) may provide a wider spread of beneficiaries. Furthermore, improved accessibility may strengthen the overall demand for the HSR network and its overall national economic efficacy. The development of integrated transport systems around HSR station hubs increases the value of local public transport whilst strengthening the case for the HSR investment. In this way integrated local feeder services provide the link between successful local and national transport policy.

4.7.2. Design and integration of local feeder services

There are several issues to be considered with regard to local feeder services:

- Where should they be considered? – **Catchment, market and stations**;
- What sort of feeder services should be provided? – **Mode**;
- How feeder services should be integrated with HSR services? – **Timetables**;
- What the financial and socio-economic implications are? – **Revenue, costs, benefits and funding**; and
- Who should operate the feeder services? – **Operator and fares**.

Since the majority of the proposed HSR stations in Norway are located close to existing classic railway stations, and since in the sparsely populated inner regions most development occurs in a linear fashion along valleys served by existing railways, there is potential to realign those services to connect with the HSR timetable. Elsewhere, high quality bus or coach services offer further flexibility to the extension of HSR catchment areas.

The cost of these services can be off-set by revenue and government and other private sector support, depending on the service specification. A range of parties, local and national, may contribute to the funding of these services as well as their specification, so as to deliver the commercial, socio-economic and political objectives intended. Feeder services can operate, completely independently, as part of the HSR operations, or as a company set up involving a number of interested parties. Through-ticketing is clearly desirable as it enhances the experience of seamless travel.

Globally there have been many examples of the use of multi-modal connecting services to drive up the value of HSR at a local level and to provide links further afield beyond the HSR network. In Spain and France relatively remote HSR stations such as Estación de Segovia-Guiomar and Gare Le Creusot have employed connecting buses to reach a number of communities around a compromise location. In the UK the HSR station at Ebbsfleet forms the focus of a major development region via a local BRT system, Kent Fastrack. In the USA, Amtrak offer a coach based “Thruway” service, which connects regions lacking railway infrastructure to its national rail network. The UK HS1 expands the benefits of the HSR investment by having high speed trains running onto connecting classic rail lines. Global experience highlights the benefits and risks of establishing new feeder services: there are examples of feeder bus services proving to be unsustainable in the long term.

4.7.3. Potential feeder services on the Norway HSR network

Northern corridor

Accessibility analysis indicates that there is value in adjusting residual classic rail services to integrate with the proposed distribution of HSR stations. HSR stations at Værnes and Trondheim are already served by regular local rail services, which would widen the catchment of HSR stations. However, there is a case for aligning long distance services from the North with HSR services, to effectively extend the reach of HSR.

Analysis shows that the region that would benefit most from feeder services is the Otta-Oppdal railway section and suggests that both the Dovrebanen and Raumabanen deliver improved journey times to HSR stations over parallel road connections, provided interchange is timetabled at Otta or Oppdal. Analysis shows less journey time benefit from the integration of feeder services in the Hamar region despite the greater range of potential rail connections. This is due, in part, to the greater road network density, which means there is less benefit in connecting via the relatively slow rail network.

Population mapping indicates that along this corridor development is concentrated around the existing railway, and that provided it is viable, the classic rail network provides the optimal alignment for feeder services.

Western Corridor

The West corridor route passes through a number of small communities where rail provides a quicker and more direct access to HSR stations than roads. Accessibility analysis studying the impact of feeder services in conjunction with the HA2:P HSR specification suggests journey time benefits can add value at Nesbyen and Gol providing a feeder into Geilo. A similar benefit occurs at Finse and Myrdal. The analysis has demonstrated that a judicious recasting of Bergen – Voss local services, to provide a 5 minute interchange at Voss, can provide significant journey time benefits to populations around Dale and Evanger stations.

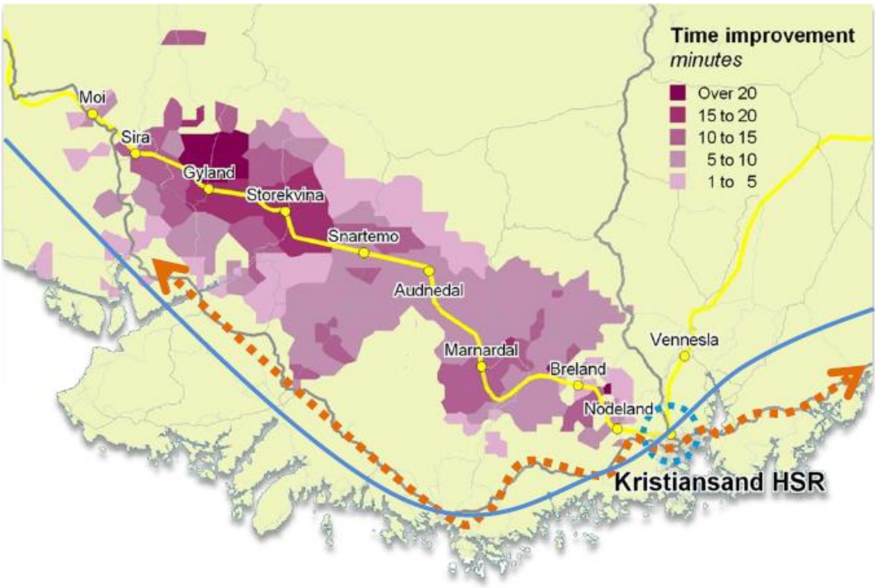
Whilst the classic rail network could successfully augment and enhance HSR along this route, there are other locations where a connecting coach service may be prudent to expand the scope of beneficiaries. At Voss local road based transit could connect to communities around the Hardangerfjorden such as Granvin and Ulvik, providing dramatically improved public transport accessibility to Oslo and Bergen. There are other examples such as at Gol where coach route 17 (Hemsedal – Ulsåk and Tuv) could be timetabled to coincide with HSR arrival times, however for the HA2:P specification the nearest HSR station is Geilo. At Hønefoss some communities around the town could be connected e.g. Jevnaker.

A challenge in this region is the dispersal of communities – populations of settlements occurring away from the linear development alongside the railway are very low. On the other hand because existing airport connectivity is poor, the change in service level will still be a significant improvement even with convoluted bus routes.

South Corridor

Unlike the North and West corridors, the railway route does not follow the main settlement chain, which is along the South coast, south of the railway. The proposed HSR route (shown in orange) also lies further south than the existing classic rail line, the Sørlandsbanen (shown in yellow in Figure 21), and the two routes could interface at Kristiansand Egersund and Porsgrunn (S8:Q service specification). Analysis shows feeder network timetabling could produce significant journey time improvements for communities along the Sørlandsbanen into Kristiansand and Egersund. However, the sparse population along the existing rail route means the number of beneficiaries would be relatively low.

Figure 21. Journey time to Oslo improvement through implementation of classic rail feeder service into Kristiansand HSR, and potential bus connections, from a multimodal hub at Kristiansand



The remoteness of the classic rail line from the HSR route and some of the largest coastal towns means that connecting coach services may have a larger role. Settlements are generally located along the E18 and E39, which lie alongside the indicative HSR route, with potential interfaces at every selected HSR station. There appears to be a good case for feeder bus services to tie together communities not served by HSR to the proposed stations. Presently Nor-way Bussekspress routes 300 and 190 serve this route and timetable connections at Mandal, Kristiansand and Arendal. A new multimodal interchange would broaden scheme beneficiaries.

East Corridor

For the East corridor, analysis of a classic rail feeder service into an HSR station at Sarpsborg shows journey time benefits to communities around Rakkestad and Mysen. Stations on the route towards

Kongsvinger would also benefit from a feeder service, coinciding the infrequent service along this corridor with any HSR service at Kongsvinger, would provide journey time benefits, albeit to a small number of passengers.

4.7.4. Overall benefits to the HSR scheme

Spatial analysis in the Phase Two Report: Location of Stations and Termini demonstrated that in the largest five Norwegian cities the location of HSR stations and their relationship with local transport networks can play a significant role in the attractiveness of the HSR system as a whole. The analysis of feeder networks extends this concept to wider, rural regions where arguably local transport needs are even greater. Intermediate stations that have been included in the appraised network specifications, often attract low patronage; particularly of the sparsely populated regions of the West and North corridors.

Harnessing the existing local rail network, which tends to serve most of the population of the rural areas on the North and West corridors increases the value of these intermediate HSR stations immensely, provided that the necessary timetable, service quality and ticketing arrangements are in place. In some areas, particularly on the southern coast, the historic railway geography precludes it forming the optimised feeder network solution, and here a high quality connecting coach may be a more appropriate means of widening network coverage.

4.8. Summary and Conclusions

4.8.1. Demand and revenue forecasts

Phase III of the Assessment Study has developed demand and revenue forecasts for selected representative alternatives on the four main corridors considered in this phase of work. Further refinements to the forecasting framework have allowed an increased level of accuracy in this phase of work, subject to the assumptions noted in this section.

In general, predicted levels of demand are higher than reported in Phase II, through better representation of intermediate trips and forecasting of HSR demand from areas where existing air services do not currently exist. Revenue forecasts have also increased from Phase II, although by a lesser extent.

In terms of the performance of alternatives between corridors, generally, there are between 4.2m and 5.5m trips per year in 2024 on each of the domestic corridors between Oslo and Bergen, Trondheim and Stavanger, apart from the Haukeli alternative which generates around 7.5m trips per year. Forecast revenues lie in a closer range, typically around 1.4 BnNOK to 1.6 BnNOK in 2024 (in 2010 prices, undiscounted) for the same corridors, with the Haukeli alternative generating around 2.7 BnNOK in 2024. This level of flow corresponds to a typical average fare paid of 280 NOK to 340 NOK, both per one-way trip, for an average journey length of between 280km and 360km.

However, sensitivity testing has shown that higher HSR fare assumptions could lead to up to 20% additional revenue in 2043 for the same alternatives, albeit with demand reducing by up to 35%.

Equivalent figures for the East corridor alternatives are slightly lower, with demand ranging between 3.7m to 4.7m and revenue between 0.7 BnNOK and 1.2 BnNOK in 2024.

4.8.2. Further development of forecasting work

The focus of the analysis work undertaken during Phase III of the Assessment Project was to forecast levels of passenger demand and revenue for representative alternatives along each of the corridors using consistent forecasting assumptions. We emphasise that actual demand and revenue forecasts will vary according to a number of factors:

- All the demand and revenue forecasts are clearly dependent on the fare and journey time assumptions for developed for each alternative. As alternatives are gradually developed, assumptions on both fares and journey times will change to match the objectives of high speed rail on that corridor. In particular, optimisation of fare levels for intermediate flows may have a significant impact on demand and revenue levels;
- Each of the alternatives has been tested individually, and in isolation. When combined, it is reasonable to expect an increased “network effect”, where high speed rail services provide greater connectivity to

other parts of the national rail network, including those served by both high speed and conventional or Inter-City services. In particular, extending services on the West and South corridors through to Gardermoen Airport could significantly increase high speed rail demand and revenue for those alternatives;

- The results presented in this summary report assume no changes to other modes, particularly air and the existing rail services. As described elsewhere – and in Phase II reports – the response of airlines is difficult to predict, but reductions in air service frequency would, in turn, increase the attractiveness of high speed rail services, with associated increases in demand and revenues for each alternative. A similar situation may occur with competing bus, coach and existing rail services – although there is much greater potential for the “slower” modes to compete on price;
- Station accessibility is a critical factor in determining the attractiveness of high speed rail services, both in terms of station location and catchment area, and connectivity by road, rail and bus. Our analysis has demonstrated different ways that a high speed rail network could be accessed by different modes, which will in turn have an effect on high speed rail patronage; and
- The train specification used allows for peaks in the demand for services, but further work would be required going forward to optimise the distribution of peak and non-peak services and any other differentials (for example in the calling pattern) between those services.

Finally, we emphasise that all alternatives have been modelled on a consistent basis, reflecting the level of development of each of the alternatives at this stage and the need to cross-compare demand and revenue forecasts between alternatives. Going forward, bespoke approaches would be developed for each corridor to match its individual market potential which will further increase the accuracy of demand and revenue forecasts.

5. HSR Freight Market Analysis

5.1. Introduction

This section of the report presents the Phase III analysis of the potential market for freight in the context of the introduction of HSR.

The issue of freight has been examined in two phases of the overall Norway HSR Assessment Study. The opportunity for both high-speed and fast rail freight – that is above 200 kph and above 120 kph respectively, was completed during Phase II of the study. This concluded that there was unlikely to be any significant demand for freight above 200 kph.

In Phase III, the analysis concentrated on fast (intermodal) freight exclusively as the sector identified as having the greatest market potential. It concentrated exclusively on trains capable of running at 120 kph on the high speed lines, with that speed calculated to be the minimum required to not unduly impact on passenger trains running at maximum speeds between 250 and 330 kph.

Three approaches were used to understand the market potential:

- Demand modelling,
- Consultation; and
- Comparison with international experience

The analysis presented in this chapter is reported more comprehensively in the following report:

- ***"Norway HSR Assessment Study Phase III: Freight Market Analysis", Final Report, 25 January 2012***

5.2. Freight modelling results

Three main opportunity areas for high speed freight have been examined:

- Transfer from air (high speed only);
- Postal services; and
- Transfer from other modes (all speeds above 120 kph).

5.2.1. Transfer from air: market potential

Air freight is, in tonnage terms, very small compared to the totals for road and sea transport, even though it represents an obvious part of the potential market for high speed rail (HSR) freight. The total air cargo market on the seven identified HSR corridors is on average around one truck load per day, and therefore is highly unlikely to ever form a central component for the business case for HSR.

The air freight market is dominated by Oslo airport, which handles nearly all of the international connections and is the hub for domestic air cargo. This implies that any HSR services seeking to capture domestic or international air cargo would probably need to be orientated around serving Oslo airport (which is different to but not incompatible with the passenger market based at it is on Oslo Central station). Air freight handled at Oslo Airport has been broadly constant over the last ten years at 70,000 to 100,000 tonnes per annum, with a peak in 2007 followed by a decline in more recent years. The large majority of air freight is carried on scheduled passenger services – nearly 92% in 2009. As is common in most of Europe, much inter-Europe "air" freight transport is actually transported by road.

With 46 airports spread all over Norway, Avinor handles close to 96% of Norwegian air traffic. Avinor report that 43% of air freight arriving at Oslo Airport is transported onwards by road, with the rest transferred to domestic air services. Therefore to compete with air, rail would need to either provide dedicated high speed trains (which are not feasible given the volumes below) or have space within the proposed passenger service. This would mean running all trains via Oslo Airport and having sufficient time and facilities to load and unload trains at those destinations (as well at the terminal stations). Such a transfer would require a shift by freight users in their current logistics arrangements to reduce double handling costs.

Avinor has also provided detailed statistics on the annual freight (mail and air freight) in tonnes between cities most likely to be served by HSR by route. There has been a slight decrease in the total amount of goods from 2007-2009 between all the listed cities but the single 'busiest' connection (Oslo-Gothenburg) has remained constant throughout with a third of the total volume of the total volume on the selected routes (2,415 tonnes in 2009) but even this is equivalent to less than a lorry load per day (based on a 350-day year).

Table 22. Air Freight Traffic on Selected Routes (tonnes)

Routes	Air Freight Tonnes 2007	Air Freight Tonnes 2008	Air Freight Tonnes 2009
Oslo - Gothenburg	3,182	2,975	2,415
Oslo - Bergen	1,786	1,398	1,406
Oslo - Stockholm	1,815	1,401	1,143
Oslo - Stavanger	1,440	1,252	929
Oslo - Trondheim	1,488	1,126	754
Oslo - Kristiansand	494	435	299
Stavanger - Bergen	427	336	277

This means that for high speed freight to succeed it will need to target markets other than airfreight.

5.2.2. Postal market potential

Posten Norge distributes to roughly two million households and businesses in Norway. In 2008, Posten Norge entered into Norway's biggest ever railway contract and buys rail transport worth 1 billion NOK each year. More than 80% of all the mail in Norway, over distances covered by railway lines, is transported by rail. In April 2009, Posten Norge’s major road transport route between Oslo and Bergen became fully rail-based. As a result, a total of 1,250 trucks have been replaced by rail transport between Norway’s two largest cities. Other transport routes are close to achieving a 100% rail-based service, but challenges remain in terms of continuing to meet customers’ quality and time requirements.

Therefore there is likely to be little direct growth from having faster rail services. This is particularly the case in a market where the number of letters is falling.

To a large extent this fall in classic postal volumes is being off-set by a growth in non-letter express mail and packages. However this does not present a separate opportunity for rail freight. National post offices are not always considered to be part of the express freight industry, probably due to their special status and historical background as state-owned monopolies, but the services offered by them are adapting to a more commercial and competitive environment. This is particularly true in Scandinavia, where the activities of the national postal companies are extending beyond national borders as their newer services face the same market as their private counterparts. As their ‘protected’ status is eroding, it appears to be justified to include them in the express freight industry. Furthermore, an HSR freight service addressing and meeting the needs of the post offices may, to a large extent, be of interest to and applicable to the transport needs of private express companies as well. However, the failure to develop the TGV Fret service indicates that this is not without challenges.

Therefore, the market for exclusive postal service is highly unlikely, of its own, to form a central component for the business case for HSR. This does not mean that HSR will not help retain and strengthen the position of rail as compared to other modes in the longer term. It does however mean that for HSR freight to succeed it will need to target other markets, including express packages.

5.2.3. Transfer from other modes

The initial modelling results for testing the impacts of enabling high speed freight on rail, undertaken using the Norwegian National Freight Model, indicated that there was little market potential for freight at speeds at or above 200 kph. However, in order to further test market potential, the freight model has been re-run with a lower assumed speed of 120 kph (compared with a typical speed of closer to 65 kph today). The rail journey speed for the six lines changes from 52.9-65.0 kph in the reference case to 120 km/hr on all six lines in the test case. This has been modelled as a reduction in the time between the rail terminals and within the rail terminal by about 50% (although it could be argued that terminal times would not be reduced, they form only a relatively low percentage of the total rail transit times). Apart from time between and within terminals, total freight costs also include time required for road transport from origin to first rail terminal, from last rail terminal to destination. The total reduction in time caused by the increase in line speed was therefore typically modelled as between roughly 30% – 45% of total cost subject to the route.

The net extra tonnage between city pairs forecast by the model to result from the increase in line speed by corridor can be seen below in Tables 23, 24 and 25:

Table 23. Forecast increase in freight tonnage by route per year

Route (both directions)	Absolute difference with base Tonnes per year
Oslo-Stockholm	30,024
Oslo-Gothenburg	2,611
Oslo-Stavanger	56,104
Oslo-Bergen	435,739
Oslo-Trondheim	150,720

Table 24. Forecast increase in freight tonne km by route per year

Route (both directions)	Absolute difference with base TonneKm per year
Oslo-Stockholm	17,329,131
Oslo-Gothenburg	869,329
Oslo-Stavanger	29,096,308
Oslo-Bergen	188,294,298
Oslo-Trondheim	86,952,671

Please note that only products typically carried on intermodal services are included in these figures because single commodity, bulk trains (such as those for iron ore, coal, oil or aggregate) are not capable of sustaining running speeds of 120 kph and therefore will not be able to take direct advantage of the high speed line. The modelling results above also include international traffic where such traffic enters/leaves Norway.

It is also important to note that whilst these results are presented by corridor, a national model was used and therefore the results are more reliable at the national level. The model total was calibrated against the national rail tonnage total of around 29,000 million tonnes per annum. However, this total includes all rail freight (including large commodity specific trains) and the attribution of the tonnage to routes and estimated growth on those routes was modelled rather than based on observed data. One example of this can be seen on the Stavanger – Bergen route. Currently all mode traffic volumes are low and rail is zero, as there is no direct route. The modelled result for this route is zero but in reality there would be opportunity for rail freight to capture a very high percentage of the freight between these destinations, but only if an aggregator was willing to price to effectively corner a niche market. In assessment terms therefore the total figures shown below (tonnes and tonne kms) should be given more weight than the results per route.

At the next stage of analysis a more detailed route model would need to be constructed to test the particular response of local markets.

Table 25. Forecast increase in total tonnes and tonne kms by year across all city to city movements

Six routes (both directions)	Absolute difference with base
Tonnes per year	675,217 tonnes
Tonne km per year	c.335,540,000 tonne/km

The numbers presented in Table 25 compare with the following estimates of base tonnes and tonne kilometres in Table 26. Again, the national total should be considered more reliable than the disaggregate figures by route, that are shown for information.

Table 26. Total base tonnes per year (city to city movements)

Route (both directions)	Base tonne km year
Oslo-Stockholm	2,963 tonnes
Oslo-Gothenburg	0 tonnes
Oslo-Stavanger	470,514 tonnes
Oslo-Bergen	579,952 tonnes
Oslo-Trondheim	171,337 tonnes
Total	1,224,496 tonnes

Comparison of Tables 25 and 26 shows that the reduction in running times (direct and indirect), therefore, has been modelled to generate a 55% increase in total tonnes across the city to city movements considered.

This seems high but is on a low base (considering a specific subset of national freight demand) and equates to only 2,000 tonnes per day. On the single busiest route this equals 1,244 tonnes per day (on 350 days per year) – which equates to about 3 trains per day carrying less than a full trailing load.

As a result of the reduction in journey times, rail freight operating costs fall. This is made possible by the improved utilisation of the rolling stock (locomotives, wagons on-vehicle staff). The modelling assumed that the total rail costs would fall by between 22% and 29% as a result of the 120 kph line, dependent on the route. This is lower than the reduction in running times because not all asset types are time proportional – e.g. the amount of energy used (if anything) slightly increases with faster trains.

In the model the total reduction in costs (direct and indirect) to end users was assumed to be between 2.2% and 2.9%. This is lower than the 22% - 29% reduction in rail haulage costs because the vast majority of the total costs on intermodal carriage by rail are not rail related. This factor is determined in large part by the costs for terminal handling and distribution and road distribution which were both taken from the Norwegian National Freight Transport model. These costs are very much higher in Norway than in some equivalent models elsewhere in Europe. A reduction in their value could increase the price benefit from HSR to intermodal type freight by between 10% and 20%.

In the model it was assumed that 100% of the cost savings have assumed to be passed to the client. It might however be argued that some should be paid to the funder of the HSR infrastructure for extra costs that would be incurred from the construction of the new rail line. This issue is significant. Running freight trains on the high speed line will incur additional infrastructure costs. Freight trains will require:

- Extra infrastructure (mainly passing loops) over and above that required for the regulation with local passenger services to allow freight trains to be regulated with high speed passenger trains;
- Extra maintenance to repair the wear caused by freight trains which because of the high axle weights will be greater per train than for passenger trains (and particularly expensive because of the high inspection and high ride quality required for passenger trains); and

- Earlier requirement for renewal of infrastructure. These costs have not been quantified at this stage but may need to be in any further work

It is noted that no increase in reliability was assumed to result from the introduction of 120kph lines in the modelling. This is because at this stage in the project, particularly while the use of the residual lines remains unclear, no metric for changes to the reliability of freight traffic can be reasonably calculated particularly on a multi-corridor level. However, one of the key findings of the consultation exercise below was that reliability was perceived to be more important than speed. Therefore if there is a further phase of development and more detailed route specific freight forecast modelling is required, it is recommended that this factor is included.

5.3. Consultation

Two separate consultation exercises were undertaken. The first for high speed railfreight and the second for fast freight. In addition the results from previous, more detailed, consultations were used to calibrate the demand model.

The key responses from the first consultation were:

- For many freight integrators an early morning delivery is essential (i.e. overnight haulage);
- Reliable delivery times are important;
- The shippers typically rated the probability of transfer of some freight to HS railfreight at 50-60%;
- The tonnages and products carried by the individual freight integrators vary significantly;
- Domestic air transport costs are about 4 times those of road distribution – around 500 NOK/m^3 for road and 2000 NOK/m^3 for air;
- There is a reluctance to pay a premium for HSR freight trains, excepting freight moving from air; and
- Most shippers were happy with their existing arrangements.

The key responses from the second consultation were:

- All but one of the (potential) users of fast rail freight services (carrier/forwarder/shipper) that we interviewed would use it for some of their traffic;
- However should the infrastructure have to be paid for with premium pricing then the market potential would be severely reduced;
- The markets with greatest potential are for containers and rail carrying road trailers; and
- All the three operators interviewed argued that the model assumptions that costs would fall are ambitious and that cost increase in maintenance, power and personnel would outweigh the savings from increased asset utilisation. Although this may be market positioning there must remain a significant risk against the forecast increase in freight.

The results from the two separate consultations therefore are compatible. They also match a more detailed study from Sweden used to calibrate the model which also emphasised the relative importance of reliability and price over speed. Critically the consultation responses are compatible with the modelling results and therefore reinforce the overall conclusions.

In summary this means that whilst high speed has a perceived benefit, it does not address the main concern of the rail freight industry. However, it is worth noting that if the high speed lines result in long distance passenger services being displaced from the existing network, this could benefit the existing railfreight market by freeing capacity; which would in turn improve reliability, might allow for over-night services and could potentially lead to a different maintenance regime (with a different, potentially lower, cost base).

5.4. International experience

In order to check the modelling and the consultation experience, a survey was undertaken of international case studies. A number of examples of successful and unsuccessful HSR/fast freight were identified. The most successful included:

- TGV La Poste: a dedicated HSR freight train; and
- IC:Kurier (German ICE): the use of HSR passenger trains to carry courier and express parcels

However, it is worth noting that TGV La Poste has recently reduced the frequency of its services, due to falling postal volumes and a recent TGV Fret initiative has not been developed, apparently due to lack of interest from other potential users.

On a more positive note, other relevant initiatives such as the air/rail freight proposals from Euro-Carex and Air Cargo Express, have been launched to try to set up rail services to carry express and freight shipments between major European airports. These are typically based on using converted or modified passenger rolling stock and work operationally. The prospects for diverting express and freight shipments in Europe from air and road transport to HSR services are therefore promising at a macro level. However these services remain largely aspirational as they have been caught up in financial and political problems. There are therefore no reasons why fast railfreight services would not be technically feasible; but the prospect of commercial success - particularly for dedicated HSR freight trains – remains elusive and nowhere in Europe has the construction of high speed passenger lines been accompanied by a significant growth in higher speed railfreight traffic.

It is worth noting that with the exception of the older German high speed lines, most new continental European high speed lines have been specifically designed with the intention that freight will *not* be carried, although freight as well as passenger traffic benefits from the new construction because paths are freed for freight on the conventional network. The UK Channel Tunnel Rail Link, now renamed High Speed 1 (HS1), was designed to handle freight - at significant extra cost – but very few paths have been set aside for freight and it is unclear whether even these trains will ever be carried (although further tests are currently being carried out).

It is also worth noting that as the speed for freight increases the applicability of the physical constraints usually applied to the carriage of freight are reduced. The TGV Poste and other higher speed freight trains are typically operated by trains with operational characteristics similar to passenger trains and therefore are not constrained from passenger routes on operational grounds. Some of the innovative services in Sweden and across Europe use other passenger trains converted for freight traffic. They are able to do so because the freight market that requires the fastest transit time typically is light and premium priced. European experience would suggest therefore that fast freight using converted passenger trains will not be automatically precluded should any lines be designed for passenger (i.e. non-conventional freight) only use. Even intermodal trains (whether containers or pallets in a curtain-sider) can be light loaded to overcome vertical gradient constraints.

In summary, therefore, an international comparison would seem reinforce the conclusions of the modelling and the consultation exercise, that there is a potential market for higher speed freight on freight lines but that the business case has proved difficult to sustain.

5.5. Summary and Conclusions

In summary, there seems to be some potential for freight to be switched to rail through the construction of HSR. This is despite the relatively high current levels of rail freight in Norway when compared with other modes, even though not high in absolute terms.

Whilst some higher speed rail freight traffic will be generated by the construction of a high speed line, the absolute number of freight trains is likely to be low. However, the indirect impact on the potential for conventional rail freight (or even higher speed rail freight) on the existing network could be at least as significant.

The modelling, consultation exercise and survey of international experience were compatible and all had similar conclusions; that is whilst there is a potential market for higher speed rail freight, there is no evidence that rail freight will pay for the high speed line through premium pricing or be anything more than a small component of the main passenger high speed business case. In order to construct a business case for freight the incremental costs would need to be evaluated. This will be better undertaken at the next phase of work where the costs can be route specific and the potential freight flows understood in more detail, accounting for changes in future conditions and factors that might affect market response and the relative competitive position of freight modes.

It is worth noting that freight modelling has been undertaken on a macro level. Most rail freight, even intermodal rail freight, is route sensitive. The modelling used the National Norwegian Freight Model. Whilst this gives a national result, it is clear that there are significant variances between routes. Using a national model is the only practical option when the number of alternatives is large as it has been for this phase of the study. Should there need to be a further phase of work it is recommended that freight modelling be undertaken on a route specific basis and also examine the potential impact of a range of changes in market conditions into the future.

Other key issues are the fit of rail freight with the design of the high speed alignment, the need for renewals and the use of the residual network. On the Østerdalen alternative, over the steepest section of track, freight uses the existing line which diverts from the direct route proposed for the high speed passenger trains. This allows a steeper gradient to be used for the high speed line, avoiding significant cost. Examination of whether there are more examples of this type of opportunity may be worth considering in any future phase of work.

Perhaps more significant is the opportunity afforded to freight on the residual lines. If some existing passenger services are diverted from the existing lines to the high speed line there will be an opportunity to use the capacity released to run more freight trains and/or run the existing freight traffic faster/more reliably.

Finally, the addition of freight traffic on the high speed line will have an impact not only on the design of the lines themselves but on their maintenance and renewal (even if mitigated by the use of converted passenger vehicles). Therefore the concentration of freight on the residual lines either for sections (as per the Østerdalen alternative) or for longer sections should be considered.

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6. Estimation and Assessment of Investment Costs

6.1. Introduction

This chapter summarises outputs of Subject 2: Estimation and Assessment of Investment Costs of the Financial and Economic Analysis contract for Jernbaneverket (JBV) assessing High Speed Rail in Norway. The primary outputs are to provide the estimated capital and life cycle cost assessments, by route, based around the Cost Model Template presented in Phase II. The outputs will enable JBV to make informed decisions on various High Speed Rail Route Alternatives.

The Cost Model developed for this purpose identifies Capital (CAPEX) and Life Cycle Costs (LCC) which are used in the Financial Model to enable confident decision making on route alternatives. These models have been harmonised to reflect local working and rates and have been used to present the cost estimates. In addition, estimates and assessment of risk associated with HSR Alternatives have been considered, and accounted for in final cost estimates presented.

The cost reports identify and price the various route scenario alternatives being considered by route corridor based on alignment data provided by JBV's alignment design consultants. The data and cost reports have been presented and reported in a manner to feed and support the process of Economic and Financial Appraisal.

The results presented in this chapter are for the C/D Scenario HSR Alternatives previously described in Chapter 2. Scenario B results are dealt with separately as a section of Chapter 8 of this report.

The remainder of this chapter addresses the following areas in turn:

- Capital Costs (CAPEX);
- Life Cycle Costs (LCC);
- Risk estimates; and
- Overall Cost and Risk Summary and Conclusions.

The focus of this chapter is providing a summary of the outputs of the Cost and Risk Analysis of HSR Alternatives carried out. For detailed information on the methods adopted, assumptions underpinning the work and the results themselves reference should be made to the following report:

- ***"Norway HSR Assessment Study Phase III: Estimation and Assessment of Investment Costs", Final Report, 25 January 2012***

6.2. Capital Costs (CAPEX)

6.2.1. Overview

The purpose of the Capital Cost modelling activities undertaken in Phase II and the cost estimating in Phase III is to produce a robust cost model to enable the confident and informed decision making in selecting the most economically viable High Speed Rail route. There are several studies that have been considered as part of this activity including the previous JBV studies, HS2 from the UK and J.P. Baumgartner percentages of capital construction cost. In addition published data on various European High Speed programmes have been considered.

The methodology and associated excel based cost model will enable the comparison by route of alternative scenarios reflecting the proposed High Speed routes.

To enable the population of the cost model a schedule of parameters was established, together with an assumed specification based on historical high speed criteria. In addition a Data Input Spreadsheet was prepared to allow the Alignment Engineers to populate for each of the alternative route scenarios being considered.

It should be noted that the route alternative specifications have not been defined in detail at this stage, but are sufficient to support the cost model and include key data specifying lengths and type of track, number and type of structures, number of crossings, passing loops, length of tunnels and stations for example.

It is anticipated that minor modifications to the methodology and model may be required once more detailed specifications have been produced. The model makes assumptions regarding the basic specification of the system on such items as Permanent Way, Electrification, Signalling and Telecommunications. The base date for the cost model is 4th Quarter 2011. The Model can be modified to produce outturn costs which will reflect inflation and other such market conditions.

The High Speed Rail Cost Model compiled consists of two cost models: an estimating cost model and a regression cost model. The first generates costs from a set of unit rates and respective quantities whilst the second resorts to historical data gathered from a number of projects of a similar nature in a similar geographic area. The former is benchmarked against the latter to verify data integrity.

The estimating model has been developed with a series of high level elemental costs for items such as route length, extent of route in tunnel, number of stations etc. To these quantities, a series of “all-in” benchmarked unit rates, derived from historical and published cost data, are applied to arrive at an overall scheme cost. The unit rate data has also been supplemented by in-house historical data, client supplied data and resource led “bottom up” estimates.

The Cost Model allows the input of quantities by two methods. Firstly, using data provided by the Alignment Engineers for key elements. Secondly using the key input data interpolating secondary quantities on a percentage/pro rata basis of element per route km. The Cost Model format follows a recognised standardised layout which can be used to manage cost estimates throughout the scheme development and investment cycle, from output definition to project close out.

6.2.2. Outputs & Results

Table 27 below presents the headline capital cost estimates derived from the cost modelling process. Costs are presented in BnNOK and are in Q4 2011 prices and undiscounted. These costs are inclusive of preliminaries, management costs and risk allowances and estimates. The risk component of costs is discussed in more detail in section 6.4 of this chapter.

Table 27. HSR Alternative Anticipated Final Costs – Capital Costs (BnNOK, Q4 2011 prices, undiscounted)

Corridor	Alternative Ref.	Number of New Stations	Total Length (km)	Length Upgraded (km)	Capital Cost (BnNOK)
North	**G3:Y (250kph)**	6	525	448	**185.49**
	Ø2:P (330kph)	4	483	409	**145.36**
West	**N1:Q (250kph)**	6	399	362	**158.89**
	HA2:P (330kph)	4	367	367	**167.80**
	H1:P (330kph)	6	563	531	**262.05**
	BS1:P (330kph)	4	230	230	**114.71**
South	**S8:Q (250kph)**	10	538	421	**218.88**
	S2:P (330kph)	8	498	440	**222.06**
East	**ST5:U (250kph)**	2	510	331	**129.33**
	ST3:R (330kph)	2	492	319	**114.24**
	GO3:Q (250kph)	5	337	184	**66.32**
	GO1:S (330)	2	308	195	**69.02**

Table 28 below presents a summary breakdown of the cost components underpinning the headline estimates.

Table 28. Summary Capital Cost Report (MnNOK at Q4 2011 prices, undiscounted)

	Northern		Western				Southern		Eastern			
Route ID	G3:Y	O2:P	N1:Q	Ha2:P	H1:P	BS1:P	S8:Q	S2:P	GO3:Q	GO1:S	ST5:U	ST3:R
Notes			Exc Oslo - Drammen		Exc Oslo - Drammen		Exc Oslo - Drammen	Exc Oslo - Drammen				
Scenario Speed (Kph)	**250**	**330**	**250**	**330**	**330**	**330**	**250**	**330**	**250**	**330**	**250**	**330**
Total Route Length (Km)	**525**	**483**	**399**	**367**	**563**	**230**	**538**	**498**	**337**	**308**	**510**	**492**
Upgrade Length - Construction (km)	**448**	**409**	**362**	**367**	**531**	**230**	**421**	**440**	**184**	**195**	**331**	**319**
Total Construction Cost E (MNoK)	**148,197**	**113,904**	**123,437**	**124,786**	**208,029**	**89,791**	**173,128**	**176,058**	**47,068**	**50,057**	**98,718**	**86,158**
Construction Cost per Km - Total Route (MNoK)	**282**	**236**	**309**	**340**	**369**	**390**	**322**	**354**	**140**	**163**	**193**	**175**
Construction Cost per Km - Upgraded (MNoK)	**331**	**278**	**341**	**340**	**392**	**390**	**412**	**400**	**256**	**257**	**225**	**202**
Project Anticipated Final Cost (AFC) (MNoK)	**185,493**	**145,356**	**158,893**	**167,799**	**262,049**	**114,708**	**218,878**	**222,059**	**66,319**	**69,022**	**129,327**	**114,236**
Construction Period (Years)	**10**	**8.5**	**7**	**7**	**10**	**6**	**9**	**9**	**5**	**5**	**7**	**7**
Route Tunnel Percentage	**61%**	**42%**	**43%**	**56%**	**66%**	**63%**	**48%**	**58%**	**25%**	**30%**	**17%**	**13%**
	(MNoK)	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**
Contractor's direct costs												
Signalling & Telecoms	2,743	2,430	2,167	2,260	3,171	1,536	2,621	2,796	1,185	1,284	1,936	1,894
Electrification & Plant	5,616	5,164	4,642	4,678	6,744	2,504	5,524	5,579	2,474	2,554	4,245	4,158
Track	10,446	9,265	8,115	8,457	12,199	5,276	9,872	10,448	4,003	4,412	7,235	7,079
Operational Property	1,610	1,073	1,362	932	1,610	1,214	2,261	1,865	1,130	537	537	537
Structures	81,120	54,706	58,921	67,449	115,710	50,558	95,708	100,190	15,569	17,657	21,668	15,835
General Civils	9,507	12,210	16,958	9,439	16,514	5,586	14,224	11,418	9,607	9,487	18,617	17,036
Utilities	71	32	150	119	169	63	101	225	30	352	645	603
Depots	1,877	1,877	1,877	1,877	2,815	1,877	1,877	1,877	1,877	1,877	1,877	1,877
Sub-Total A	**112,990**	**86,757**	**94,190**	**95,211**	**158,932**	**68,614**	**132,188**	**134,396**	**35,875**	**38,160**	**56,759**	**49,018**
Contractor's indirect costs												
Preliminaries	22,634	17,341	18,788	19,006	31,699	13,578	26,456	26,923	6,978	7,449	11,267	9,712
Design	6,061	4,702	5,035	5,100	8,422	3,661	7,003	7,139	1,972	2,101	3,128	2,735
Testing & Commissioning	867	770	719	713	1,034	510	876	885	452	441	623	613
Other	5,645	4,334	4,706	4,757	7,941	3,428	6,605	6,715	1,792	1,906	2,834	2,448
Sub - Total B	**35,207**	**27,147**	**29,247**	**29,575**	**49,097**	**21,177**	**40,939**	**41,663**	**11,193**	**11,897**	**17,853**	**15,508**
Total Construction Cost E (A+B)	**148,197**	**113,904**	**123,437**	**124,786**	**208,029**	**89,791**	**173,128**	**176,058**	**47,068**	**50,057**	**74,612**	**64,526**
Swedish Route Total	-	-	-	-	-	-	-	-	-	-	26,035	23,401
Client's indirect and other costs												
Client's Project Management	5,650	4,338	4,710	4,761	7,947	3,431	6,609	6,720	1,794	1,908	2,838	2,451
Planning & associated costs	1,755	2,315	2,003	1,425	1,816	777	4,122	4,311	1,801	1,909	2,150	1,938
Land / Property Costs & compensation	778	1,023	891	633	405	346	1,823	1,913	796	861	982	887
Sub - Total C	**8,182**	**7,676**	**7,604**	**6,818**	**10,167**	**4,554**	**12,555**	**12,944**	**4,390**	**4,678**	**5,970**	**5,276**
Total (A+B+C)	**156,378**	**121,580**	**131,041**	**131,604**	**218,196**	**94,345**	**185,683**	**189,003**	**51,458**	**54,734**	**106,617**	**93,203**
Uplift for Risk and Contingency												
Price, Design and Development Risk	29,114	23,776	27,852	36,396	43,853	20,362	33,195	33,057	14,860	14,287	22,710	21,033
Project Anticipated Final Cost (AFC)	**185,493**	**145,356**	**158,893**	**167,799**	**262,049**	**114,708**	**218,878**	**222,059**	**66,319**	**69,022**	**129,327**	**114,236**

The undiscounted base capital costs, excluding risk, range from between 52 BnNOK for GO3:Q in the East corridor to close to 220 BnNOK for H1:P in the West, albeit that this alternative combines three routes between Oslo, Bergen and Stavanger – by way of example it is less costly than the combined cost of N1:Q and BS1:P alternatives in the West. When risk is also taken into account, the range of cost increases to between 66 BnNOK (GO3:Q) and 262 BnNOK (H1:P). The cost per km (exclusive of risk) of total route ranges from 140 MnNOK for GO3:Q in the East corridor to 390 MnNOK for BS1:P in the West, which is a relatively short route featuring very costly structures on an entirely new line. In the West and South all alternatives present a cost per km (exclusive of risk) of total route length exceeding 300 MnNOK.

A comparison of the HSR Alternatives clearly shows the impact of tunnels, earthworks and structure cost components on alternative costs, reflected in the higher cost of routes in the North, West and South corridors, and indeed differences between alternatives within corridors. All three of these corridors provide very challenging topographies for the construction of HSR lines. The East corridor routes by comparison are consequently significantly less costly, reflecting greater use of existing lines rather than entirely new line construction and relatively less challenging terrain for construction where this is required.

6.3. Life Cycle Costs (LCC)

6.3.1. Overview

The purpose of the life cycle modelling is to provide JBV with order of cost estimates for maintenance, renewals and operation in addition to the capital to ensure that the life cycle costs (LCCs) over the long-term are included as part of the overall economic assessment at this feasibility stage. The life cycle model is an integral part of the overall JBV High Speed Rail Cost Model.

The aim is to provide a robust and workable high-level life cycle costing appraisal model that can test different high speed rail alternatives. The LCC model has to conform to the capital cost data structure and input into the reporting requirements of the economic and financial models. For the Phase III cost modelling a life cycle period of 25 and 40 years has been provided.

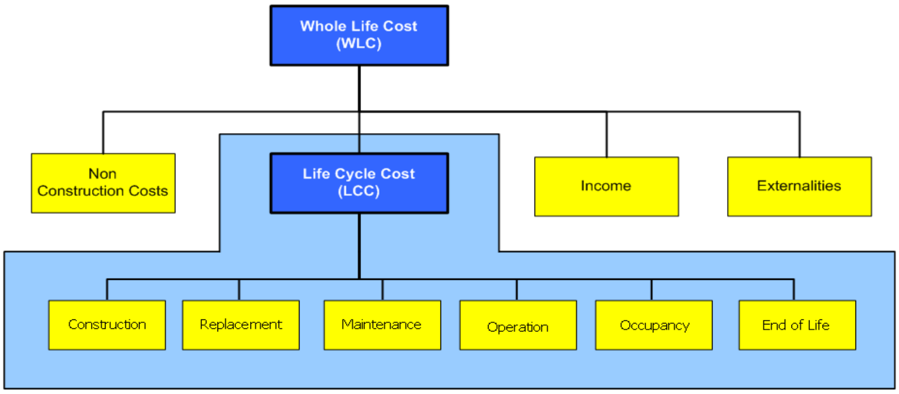
The life cycle costing methodology conforms to BS ISO 15686-5:2008 Building & constructed assets - Service life planning- Part 5 and to the 'Standardized Method of Life Cycle Costing for Construction Procurement' which is a supplement to BS ISO 15686-5:2008.

The main life cycle cost headings incorporated into the model include, as items relating to construction, maintenance including replacement or repair and operations of infrastructure and train operation, including rolling stick.

6.3.2. Scope & Definitions

The scope of each LCC estimate includes for the incremental life cycle replacement, maintenance and operation costs for each high speed rail line alternative only. The following diagram shows the major cost headings in accordance with the 'Standardized Method of Life Cycle Costing for Construction Procurement' cost data structure as presented in Figure 22 below:

Figure 22. **'Standardized Method of Life Cycle Costing for Construction Procurement' structure**



The SMLCC definitions for life cycle are as follows:

- Replacement costs - Scheduled replacement and redecoration of major systems and components. This will form the detailed asset life cycle replacement cost programme;
- Maintenance costs - Scheduled and unscheduled replacement of parts, maintenance and repairs to components and associated making good and minor redecorations including planned preventative, reliability centred and reactive maintenance; and
- Operation costs - Costs of operating the assets and buildings including operational staff, management, cleaning and energy costs.

The LCC estimate therefore covers the following:

- Capital renewal replacement of the signalling & telecommunication; electrification & plant; permanent way; and civil engineering works;
- Planned and reactive maintenance of the signalling & telecommunication; electrification & plant; permanent way; civil engineering works; mechanical and maintenance overheads;
- Incremental station staffing including train dispatch, ticket office, passenger assistance, cleaning and station management;
- Operational energy costs for trains and new stations; and
- Rolling stock leasing costs.

Other costs such as finance and strategic non-construction that relate to Whole Life Costs are covered in the financial model. End of Life Costs are not included in the LCC model. Where appropriate, a residual value for assets which have life remaining at the end of the assessment period are calculated in the financial model using asset lives determined as part of the LCC estimation process

6.3.3. Outputs & Results

Tables 29 and 30 present the undiscounted LCCs at Q4 2011 prices over 25 and 40 year periods for the HSR Alternatives under consideration.

The LCC comparison for HSR Alternatives is consistent with the capital cost estimates reflecting the fact that a significant component of LCC cost is related to the infrastructure assets. H1:P in the West corridor is consequently the most costly alternative at 77 BnNOK over 25 years, which also reflects the high train service related costs, including rolling stock, for this alternative where three services are utilising the infrastructure. The Gothenburg alternatives in the East corridor are the lowest cost alternatives in the region of 25-30 BnNOK over 25 years.

LCCs presented here are for the HSR Alternatives under Passenger Service Scenario 1 (PSS1) with both Core and Peak services in operation. Adoption of PSS2 (Core service only) reduces the train service component including rolling stock by between 33% - 45% with a consequent overall reduction in life cycle costs for a 25 year period of between 9% - 18%.

Table 29. LCC HSR Alternative 25 Year Headline Summary (MnNOK Q4 2011 prices, undiscounted)

Corridor	Alternative	Life Cycle Replacement Costs	Life Cycle Maintenance Costs	Life Cycle Operating Costs	On Costs	Total
North	**G3:Y**	19,973	9,932	15,409	9,063	**54,378**
	Ø2:P	16,337	9,674	13,591	7,920	**47,522**
West	**N1:Q**	16,093	7,502	12,456	7,210	**43,262**
	HA2:P	16,161	7,676	10,668	6,901	**41,405**
	H1:P	25,764	11,019	27,327	12,822	**76,932**
	BS1:P	12,043	4,968	7,344	4,871	**29,226**
South	**S8:Q**	21,117	9,879	18,629	9,925	**59,550**
	S2:P	21,639	9,642	16,134	9,483	**56,898**
East	**GO3:Q**	7,682	4,308	12,258	4,850	**29,098**
	GO1:S	7,808	4,423	9,200	4,286	**25,717**
	ST5:U	14,927	9,113	13,430	7,494	**44,964**
	ST3:R	14,025	9,089	13,399	7,302	**43,815**

Table 30. LCC HSR Alternative 40 Year Headline Summary (MnNOK Q4 2011 prices, undiscounted)

Corridor	Alternative	Life Cycle Replacement Costs	Life Cycle Maintenance Costs	Life Cycle Operating Costs	On Costs	Total
North	**G3:Y**	56,010	15,899	24,655	19,313	**115,877**
	Ø2:P	45,588	15,485	21,746	16,564	**99,382**
West	**N1:Q**	47,412	12,009	19,929	15,870	**95,221**
	HA2:P	46,612	12,288	17,068	15,194	**91,161**
	H1:P	74,504	17,640	43,723	27,174	**163,041**
	BS1:P	34,346	7,952	11,751	10,810	**64,859**
South	**S8:Q**	65,261	15,814	29,806	22,176	**133,057**
	S2:P	65,965	15,435	25,814	21,443	**128,657**
East	**GO3:Q**	19,761	6,895	19,613	9,254	**55,524**
	GO1:S	19,940	7,079	14,719	8,348	**50,086**
	ST5:U	40,571	14,588	21,489	15,330	**91,977**
	ST3:R	37,157	14,550	21,438	14,629	**87,773**

Tables 31 and 32 below provide a more comprehensive breakdown of the LCCs over the 25 and 40 year periods respectively.

Table 31. HSR Alternatives 25 Year Life Cycle Cost Report (MnNOK, Q4 2011 prices, undiscounted)

25 Year Full Appraisals Life Cycle Cost Estimate Breakdown		Northern		Western				Southern		Eastern			
		G3:Y	O2:P	N1:Q	Ha2:P	H1:P	BS1:P	S8:Q	S2:P	GO3:Q	GO1:S	ST5:U	ST3:R
Life Cycle Replacement Costs													
Signalling & Telecoms		1,925	1,742	1,472	1,585	2,241	1,062	1,833	1,876	866	853	1,915	1,872
Electrification & Plant		149	139	120	128	172	90	142	147	77	80	155	152
Track		7,756	7,004	5,805	6,298	9,079	3,936	7,371	7,613	3,120	3,312	7,407	7,289
Operational Property		532	355	469	332	532	377	820	665	410	177	235	237
Structures		7,888	5,315	6,538	6,043	11,245	4,909	9,280	9,719	1,513	1,717	2,779	2,049
General Civils		159	218	126	210	150	106	106	55	133	104	368	338
Depots		1,564	1,564	1,564	1,564	2,346	1,564	1,564	1,564	1,564	1,564	2,069	2,088
Sub-Total A NOK 000,000		**19,973**	**16,337**	**16,093**	**16,161**	**25,764**	**12,043**	**21,117**	**21,639**	**7,682**	**7,808**	**14,927**	**14,025**
Life Cycle Maintenance Costs													
Signalling & Telecoms		2,209	2,202	1,839	1,845	2,574	1,121	2,204	2,208	1,112	1,114	2,208	2,205
Electrification & Plant		810	699	646	669	955	420	790	805	385	393	803	794
Track		5,331	5,202	3,657	3,872	5,694	2,444	5,311	5,049	2,032	2,133	4,678	4,669
Civil Engineering Works		514	503	483	414	537	298	506	512	284	288	357	353
Mechanical		955	955	765	765	1,147	574	955	955	383	383	955	955
Maintenance Overheads		112	112	112	112	112	112	112	112	112	112	112	112
Sub-Total B NOK 000,000		**9,932**	**9,674**	**7,502**	**7,676**	**11,019**	**4,968**	**9,879**	**9,642**	**4,308**	**4,423**	**9,113**	**9,089**
Life Cycle Operating Costs													
Organisation Management		365	365	365	365	365	365	365	365	365	365	365	365
Operational Management		122	122	122	122	122	122	122	122	122	122	103	103
Operational Staff	- Cleaning Staff	400	400	300	275	425	275	575	475	300	300	275	275
	- Train Staff (OBS)	4,834	4,143	4,143	3,453	10,358	2,762	5,524	4,834	4,143	2,762	4,834	4,834
	- Station Staff	2,429	2,148	1,354	981	1,728	1,027	3,970	3,036	1,588	1,354	747	747
Exterior Train Cleaning	- Train Washer	3	3	3	2	7	2	3	3	3	2	3	3
	- Shunt Driver	133	133	133	133	200	133	133	133	133	133	183	183
Energy Consumption	- Infrastructure	179	179	120	90	120	60	329	239	90	90	0	0
	- Traction Rolling Stock	1,184	1,057	875	927	2,392	347	1,126	1,167	474	471	1,159	1,127
Cost Of Sale		0	0	0	0	0	0	0	0	0	0	0	0
Rolling Stock Leasing Costs		5,760	5,040	5,040	4,320	11,610	2,250	6,480	5,760	5,040	3,600	5,760	5,760
Sub - Total C NOK 000,000		**15,409**	**13,591**	**12,456**	**10,668**	**27,327**	**7,344**	**18,629**	**16,134**	**12,258**	**9,200**	**13,430**	**13,399**
Total Life Cycle Cost Estimate excl. on-costs (A+B+C)	**NOK 000,000**	**45,315**	**39,602**	**36,051**	**34,504**	**64,110**	**24,355**	**49,625**	**47,415**	**24,249**	**21,430**	**37,470**	**36,512**
On Costs													
Risk/Contingency @ 20%		9,063	7,920	7,210	6,901	12,822	4,871	9,925	9,483	4,850	4,286	7,494	7,302
Sub - Total D NOK 000,000		**9,063**	**7,920**	**7,210**	**6,901**	**12,822**	**4,871**	**9,925**	**9,483**	**4,850**	**4,286**	**7,494**	**7,302**
Total Life Cycle Cost Estimate incl. on-costs	**NOK 000,000**	**54,378**	**47,522**	**43,262**	**41,405**	**76,932**	**29,226**	**59,550**	**56,898**	**29,098**	**25,717**	**44,964**	**43,815**
Average Cost per annum	***NOK 000,000***	2,175	1,901	1,730	1,656	3,077	1,169	2,382	2,276	1,164	1,029	1,799	1,753

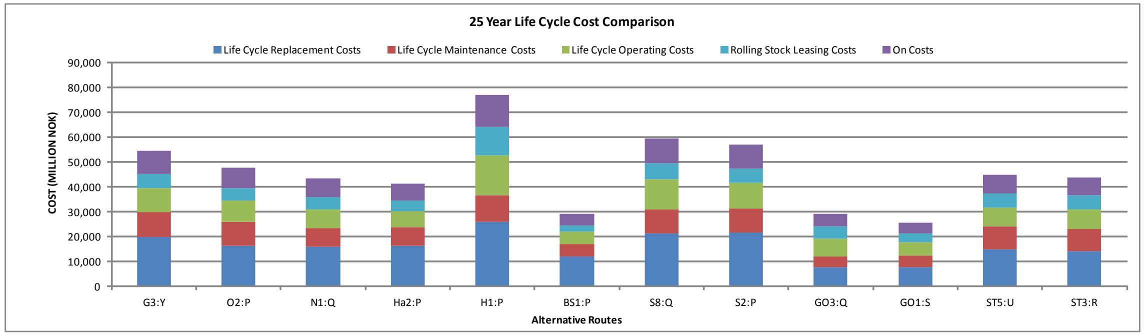
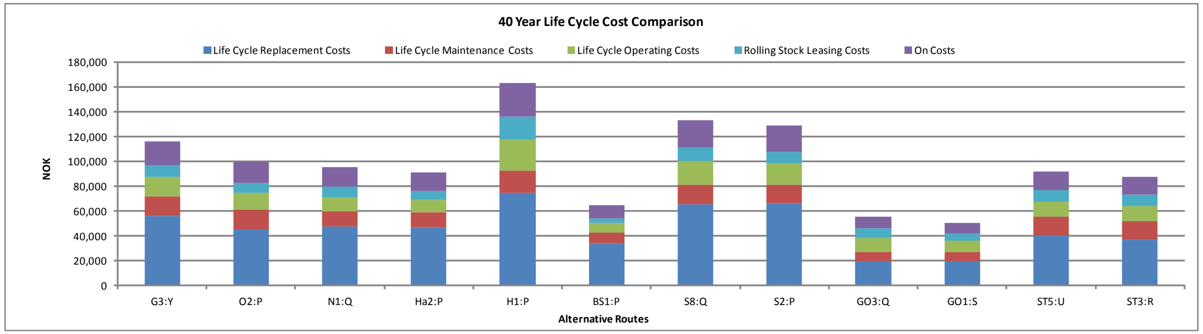


Table 32. HSR Alternatives 40 Year Life Cycle Cost Report (MnNOK, Q4 2011 prices, undiscounted)

40 Year Full Appraisals Life Cycle Cost Estimate Breakdown		Northern		Western				Southern		Eastern			
		G3:Y	O2:P	N1:Q	Ha2:P	H1:P	BS1:P	S8:Q	S2:P	GO3:Q	GO1:S	ST5:U	ST3:R
Life Cycle Replacement Costs													
Signalling & Telecoms		5,064	4,485	3,843	4,097	5,883	2,756	4,818	5,080	2,127	2,225	4,759	4,681
Electrification & Plant		6,936	6,375	5,305	5,788	8,333	3,114	6,815	6,888	3,031	3,132	6,922	6,838
Track		12,267	11,360	9,245	10,157	14,375	6,253	11,743	11,658	5,289	5,318	12,415	12,173
Operational Property		1,300	866	1,146	812	1,300	921	2,004	1,624	1,002	433	573	578
Structures		27,464	19,385	24,911	22,561	40,344	18,346	37,012	37,945	5,410	5,898	11,324	8,369
General Civils		419	556	401	635	428	396	309	208	341	372	1,188	1,098
Depots		2,561	2,561	2,561	2,561	3,842	2,561	2,561	2,561	2,561	2,561	3,389	3,420
Sub-Total A NOK 000,000		**56,010**	**45,588**	**47,412**	**46,612**	**74,504**	**34,346**	**65,261**	**65,965**	**19,761**	**19,940**	**40,571**	**37,157**
Life Cycle Maintenance Costs													
Signalling & Telecoms		3,534	3,522	2,942	2,952	4,118	1,792	3,526	3,532	1,778	1,781	3,531	3,528
Electrification & Plant		1,296	1,118	1,033	1,069	1,527	671	1,263	1,288	616	629	1,284	1,270
Track		8,537	8,329	5,856	6,200	9,119	3,913	8,504	8,086	3,253	3,415	7,492	7,477
Civil Engineering Works		825	808	775	664	863	478	813	822	456	461	574	568
Mechanical		1,528	1,528	1,223	1,223	1,834	918	1,528	1,528	613	613	1,528	1,528
Maintenance Overheads		179	179	179	179	179	179	179	179	179	179	179	179
Sub-Total B NOK 000,000		**15,899**	**15,485**	**12,009**	**12,288**	**17,640**	**7,952**	**15,814**	**15,435**	**6,895**	**7,079**	**14,588**	**14,550**
Life Cycle Operating Costs													
Organisation Management		584	584	584	584	584	584	584	584	584	584	584	584
Operational Management		195	195	195	195	195	195	195	195	195	195	165	165
Operational Staff	- Cleaning Staff	641	641	480	440	681	440	921	761	480	480	440	440
	- Train Staff (OBS)	7,734	6,629	6,629	5,524	16,573	4,420	8,839	7,734	6,629	4,420	7,734	7,734
	- Station Staff	3,886	3,437	2,167	1,569	2,765	1,644	6,352	4,857	2,541	2,167	1,196	1,196
Exterior Train Cleaning	- Train Washer	5	4	4	3	10	3	5	5	4	3	5	5
	- Shunt Driver	214	214	214	214	320	214	214	214	214	214	294	294
Energy Consumption	- Infrastructure	287	287	191	143	191	96	526	383	143	143	0	0
	- Traction Rolling Stock	1,894	1,691	1,400	1,482	3,827	556	1,802	1,866	759	753	1,854	1,804
Cost Of Sale		0	0	0	0	0	0	0	0	0	0	0	0
Rolling Stock Leasing Costs		9,216	8,064	8,064	6,912	18,576	3,600	10,368	9,216	8,064	5,760	9,216	9,216
Sub - Total C NOK 000,000		**24,655**	**21,746**	**19,929**	**17,068**	**43,723**	**11,751**	**29,806**	**25,814**	**19,613**	**14,719**	**21,489**	**21,438**
Total Life Cycle Cost Estimate excl. on-costs (A+B+C)	**NOK 000,000**	**96,564**	**82,819**	**79,351**	**75,968**	**135,868**	**54,049**	**110,880**	**107,214**	**46,270**	**41,738**	**76,648**	**73,144**
On Costs													
Risk/Contingency @ 20%		19,313	16,564	15,870	15,194	27,174	10,810	22,176	21,443	9,254	8,348	15,330	14,629
Sub - Total D NOK 000,000		**19,313**	**16,564**	**15,870**	**15,194**	**27,174**	**10,810**	**22,176**	**21,443**	**9,254**	**8,348**	**15,330**	**14,629**
Total Life Cycle Cost Estimate incl. on-costs	**NOK 000,000**	**115,877**	**99,382**	**95,221**	**91,161**	**163,041**	**64,859**	**133,057**	**128,657**	**55,524**	**50,086**	**91,977**	**87,773**
Average Cost per annum	***NOK 000,000***	2,897	2,485	2,381	2,279	4,076	1,621	3,326	3,216	1,388	1,252	2,299	2,194



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6.4. Risk and Uncertainty

6.4.1. Overview

All projects carry an element of risk and this is reflected in the contingency allowances added. The extent of risk depends on the level/stage of study which is managed throughout the project life.

The primary objective in managing project risk is to identify, understand and then remove completely all risks, if it is possible to do so. Where this is not possible they should be reduced and stakeholders informed of the level of residual risk.

Several studies have indicated that project cost estimates tend to underestimate costs and delivery times and overestimate benefits and revenue streams. This is usually due to biases unwittingly inherent in any project’s early development, and risks and uncertainties that materialise in the course of the project.

Three main stages in the life of a transport project have been identified which give an indication of the quality of risk assessment and cost estimate typical of schemes at the different stages of scheme development. The three stages are:

- Stage 1 – Pre Feasibility – minimal ability to undertake detailed risk assessment due to limited information;
- Stage 2 – Alternative Selection – qualitative/ pseudo Quantified Risk Assessment (QRA) can be undertaken; and
- Stage 3 – Design development – quantified risk assessment is possible.

Most scheme promoters expect a project to provide evidence that they have adopted a systematic approach to risk management. This is in essence a structured approach to identifying, assessing, and responding to risks that occur during a project. In order to adjust the base cost for the risks associated with any project, a QRA is normally conducted.

In this instance risk has been “assessed” at a high level for capital cost only. A Quantitative Cost Risk Assessment (QCRA) was undertaken for each corridor and the results interpolated to a risk contingency value. This value has been included within the capital cost estimate

Reference is also made to the consideration of influences outside the project confines but which may have an effect on the total project out turn costs. In the UK this is known as Optimism Bias

From the rate compilation and comparison exercises undertaken so far, it is clear that there exists the potential for a considerable range of costs dependant on the design proposals which are ultimately developed. During the preparation of this estimate, in conjunction with the Alignment engineers, a considered view has been taken as to the most suitable cost within this range, weighted in line with the anticipated scheme specification and characteristics identified from the development work undertaken to date.

Because of this and the nature of the supporting information and level of development of the Capital Cost estimates presented to date, the estimates should currently be regarded as having an average tolerance of no better than +30 to -10%, although individual elements of the estimate may better or exceed this.

As better data becomes available, a more sensitive estimating tolerance exercise should be undertaken.

6.1 Risk Assessment Methodology

The risk allowance figures for each section were determined by assessing and combining:

- route specific risks;
- pricing risk, and;
- design risks.

6.4.2. Route Specific Risks

Route specific risks were established following a series of risk workshops held in Norway, to analyse the Northern, Eastern, Southern and Western Corridors. During these workshops, attendees were guided through the process of identifying appropriate risks and assessing them in terms of likelihood of occurrence. A few risks were then quantified in terms of their impact by the Alignment Engineers whilst all remaining risks were quantified post-workshop by the Faithful+Gould cost consultants in the United Kingdom.

This information, captured in the risk register for each route, then enabled a Quantitative Cost Risk Analysis (QCRA). This was used to determine the level or risk allowance attributable to varying levels of confidence. Faithful+Gould have reported the P80 risk allowance figures which correspond to an 80% confidence that the allowance is sufficient for the risks captured in the risk register.

6.4.3. Pricing Risks

A 5% pricing risk allowance has been applied.

6.4.4. Design Risks

A 12.5% design risk allowance has been applied to the Eastern and Western Corridors with a 10% design risk allowance to the Northern and Southern Corridors.

6.5. Optimism Bias (OB)

6.5.1. Overview

The use of Optimism Bias (OB) is best practice in the United Kingdom. It is applied during the economic appraisal of any public sector capital spend project. OB relates mainly to changes of project scope which increase costs between the Outline Business Case and the Final Business Case. It also addresses any post-contract risks that are not covered by design contingencies or a quantified risk analysis. It allows for changes to national policy, changes in how services are to be delivered and design development, and is assessed by considering a number of contributing factors within the following categories:

- Procurement;
- Project Specific;
- Client Specific;
- Environment, and
- External Influences.

Faithful+Gould has identified the appropriate levels of OB that could be applied to the Anticipated Final Capital Cost for each corridor. This has involved an assessment of the extent to which contributory factors to recommended OB values have been mitigated. The resultant OB values for Norway HSR Alternatives are as follows:

- 42% for the Northern Corridor.
- 41% for the Western Corridor,
- 42% for the Southern Corridor and
- 40% for the Eastern Corridor.

It is recognised that it is not standard practice or guidance for Economic and Financial Appraisals in Norway to apply Optimism Bias and consequently, the values identified and their potential implications for costs used in HSR appraisal are provided for information only at this stage. Optimism Bias has not been applied in the Economic and Financial Appraisal results presented in Chapter 7 of this report.

6.6. Risk and uncertainty outputs and resultant Anticipated Final Costs

Table 33 below presents a summary of the risk and uncertainty outputs prepared by F+G and their implications for the Anticipated Final Cost (AFC) of the HSR Alternatives considered.

Table 33. Application of risk and OB to HSR Alternative Capital Costs (MnNOK Q4 2011 prices, undiscounted)

	MNoK							
	Base Cost BC	Pricing Risk Allowance (5%) A	Design Risk Allowance B	QCRA (P80) C	Total Risk Allowance (%) (A+B+C) / BC	**Anticipated Final Costs (AFC)** **BC+A+B+C**	Optimism Bias (OB)	**AFC + OB**
HSR Options								
Northern Corridor								
G3:Y	156,378	7,819	15,638	5,657	19%	**185,493**	77,907	**263,399**
O2:P	121,580	6,079	12,158	5,539	20%	**145,356**	61,049	**206,405**
Western Corridor								
N1:Q	131,041	6,552	16,380	4,919	21%	**158,893**	65,925	**226,717**
Ha2:P	131,604	6,580	16,451	13,366	28%	**168,000**	68,499	**235,569**
H1:P	218,196	10,910	27,274	5,669	20%	**262,049**	107,440	**369,489**
BS1:P	94,345	4,717	11,793	3,852	22%	**114,708**	47,030	**161,738**
Southern Corridor								
S8:Q	185,683	9,284	18,568	5,343	18%	**218,878**	91,929	**310,807**
S2:P	189,003	9,450	18,900	4,706	17%	**222,059**	93,265	**315,324**
Eastern Corridor								
GO3:Q	51,458	2,573	6,432	5,855	29%	**66,319**	26,528	**92,846**
GO1:S	54,734	2,737	6,842	4,709	26%	**69,022**	27,609	**96,631**
ST5:U	106,617	5,331	13,327	4,052	21%	**129,327**	51,731	**181,057**
ST3:R	93,203	4,660	11,650	4,723	23%	**114,236**	45,695	**159,931**

6.7. Summary and Conclusions

Capital and Life Cycle Costs (LCCs) are both largely driven by route characteristics and resultant design requirements. In the case of LCCs, the service assumptions also have a significant bearing given that rolling stock costs are also a key driver.

Overall, Capital costs, inclusive of risk, fall in the range of 66 BnNOK to 262 BnNOK – with costs per km being shown to fall within the benchmarked range for HSR projects in Europe.

The extent of tunnelling and the need for major structures has a very large bearing on final costs. Each of the corridors for which HSR Alternatives are being considered have differing characteristics, though all present challenges.

North corridor alternatives exhibit long route lengths and feature significant environmental consideration such as National Parks. Extensive use of tunnels is a key feature. The West corridor exhibits similar characteristics to the North to some degree though topography is perhaps even more challenging and requires a number of very large structures (bridges and tunnels). Route lengths between Oslo-Bergen/Stavanger are long and also contribute to higher costs. The South corridor alternatives introduce particular challenges of waterway crossings resulting in the need for a large number of special structures. In addition, on the route via Vestfold, the number of new stations is greater than for other alternatives. Finally, in the South corridor the topography is generally less challenging as is the requirement for entirely new rail alignments. East corridor alternatives exhibit the greatest proportion of upgrade to existing lines rather than new HSR lines. These factors result in less costly HSR Alternatives in the East.

The LCC comparison for HSR Alternatives is consistent with the capital cost estimates reflecting the fact that a significant component of LCC is related to the infrastructure assets. H1:P in the West corridor is consequently the most costly alternative at 77 BnNOK over 25 years, which also reflects the high train service related costs, including rolling stock, for this alternative where three services are utilising the infrastructure. The Gothenburg alternatives in the East corridor are the lowest cost alternatives in the region of 25-30 BnNOK over 25 years.

With respect to risk, alternatives fall within the overall risk range of 17% to 29%. The East Alternatives are less certain with respect to design as a consequence of the relative lack of design development on the Swedish side of the border coupled with, in the case of Gothenburg, particular interface issues with Inter-City rail infrastructure and the urban fabric. This is reflected in relatively higher risk values. The Hallingdal (HA2:P) alignment in the West is also a particularly challenging and risky alignment. The South corridor alternatives are deemed to represent the lowest level of risk.

The estimation and assessment of investment costs for HSR Alternatives can be considered robust for comparative consideration of alternatives for this stage of study and reflective of available data and stage of design development. Subsequent design development would enable estimation and assessment of investment costs to progress towards greater confidence on absolute costs of alternatives, albeit requiring the support of more detailed assessment and quantification of risk.

Table 34. HSR Alternatives – Summary of Total Costs (MnNOK Q4 2011 prices, undiscounted)

	MnNOK				
Corridor & HSR Alternative	**Base Cost**	**Price, Design and Development Risk**	**Anticipated Final Cost (AFC)**	**Total Life Cycle 25 Year Cost Estimate incl. on-costs**	**Total Life Cycle 40 Year Cost Estimate incl. on-costs**
North Corridor					
G3:Y	**156,378**	**29,114**	**185,493**	**54,378**	**115,877**
Ø2:P	**121,580**	**23,776**	**145,356**	**47,522**	**99,382**
West Corridor					
N1:Q	**132,731**	**28,211**	**160,942**	**43,262**	**95,221**
HA2:P	**130,875**	**36,195**	**167,070**	**41,405**	**91,161**
H1:P	**218,196**	**43,853**	**262,049**	**76,932**	**163,041**
BS1:P	**94,345**	**20,362**	**114,708**	**29,226**	**64,859**
South Corridor					
S8:Q	**185,683**	**33,195**	**218,878**	**59,550**	**133,057**
S2:P	**189,003**	**33,057**	**222,059**	**56,898**	**128,657**
East Corridor					
GO3:Q	**51,458**	**14,860**	**66,319**	**29,098**	**55,524**
GO1:S	**54,734**	**14,287**	**69,022**	**25,717**	**50,086**
ST5:U	**106,617**	**22,710**	**129,327**	**44,964**	**91,977**
ST3:R	**93,203**	**21,033**	**114,236**	**43,815**	**87,773**

7. Economic and Financial Analysis

7.1. Introduction

This chapter draws on the cost and demand forecasting information presented in the previous chapters to provide an economic and financial appraisal of the twelve alternatives described above, along with various sensitivity tests.

Alternative appraisal is intended to consider the relative scale of scheme costs and benefits on a standard basis over an identified lifetime, to allow consistent comparisons between alternatives. Socio-economic appraisal is a form of appraisal that attempts to assess the full impacts of each alternative across society, including effects on transport providers, the public sector, transport users and third parties, such as:

- construction costs (including risk allowances, costs of financing through taxation and an allowance for residual values of assets);
- ongoing maintenance and renewal costs;
- rail service operating costs and revenue;
- journey improvements for users (including journey time savings, changes in fares, improvements in journey quality for passengers and freight users); and
- external effects (in particular the monetary valuation of CO_2 impacts).

The economic appraisal presented in this report focuses on those impacts that can be attributed a monetary value. Other impacts have been considered in other elements of the Phase III work, particularly the reports produced by the alignment engineers (as referenced in Chapter 2).

Financial appraisal takes a more focussed perspective, concentrating on the comparative scale of monetary costs and benefits generated by scheme operation.

For detailed reporting of appraisal methods, assumptions and results summarised in this chapter, reference should be made to the following report:

- ***"Norway HSR Assessment Study Phase III: Economic and Financial Analysis", Final Report, January 2012.***

7.1.1. Standard and Alternative/Extended Assessment Frameworks

The appraisals presented below have been undertaken using both a 'Standard' and an 'Alternative/Extended' assessment framework.

The Standard Framework is consistent with the JBV guidance ("***Metodehåndbok JD 205, Samfunnsokonomiske analyser for jernbanen", versjon 3.0 juli 2011***), meeting the HSR mandate's requirement to apply the Norwegian assessment methodology for the study. The only changes required to enable the alternatives to be assessed were associated with the consideration of HSR as a new transport mode (with different characteristics from existing modes). As the JBV guidance is primarily intended for smaller scale, conventional rail schemes it does not include guidance for the treatment of HSR. In particular it does not include a relevant value of time for the mode or guidance on the treatment of 'new mode' benefits. To overcome the issues raised, HSR and Air were treated as a combined 'fast transport mode' in the Standard Framework. Although no ideal solution exists, this was considered the most appropriate solution given the structure of the demand forecasting model and the responses to the Stated Preference survey.

The Alternative/Extended Framework was developed in Phase II of the study to build on the Standard approach in recognition of the additional requirements for the appraisal of High Speed rail schemes beyond the needs for the appraisal of the smaller, conventional rail schemes typically covered by the JBV guidance. The revisions reflect the likely range of impacts of HSR and an international review of best practice in economic assessment. The key revisions include:

- extension of the assessment period to 40 years from the 25 year period used in the Standard Framework, to capture scheme impacts over a longer time period, in keeping with the scale of the alternatives and in line with international practice;

- application of an uplift for real growth in costs, using a rate of 1.9% above standard inflation until 2025 on the basis of recent trends;
- revised treatment of benefits for the new mode and associated treatment of values of time. A ‘logsum’ approach is used which calculates changes in benefits to transport users directly from the changes in travel costs and patterns in the model, providing consistency between the model and appraisal process. This approach makes use of values of time derived from the Stated Preference survey used to establish the parameters underpinning the model, including a mode specific value of time and values for other modes specific to the choices being faced in relation to decisions over long distance journeys;
- an allowance for fast rail freight impacts, based on an assessment of the impact of introducing 120kph lines on the cost of transporting current freight loads in current economic conditions; and
- an allowance for potential wider economic impacts, using sensitivity tests to provide an illustration of the possible scale of impact, as detailed impacts cannot yet be calculated in the absence of necessary local information.

A number of key assumptions are made in the assessments, drawn from the JBV guidance where possible. Scenario specific assumptions include assuming that the alternatives would all be entirely government funded and financed from tax revenue, that rolling stock would be leased and the system would be managed and operated by the public sector, without a franchise or infrastructure charging regime.

As in the demand forecasting process, it has been assumed that there is no change in the provision of infrastructure or services for other modes.

Construction start date for each alternative was assumed to be 2017 with operations starting between 2022 and 2027, depending on the forecast construction period for each alternative.

Further details on both frameworks and the underlying assumptions are provided in the Final Economic and Financial Appraisal report (“***Norway HSR Assessment Study Phase III: Economic and Financial Analysis”, Final Report, 25 January 2012).***.

7.1.2. Presentation of Results

The following sections present the results of the economic and financial appraisals for the twelve appraisal alternatives, under both PSS1 and PSS2 and for a number of sensitivity tests. Unless otherwise stated, all values are presented in terms of net present values (with a 2015 base), in MnNOK and 2009 prices (in line with JBV guidance).

When interpreting the results it is important to recognise that the study has focussed on undertaking a consistent appraisal to understand the comparative performance of a large number of alternatives across several corridors. The aim is therefore to indicate the level of economic and financial performance that might be delivered by HSR in Norway ‘in principle’, rather than determining the absolute economic and financial performance in detail, which would not be practical at this stage.

Consequently, the alternatives have not yet been optimised for economic or financial return (in terms of issues such as service frequencies and stopping patterns). The assessments therefore provide a basis for the consistent comparison of alternatives, as intended, but there is likely to be significant scope to reduce costs and improve benefits and financial return with more detailed alternative development at a later stage..

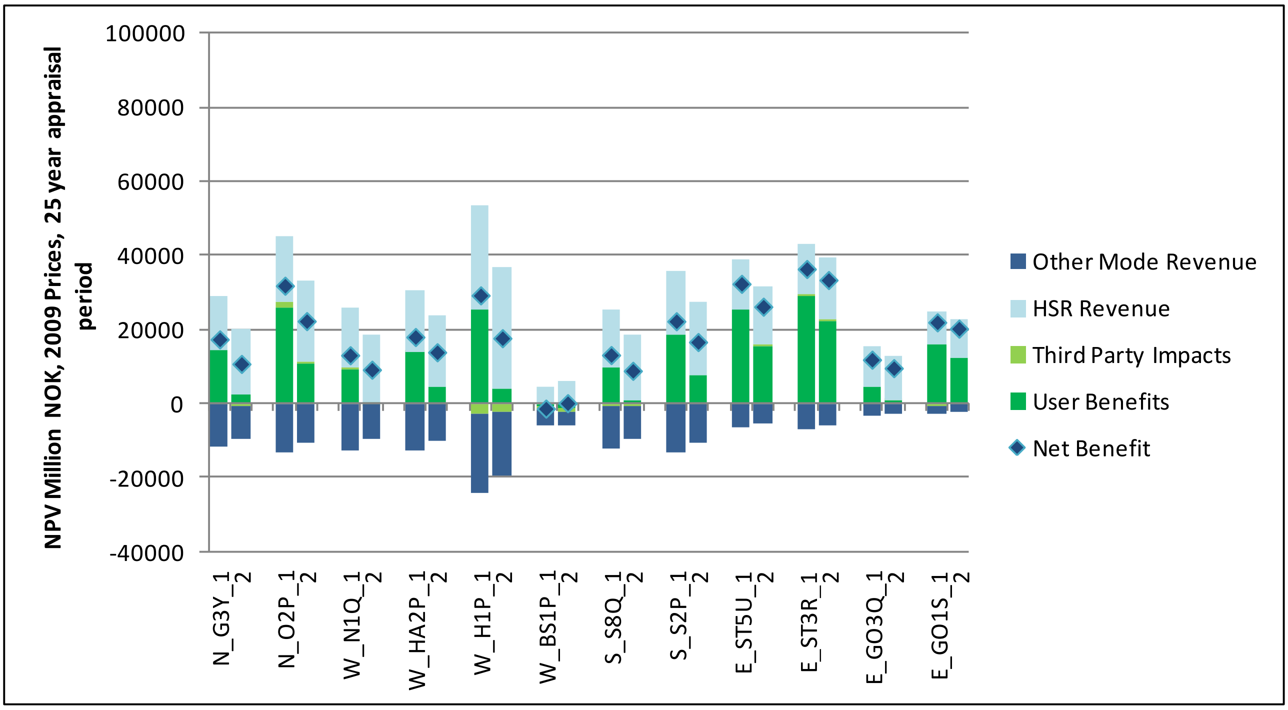
7.2. Economic Appraisal Results

7.2.1. User Benefits, Revenue and Third Party Impacts

The key benefits associated with the introduction of HSR are the improvements in journey alternatives and costs for passengers (including time and quality) and the revenue received by the operator (although this is offset by losses in revenue for other modes as passengers switch away to HSR). Impacts on third parties can be either positive or negative, depending particularly on the scale of impact on CO_2 emissions, as discussed further in the Phase III Climate Impacts Report (***Norwegian High Speed Railway Project, Phase 3, Final report Version 2 - Environmental analysis – Climate, 03.02.2012, Asplan Viak AS, MISA AS***).

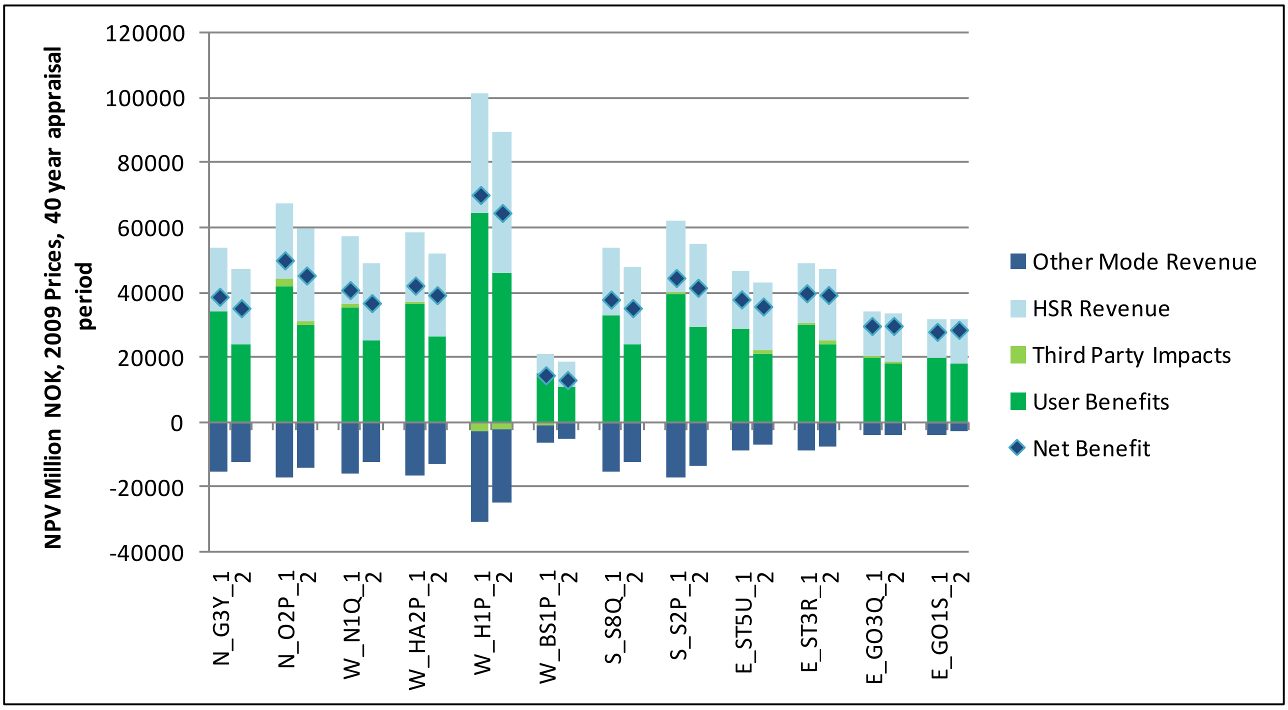
Figures 23 and 24 summarise the scale of these impacts for each alternative under both PSS1 and PSS2, assessed using the Standard and Alternative Frameworks respectively. The ‘Net Benefit’ indicator in each column identifies the net effect of the four other impacts presented for each scenario. The first column for each alternative refers to PSS1 (with peak service and fares at 60% of air fares) and the second to PSS2 (without peak services and with fares at 100% of air fares).

Figure 23. User Benefits, Revenue and Third Party Impacts, Standard Framework (NPV, MnNOK, 2009 prices, 2015 base, 25 year appraisal period)



North	**G3Y**	Oslo – Trondheim (Hamar & Gudbrandsdalen)	**South**	**S8Q**	Oslo – Stavanger (via Vestfold)
	O2P	Oslo – Trondheim (Østerdalen)		**S2P**	Oslo – Stavanger (direct)
West	**N1Q**	Oslo – Bergen (Numedal)	**East**	**ST5U**	Oslo – Stockholm (via Ski)
	Ha2P	Oslo – Bergen (Hallingdal)		**ST3R**	Oslo – Stockholm (via Lillestrøm)
	H1P	Oslo–Bergen (Haukeli)/Oslo–Stavanger/Bergen–Stavanger		**GO3Q**	Oslo – Gothenburg (via Moss)
	BS1P	Bergen – Stavanger (coastal route)		**GO1S**	Oslo – Gothenburg (direct)

Figure 24. User Benefits, Revenue and Third Party Impacts, Alternative Framework (NPV, MnNOK, 2009 prices, 2015 base, 40 year appraisal period)



7.2.2. Comparison of Alternatives and Scenarios

The figures show considerable variation between the alternatives that produce the lowest and highest levels of benefits. The net benefits generated by H1:P are approximately 70 BnNOK (over 40 years in PSS1, Alternative framework) and are therefore nearly five times as large as the 5 BnNOK forecast to be generated by BS1:P. However, H1:P is not directly comparable with the other alternatives as it has a 'Y' shape and serves three routes rather than one.

The net impacts of most of the single route alternatives in the North, West, South and Stockholm East corridors are relatively consistent, with net benefits ranging between just under 40 BnNOK and 50 BnNOK (NPV, 40 years). The Gothenburg corridor net benefits are about 25% lower at just under 30 BnNOK.

In all alternatives, user benefits are the most significant contributors to total benefits. HSR revenue levels are also significant, however, the gains are typically largely offset by reductions in revenue on other modes (particularly air). These losses equate to between 70% and 80% of the HSR revenue gains in PSS1. The higher fares and associated revenue in PSS2 mean that the proportion offset is reduced to around 50% and less for most alternatives, improving the financial performance of the alternatives, as discussed further below. Third party impacts which include contributions to climate change in terms of carbon emissions (positive or negative) are only a marginal contributor to the overall economic appraisal.

The scale of user benefits generated by each alternative depends on both; the scale of door to door journey advantage that HSR offers for the route served compared to the alternatives available (by air, car and/or coach) and the scale of demand on the route. Both of these factors vary significantly between the corridors and alternatives, leading to the variation in benefits seen.

Similarly, levels of revenue generated depend on passenger numbers and fares paid. The patterns and levels of benefits experienced for each alternative therefore are strongly influenced by the patterns of demand described in Chapter 5, with the greatest benefits and revenue seen on the routes with the greatest levels of longer distance demand, such as Ø2:P.

Average benefits experienced per HSR passenger are broadly consistent between alternatives, ranging between 280 and 330 NOK per trips (in 2024, 2009 prices) for most alternatives in PSS1. The Gothenburg alternatives experience lower than average benefits per trip (approximately 220 NOK per trip), reflecting the shorter length of the alternatives and the associated limited scope for journey improvements.

BS1:P delivers the greatest benefit per passenger (360 NOK in PSS1). However, the limited levels of demand identified in Chapter 5 result in limited total levels of user benefits and revenue (the lowest levels across all the alternatives).

Similarly, the relatively limited demand for the alternatives in the East corridor (particularly to Gothenburg), combine with the relatively low benefits per trip to produce low overall levels of total benefit accrued.

The high demand levels for the H1:P alternative mean that it delivers the greatest total benefits. However, this reflects the fact that it is not directly comparable with the other alternatives as it is made up of a Y-network, with two branches and therefore able to serve three routes rather than one, allowing services between several large urban areas (Oslo – Bergen, Oslo – Stavanger and Bergen – Stavanger).

PSS2 reduces user benefits for each alternative by about 30%. This reflects the reduction in journey benefits caused by reduced service frequency and increased fares which reduce the level of demand and reduce the average benefit per passenger by about 5% on average. However, despite the reduced patronage, increased fares lead to revenue levels that are over 15% greater for PSS2 than PSS1 across the alternatives.

7.2.2.1. Comparison of Assessment Frameworks

The results from the Standard and Alternative/Extended Frameworks show similar patterns in terms of the relative performance of the different alternatives. However, there is greater variation between alternatives and between Service Scenarios in the Standard Framework results. The graphs show that this is largely due to variation in user benefits which reflects the differences in the benefit calculation approach in the two frameworks. As described, the Alternative Framework has been devised specifically for this study. It is therefore able draw directly on transport costs as represented in the demand forecasting model when calculating user benefits, making use of the specific form of model used, rather than using the generalised estimates of the relative value of different elements of journey costs (such as waiting and walking) as specified in the Standard Framework (which needs to be applicable for more widespread use).

The use of different journey costs in the modelling and appraisal processes (as in the Standard Framework) can lead to inconsistencies in the travel patterns modelled and appraised, leading to counter intuitive results such as the large variation in user benefits between PSS1 and PSS2 for some alternatives and the presence of slight negative user benefits for alternative BS1:P in Figure 23. These negative impacts cannot be a realistic reflection of the effect of the scheme as it is specified as only bringing improvements to transport users, without generating any losers. It therefore reflects the inconsistencies between the modelling and appraisal approach in the Standard Framework where passengers can choose an alternative that appears cheaper when considered in terms of the costs used in the model but is more expensive when considered in terms of the cost valuations used for appraisal (for instance due to different relative weightings applied to in vehicle time, wait time and access/egress time).

For these reasons, the Alternative Framework is preferred as a means of identifying the impacts of the alternatives and is the main focus for analysis in the remainder of the chapter.

7.2.2.2. Overall Economic Appraisal Results

The overall economic appraisal of each alternative combines the benefits outlined above with the costs of construction, operation, maintenance and renewal (including the cost of financing the scheme through taxation).

Figures 25 and 26 below show the results of the economic appraisal for each alternative under PSS1 and PSS2, using the Standard and Alternative Framework respectively. They follow the same format as the graphs presented above, with the first column for each alternative representing PSS1 and the second representing PSS2. The user benefits and third party impacts shown in Figures 23 and 24 above have been combined in a single entry and the revenue has been combined with the costs of construction and operation to provide a net impact on the public sector. The indicator diamond in each column shows the net impact of all the impacts and equates to the Net Present Value (NPV) of each alternative.

Figure 25. Economic Appraisal Results, Standard Framework (NPV, MnNOK, 2009 prices, 2015 base, 25 year appraisal period)

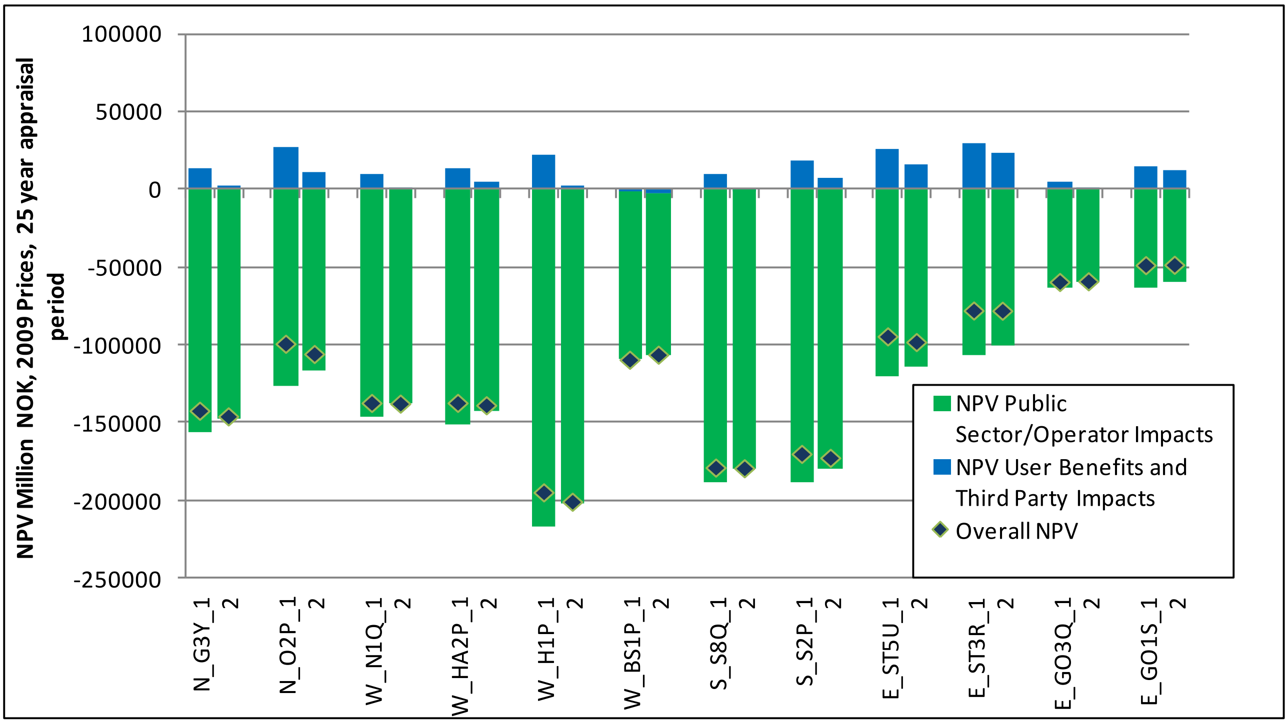
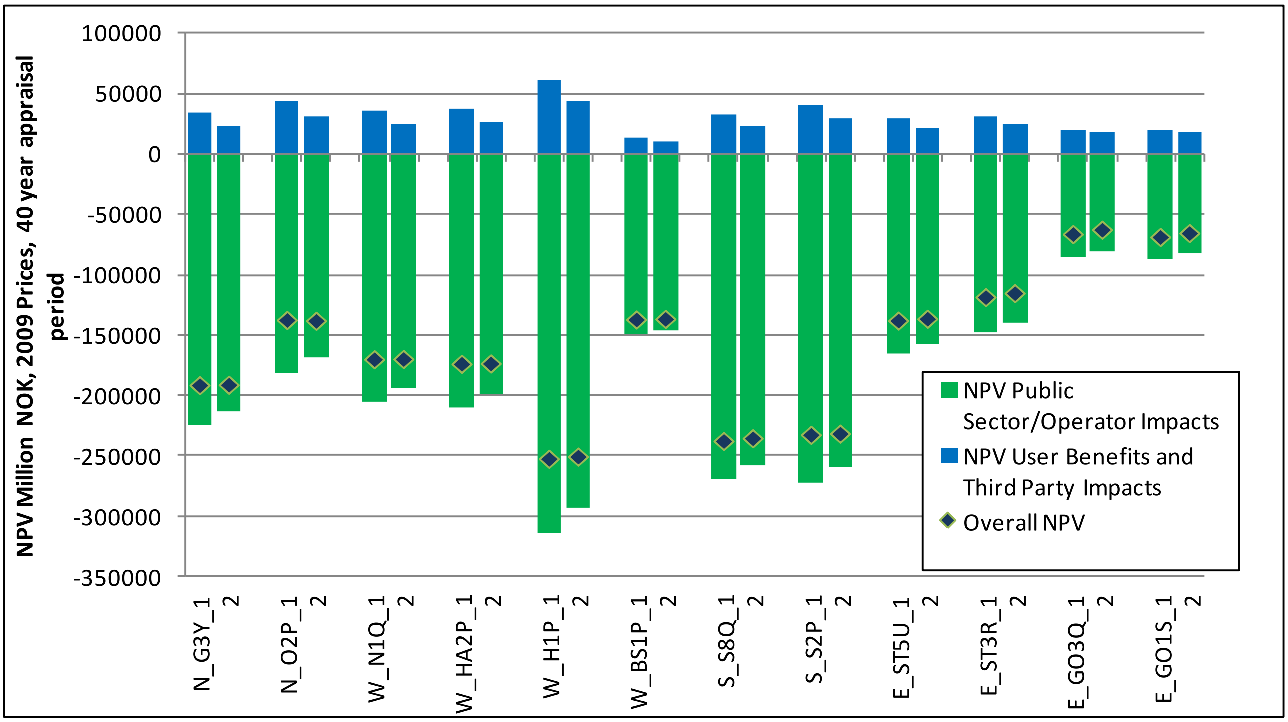


Figure 26. Economic Appraisal Results, Alternative Framework (NPV, MnNOK, 2009 prices, 2015 base, 40 year appraisal period)



Again the patterns of results and relative performance of alternatives are similar for both appraisal frameworks, although the 40 year appraisal period increases the value of both costs and benefits. For the reasons discussed above, analysis will focus on the Alternative Framework.

In all cases the lifetime costs of the alternatives exceed the monetised benefits accrued over the appraisal period. Total costs are typically five to ten times greater than benefits in the Alternative Framework (and over ten times as great in the Standard Framework).

Consequently all alternatives generate a negative NPV, with negative values exceeding -100 BnNOK for all alternatives except those in the East corridor. These net effects reflect the combination of the scale and physical challenge of the alternatives under consideration and the associated substantial construction costs, and the relatively dispersed nature of the population to be served by much of each route.

In line with these factors, H1:P has the largest negative NPV (over 250 BnNOK, 2009 prices), reflecting the fact that it is considerably the longest alternative. Similarly, the relatively small negative NPVs associated with the Gothenburg corridor alternatives (less than 70 BnNOK, NPV 2009 prices) reflect their smaller scale and limited need for structures along the route.

PSS2 reduces both costs and benefits relative to PSS1 by increasing revenue but decreasing user benefits. The two effects virtually offset each other, leading to almost no change in NPV as shown above in Figure 26.

7.2.3. Inter-City (IC) Scenario Results

A key area of sensitivity in the impacts of three of the High Speed alternatives (S8:Q on the South Corridor, G3:Y on the North Corridor and GO3:Q on the East Corridor) is their potential interaction with alternatives to improve Inter-City services on the routes out of Oslo.

These potential Inter-City (IC) improvements are the subject of a separate study, due to report early in 2012 and some results have been shared between the studies as they have progressed in parallel.

The IC interface and its impact on economic and financial appraisal has been examined in two ways:

- Indicatively capturing the additional benefits to IC services of the improvement in capacity and journey times that HSR alternatives could offer, as forecast by the IC Study; and
- Understanding the implications for HSR alternatives of a scenario where the IC project delivers infrastructure that could be used by HSR.

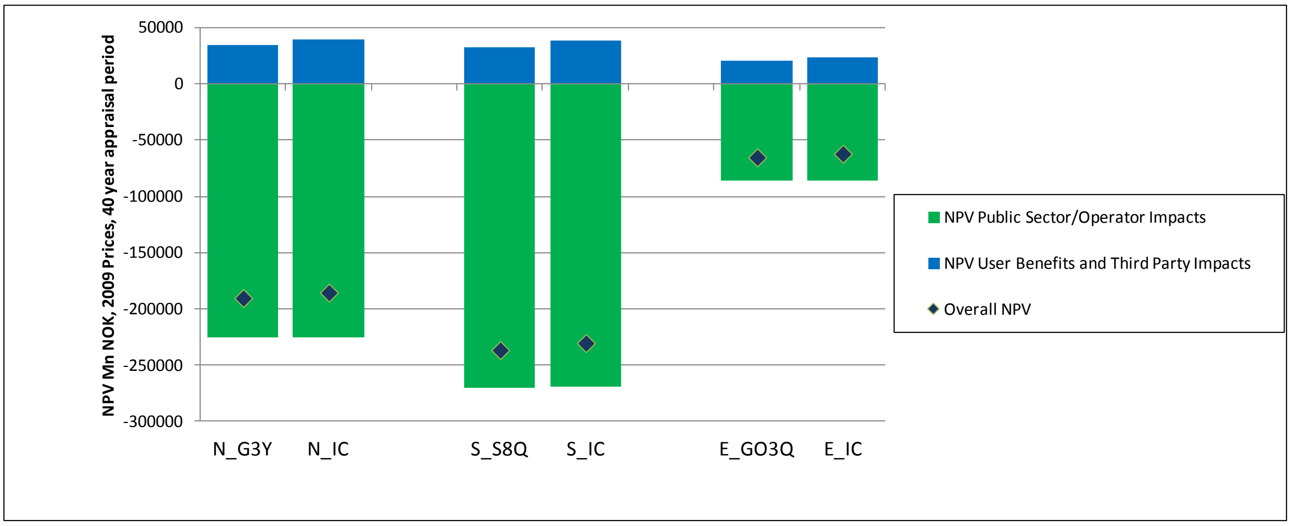
7.2.3.1. Capture of potential additional Inter-City service impacts of HSR infrastructure improvements

Additional Inter-City services could make significant use of the infrastructure provided by the relevant HSR alternatives, adding to the benefits experienced on longer high speed trips as estimated using the forecasting model.

Figure 27 provides an indication of the potential impact of including these benefits on the overall economic appraisal results for the affected HSR alternatives. The estimate included in these figures is based on results provided by the Inter-City study which included estimated annual user benefits and operator impacts for the affected services along the corridors to Halden, Lillehammer and Porsgrunn.

It is noted that these estimates are intended to provide an indication of the potential scale of impact only. They should be treated with caution and not used for detailed comparison as they are based on the combination of results from two separate models with the potential for issues such as overlapping as well as different approaches to modelling and economic appraisal. Finally, the estimated benefits were also provided for the year of 2025 only and so have been converted to approximated benefits across the appraisal period using the JBV economic guidance spreadsheet and default assumptions.

Figure 27. Economic Appraisal Results, Additional Inter-City Trips, Alternative Framework (NPV, MnNOK, 2009 prices, 2015 base, 40 year appraisal period)



The figures indicate that the use of High Speed infrastructure for Inter-City service provision could add significantly to the economic case for the relevant alternative, increasing user benefits by an estimated 15% in each case. Revenue could also be increased, by around 10% in the estimates presented, although about 60% to 80% of the increase is offset by increased operating costs for the additional IC services.

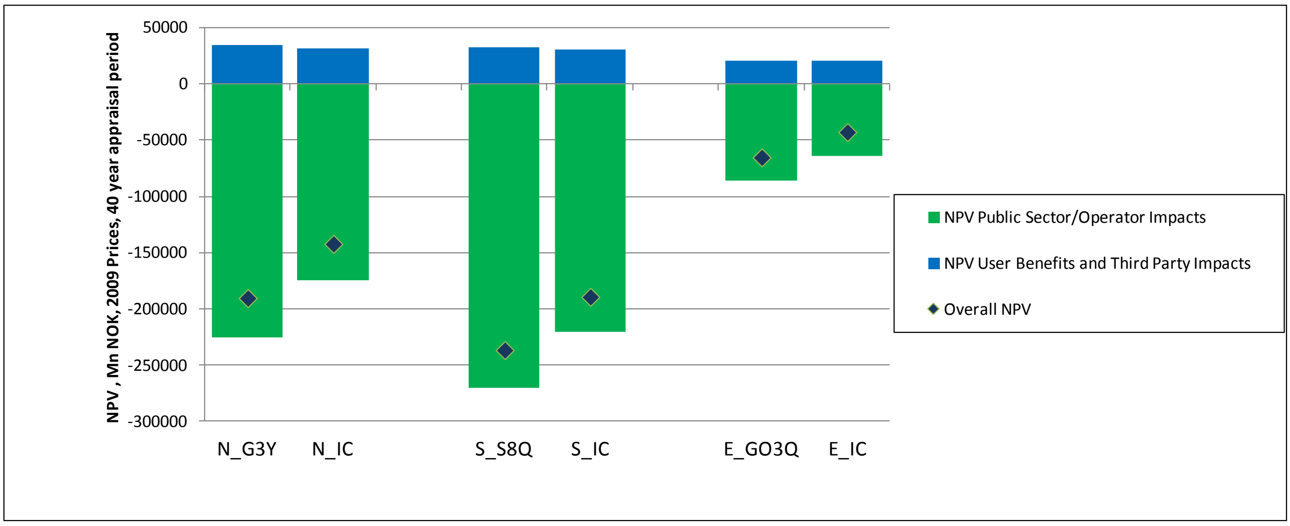
The overall effect of the consideration of additional impacts associated with Inter-City services is to reduce the negative scale of the NPV by the order of 5 BnNOK.

7.2.3.2. Impact of Inter-City Project delivering HSR usable infrastructure in advance

The IC Project could impact on the economic case for HSR Alternatives should it provide infrastructure that HSR services require. This would reduce the construction costs associated with any relevant HSR alternative subsequently commissioned, as some of the necessary infrastructure would already have been put in place. It would also cause a slight delay in construction timetables and may cause a slight reduction in benefits and revenue relative to a route designed specifically for HSR.

Figure 28 below shows the impact of this possible scenario for each relevant alternative, assuming that it delays opening of the HSR alternative by up to 2 years. A reduction of 5% has also been applied to account for possible user benefit and revenue reduction, although analysis using the forecast model suggests that this is a very prudent assumption and the impact is likely to be smaller.

Figure 28. Economic Appraisal Results, Early Inter-City Improvements, Alternative Framework (NPV, MnNOK, 2009 prices, 2015 base, 40 year appraisal period)



The comparisons show that the reductions in cost associated with the separate construction of an Inter-City alternative are significant, reducing the scale of the negative NPV by around 50 BnNOK (2009 NPV) for the North and South alternatives (25% and 20% respectively) and 20 BnNOK for the East alternative (35%).

7.2.4. Economic Appraisal Sensitivity Analysis

A number of sensitivity tests have been undertaken to assess the impact on the economic appraisal results of varying a number of key assumptions and so to provide a better understanding of the key influences on the results.

For simplicity, all sensitivity tests are presented for the Alternative Framework and PSS1 and only for three core tests, identified by JBV:

- G3:Y: Oslo to Trondheim in the North corridor (via Hamar and Gudbrandsdalen);
- HA2:P: Oslo to Bergen in the West corridor, via Hallingdal; and
- S:IC: S8:Q Oslo to Stavanger in the South corridor (via Vestfold) assuming that the Inter-City improvements are implemented before HSR construction.

These tests are taken as representative of the range of alternatives, the scale and nature of impacts of the equivalent sensitivity tests on other alternatives would be similar.

The sensitivity analysis undertaken focussed on the following issues:

- Discount rate – with tests for 2% and 5.5%;
- Assessment period – with tests for 25 and 60 years;
- Optimism bias – with the addition of an allowance (around 40%, but variable by corridor) to reflect the systematic tendency for scheme costs to be underestimated at an early stage;
- Wider economic impacts – with the addition of an indicative allowance to illustrate the potential impact of wider economic impacts (which cannot currently be quantified) should they equate to 15% or 30% of conventional user benefits; and
- Competitive response – a test of the second ‘end point’ of the range of economic impact of the potential responses of operators of other (non HSR) modes to the introduction of HSR. Although competitive response is likely to be significant, it is difficult to identify the possible impact accurately due to the variety and complexity of choices involved. The approach adopted here is therefore to identify the range within which the value of impacts would be likely to fall. The core assessments assume that operators would accept all revenue losses associated with changes in travel behaviour after the introduction of HSR without reducing costs (and therefore without impacting on services for remaining users). This was adopted as a straightforward, internally consistent and transparent assumption. However, it is conservative. The other end point, tested as a sensitivity test, is the hypothetical assumption that the operators are able to take measures to reduce their costs to match their revenue loss without impacting

on the services and costs for remaining passengers (for instance flying smaller planes on the same routes). The economic impact of the actual response is likely to be between these two extremes with a different distribution of impacts between transport users and operators.

Figure 29 shows the impacts on the overall economic appraisal of the discount rate and appraisal period tests. Figure 30 shows the results of the optimism bias, wider impact and competitive response tests.

Figure 29. Economic Appraisal Results for Discount Rate and Appraisal Period Sensitivity Tests, Standard Framework (NPV, MnNOK, 2009 prices, 2015 base, 25, 40 or 60 year appraisal period)

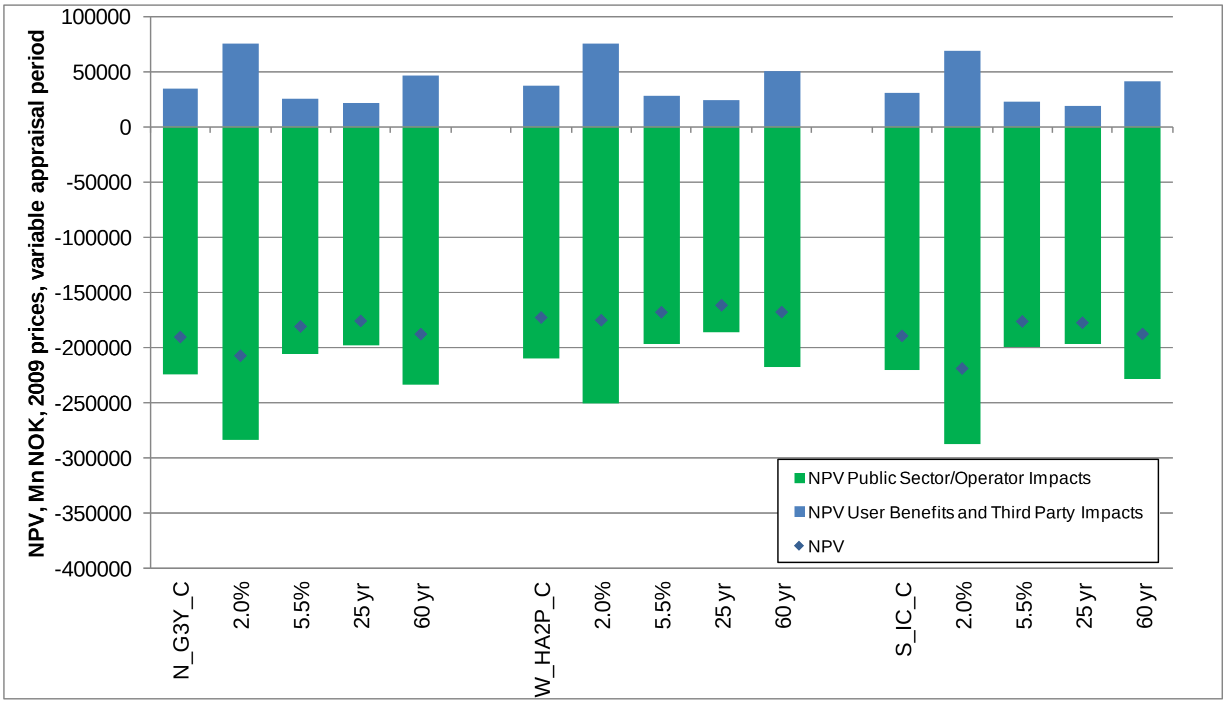
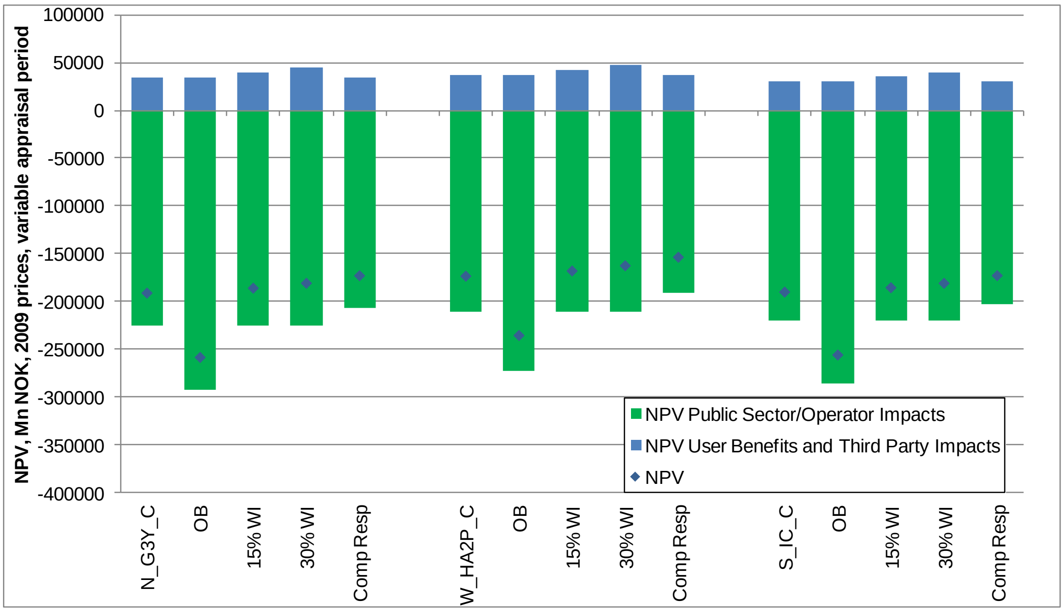


Figure 29 shows that, as expected, reduced discount rates increase both costs and benefits whilst the increased discount rate has the opposite effect. For instance, the use of the 2% rate approximately doubles user benefits and third party impacts but also adds 20% to 30% to the negative public sector impacts. Given the relative scale of the impact, the increased costs more than offset the improvement in user benefits to cause a slight decrease in NPV. The opposing impacts balance more closely for the 5.5% discount rate and the change causes only a limited impact on the overall NPV in all alternatives.

Similarly, the appraisal period tests either reduce or increase both costs and benefits simultaneously. The net effect on NPV is therefore limited, although the 25 year period reduces costs more than benefits in each case, resulting in a slightly less negative NPV in all alternatives.

Figure 30. Economic Appraisal Results for Optimism Bias, Wider Impact and Competitive Response Sensitivity Tests, Alternative Framework (NPV, MnNOK, 2009 prices, 2015 base, 40 year appraisal period)



The optimism bias test only impacts on costs. As they are significantly increased without any offsetting impact on benefits, it leads directly to a significant increase in the scale of the negative NPV in each alternative (of about 35%).

The two wider economic impacts tests increase the value of user benefits and therefore reduce the scale of the negative NPV. However, as the scale of user benefits is relatively limited compared to the overall impacts of the scheme, the net effect on the NPV is also limited.

It should be stressed that these are intended as indicative tests only. As described the ***Phase II Economic and Financial Analysis Report, ("Norway HSR Assessment Study: Contract 6: Financial & Economic Analysis: Subject 4: Economic Analysis": Final Report, February 2011)***, the identification of wider economic benefits is a complex and contested subject and detailed quantification of benefits would be reliant on extensive research into the local economic structures and conditions around the stations served by each route. It is also important to note that the scale of wider impacts achieved would be likely to vary considerably by alternative, reflecting varied economic conditions and structures in the corridors affected.

The competitive response test causes a reduction in the costs of the scheme by assuming that other mode operators are able to make cost savings to offset the revenue loss caused by the introduction of HSR, which in turn removes the need for increased public sector subsidy. This test has the largest positive impact on NPV of all of the sensitivity tests presented, reducing the figure by around 10% in each alternative shown.

As discussed, this test is intended to provide an estimate of the upper bound of the possible positive impact of competitive response on the alternatives' NPVs. The final impact would fall somewhere below 10% for the alternatives shown and would be the net effect of changes in costs, revenues and user benefits on other modes and on HSR, reflecting adjustments to service provision.

For instance, the final equilibrium position is likely to involve a reduction in service on other modes. This would imply that the overall impact would be the net effect of reductions in revenue and costs on the other modes, reductions in user benefits for those currently using those modes (facing a reduced service) and increases in revenue for HSR which would now appear relatively more attractive than the other modes, attracting more passengers. One implication of this would be improved financial performance for HSR relative to the core assessments presented in the next Chapter

7.2.5. Economic Appraisal Conclusions

The economic analysis presented has confirmed that the use of the Alternative Framework better captures and represents the behavioural response and associated benefits of introducing HSR services than the Standard Framework, as intended. It is therefore recommended that the Alternative Framework be adopted as the primary basis for assessment looking forward.

Examining the economic performance of the HSR alternatives themselves, it is apparent that a number of alternatives have the potential to generate significant user benefits and revenue, particularly those providing significant time savings on long distance routes with relatively high levels of demand. PV of User benefits over 40 years range from 20 BnNOK to nearly 70 BnNOK (2009 prices, Alternative Framework, PSS1),

However, each alternative (particularly the long distance ones identified) involves significant and challenging construction work which, as presented in Chapter 6, will be costly. Consequently, monetised benefits do not offset costs across the appraisal time period for any of the alternatives considered and each one generates a significant negative NPV, with these over a 40 year appraisal period ranging from -66 BnNOK to -252 BnNOK (2009 prices, Alternative Framework, PSS1).

Sensitivity analysis indicates some areas in which changes would improve the balance between costs and benefits, such as the consideration of additional benefits (wider economic impacts or interactions with Inter-City improvements) and an alternative view on competitive response. However, costs continue to significantly exceed benefits for each of the alternatives, even with more optimistic assumptions in these areas.

These findings on overall economic performance reflect the relatively small scale of market available in Norway from which benefits and additional net revenue can be derived relative to the overall high investment costs. These costs are commensurate with the delivery of HSR schemes elsewhere aimed at serving more sizable populations and densities. The market is also relatively well served by existing modes (particularly air), limiting the benefits generated by the implementation of HSR. Consequently, the resulting negative NPVs are to be expected.

It is noted that consequential impacts of introducing HSR have not been examined in detail at this stage and that the equilibrium transport network and offer after the implementation of HSR is still to be determined. This could improve the case for HSR. However the sensitivity test on the possible range of impact of competitive response presented above shows that it would not alter the overall negative economic NPV position, given the scale of investment costs.

However, the results presented in the economic appraisal do suggest that there might be scope for HSR Alternatives to more than offset the ongoing costs of maintaining and operating infrastructure and services if the up-front capital investment costs are excluded. Examining this issue is the focus of the Financial Appraisal presented in the next section.

Tables 35 and 36 set out the headline economic results in more detail for each alternative under PSS1 and PSS2 and using the Standard and Alternative Appraisal Frameworks respectively.

Table 35. Economic Appraisal Results by Alternative for PSS1 and PSS2, Standard Framework, (NPV, MnNOK, 2009 prices, 25 year appraisal period)

	North		West				South		East			
	G3Y	**O2P**	**N1Q**	**HA2P**	**H1P**	**BS1P**	**S8Q**	**S2P**	**ST5U**	**ST3R**	**GO3Q**	**GO1S**
1) PSS1												
a) User Benefits	14,182	26,065	9,328	13,805	25,323	- 977	9,750	18,725	25,451	29,132	4,553	16,005
b) Third Party Effects	- 266	1,370	261	227	- 2,575	- 835	- 506	- 68	- 65	263	- 1	- 689
c) Net Public Sector/Op. Effects	- 156,080	- 126,551	- 146,759	- 151,153	- 217,400	- 107,575	- 187,962	- 188,589	- 119,739	- 107,135	- 63,928	- 63,860
d) NPV (a+b+c)	***- 142,165***	***- 99,116***	***- 137,170***	***- 137,120***	***- 194,652***	***- 109,386***	***- 178,718***	***- 169,933***	***- 94,353***	***- 77,740***	***- 59,376***	***- 48,544***
e) Costs *(included in b)*												
Construction/Renewals	- 119,695	- 95,536	- 112,491	- 116,993	- 169,624	- 81,739	- 145,176	- 147,207	- 89,144	- 78,807	- 48,100	- 50,142
Operating/Maintenance	13,008	12,709	11,870	11,142	19,862	7,270	14,991	13,911	12,644	12,562	9,566	8,072
Cost of Taxation	- 28,224	- 21,935	- 26,707	- 27,067	- 38,948	- 19,899	- 33,980	- 33,800	- 18,674	- 16,082	- 11,098	- 10,469
f) Revenue *(included in b)*												
HSR	15,060	17,551	16,038	16,703	28,087	4,735	15,778	16,948	13,590	13,813	10,694	9,050
Other	- 11,573	- 13,097	- 12,515	- 12,699	- 21,549	- 4,222	- 11,853	- 13,311	- 6,583	- 6,802	- 3,331	- 2,362
2) PSS2												
a) User Benefits	2,579	10,823	498	4,341	4,039	- 1,438	602	7,663	15,370	22,235	625	12,257
b) Third Party Effects	- 655	828	- 227	- 148	- 2,341	- 94	- 63	- 415	340	620	430	- 369
c) Net Public Sector/Op. Effects	- 147,722	- 117,154	- 137,868	- 142,844	- 202,373	- 104,080	- 179,010	- 179,702	- 113,756	- 100,735	- 59,999	- 60,230
d) NPV (a+b+c)	***- 145,798***	***- 105,503***	***- 137,598***	***- 138,651***	***- 200,675***	***- 105,612***	***- 178,471***	***- 172,454***	***- 98,046***	***- 77,879***	***- 58,944***	***- 48,342***
e) Costs *(included in b)*												
Construction/Renewals	- 119,695	- 95,536	- 112,491	- 116,993	- 169,624	- 81,739	- 145,176	- 147,207	- 89,144	- 78,807	- 48,100	- 50,142
Operating/Maintenance	11,208	10,901	9,799	9,801	16,105	6,123	12,442	12,032	10,555	10,486	7,295	6,579
Cost of Taxation	- 27,280	- 21,003	- 25,549	- 26,036	- 37,468	- 19,304	- 32,917	- 32,816	- 18,371	- 15,417	- 10,708	- 10,110
f) Revenue *(included in b)*												
HSR	17,732	21,482	18,199	19,497	32,970	5,853	17,927	19,707	16,087	16,394	11,611	10,532
Other	- 8,885	- 10,617	- 9,262	- 9,770	- 16,951	- 3,634	- 8,879	- 10,281	- 5,589	- 5,824	- 3,038	- 2,125

Table 36. Economic Appraisal Results by Alternative for PSS1 and PSS2, Alternative Framework, (NPV, MnNOK, 2009 prices, 40 year appraisal period)

	North		West				South		East			
	G3Y	**O2P**	**N1Q**	**HA2P**	**H1P**	**BS1P**	**S8Q**	**S2P**	**ST5U**	**ST3R**	**GO3Q**	**GO1S**
1) PSS1												
a) User Benefits	34,255	41,896	35,525	36,307	64,619	14,765	33,051	39,483	28,620	30,027	19,921	20,006
(Av. user benefit/HSR trip, NOK)	*285*	*332*	*284*	*321*	*327*	*363*	*258*	*278*	*294*	*293*	*223*	*224*
b) Third Party Effects	103	2,305	766	728	- 2,743	- 900	- 204	465	215	678	222	- 761
c) Net Public Sector/Operator Effects	- 225,135	- 180,989	- 205,609	- 210,121	- 313,643	- 150,242	- 269,877	- 271,856	- 166,117	- 148,549	- 85,782	- 87,261
d) NPV (a+b+c)	***- 190,777***	***- 136,788***	***- 169,318***	***- 173,085***	***- 251,768***	***- 136,377***	***- 237,029***	***- 231,908***	***- 137,281***	***- 117,844***	***- 65,639***	***- 68,016***
e) Costs *(included in b)*												
Construction/Renewals	- 139,779	- 109,623	- 126,025	- 131,907	- 198,903	- 90,415	- 166,871	- 169,390	- 99,913	- 87,997	- 52,869	- 55,306
Operating/Maintenance	16,873	16,383	15,453	14,543	25,677	9,518	19,518	18,187	16,280	16,123	12,157	10,308
Cost of Taxation	- 36,706	- 28,627	- 33,279	- 33,927	- 49,991	- 24,718	- 44,205	- 44,222	- 26,424	- 23,339	- 13,257	- 13,582
f) Revenue *(included in b)*												
HSR	19,525	23,049	20,732	21,665	36,510	6,072	20,469	21,960	17,670	17,986	13,881	11,717
Other	- 15,151	- 17,262	- 16,205	- 16,514	- 28,221	- 5,430	- 15,442	- 17,365	- 8,579	- 8,867	- 4,309	- 3,046
2) PSS2												
a) User Benefits	23,994	29,814	24,897	26,187	45,946	10,784	23,832	29,122	21,105	24,152	17,715	17,893
b) Third Party Effects	- 405	1,267	122	228	- 2,432	- 78	62	22	765	1,171	816	- 339
c) Net Public Sector/Operator Effects	- 213,993	- 168,601	- 194,134	- 199,219	- 293,464	- 146,086	- 258,087	- 260,066	- 157,648	- 139,884	- 80,521	- 82,348
d) NPV (a+b+c)	***- 190,403***	***- 137,520***	***- 169,115***	***- 172,805***	***- 249,950***	***- 135,381***	***- 234,194***	***- 230,921***	***- 135,778***	***- 114,562***	***- 61,990***	***- 64,794***
e) Costs *(included in b)*												
Construction/Renewals	- 139,779	- 109,623	- 126,025	- 131,907	- 198,903	- 90,415	- 166,871	- 169,390	- 99,913	- 87,997	- 52,869	- 55,306
Operating/Maintenance	14,683	14,179	12,921	12,920	21,089	8,102	16,394	15,898	13,718	13,578	9,348	8,469
Cost of Taxation	- 35,306	- 27,117	- 31,878	- 32,588	- 47,589	- 24,266	- 42,704	- 42,776	- 25,389	- 22,181	- 12,521	- 12,892
f) Revenue *(included in b)*												
HSR	23,402	28,295	23,914	25,689	43,540	7,578	23,658	25,942	21,173	21,599	15,165	13,741
Other	- 11,788	- 14,138	- 12,149	- 12,860	- 22,441	- 4,705	- 11,732	- 13,580	- 7,333	- 7,640	- 3,945	- 2,756

7.3. Financial Appraisal Results

7.3.1. Financial Appraisal of HSR Alternatives

The economic appraisal results described above are useful in the consideration of the life time impact of each alternative across society. However, it is also valuable to consider each alternative from the perspective of financial performance. This considers the extent to which the ongoing financial costs of the alternative are covered by the revenue generated by the scheme, once construction is complete.

The scope of the ongoing costs that should be considered in the comparison of revenue and costs could be defined in several ways. At the minimum level, costs could be considered to be the service and infrastructure operating and maintenance costs, including rolling stock costs but excluding capital renewals. A second, wider definition would include renewals in the costs considered.

A further more comprehensive definition could also consider the wider impacts on the economy of the need to raise funding for the scheme through taxation (with the associated impact on the efficiency of the economy). The Norwegian economic guidance suggests that this cost of taxation should be considered to be the equivalent of a further 20% of public sector costs over the appraisal lifetime. Taken to the furthest extent, this analysis would therefore include the full taxation costs of financing the initial construction of the scheme and any ongoing subsidies required in the definition of the costs to be compared to revenue.

An alternative perspective would focus only on public sector costs/subsidies after construction, treating the costs of financing construction as sunk costs, along with the construction costs themselves. In this approach, any alternatives able to support their own operating, maintenance and renewals costs would not require public subsidy and so would not incur ongoing costs associated with tax financing (as costs would be fully covered by revenue raised). For those alternatives not able to cover full costs, the cost of taxation would add 20% to any costs not covered by revenue.

Indirect, economy wide effects of this nature are not normally included in financial appraisal which typically focuses on direct costs of running a rail system as experienced by the operator (i.e. the first two definitions of costs outlined above). However, analysis relating to the wider definition (full lifetime taxation costs) is also presented below for completeness.

Figures 31 and 32 show the ‘net revenue’ generated by each alternative when comparing incoming HSR revenue with each of the three definitions of cost outlined above, under PSS1 and PSS2 respectively. The first column in each group shows the total HSR revenue generated by the alternative to provide a sense of scale. Results are presented for a 4.5% discount rate and 25 year lifetime, in line with current Norwegian guidance.

Figure 31. Financial Appraisal Results, PSS1 (NPV, MnNOK, 2009 prices, 2015 base, 25 year appraisal period)

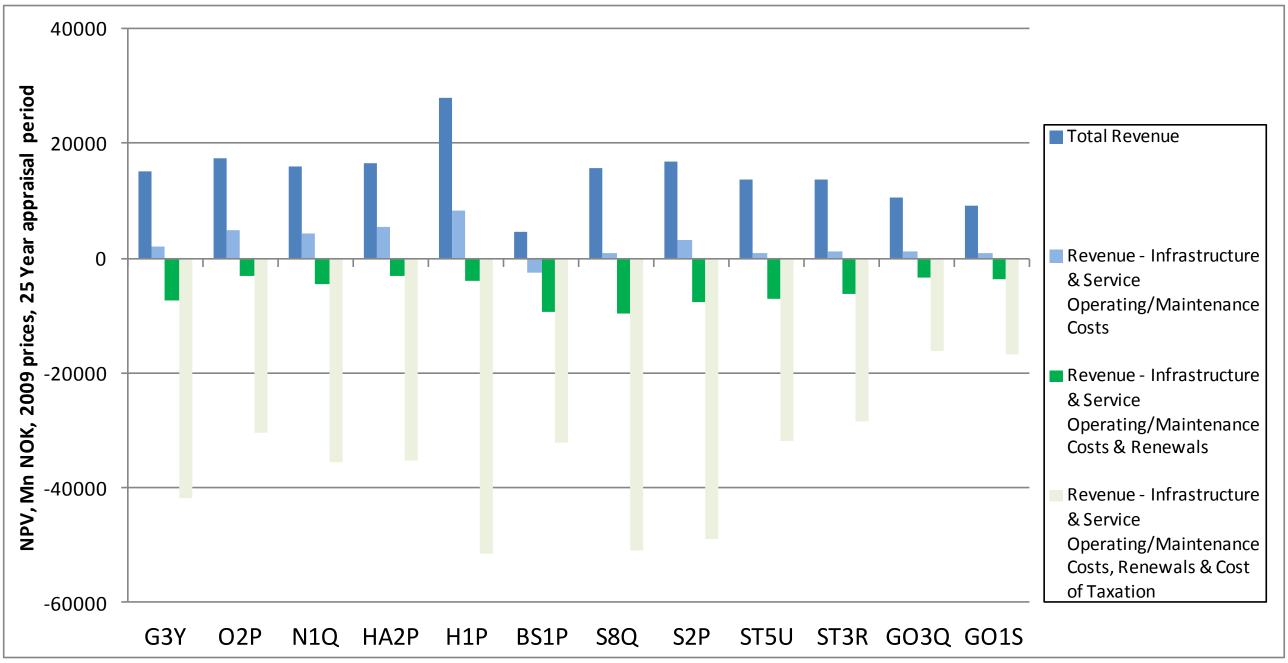
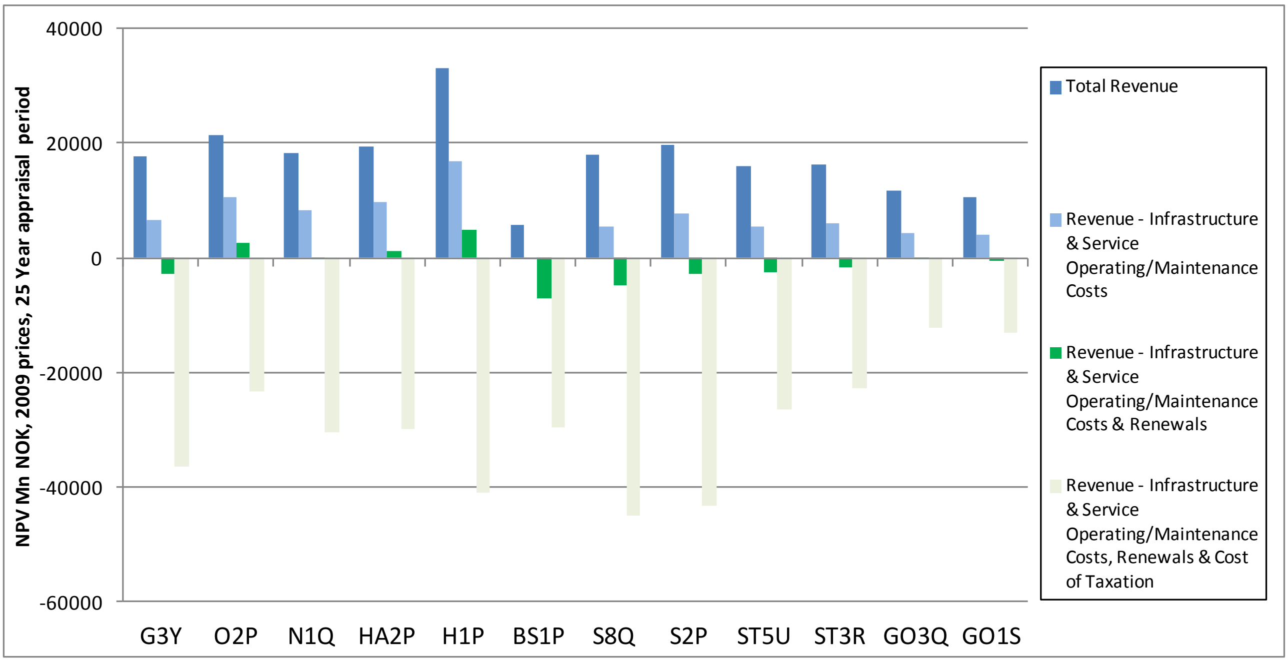


Figure 32. Financial Appraisal Results, PSS2 (NPV, MnNOK, 2009 prices, 2015 base, 25 year appraisal period)



The figures show that the revenue generated by each of the alternatives is sufficient to more than cover the associated service and infrastructure operating and maintenance costs. This indicates that there is a strong likelihood that HSR services on most routes could operate as commercial and financially sustainable operations if costs of infrastructure implementation, renewal and capital financing are excluded, particularly when service specification is commercially oriented (PSS2). The best performing alternatives serving a single route in this respect are Ø2:P in the North, HA2:P in the West, S2:P in the South and ST3:R in the East. H1:P in the West performs best overall but this reflects the fact it combines delivery of three service routes in a single large HSR scheme and is therefore not directly comparable with the other alternatives which each serve one route only.

In PSS1 none of the alternatives can completely cover the full cost of capital renewals over a 25 year life time, or cover the costs of the taxation required to fund the substantial construction costs of each scheme. PSS2 is specified to perform more effectively financially and proxy a more commercially oriented service operation, and this is evident in the fact that alternatives Ø2:P, H1:P and HA2:P are able to cover renewal costs and several other alternatives are close to being able to do so.

Despite the improved performance, all alternatives continue to fall well short of covering the costs caused by the taxation required to fund the schemes in PSS2. However if cost of taxation considered is limited to funding public sector costs after construction, Ø2:P, H1:P and HA2:P would incur no taxation costs as they are able to cover ongoing operating, maintenance and renewals from revenue (without need for taxation). For the other alternatives, tax financing costs would add 20% to the costs not covered by revenue (i.e. the costs below the axis in the graphs for the renewals column).

Table 37 below presents the breakdown of the financial appraisal results shown in Figures 31 and 32.

Table 37. Financial Appraisal Results by Alternative for PSS1 and PSS2, , NPV, MnNOK, 2009 prices, 25 year appraisal period

	North		West				South		East			
	G3Y	O2P	N1Q	HA2P	H1P	BS1P	S8Q	S2P	ST5U	ST3R	GO3Q	GO1S
1) PSS1												
Revenue												
a) Revenue	*15,060*	*17,551*	*16,038*	*16,703*	*28,087*	*4,735*	*15,778*	*16,948*	13,590	13,813	10,694	9,050
Ongoing Costs												
b) Operating/Maintenance Costs	13,008	12,709	11,870	11,142	19,862	7,270	14,991	13,911	12,644	12,562	9,566	8,072
c) Renewals	***9,386***	***8,061***	***8,620***	***8,656***	***12,107***	***6,725***	***10,370***	***10,626***	***7,995***	***7,512***	***4,468***	***4,542***
d) Cost of Taxation for Scheme Funding	34,607	27,160	31,254	32,076	47,648	23,035	41,344	41,529	24,967	22,123	12,793	13,139
Net Revenue												
a- b	2,052	4,842	4,168	5,560	8,226	- 2,535	787	3,037	946	1,251	1,128	978
a - (b + c)	- 7,334	- 3,219	- 4,452	- 3,096	- 3,881	- 9,260	- 9,583	- 7,589	- 7,049	- 6,261	- 3,341	- 3,564
a - (b + c + d)	- 41,941	- 30,379	- 35,706	- 35,172	- 51,529	- 32,296	- 50,927	- 49,118	- 32,017	- 28,384	- 16,134	- 16,703
2) PSS2												
Revenue												
a) Revenue	*17,732*	*21,482*	*18,199*	*19,497*	*32,970*	*5,853*	*17,927*	*19,707*	16,087	16,394	11,611	10,532
Ongoing Costs												
b) Operating/Maintenance Costs	*11,208*	*10,901*	*9,799*	*9,801*	*16,105*	*6,123*	*12,442*	*12,032*	10,555	10,486	7,295	6,579
c) Renewals	*9,386*	*8,061*	*8,620*	*8,656*	*12,107*	*6,725*	*10,370*	*10,626*	7,995	7,512	4,468	4,542
d) Cost of Taxation for Scheme Funding	*33,507*	*25,928*	*30,137*	*31,023*	*45,744*	*22,660*	*40,158*	*40,387*	24,149	21,218	12,203	12,595
Net Revenue												
a- b	*6,523*	*10,581*	*8,400*	*9,696*	*16,865*	- *270*	*5,485*	*7,675*	5,532	5,908	4,316	3,952
a - (b + c)	- *2,863*	*2,520*	- *220*	*1,040*	*4,758*	- *6,995*	- *4,885*	- *2,951*	- 2,464	- 1,604	- 153	- 589
a - (b + c + d)	- *36,370*	- *23,408*	- *30,357*	- *29,983*	- *40,986*	- *29,655*	- *45,043*	- *43,338*	- 26,612	- 22,822	- 12,356	- 13,184

It is noted that use of a longer (40 year) appraisal period would potentially alter this picture. Although both revenues and costs would increase with the extended period, there would be a particular increase in the renewal costs as much of the capital infrastructure for the alternatives would require renewal between the 25th and 40th year of operation. An even longer appraisal period could potentially improve the balance again with renewals rates remaining at a similar level and revenue levels increasing with increased demand. However, there is considerable uncertainty in forecasts made over this length of time, particularly for revenue.

It is also worth noting that assumptions made on the real growth in costs of capital renewals above standard inflation rates has a significant bearing on the outturn costs used in this assessment. If a lower rate of real growth was adopted, a greater number of the alternatives could be expected to cover their renewals under PSS2. For instance, if no additional growth above standard inflation is assumed, Ø2:P, H1:P and HA2:P come close to covering their renewals under PSS1. With this assumption under PSS2, BS1:P and S8:Q are the only alternatives that do not cover renewals costs and several alternatives cover them comfortably.

7.3.2. Financial Appraisal Discount Rate Sensitivity

Alternative discount rates can be adopted when considering the alternatives' performance from a financial perspective. The 4.5% adopted for socio-economic appraisal might not necessarily be considered the most appropriate. Figures 33 and 34 therefore present the equivalent analysis to Figures 31 and 32 for a discount rate of 2%.

Figure 33. Financial Appraisal Results, PSS1, 2% Discount Rate (NPV, MnNOK, 2009 prices, 2015 base, 25 appraisal period)

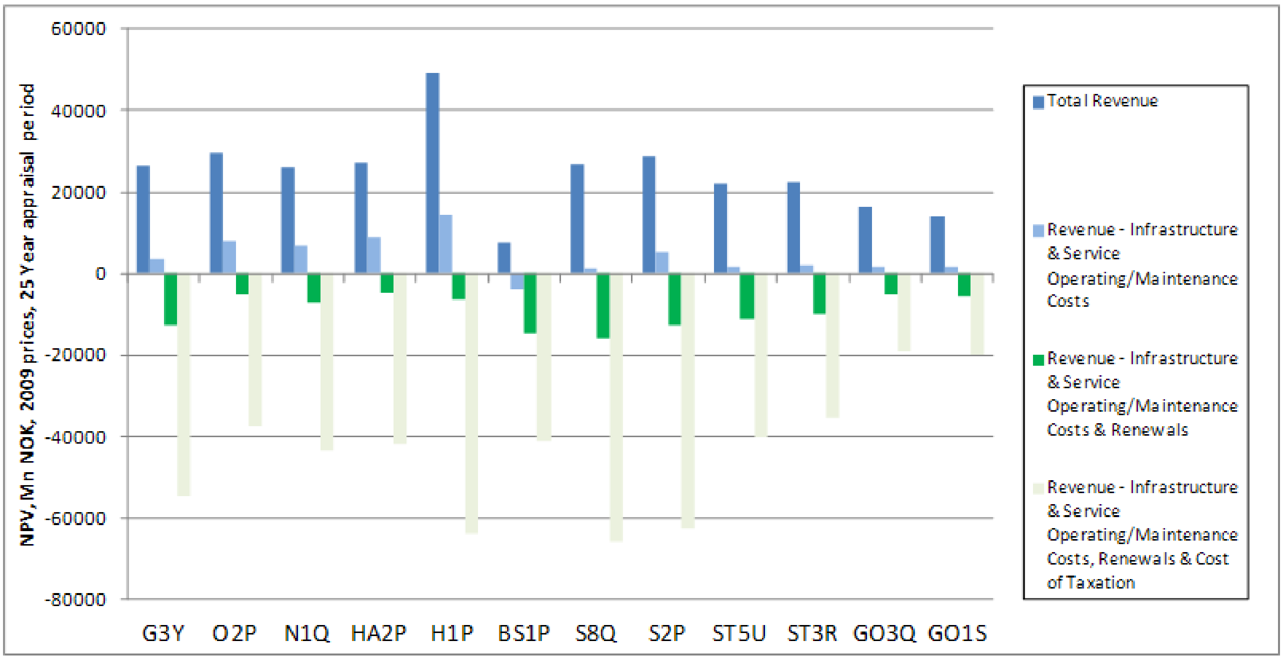
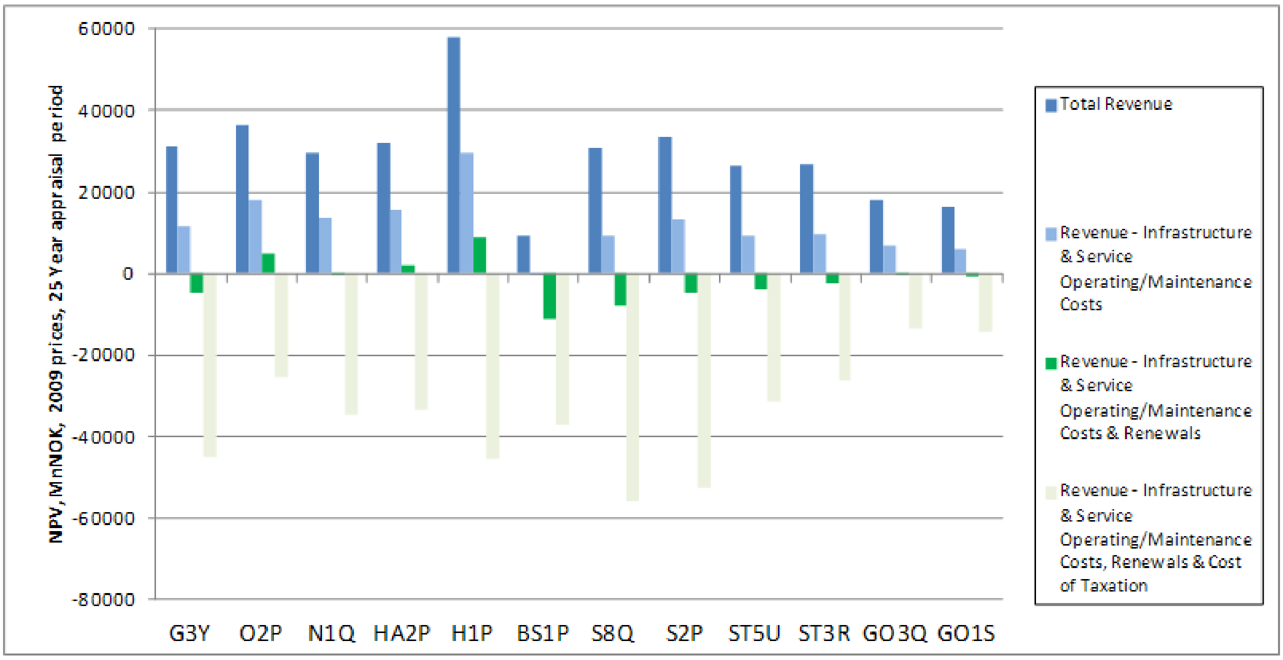


Figure 34. Financial Appraisal Results, PSS2, 2% Discount Rate (NPV, MnNOK, 2009 prices, 2015 base, 25 appraisal period)

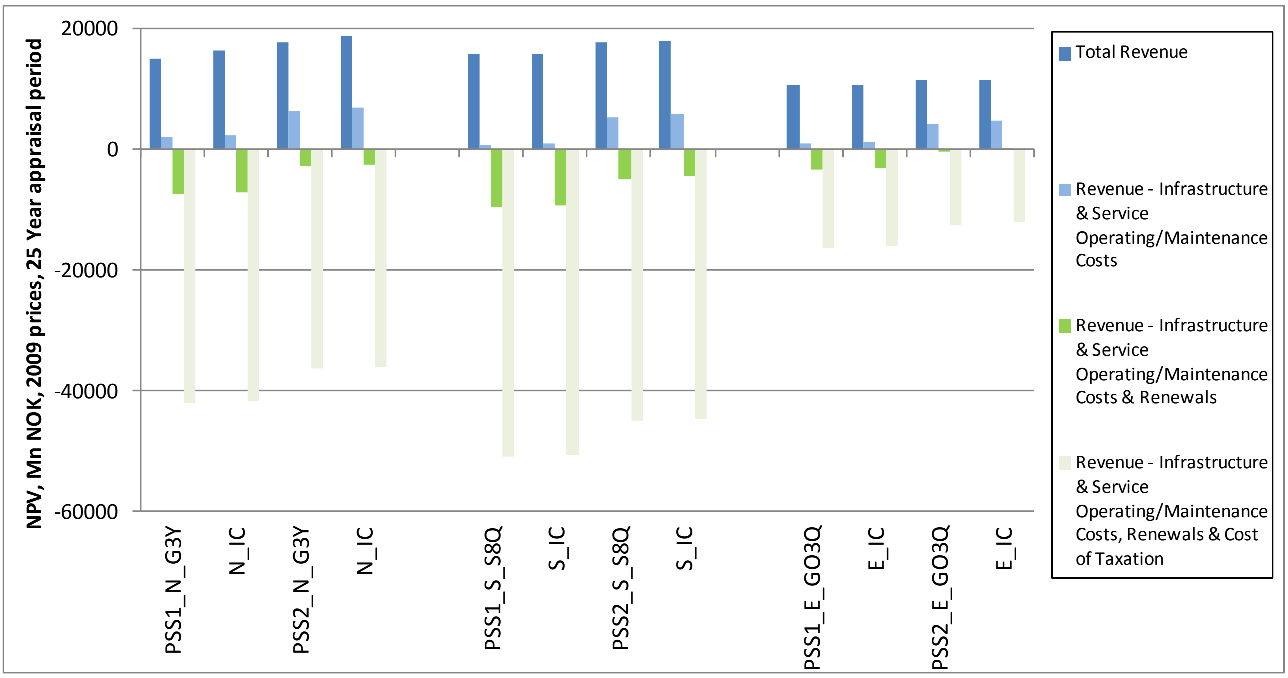


The figures show that as the costs and benefits considered in the financial appraisal are relatively evenly distributed over the appraisal period, the change in discount rates has a relatively balanced impact on each and therefore a relatively small impact on the overall pattern of results and performance of the alternatives. The only alternatives that are able to cover renewals are Ø2:P, H1:P and HA2:P in PSS2.

7.3.3. Inter-City Scenario Financial Appraisal Results

The interaction with possible Inter-City improvements also has the potential to influence the financial performance of the relevant HSR alternatives. Figure 35 below presents the equivalent financial analysis for scenarios assuming that Inter-City Services make use of the HSR infrastructure, presenting results for both PSS1 and PSS2, using a 4.5% discount rate and 25 year appraisal period. Results are presented alongside the equivalent core scenario in each case.

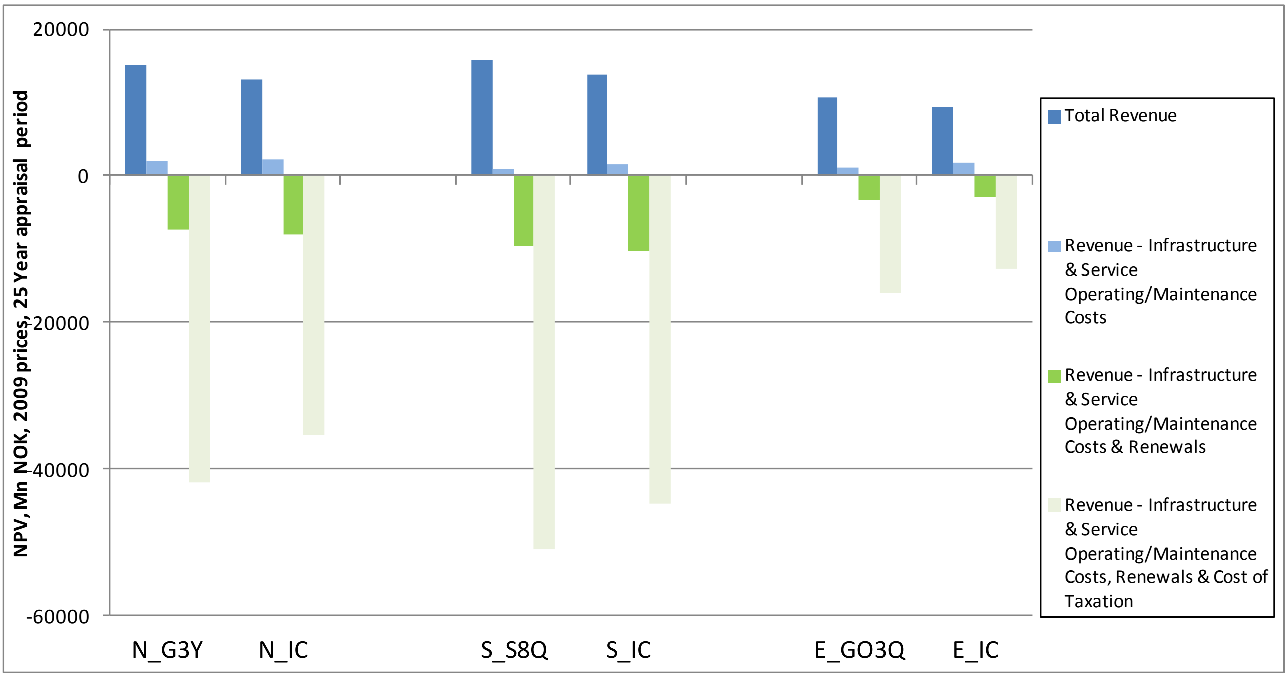
Figure 35. Financial Appraisal Results for Inter-City scenarios (MnNOK, 2009 prices, 2015 base, 25 year appraisal period)



In all three corridors the additional revenue associated with the extra Inter-City services exceeds the associated additional operating costs. Consequently, the consideration of these trips improves the financial performance of each of the three alternatives. However, the improvement is relatively slight compared to total costs and is not large enough to change the picture of financial performance substantially.

Figure 36 shows the equivalent results for the scenarios assuming that Inter-City schemes are built on each corridor in advance of the main HSR alternative, under PSS1.

Figure 36. Financial Appraisal Results for Inter-City scenarios, PSS1 (MnNOK, 2009 prices, 2015 base, 25 year appraisal period)



These scenarios result in a significant reduction in construction cost incurred for the High Speed scheme and therefore the associated cost of taxation. However, in each case the cost remains two to four times as great as total revenue generated. Additionally, the delayed start of the operations and assumed 5% reduction in total revenue, reduces revenue by over 10% relative to the core scenario in each case. Overall therefore, on average these scenarios slightly worsen the financial performance of the relevant alternatives, under current assumptions.

7.3.4. Financial Appraisal Conclusions

The financial appraisal considered above has demonstrated that under PSS1, the revenue generated by virtually all of the alternatives is sufficient to cover the direct ongoing service and infrastructure operating and maintenance costs, excluding renewals. However, none of the alternatives generate sufficient revenue to cover the ongoing cost of renewals.

The improved financial performance of PSS2 means that three alternatives, Ø2:P in the North corridor and HA2:P and H1P in West corridor, are able to cover their renewals over a 25 year time frame under this scenario and several others are sufficiently close that further optimisation to balance revenues against ongoing costs is likely to make it possible.

Although financial appraisal typically focuses on direct costs associated with rail operations rather than economy wide, indirect considerations, a particularly wide definition of ongoing costs would also include the costs of the decreased efficiency of the economy caused by the additional taxation required to fund each alternative. Given the scale of construction costs, this is a large cost and therefore none of the alternatives are able to come close to covering it through ongoing revenues (in PSS1 or PSS2). However, if the cost of taxation considered is limited to the level required to finance ongoing public sector costs after construction, Ø2:P, H1:P and HA2:P would incur no taxation costs as they are able to cover ongoing operating, maintenance and renewals from revenue (without need for taxation).

Using an alternative discount rate for the analysis and considering additional trips on the Inter-City infrastructure could also help improve performance, as would a reduced rate of real growth of costs above inflation. However, considering the balance over a 40 year time frame is likely to reduce the ability of alternatives to meet renewal costs, as significant elements of the infrastructure will be subject to replacement between the 25th and 40th year of operation. An even longer period of assessment could however improve the balance again, depending on the balance between renewals requirement and demand and revenue growth.

Additionally, as noted above, the focus of this stage of appraisal has been consistent, comparative assessments of a number of alternatives. Consequently, the alternatives have not been optimised and there is likely to be scope to improve financial performance through detailed balancing of service provision and associated costs and revenue. The comparison between PSS2 and PSS1 provides an indication of the type of change that might be achieved through more detailed analysis, noting that improved financial performance is often achieved at the expense of some wider socio-economic benefits.

The financial appraisal could also alter significantly if the opportunity for consequential cost/subsidy savings relating to other operations with HSR's introduction could also be viewed as offsetting ongoing costs. The future of the wider rail network and the financial implications in the context of HSR is an area of worthy further investigation. The final equilibrium position of transport provision on competing modes after HSR implementation is also likely to improve the financial position of HSR as it is likely to reduce the attractiveness of other modes (as they reduce service provision), increasing patronage on HSR.

8. Analysis of Scenario B

8.1. Introduction and description of Scenario B alternatives

As discussed in Chapter 2, the mandate given to JBV for investigation of HSR in Norway has required that the upgrade of existing lines as an alternative be examined. It is recognised that this does not deliver a high speed rail offer but would indicate the scope to secure benefits in the HSR corridors via existing lines.

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 was required. JBV's alignment design teams each examined possible options for delivery of Scenario B and provided high level specifications 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 38 below.

Table 38. 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-Charlottenburg time: equates to a 5% reduction in Oslo-Stockholm time

The exceptional Scenario B alternative is clearly the East corridor alternative between Oslo and Stockholm where the specification aims only to achieve a 20% reduction in journey time between Oslo and Charlottenburg. 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. This should be borne in mind when considering the results presented in this Chapter.

8.2. Scope of analysis

The scope of analysis undertaken for Scenario has been significantly less than that for Scenario C/D alternatives as presented in the rest of this report. This reflects the level of scheme development associated with Scenario B which has been significantly less than that for Scenario C/D HSR alternatives, and the requirements and remit for Scenario B analysis, as advised by JBV.

The scope of analysis for Scenario B undertaken by Atkins has covered the following areas, which in each case have been subject to a lesser, though appropriate, level of overall detail than was the case with Scenario C/D, though where possible, like for like methods and outputs have been adopted for:

- Journey time analysis;
- Market, demand and revenue analysis;
- Estimation and analysis of investment costs; and
- Economic and financial analysis.

Each of these areas is summarised in turn in the remainder of this chapter with more detailed information and analysis on Scenario B available in the relevant technical reports listed in Chapter 1, Section 1.3.

8.3. Scenario B Journey Time Analysis

Scenario B has been specified to involve a reduction in journey time of 20% on the existing rail corridors in Norway, compared with the current situation. It has been assumed that there is no journey time improvement within Sweden, and that there is no improvement in service frequency. Testing has been carried out on four corridors:

- Oslo-Trondheim;
- Oslo-Bergen;
- Oslo-Kristiansand-Stavanger; and
- Oslo-Charlottenburg (Stockholm).

Atkins calculated the overall change in journey time based on the current fastest timetabled journey times for each route, as shown in Table 39 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 HSR 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 39. Scenario B Journey Times

Corridor	2011 Fastest Journey Time	Scenario B Journey Time	*HSR Alternative 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-Charlottenburg)	5:55 (1:43)	5:34 (1:22)	*2:56 (ST5:U)*

To implement these Scenarios in NTM5 (the model used for demand forecasting), corridor specific adjustments were applied to the relevant services on the relevant links. The factors are multiplicative, and were applied within the EMME data repository. The derivation of these factors is based on the current journey times contained within NTM5.

These factors have been applied to the sections of each route, based on where the line upgrades have been specified in the alignment data, as described in Table 38.

The time saving required from the current NTM5 times to achieve the Scenario B times was calculated, and a reduction factor was then derived to apply to the journey time of the section where the Scenario B improvements have been made. This working is shown in Table 40 below. Note that the journey time was calculated separately for each direction, labelled as “from Oslo” and “to Oslo” in the table.

Table 40. NTM5 Journey Time Factor

Corridor	Current NTM5 Time (Reference Case)		Time Saving Required		NTM5 JT over Upgraded Section		Journey Time Reduction Factor Applied to Section	
	From Oslo	To Oslo	From	To	From	To	From	To
Oslo-Trondheim	6:22	6:22	1:06	1:06	4:25	4:21	0.75	0.75
Oslo-Bergen	6:12	6:24	1:02	1:14	4:43	5:00	0.78	0.75
Oslo - Kristiansand – Stavanger	6:49	6:39	0:40	0:30	6:13	6:02	0.89	0.92
Oslo-Charlottenburg	1:44	1:48	0:22	0:26	1:01	0:57	0.64	0.54

As a result, the changes modelled in these NTM5 tests represent an improvement in journey time on sections of track where the upgrades are to be implemented, with the end-to-end journey time representing a 20% reduction to the current rail service. This will enable more local demand responses to supply changes at specific locations to be identified.

8.4. Scenario B Market, Demand and Revenue Analysis

This section presents a summary of the key results from the testing of the four corridors under Scenario B.

8.4.1. Key Assumptions

Scenario B represents a relatively small improvement to the base-case rail network. NTM5 therefore provides a suitable basis for forecasting the demand impacts for each scenario.

Atkins was supplied with the NTM5 network specifications and associated socio-economic data, as used for the recent National Transport Plan work in Norway. The networks were identical for the two forecast years under scrutiny (2024 and 2043).

The specification for the service improvements under Scenario B is described in the previous section, and involves a reduction in journey time only. It should be noted that these changes were applied to long distance services on each corridor, including “Night Trains”, as well as Oslo-Kristiansand and Kristiansand-Stavanger regional services. All the services mentioned are specified in NTM5, and equally contribute to supply and are available for assignment, as the model is based on aggregate daily demand and supply levels.

Each corridor has been tested individually, with Scenario B improvements applied to one corridor for each test, in order to identify the relative effect on demand of Scenario B to each corridor.

Revenue calculations have been made based on the forecast demand in NTM5 and the fare assumptions stored within the NTM5 model.

8.4.2. Demand and Revenue Performance

The following tables and charts summarise the demand forecasts from NTM5 for Scenario B tests in 2024 and 2043, and the associated revenue[3]. The demand and revenue shown is the forecast increase in rail passengers as a result of the journey time improvements made under Scenario B, compared with the base scenario in NTM5. The train kilometres shown are for the long distance rail services to which the journey time improvements were applied. The station boardings are shown for the long distance rail services only and for a selection of key stations, with demand for smaller stations merged with the nearest key station. The figures represent the total boardings under Scenario B for long distance services.

8.4.2.1. Oslo – Trondheim

Table 41 below summarises the forecast change in demand due to Scenario B being applied on the Oslo – Trondheim route.

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[3] Please note that figures presented for Scenario B and Scenario C/D alternatives are not directly comparable. This is principally because (a) the NTM5 demand modelling in Scenario B does not include short distance trips of less than 100km which are estimated using a gravity model approach in Scenario C/D alternatives, and (b) Scenario C/D figures are shown inclusive of extraction from existing classic rail services, hence the net increase to all types of rail services would be slightly lower. However, these effects are relatively small and demand figures for equivalent Scenario C/D alternatives remain 10-20 times as large as for equivalent Scenario B alternatives. This applies to the comparison between Scenario B and Scenario C/D in each of the four corridors.

Table 41. Summary of Demand & Revenue: Oslo – Trondheim

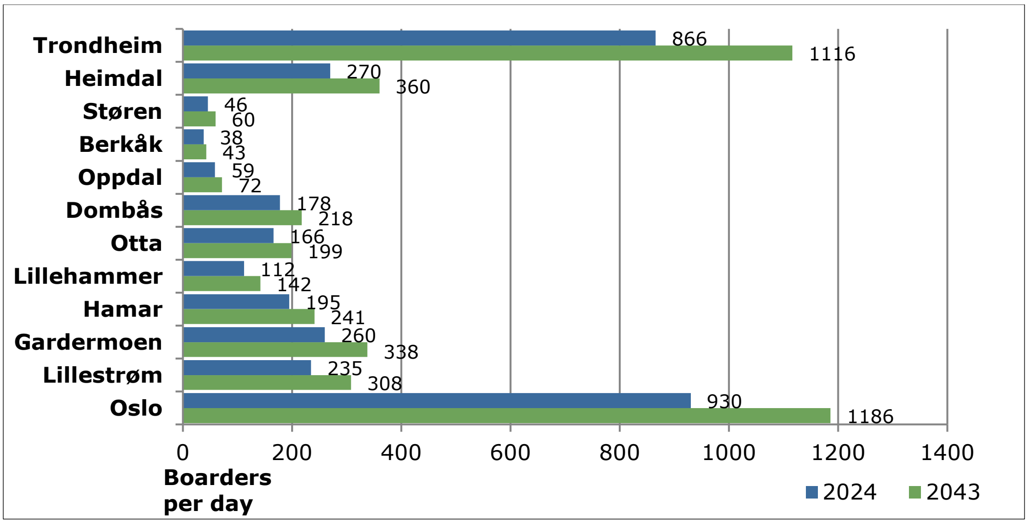
Demand & Revenue	Annual		Per day	
	2024	**2043**	**2024**	**2043**
Change in Rail Passengers	169,140	216,590	460	590
Change in Rail Passenger km (thousands)	104,950	134,330	290	370
Train km (thousands)	2,530	2,530	6.9	6.9
Change in Revenue (NOK thousands)[4]	96,670	124,820		

It can be seen that there is an increase in annual rail demand of approximately 170,000 passengers in 2024 as a result of the Scenario B improvements, rising to nearly 220,000 in 2043. This increase in demand generates revenue of approximately 95 million NOK in 2024 and 125 million NOK in 2043.

The annual increase in demand of 170,000 passengers and 95 million NOK in 2024 compares with annual HSR demand of 4.4 million and revenue of 1.5 billion NOK under the G3:Y scenario. Clearly the implementation of Scenario B has a very minor impact on rail travel on this corridor compared with that of a new HSR line.

Figure 37 summarises total daily boardings for long distance services at key stations along the Oslo – Trondheim corridor.

Figure 37. Long Distance Boardings by Station: Oslo – Trondheim



8.4.2.2. Oslo – Bergen

Table 42 below summarises the forecast change in demand due to Scenario B being applied on the Oslo – Bergen route.

Table 42. Summary of Demand & Revenue: Oslo – Bergen

Demand & Revenue	Annual		Per day	
	2024	**2043**	**2024**	**2043**
Change in Rail Passengers	168,220	217,350	460	600
Change in Rail Passenger km (thousands)	88,640	115,060	240	320
Train km (thousands)	2,120	2,120	5.8	5.8
Change in Revenue (NOK thousands)	75,260	99,050		

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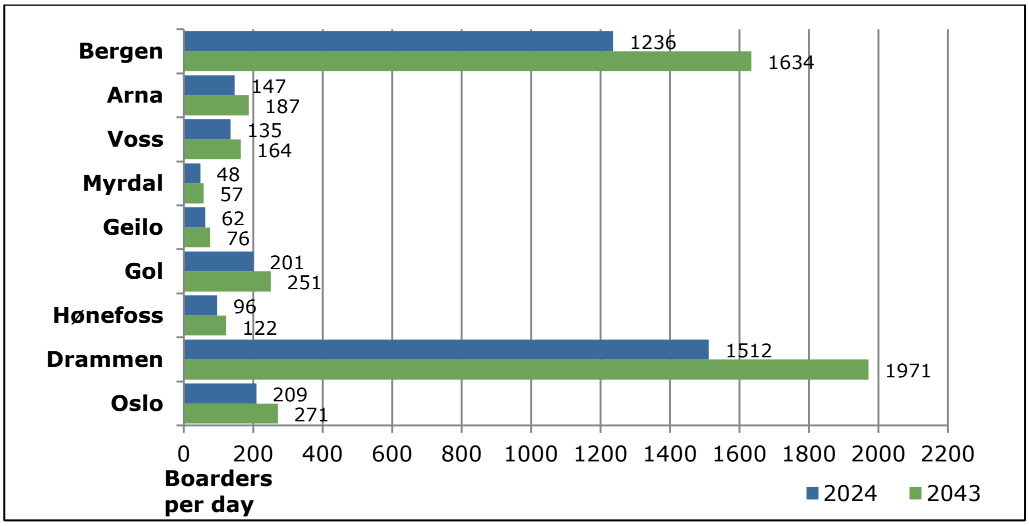
[4] Revenue is given in 2009 NOK prices

It can be seen that there is an increase in annual rail demand of approximately 170,000 passengers in 2024 as a result of the Scenario B improvements, rising to nearly 220,000 in 2043, which is very similar to the impact on the Trondheim corridor. This increase in demand generates revenue of approximately 75 million NOK in 2024 and 100 million NOK in 2043. The lower revenue on this corridor compared with Oslo – Trondheim is as a result of a lower average trip length.

The annual increase in demand of 170,000 passengers and 75 million NOK in 2024 compares with annual HSR demand of 4.2 million and revenue of 1.4 billion NOK under the HA2:P scenario. Again the implementation of Scenario B has a very minor impact on rail travel on this corridor compared with the new HSR line.

Figure 38 summarises total daily boardings for long distance services at key stations along the Oslo – Bergen corridor. Note that due to the assignment of demand to the network within the NTM5 model for this alternative, the majority of demand from the Oslo area boards at Drammen. In reality it is likely that a large proportion of this demand would board at Oslo.

Figure 38. Long Distance Boardings by Station: Oslo – Bergen



8.4.2.3. Oslo – Stavanger

Table 43 summarises the forecast change in demand due to Scenario B being applied on the Oslo – Stavanger route.

Table 43. Summary of Demand & Revenue: Oslo – Stavanger

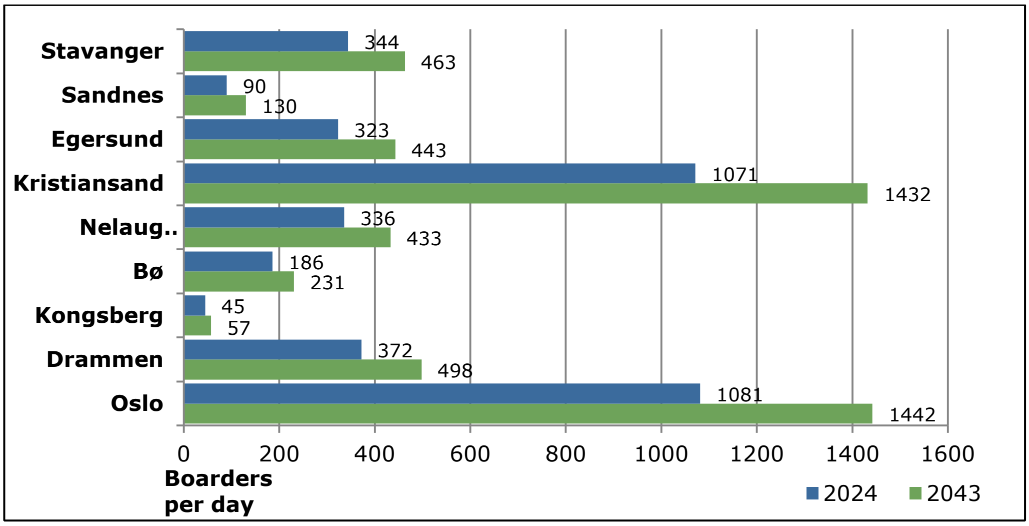
Demand & Revenue	Annual		Per day	
	2024	2043	2024	2043
Change in Rail Passengers	72,040	96,440	200	260
Change in Rail Passenger km (thousands)	36,060	48,580	100	130
Train km (thousands)	3,410	3,410	9.3	9.3
Change in Revenue (NOK thousands)	32,820	44,810		

It can be seen that there is an increase in annual rail demand of approximately 70,000 passengers in 2024 as a result of the Scenario B improvements, rising to nearly 100,000 in 2043. The lower demand increase on this corridor is as a result of the smaller journey time improvement in Scenario B compared with the reference case in NTM5, which has shorter journey times compared with those in the present day timetable. The increase in demand generates revenue of approximately 35 million NOK in 2024 and 45 million NOK in 2043.

The annual increase in demand of 70,000 passengers and 35 million NOK in 2024 compares with annual HSR demand of 5.1 million and revenue of 1.5 billion NOK under the S8:Q scenario. Again the implementation of Scenario B has a very minor impact on rail travel on this corridor compared with the new HSR line.

Figure 39 summarises total daily boardings for long distance services at key stations along the Oslo – Stavanger corridor.

Figure 39. Long Distance Boardings by Station: Oslo – Stavanger



8.4.2.4. Oslo – Charlottenburg (Stockholm)

Table 44 below summarises the forecast change in demand due to Scenario B being applied on the Oslo – Charlottenburg route.

Table 44. Summary of Demand & Revenue: Oslo – Stockholm

Demand & Revenue	Annual		Per day	
	2024	**2043**	**2024**	**2043**
Change in Rail Passengers	340	400	1	1
Change in Rail Passenger km (thousands)	40	50	0.1	0.1
Train km (thousands)	200	200	0.6	0.6
Change in Revenue (NOK thousands)	60	70		

It can be seen that the demand change in the Stockholm corridor as a result of Scenario B improvements is negligible, reflecting the very small improvement in overall journey time this offers. It also reflects the fact that there is no Swedish demand in the NTM5 model, and therefore there is very little demand on the long distance service to Stockholm in the reference case. The increase in rail demand is calculated from a very low base level of demand and hence is almost zero. However, also note that improvements have been made to the Norway side only, so there is a relatively small effect on cross-border demand and demand within Sweden.

8.4.3. Conclusions

Phase III of the Assessment Study has developed demand and revenue forecasts for selected representative alternatives for Scenario B on the four main corridors considered in this phase of work. The assumptions of journey time improvements to be made under Scenario B have been refined since Phase II to account for the alignment designs. This has enabled journey times to be applied only to sections of the network where upgrades have been designed.

The overall demand results are at a similar level to those forecast in Phase II and they demonstrate that the impact of Scenario B on long distance travel in Norway is comparatively very small. For the Stockholm corridor the impact of Scenario B is negligible, which is a result of the very low levels of demand in the reference case in NTM5 and the fact that the overall journey time improvement is only 5%. In contrast, the impact of the step-change provided by full HSR implementation on long distance travel is significant, with the increase in demand typically 10 – 20 times as large. Further investigation of the impact of Scenario B on shorter distance trips may improve the demand and revenue potential, but it is almost certain that this will still fall very short of the demand and revenue forecasts for full HSR implementation given the very significantly greater improvement in journey time that HSR alternatives offer in comparison.

8.5. Estimation and Assessment of Investment Costs

8.5.1. Introduction

This section summarises outputs of Subject 2: Estimation and Assessment of Investment Costs of the Financial and Economic Analysis contract for Jernbaneverket (JBV) assessing High Speed Rail in Norway. The primary outputs are to provide the estimated capital and life cycle cost assessments, by route in upgrading existing route corridors to improve travel times, based around the Cost Model Template presented in Phase II. The outputs will enable JBV to make informed decisions on various High Speed Rail Route Alternatives.

The Cost Model developed for this purpose identifies Capital (CAPEX) and Life Cycle Costs (LCC) which are used in the Financial Model to enable confident decision making on route alternatives. These models have been harmonised to reflect local working and rates and have been used to present the cost estimates. In addition, estimates and assessment of risk associated with the Route Upgrade Alternatives have been considered, and accounted for in final cost estimates presented.

The cost reports identify and price the various route scenario alternatives being considered by route corridor based on alignment data provided by JBV's alignment design consultants. The data and cost reports have been presented and reported in a manner to feed and support the process of Economic and Financial Appraisal.

This section presents the results for Scenario B Route Upgrade Alternatives previously described in Chapters 2 and 6 and addresses the following in respect of Scenario B only:

- Capital Costs (CAPEX);
- Life Cycle Costs (LCC);
- Risk estimates; and
- Overall Cost and Risk Summary and Conclusions.

The focus of this section is providing a summary of the outputs of the Cost and Risk Analysis of the Route

8.5.2. Capital Costs (CAPEX)

8.5.2.1. Overview

The same procedures and methodology were followed for Scenario B as for the previous Scenarios C/D and the statements and descriptions in Chapter 6 apply equally here, unless otherwise qualified below.

The parameters were amended to reflect the required outputs for this scenario, and an alternative data Input Spreadsheet was prepared by the Alignment Engineers

It should be noted that the route alternative specifications have not been defined in detail at this stage, similar to Scenarios C/D, but is sufficient to support the cost model and includes key data specifying lengths and type of track, extent of renewal (single or double track), number and type of structures, number of crossings, passing loops, length of tunnels and stations for example.

8.5.2.2. Outputs & Results

Tables 45 and 46, present the headline and summary breakdown report on capital cost estimates respectively, as derived from the cost modelling process. Costs are presented in BnNOK and are in Q4 2011 prices and undiscounted. These costs are inclusive of preliminaries, management costs and risk allowances and estimates. The risk component of costs is discussed in more detail in section 8.5.4 of this chapter.

Table 45. Scenario B Anticipated Final Costs – Capital Costs (BnNOK, Q4 2011 prices, undiscounted)

Scenario B Corridor	Total Length (km)	Length Upgraded (km)	Capital Cost (Bn NoK)
North	**397**	**163**	**63.12**
West	**526**	**77**	**35.46**
South	**518**	**165**	**52.75**
East	**97*** **(Route section Oslo to Konsvinger only)**	**60**	**7.25**

The undiscounted base capital costs, excluding risk, range from between 28 BnNOK for the Western corridor and 50 BnNOK for the Northern. This excludes the consideration of the Eastern corridor which only addresses improving part of the route journey time between Oslo to Konsvinger. When risk is taken into account, the range of cost increases to between 35 BnNOK and 63 BnNOK.

The cost per km (exclusive of risk) ranges from 258 MnNOK for the Southern corridor to 360 MnNOK for the Western corridor, (again excluding the Eastern corridor)

A comparison of the Scenario B Alternatives clearly shows the impact of tunnels, earthworks and structure cost components on alternative costs, even for track alteration works. This is particularly reflected in the Southern route, when compared to the North and West, with it having a much higher proportion of tunnelling at over twice the length of the other two routes.

A number of key assumptions were made in relation to the parameters and criteria for upgrading the existing routes, as follows:

- Where new track, single or double, power provision was enhanced;
- Signalling requirements upgraded in line with track upgrade;
- Allowance for connecting into existing control systems;
- Provision of Passing Loops as an alternative to double tracking within the body of the route; and
- The existing line would be closed whilst upgrade works continued.

Table 46. Scenario B, Summary Capital Cost Report (MnNOK at Q4 2011 prices, undiscounted)

SCENARIO B	**Northern**		**Western**		**Southern**		**Eastern**
Route ID	**(MNoK)**		**(MNoK)**		**(MNoK)**		**(MNoK)**
Notes							
Scenario Speed (Kph)							
Total Route Length (Km)	**397**		**526**		**518**		**97***
Upgrade Length - Construction (km)	**163**		**77**		**165**		**60**
Total Construction Cost E (MNoK)	**50,202**		**27,712**		**42,493**		**4,697**
Construction Cost per Km - Total Route (MNoK)	**126**		**53**		**82**		**48**
Construction Cost per Km - Upgraded (MNoK)	**308**		**360**		**258**		**78**
Project Anticipated Final Cost (AFC) (MNoK)	**63,123**		**35,463**		**52,753**		**7,250**
Construction Period (Years)	**5**		**5**		**5**		**2**
Route Tunnel Percentage	**39%**		**82%**		**42%**		**2%**
Contractor's direct costs							
Signalling & Telecoms	1,169		662		330		177
Electrification & Plant	3,108		3,211		2,545		498
Track	4,443		1,951		2,954		801
Operational Property	544		0		272		272
Structures	21,872		12,038		20,002		551
General Civils	6,937		2,326		5,160		1,093
Utilities	0		0		0		0
Depots	0		0		0		0
Sub-Total A	**38,073**		**20,188**		**31,263**		**3,392**
Contractor's indirect costs							
Preliminaries	7,790		4,137		6,302		705
Design	2,079		1,109		1,613		196
Testing & Commissioning	358		260		190		65
Other	1,902		2,018		3,125		339
Sub - Total B	**12,129**		**7,524**		**11,230**		**1,305**
Total Construction Cost E (A+B)	**50,202**		**27,712**		**42,493**		**4,697**
	-		-		-		-
Client's indirect and other costs							
Client's Project Management	1,903		1,010		1,563		170
Planning & associated costs	970		247		796		807
Land / Property Costs & compensation	0		0		0		156
Sub - Total C	**2,873**		**1,257**		**2,359**		**1,133**
Total (A+B+C)	**53,075**		**28,969**		**44,852**		**5,830**
Uplift for Risk and Contingency							
Price, Design and Development Risk	10,048		6,494		7,901		1,420
Project Anticipated Final Cost (AFC)	**63,123**		**35,463**		**52,753**		**7,250**

8.5.3. Life Cycle Costs

8.5.3.1. Overview

The same procedures and methodology for modelling the life cycle costs (LCC) were followed for Scenario B as for the previous Scenarios C/D and the statements and descriptions in Chapter 6 apply equally here, unless otherwise qualified below.

The LCC models for Scenario B conform to the capital cost data structure and input into the reporting requirements of the economic and financial models. For the Phase 3 cost modelling a life cycle period of 25 and 40 years has been provided. The life cycle costing methodology conforms to BS ISO 15686-5:2008 Building & constructed assets - Service life planning- Part 5 and to the 'Standardized Method of Life Cycle Costing for Construction Procurement' which is a supplement to BS ISO 15686-5:2008.

The scope of each LCC estimate includes for the incremental life cycle replacement, maintenance and operation costs for each Scenario B alternative only. The LCC estimates for Scenario B therefore cover the following:

- Capital renewal replacement of the signalling & telecommunication; electrification & plant; permanent way; and civil engineering works;
- Planned and reactive maintenance of the signalling & telecommunication; electrification & plant; permanent way; civil engineering works; mechanical and maintenance overheads;
- Incremental staffing costs for new stations and any additional night train service; and
- Incremental operational energy costs for new stations and additional night trains only.

Other costs such as finance and strategic non-construction that relate to Whole Life Costs are covered in the financial model. End of Life Costs are not included in the LCC model.

8.5.3.2. Outputs & Results

Tables 47 and 48 below present the undiscounted LCCs at Q4 2011 prices over 25 and 40 year periods for the Scenario B Alternatives under consideration. The LCC comparison for Scenario B Alternatives is consistent with the capital cost estimates reflecting the fact that a significant component of LCC cost is related to the extent of infrastructure assets.

Table 47. LCC Scenario B 25 Year Headline Summary (MnNOK Q4 2011 prices, undiscounted)

Scenario B Alternative	Life Cycle Replacement Costs	Life Cycle Maintenance Costs	Life Cycle Operating Costs	On Costs	Total
North	6,795	4,444	2,313	2,710	**16,263**
West	3,403	2,216	576	1,239	**7,434**
South	4,485	3,688	1,453	1,925	**11,551**
East	1,017	1,350	1,151	703	**4,221**

Table 48. LCC Scenario B Alternatives 40 Year Headline Summary (MnNOK Q4 2011 prices, undiscounted)

Scenario B Alternative	Life Cycle Replacement Costs	Life Cycle Maintenance Costs	Life Cycle Operating Costs	On Costs	Total
North	20,488	7,113	3,700	6,260	**37,561**
West	11,397	3,545	922	3,173	**19,037**
South	15,180	5,902	2,325	4,681	**28,088**
East	2,662	2,160	1,841	1,333	**7,996**

Tables 49 and 50 provide a more comprehensive breakdown of the LCCs over the 25 and 40 year periods respectively.

Table 49. Scenario B Alternatives 25 Year Life Cycle Cost Report (MnNOK, Q4 2011 prices, undiscounted)

SCENARIO B : 25 Year Life Cycle Cost Summary		**Northern**	**Western**	**Southern**	**Eastern**
Life Cycle Replacement Costs					
Signalling & Telecoms		962	724	290	214
Electrification & Plant		74	42	48	33
Track		3,312	1,449	2,010	543
Operational Property		222	0	111	111
Structures		2,123	1,173	1,940	53
General Civils		102	14	86	63
Depots		0	0	0	0
	Sub-Total A NOK 000,000	**6,795**	**3,403**	**4,485**	**1,017**
Life Cycle Maintenance Costs					
Signalling & Telecoms		1,109	739	1,099	386
Electrification & Plant		374	211	335	112
Track		2,298	632	1,605	415
Civil Engineering Works		280	250	266	244
Mechanical		383	383	383	193
Maintenance Overheads		0	0	0	0
	Sub-Total B NOK 000,000	**4,444**	**2,216**	**3,688**	**1,350**
Life Cycle Operating Costs					
Organisation Management		285	285	285	285
Operational Management		0	0	0	0
Operational Staff	- Cleaning	150	0	75	75
	- Train Staf	230	230	230	0
	- Station St	1,401	0	701	701
Energy Consumption	- Infrastruc	179	0	90	90
	- Traction P	67	61	72	0
Cost Of Sale		0	0	0	0
Rolling Stock Leasing Costs		0	0	0	0
	Sub - Total C NOK 000,000	**2,313**	**576**	**1,453**	**1,151**
On Costs					
Risk/Contingency @ 20%		2,710	1,239	1,925	703
	Sub - Total D NOK 000,000	**2,710**	**1,239**	**1,925**	**703**
Total Life Cycle Cost Estimate incl. on costs	**NOK 000,000**	**16,263**	**7,434**	**11,551**	**4,221**
Average Cost per annum	***NOK 000,000***	651	297	462	169

Table 50. Scenario B Alternatives 40 Year Life Cycle Cost Report (MnNOK, Q4 2011 prices, undiscounted)

SCENARIO B : 40 Year Life Cycle Cost Summary		Northern	Western	Southern	Eastern
Life Cycle Replacement Costs					
Signalling & Telecoms		2,290	1,610	690	453
Electrification & Plant		3,735	3,771	3,004	571
Track		5,621	2,411	3,363	924
Operational Property		541	0	271	271
Structures		8,015	3,566	7,613	269
General Civils		285	38	238	174
Depots		0	0	0	0
	Sub-Total A NOK 000,000	**20,488**	**11,397**	**15,180**	**2,662**
Life Cycle Maintenance Costs					
Signalling & Telecoms		1,773	1,182	1,757	617
Electrification & Plant		598	338	536	180
Track		3,679	1,012	2,570	665
Civil Engineering Works		450	400	426	390
Mechanical		613	613	613	308
Maintenance Overheads		0	0	0	0
	Sub-Total B NOK 000,000	**7,113**	**3,545**	**5,902**	**2,160**
Life Cycle Operating Costs					
Organisation Management		456	456	456	456
Operational Management		0	0	0	0
Operational Staff	- Cleaning	240	0	120	120
	- Train Staf	368	368	368	0
	- Station St	2,242	0	1,121	1,121
Energy Consumption	- Infrastruc	287	0	143	143
	- Traction P	107	98	116	0
Cost Of Sale		0	0	0	0
Rolling Stock Leasing Costs		0	0	0	0
	Sub - Total C NOK 000,000	**3,700**	**922**	**2,325**	**1,841**
On Costs					
Risk/Contingency @ 20%		6,260	3,173	4,681	1,333
	Sub - Total D NOK 000,000	**6,260**	**3,173**	**4,681**	**1,333**
Total Life Cycle Cost Estimate incl. On Costs	**NOK 000,000**	**37,561**	**19,037**	**28,088**	**7,996**
Average Cost per annum	***NOK 000,000***	1,502	761	1,124	320

The total 25 year life cycle costs range from between 7 BnNOK for the Western corridor to 16 BnNOK for the Northern. The total 40 year life cycle costs range from between 19 BnNOK for the Western corridor to 37 BnNOK for the Northern. This excludes the consideration of the Eastern corridor which only addresses improving part of the route journey time between Oslo to Konsvinger.

A comparison of the LCCS for the Route Upgrade Scenario B Alternatives similarly mirrors the same impact the tunnels, earthworks and structure cost components for the track alteration works had on the capital costs. This is particularly reflected in the Southern route, when compared to the North and West, having a high proportion of tunnelling, over twice the other two routes.

A number of key assumptions have been made in establishing the LCC estimates for upgrading the existing routes, as follows:

- Rolling stock as existing and no new trains needed to run the proposed service; and
- Additional night train service to run once in each direction on all routes except East.

8.5.4. Risk and Uncertainty

8.5.4.1.1. Overview

The same procedure and methodology was applied to Scenario B as for Scenarios C/D, described in Chapter 6, including the application of percentage additions.

Optimism Bias has also been considered for Scenario B with the same resultant percentages being suggested as for Scenarios C/D which are:

- 42% for the Northern Corridor;
- 41% for the Western Corridor;
- 42% for the Southern Corridor; and
- 40% for the Eastern Corridor.

It is recognised that it is not standard practice or guidance for Economic and Financial Appraisals in Norway to apply Optimism Bias and consequently, the values identified and their potential implications for costs used in the HSR appraisal are provided for information only at this stage. Optimism Bias has not been applied in the Economic and Financial Appraisal results presented below.

8.5.4.2. Risk and uncertainty outputs and resultant Anticipated Final Capital Costs

Table 51 below presents a summary of the risk and uncertainty outputs prepared by F+G and their implications for the Anticipated Final Cost (AFC) of the Route Upgrade Alternatives considered

Table 51. Application of risk and OB to Route Upgrade Alternatives Capital Costs (MnNOK Q4 2011 prices, undiscounted)

Route	Base Cost	Price Risk Allowance	Design Risk Allowance	QCRA (P80)	Total Risk (%) ((A+B+C)/BC)	Anticipated Final Cost (AFC)	Optimism Bias (OB)	AFC + OB
	BC	**A**	**B**	**C**	**D**	**BC + D**		
Northern	53,075	2,650	5,300	2,098	**19%**	**63,123**	26,511	89,634
Western	28,969	1,450	2,895	2,149	**22%**	**35,463**	14,540	50,003
Southern	44,852	2,240	4,485	1,176	**18%**	**52,753**	22,156	74,909
Eastern	5,830	290	585	545	**24%**	**7,250**	2,900	10,150

8.5.5. Summary and Conclusions

Capital and Life Cycle Costs (LCCs) are both largely driven by route characteristics and resultant design requirements. In the case of LCCs, the service assumptions also have a significant bearing given that operational costs are also a key driver.

Overall, Capital costs, inclusive of risk fall in the range of 35 BnNOK to 63 BnNOK (excluding Eastern corridor). It is difficult to make a fair comparison with other European project costs as the extent of upgrading work varies significantly between routes and locations.

The extent of tunnelling and the need for major structures still has a very large bearing on final costs for this scenario. Each of the corridors for which the route upgrade is being considered have differing characteristics, though all present challenges.

All alternatives follow an existing route alignment and therefore are governed by the exiting environmental, geographical and topographical issues which affected the original route. In addition the same restrictions as identified in Chapter 6 also apply here.

With respect to risk, alternatives fall within the overall risk range of 17% to 29%. With the exception of the Eastern route the same criteria apply as for Scenarios C/D.

The estimation and assessment of investment costs for Scenario B Alternatives can be considered robust for comparative consideration of alternatives for this stage of study and reflective of available data and stage of design development. Subsequent design development would enable estimation and assessment of investment costs to progress towards greater confidence on absolute costs of alternatives, albeit requiring the support of more detailed assessment and quantification of risk.

Table 52 below presents a headline summary of all investment costs outlined above.

Table 52. Route Upgrade Alternatives – Summary of Total Costs (MnNOK Q4 2011 prices, undiscounted)

	MnNOK				
Scenario B Alternative	**Base Cost**	**Price, Design and Development Risk**	**Anticipated Final Costs (AFC)**	**Total Life Cycle 25 Year Cost Estimate incl. on-costs**	**Total Life Cycle 40 Year Cost Estimate incl. on-costs**
Northern Corridor	**53,075**	**10,048**	**63,123**	**16,263**	**37,561**
Western Corridor	**28,969**	**6,494**	**35,463**	**7,434**	**19,037**
Southern Corridor	**44,852**	**7,901**	**52,753**	**11,551**	**28,088**
Eastern Corridor	**5,830**	**1,420**	**7,250**	**4,221**	**7,996**

8.6. Economic and Financial Analysis

This section summarises the key results from the economic and financial appraisal of the implementation of Scenario B in the four corridors.

8.6.1. Key Assumptions

The Scenario B alternatives have been appraised using the Standard and Alternative/Extended Frameworks described in Chapter 7 for Scenarios C/D as far as possible. However, a revision to the calculation of user benefits was required because, as outlined above, the travel demand impacts of the alternatives have been forecast using NTM 5 rather than the HSR demand forecasting model.

NTM5 is considered the more appropriate modelling tool for these alternatives as Scenario B represents a relatively small improvement to the existing reference case rail network, which is best represented in NTM5, rather than the step change in transport provision provided by Scenarios C/D. However, the ‘logsum’ approach to calculating user benefits in the Alternative Framework for Scenarios C/D relies on the use of the HSR model as the calculation is dependent on the particular structure of the model and the use of costs and parameters from it, including the values of time derived through the Stated Preference survey. The use of NTM 5 therefore prevented the use of the ‘logsum’ calculation for the appraisal of the Scenario B tests.

Consequently, a ’40 year’ assessment was undertaken alongside the Standard Framework which applied all the other assumptions included in the Alternative Framework (including the extended appraisal period and application of real growth in costs) but used the Standard Framework approach to calculating user benefits. This followed the approach set out in JBV guidance (i.e. using the ‘rule of half’), valuing rail time benefits at the standard rail value of time.

This variation in approach means that the benefits calculated for the Scenario B alternatives are not directly comparable with those calculated for the Alternative Framework for Scenarios C/D. However, they provide an appropriate basis for identifying the relative scale of impacts, allowing comparison between the Scenario B alternatives and against the relevant Scenario C/D alternatives.

NTM5 is intended as a strategic model and therefore includes only long distance trips (over 100km). As no gravity model of the type used to estimate short distance trips for scenarios C/D is available for Scenario B, the user benefits presented in the core tests represent only the benefits experienced by long distance journeys, understating the total benefits likely to be accrued. A sensitivity test has therefore been run to make an indicative allowance for shorter trips and is presented alongside the core tests below. It estimates impacts on the assumption that the number of trips of less than 100km would be broadly equal to the number over 100km and that, on average, each would accrue half of the average benefit experienced on the longer trips.

A final, more minor difference between the appraisals for Scenario B and those for Scenarios C/D is the fact that the environmental consultants did not undertake the detailed assessment the lifecycle of CO_2 emissions impacts of the Scenario B alternatives that would equate to those that they undertook for Scenario C/D. In the absence of this more detailed data, the default JBV approach is used for Scenario B, using standard emissions rates per vehicle kilometre (omitting the construction impacts included in the Scenario C/D appraisal).

8.6.2. Economic Appraisal Results

Figure 40 below summarises the overall economic appraisal results for each alternative as derived using both the Standard Framework and revised Alternative Framework, labelled the 40 year assessment. The user benefits and third party impacts entry for each alternative shows the net effect of the alternatives on transport users (particularly journey time savings) and on third parties (particularly environmental effects caused by construction and any mode shift).

The public sector/operator impacts entry shows the combined effect of the construction costs and ongoing increases in maintenance, operating and renewal costs associated with the improvements undertaken to achieve the journey time reductions, along with the impact on the economy of the taxation required to fund the investment. The indicator diamond in each column shows the net effect of all of the impacts and equates to the Net Present Value (NPV) of the alternative.

Figure 40. Economic Appraisal Results (NPV, MnNOK, 2009 prices, 2015 base, 25 and 40 year appraisal period)

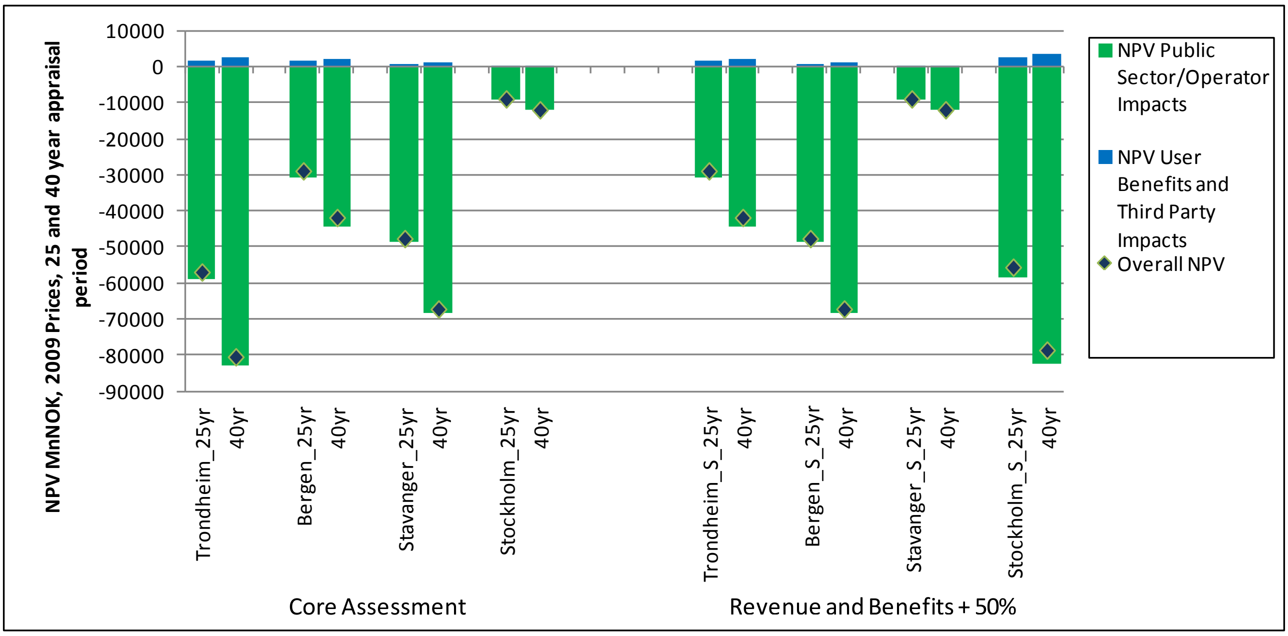


Table 53 below shows the underlying results shown in Figure 40 in more detail.

Table 53. Economic Appraisal Results by Alternative, Standard Framework and 'Revised Alternative' Framework, NPV, MnNOK, 2009 prices 25 and 40 year appraisal periods.

	Core Assessment				Revenue & Benefits + 50%			
	Trondheim	Bergen	Stavanger	Stockholm	Trondheim	Bergen	Stavanger	Stockholm
1) Standard Framework - 25 year period								
a) User Benefits	1,476	1,482	681	3	2,213	2,223	1,022	4
b) Third Party Effects	251	185	93	0	376	278	139	1
c) Net Public Sector/Op. Effects	- 58,776	- 30,626	- 48,531	- 8,970	- 58,297	- 30,266	- 48,366	- 8,969
d) NPV (a+b+c)	***- 57,050***	***- 28,958***	***- 47,757***	***- 8,967***	***- 55,708***	***- 27,765***	***- 47,205***	***- 8,965***
e) Costs *(included in b)*								
Construction/Renewals	- 44,652	- 24,488	- 37,814	- 5,294	- 44,652	- 24,488	- 37,814	- 5,294
Operating/Maintenance	3,922	1,697	2,910	1,514	3,922	1,697	2,910	1,514
Cost of Taxation	- 10,669	- 5,662	- 8,827	- 1,554	- 10,581	- 5,591	- 8,795	- 1,554
f) Revenue *(included in b)*								
HSR	1,250	985	439	1	1,875	1,477	659	1
Other	- 376	- 340	- 140	- 0	- 564	- 510	- 209	- 1
2) 'Revised Alternative Framework' - 40 year period								
a) User Benefits	2,098	2,118	982	4	3,147	3,177	1,473	6
b) Third Party Effects	353	262	132	0	529	393	198	1
c) Net Public Sector/Operator Effects	- 83,053	- 44,289	- 68,434	- 11,986	- 82,415	- 43,806	- 68,211	- 11,986
d) NPV (a+b+c)	***- 80,602***	***- 41,909***	***- 67,320***	***- 11,982***	***- 78,738***	***- 40,236***	***- 66,541***	***- 11,980***
e) Costs *(included in b)*								
Construction/Renewals	- 48,878	- 26,572	- 41,690	- 5,560	- 48,878	- 26,572	- 41,690	- 5,560
Operating/Maintenance	5,176	2,295	3,858	1,919	5,176	2,295	3,858	1,919
Cost of Taxation	- 14,120	- 7,554	- 11,649	- 2,015	- 14,002	- 7,458	- 11,606	- 2,015
f) Revenue *(included in b)*								
HSR	1,654	1,309	588	1	2,481	1,964	882	2
Other	- 491	- 445	- 184	- 0	- 736	- 667	- 276	- 1

Figure 40 and Table 53 show that the lifetime costs of each alternative considerably outweigh the monetised benefits that they generate, with each alternative generating a negative NPV over both the 25 and 40 year appraisal period. The values of the 40 year NPVs range from -12 BnNOK for Stockholm, through -42 BnNOK for Bergen, -67 BnNOK for Stavanger to the most negative value of -80 BnNOK for Trondheim (all 2009 prices).

The scale of each NPV depends primarily on the scale of public sector costs. Benefits are worth less than 5% of the costs in all alternatives and therefore have only a limited impact on the final outcome. As the Stockholm route costs the least it has the least negative NPV, despite having negligible forecast benefits (as the alternative is specified to only deliver the 20% journey time improvement within the Norway section of the end to end route – resulting in only a 5% improvement between Oslo and Stockholm).

Similarly the Trondheim route is the most expensive and therefore has the most negative NPV despite generating the greatest user benefits/third party effects (2.5 BnNOK, with the allowance for short trips).

The costs reflect the still considerable and challenging construction and engineering upgrade works required to achieve the 20% journey time savings for each corridor. As outlined in the previous section, costs vary according to environmental, geographical and topographical features as well as route length even when considering upgrade works, rather than new build.

The scale of the investment required means that the lifetime public sector costs associated with the alternatives are in the order of 20% to 35% of the costs associated with the most comparable HSR routes (for all but the Stockholm route which only covers a small proportion of the length of the equivalent HSR route). However, the transport improvements achieved as a result are considerably smaller, promoting less change in travel and consequently affecting a smaller market.

The average journey time/cost savings per affected journey (taken as all rail trips in the affected corridor) are between approximately 10% and 25% of the average benefits per HSR passenger in the HSR alternatives, at approximately 20 NOK per trip for Stavanger, 60 NOK for Trondheim and over 80 NOK for Bergen (with negligible benefits for the Stockholm corridor) (all 2009 prices).

The total benefits generated by each alternative are the result of both the average benefit experienced and the size of the market affected. Therefore, as the market on the Bergen corridor is less than three-quarters of that on the Trondheim corridor, the total benefits for the two are very similar, despite the difference in per trip benefit.

8.6.3. Financial Appraisal Results

Financial appraisal of the alternatives considers the extent to which the ongoing costs of each upgrade are covered by the revenue it generates, to identify whether it could be considered a viable commercial concern once the initial costs of improvement and construction have been committed.

As discussed in Chapter 7, the costs to be considered in the comparison can be defined in various ways. Generally they are considered as the ongoing direct costs of operating the system i.e. the operating and maintenance costs for the infrastructure and services associated with the improvement. A wider definition would also include the ongoing capital renewals required to maintain the system.

It is also possible, although less usual, to consider the indirect costs of the negative economic impact of the taxation required to fund the scheme as part of the ongoing costs. As for Scenarios C/D in Chapter 7, this interpretation is also included in the analysis below for completeness.

Figure 41 shows the ‘net revenue’ generated by each Scenario B alternative when comparing the increase in incoming rail revenue with each of the three definitions of cost outlined. The first column in each group shows the total increase in revenue generated by the alternative to provide a sense of scale. The first group of columns shows the core results and the second group shows the results in the sensitivity test outlined above where an indicative 50% increase in revenue is included to allow for the possible impact of increases in short distance trips that are not captured by NTM5.

Table 54 presents the figures underlying both sets of results in more detail.

Results are presented for a 4.5% discount rate and 25 year lifetime, in line with current Norwegian guidance.

Figure 41. Financial Appraisal Results (NPV, MnNOK, 2009 prices, 2015 base, 25 year appraisal period)

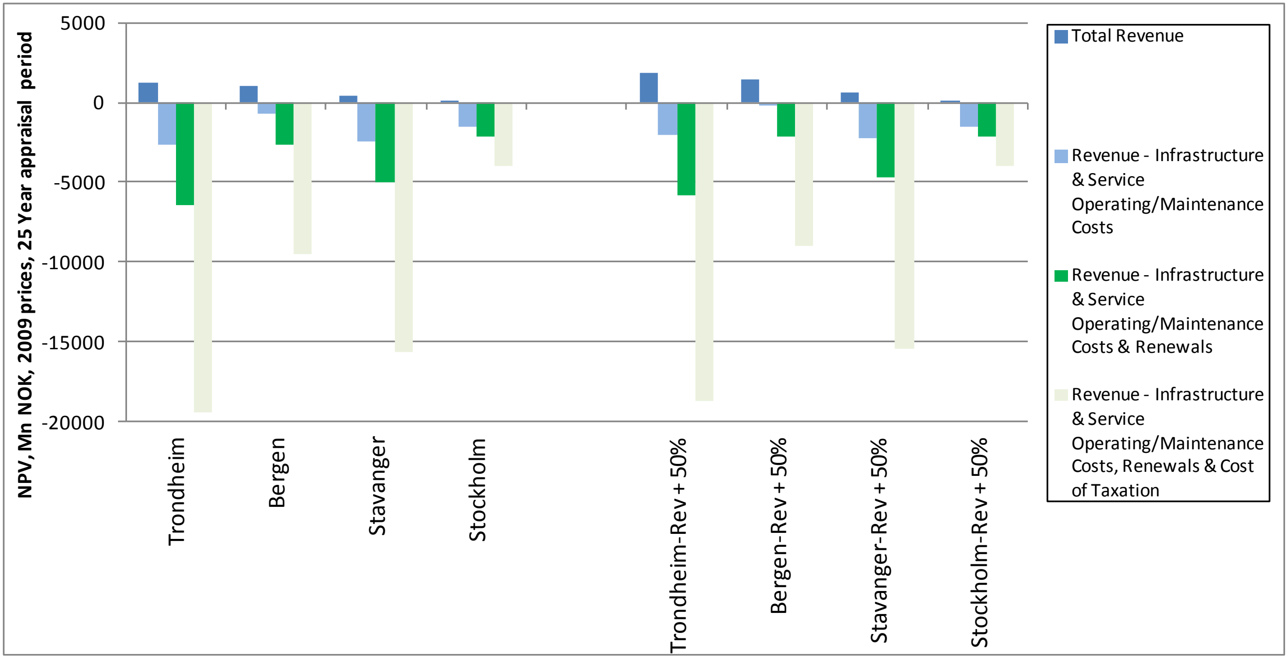


Table 54. Financial Appraisal Results, Alternative Framework, NPV, MnNOK, 2009 prices 25 year appraisal period.

	Trondheim	Bergen	Stavanger	Stockholm
Revenue				
a) Revenue	*1,250*	*985*	*439*	*1*
Ongoing Costs				
b) Operating/Maintenance Costs	3,922	1,697	2,910	1,514
c) Renewals	***3,795***	***1,900***	***2,505***	***640***
d) Cost of Taxation for Scheme Funding	12,933	6,904	10,680	1,802
Net Revenue	-	-	-	-
a- b	- 2,672	- 712	- 2,471	- 1,513
a - (b + c)	- 6,467	- 2,613	- 4,975	- 2,153
a - (b + c + d)	- 19,400	- 9,517	- 15,655	- 3,955

Figure 41 again demonstrates the balance between the relatively high costs of achieving and maintaining the upgrades relative to the small journey improvements achieved and the limited market benefiting from the improvements. In contrast to the Scenario C/D HSR alternatives, none of the Scenario B alternatives are able to cover the ongoing infrastructure and service operating and maintenance costs of the improvement, even if renewals are excluded. Even with the illustrative 50% increase in revenue to allow for possible patronage from shorter trips, only the West (Oslo-Bergen) Scenario B alternative can almost cover its ongoing maintenance and operating costs, but not the additional costs of renewals.

The cost of taxation is, on average, over 10 times as great as the incoming revenue over the 25 year period.

8.6.4. Conclusions

The Scenario B alternatives provide journey time improvements to those directly affected by the scheme. However the characteristics of the corridors and existing routes mean that the cost of achieving and maintaining the journey time improvements is still substantial, particularly in the North corridor.

In combination with the limited market directly affected by the improvements and the relatively modest scale of benefits achieved, this means that the costs of the scenarios outweigh the benefits in both lifetime economic terms and on an ongoing financial basis.

The financial performance in particular is significantly weaker than for the HSR alternatives, with little scope for any of the alternatives to cover their renewal costs.

9. Overall Summary and Conclusions

This chapter collates the key findings from the various strands of analysis undertaken.

The analysis carried out provides a good basis for comparative evaluation of the twelve HSR alternatives and four Scenario B alternatives across the four corridors, as identified by JBV for detailed appraisal. The analysis accounts for a broad range of performance criteria, costs, benefits and impacts. It is nevertheless important to recognise that findings at this stage will have a degree of uncertainty attached to them, given the relatively early stage of development of alternatives at this time. Outputs are geared towards identification and understanding of the comparative, rather than absolute performance of alternatives.

The key findings of the technical analysis undertaken by Atkins are summarised as follows:

9.1. HSR Alternative specification and journey times

- High speed rail has the potential to serve the major communities and settlements in each corridor, based on the alignment designs developed to date. Through the offering of a range of train services it is possible to construct a line that would serve both long distance high speed and intermediate demand for travel

- The study has established the key stations to be served and associated potential core and peak stopping patterns based on populations, station usage, additional market capture potential and achieving sensible operational stop spacing. These have provided the basis for calculating journey times utilising industry standard train service modelling techniques and reflecting alignment designs and appropriate train performance assumptions.

- Journey time calculations show that HSR can offer attractive and competitive journey times to/from Oslo to all the major destinations below :
    - Less than 3 hours between Oslo and Trondheim, Bergen, Stavanger or Stockholm;
    - less than 2 hours between Oslo and Gothenburg; and
    - less than 1.5 hours between Bergen and Stavanger.

- Faster journey times would be possible with more 330 kph running, a new tunnel between Drammen and Oslo, less performance allowance and adoption of rolling stock with a locally optimised mechanical engineering configuration. This value in terms of modal shift will not be proportional to the extra speed gained as the currently proposed journey times for HSR on some corridors will already have shifted over the majority of non-rail users.

- Achieving competitive speeds to destinations in Sweden (and potentially Copenhagen) through investment in high speed rail within Norway only, is difficult and only possible by ignoring capacity issues within Sweden.

- For the purposes of examining HSR alternatives, two Passenger Service Scenarios have been specified:
    - Passenger Service Scenario 1 (PSS1) focuses on capture of demand and market share, combining core and peak services (around 26 trains a day per direction) and with rail fares at 60% of air fares.
    - HSR Passenger Service Scenario 2 (PSS2) has the delivery of commercial operational performance in mind – securing revenue while keeping the associated costs for service delivery down. In this instance it is assumed that only an hourly core HSR service is provided (18 trains a day), reducing the cost of service delivery, while the rail fare is assumed to be higher than in PSS1, and equivalent to the competing air fare.

9.2. Passenger market, demand and revenue analysis

- Demand for HSR services is forecast to be at a healthy level in those corridors where it provides a very competitive time in comparison to air for end to end journeys, and provides a realistic opportunity to make journeys that would previously have not been considered attractive. In terms of performance of alternatives between corridors, with PSS1, demand is generally between 4.2m and 5.5m trips per year in

2024 on each of the domestic corridors between Oslo and Bergen, Trondheim and Stavanger, apart from H1:P which generates around 7.5m trips per year, though this combines three service routes and is therefore not directly comparable with the other alternatives which each search one route only. On these corridors high speed rail has the capacity to become the default mode of choice over longer distances even for intermediate travel

- Forecast revenues lie in a closer, range, typically around 1.4 BnNOK to 1.6 BnNOK in 2024 (in 2009 prices, undiscounted) for the same corridors, with H1:P generating around 2.7 BnNOK in 2024. This corresponds to a typical average fare paid of 280 NOK to 340 NOK, both per one-way trip, for an average journey length of between 280km and 360km,

- Equivalent figures for the East corridor alternatives are slightly lower, with demand ranging between 3.7m to 4.7m and revenue between 0.7 BnNOK and 1.2 BnNOK in 2024.

- Adopting higher HSR fares, even when combined with some reduction in service levels, could lead to up to 20% additional revenue in 2043 for the same alternatives, albeit with demand reducing by up to 35%.

- The scale of mode shift presented in the forecasts for HSR indicates that this could result in an impact on existing services (rail and air) which might as a consequence be unsustainable, further increasing HSR modal share but at the expense of choice. However, at this stage no forecasting or detailed examination of consequential network and market responses to HSR has been undertaken, though this should be considered a key area of analysis during subsequent phases of HSR development.

- There is significant scope to enhance the demand, revenue and operating cost performance of HSR alternatives through a combination of more sophisticated service and fare specification and identification of optimal timetabling and fleet management. This process of optimisation should be a key consideration in subsequent development of any HSR alternative(s) going forward.

- All alternatives have been modelled on a consistent basis, reflecting the level of development of each of the alternatives at this stage and the need to compare demand and revenue forecasts between alternatives. Going forward, bespoke approaches would need to be developed for each corridor to match its individual market potential which will further increase the accuracy of demand and revenue forecasts.

9.3. HSR freight market analysis

- There is a very small market in absolute terms for very high speed freight (200 kph plus) and although some of this traffic could be shifted to rail this is unlikely to grow significantly or sufficiently to warrant designing for its operation.

- Whilst higher speed freight on rail (120 kph) may grow significantly with the construction of high speed lines, it is unlikely to be able to attract a premium price and will therefore operate on the margin commercially.

- Surveys have shown that high speed freight is considered less important by railfreight users than price and reliability. This will be influenced by the allocation of any spare paths on the existing lines caused by passenger trains being shifted to or substituted by those on the high speed lines.

- The analysis presented at this stage provides an indication of the potential scale of freight on high speed lines. However it is recognised that it is not a complete analysis. For this Phase the modelling was necessarily undertaken using the National Freight Model representing current economic conditions. In later phases of work, it would be valuable to undertake further more detailed analysis representing both:
    - Future years and the potential impact of growth in demand and change in relative freight costs (for instance due to changes in fuel costs) ; and
    - Route specific characteristics, using route specific models rather than the national model to allow relevant local freight markets and costs to be represented.

- There would also be value in further investigation of the potential for the presence of HSR to generate new freight opportunities and markets, both as a result of the high speed line itself and through the release of capacity on the existing lines. This released capacity would provide the potential to increase the number of freight paths available, improving freight journey times and, importantly, reliability. Given the widely reported importance of reliability to freight operators, this latter effect in particular could be a valuable impact of HSR implementation.

9.4. Estimation and assessment of investment costs

- Capital and Life Cycle Costs (LCCs) are both largely driven by route characteristics and resultant design requirements. In the case of LCCs, the service assumptions also have a significant bearing given that rolling stock costs are also a key driver.

- Overall capital costs, inclusive of risk are in the range of 60 BnNOK to 262 BnNOK (in Q4 2011 prices, undiscounted). The construction costs for high speed rail in Norway per km will be higher than typical in Europe but this can explained almost entirely by the challenging topography and the resulting design requirements, most notably the extent of tunnels, earthworks and structures. The exception will be the East corridor alternatives where topography is less challenging and the extent of new build railway is significantly less.

- The LCC comparison for HSR alternatives is consistent with the capital cost estimates reflecting the fact that a significant component of LCC is related to the infrastructure assets. H1:P in the West corridor is consequently the most costly alternative at 77 BnNOK over 25 years (in Q4 2011 prices, undiscounted), which also reflects the high train service related costs, including rolling stock, for this alternative where three services are utilising the infrastructure. The Gothenburg alternatives in the East corridor are the lowest cost alternatives, in the region of 25-30 BnNOK over 25 years.

- With respect to capital cost risk, the alternatives have been assessed to fall within the overall risk range of 17% to 29%. The East alternatives are less certain with respect to design as a consequence of the relative lack of design development within Sweden coupled with, in the case of Gothenburg, particular interface issues with Inter-City rail infrastructure and the urban fabric. This is reflected in relatively higher risk values. HA2:P in the West is also a particularly challenging and risky alignment. The South corridor alternatives are deemed to represent the lowest level of risk.

9.5. Economic and financial appraisal

9.5.1. Economic appraisal

- The economic analysis has confirmed that the Alternative Framework better captures and represents the behavioural response and associated benefits of introducing HSR services than the Standard Framework. It is recommended that the Alternative Framework be adopted as the primary basis for assessment looking forward.

- There is considerable variation between some of the alternatives in terms of benefits. For example, the net PV of benefits (combined user benefits, net revenue, freight impacts and third party impacts) generated by H1:P is approximately 70 BnNOK (over 40 years in PSS1, Alternative Framework, 2009 prices) and are therefore nearly five times as large as the 15 BnNOK forecast to be generated by BS1:P. However, the net impacts of most of the other alternatives in the North, West, South and Stockholm East corridors are relatively similar, with net benefits ranging between just under 40 BnNOK and 50 BnNOK (NPV, 40 years). The net benefits of the Gothenburg corridor alternatives are about 25% lower at just under 30 BnNOK.

- In all alternatives, user benefits are the most significant element of the total benefits. HSR revenue levels are also significant, however, the gains are typically largely offset by reductions in revenue on other modes (particularly air). These losses equate to between 70% and 80% of the HSR revenue gains in PSS1. The higher fares and associated revenue in PSS2 mean that this proportion is reduced to around 50% and less for nearly all alternatives, improving the financial performance of the alternatives. Third party impacts (including carbon) are only marginal to the overall economic appraisal. Freight impacts also have a very small impact.

- The scale of user benefits varies between alternatives with the scale of door to door journey advantage that HSR offers on that route and the market size associated with the route in question. Both these factors vary considerably between corridors and alternatives leading to the variations in benefits presented.

- However, given the large scale of investment costs involved, monetised benefits do not offset total costs across the appraisal time period for any of the alternatives considered and hence all have negative NPVs that range between -66 BnNOK and -252 BnNOK (2009 prices, Alternative Framework, PSS1).

- Sensitivity analysis indicates some areas in which changes would improve the balance between costs and benefits, such as the consideration of additional benefits (wider economic impacts or interactions with Inter-City improvements), lower assumed construction cost inflation rates and an alternative view on competitive response. However, investment costs continue to significantly exceed benefits for each of the alternatives, even with more optimistic assumptions in these areas.

- These findings reflect the relatively small market in Norway from which benefits and additional net revenue can be derived, relative to the overall high investment costs. These costs are commensurate with the delivery of HSR schemes elsewhere aimed at serving more sizable populations and densities. The relatively low service utilisation (1tph-2tph) compared with other European HSR schemes (typically 8tph-12tph) means that assets are relatively underused, reducing the scope to generate benefits and weakening economic performance. Performance also reflects the fact that the existing transport provision available in the reference case, particularly for end-to-end journeys by air, is reasonably good, thus limiting the scope to secure time benefits. Consequently, the resulting negative NPVs are to be expected.

- It is noted that consequential impacts of introducing HSR have not been examined in detail at this stage and that the response of air and coach operations post-HSR is uncertain. The response could improve the case for HSR, as indicated by the competitive response sensitivity tests, though given the scale of investment costs currently estimated, it would not alter the fundamental overall negative economic NPV position of HSR alternatives.

9.5.2. Financial appraisal

- The financial appraisal shows that the revenue generated by virtually all of the HSR alternatives is sufficient to cover the associated service and infrastructure operating and maintenance costs. This indicates that there is a strong likelihood that HSR services on most routes could operate as commercial and financially sustainable operations if costs of infrastructure implementation, renewal and capital financing are excluded, particularly when service specification is commercially oriented (PSS2). The best performing alternatives serving a single route are Ø2:P in the North, HA2:P in the West, S2:P in the South and ST3:R in the East. H1:P in the West does perform more strongly but this alternative is exceptional in combining the delivery of three service routes in a single larger HSR scheme and is therefore not directly comparable with the other alternatives.

- With PSS1 none of the alternatives can completely cover the full cost of capital renewals over a 25 year life time, or cover the costs of the taxation required to fund the substantial construction costs of each scheme. The improved financial performance of PSS2 (higher rail fares generating increased revenue coupled to reduced train service costs) means that three alternatives, Ø2:P in the North corridor and HA2:P and H1:P in West corridor are able to also cover their renewals over a 25 year time frame under this scenario and several others are sufficiently close that further optimisation to balance revenues against ongoing costs suggests this would be possible.

- Consideration of the balance between revenue and costs over a 40 year appraisal period decreases the ability of alternatives to meet these direct costs, as much of the capital infrastructure for the alternatives would require renewal between the 25th and 40th year of operation. However, consideration of an even longer period could improve the balance of costs and revenues again as revenue would increase with increased demand.

- Although financial appraisals typically focus on direct costs associated with rail operations and don't consider economy wide, indirect considerations, a particularly wide definition of ongoing costs would also include the costs of the decreased efficiency of the economy caused by the additional taxation required to fund each alternative. Given the scale of construction costs, this is a very large cost and therefore none of the alternatives are able to come close to covering it through ongoing revenues (in PSS1 or PSS2).

- An alternative perspective on the cost of taxation would focus only on taxation required to meet public sector costs/subsidies after construction, treating the costs of financing construction as sunk costs, along with the construction costs themselves. In this approach, any alternatives able to fund their own operating, maintenance and renewals from revenue would not require public subsidy and so would not incur ongoing costs associated with tax financing. For those alternatives not able to cover full costs, the cost of taxation would add 20% to any costs not covered by revenue.

- Using an alternative discount rate for the analysis and considering additional trips on the Inter-City infrastructure also improves the financial performance of the alternatives as would a reduced rate of real growth in construction/renewal costs above standard inflation.

- Additionally, as noted above, the focus of this stage of appraisal has been consistent, comparative assessments of a number of alternatives. Consequently, the alternatives have not been optimised and there is likely to be scope to improve financial performance through detailed balancing of service provision and associated costs and revenue. The comparison between PSS2 and PSS1 provides an indication of the type of change that might be achieved through more detailed analysis, noting that improved financial performance is often achieved at the expense of some wider socio-economic benefits

- The financial appraisal could also alter significantly if the opportunity for consequential cost/subsidy savings relating to other operations with HSR’s introduction could also be viewed as offsetting ongoing costs. The future of the wider rail network and the financial implications in the context of HSR is an area of worthy further investigation. The final equilibrium position of transport provision on competing modes after HSR implementation is also likely to improve the financial position of HSR as it is likely to reduce the attractiveness of other modes (as they reduce service provision), increasing patronage on HSR.

9.6. Analysis of Scenario B alternatives

- Analysis has been undertaken of alternative to HSR alternatives involving upgrading of existing lines to achieve journey time improvements of 20% - Scenario B. A high-level specification of works for these has been provided by the alignment engineers, and it is recognised that Scenario B has not been subject to the same level of design consideration as the Scenario C/D HSR alternatives. Routes between Oslo-Trondheim (North), Oslo-Bergen (West), Oslo-Stavanger (South) and Oslo-Stockholm (East) have been considered. In the case of the latter route the 20% improvement in journey time is only applicable to the Norwegian section of route between Oslo and Charlottenburg, with this equating to only a 5% journey time improvement for Oslo-Stockholm.

- Comparison of the improvement in journey times for Scenario B against the equivalent HSR alternatives with the slowest times, shows that the Scenario B journey times are around twice as long as those for full HSR.

- Demand and revenue forecasting of Scenario B alternatives shows that the overall demand results are at a similar level to those forecast in Phase II and they demonstrate that the impact of Scenario B on long distance travel in Norway is comparatively very small and for North, West and South corridors is between 2% and 4% of forecast HSR demand. It is noted, however, that shorter distance trips are not included in the Scenario B demand and that the HSR demand is inclusive of extraction from existing classic rail services, so the figures are not directly comparable. For the Stockholm corridor the impact of Scenario B is negligible, which is a result of the very low levels of demand in the reference case in NTM5 and the fact that the overall journey time improvement is only 5%.

- Further investigation of the impact of Scenario B on shorter distance trips may improve the demand and revenue potential, but it is almost certain that this will still fall very short of the demand and revenue forecasts for full HSR implementation, reflecting the very significant improvement in journey time, and hence step change in transport provision, that HSR alternatives offer in comparison to Scenario B.

- Scenario B Capital and Life Cycle Costs (LCCs) are both largely driven by route characteristics and resultant design requirements. Overall, Scenario B Capital costs, inclusive of risk fall in the range of 35

BnNOK to 63 BnNOK in undiscounted Q4 2011 prices (excepting the Eastern corridor alternative which is significantly lower cost).It is difficult to make a fair comparison with other European project costs as the extent of upgrading work varies significantly between routes and locations.

- Scenario B Capital costs compare to HSR costs in each case as follows:
  - North: around 35% of HSR
  - West: around 20% of HSR
  - South: around 25% of HSR
  - East: around 7% of HSR (though for only an upgrade and improvement within Norway)

- The extent of tunnelling, structures and the topography in relation to existing lines, which is significant, still has a very large bearing on final costs for Scenario B as it affects the ease with which upgrades can be delivered.

- The economic appraisal shows that the lifetime costs of each alternative considerably outweigh the monetised benefits that they generate, with each alternative generating a negative NPV over both 25 and 40 year appraisal periods. The values of the 40 year NPVs range from -12 BnNOK for Stockholm, to -42 BnNOK for Bergen, -67 BnNOk for Stavanger to the most negative value of -80 BnNOK for Trondheim (all 2009 prices).

- Financial appraisal of Scenario B demonstrates the balance between the relatively high costs of achieving and maintaining the upgrades relative to the small journey improvements achieved and the limited market benefiting from the improvements. In contrast to the Scenario C/D HSR alternatives, none of the Scenario B alternatives are able to cover the ongoing infrastructure and service operating and maintenance costs of the improvement, even if renewals are excluded. Even with an illustrative 50% increase in revenue to allow for possible patronage from shorter trips, only the West (Oslo-Bergen) Scenario B alternative can almost cover its ongoing maintenance and operating costs, but not the additional costs of renewals.

- The Scenario B alternatives provide journey time improvements to those directly affected by the scheme. However the characteristics of the corridors and existing routes mean that the cost of achieving and maintaining the journey time improvements is still substantial, particularly in the North corridor. In combination with the limited market directly affected by the improvements and the relatively modest scale of benefits achieved, this means that the costs of the scenarios outweigh the benefits in both lifetime economic terms and on an ongoing financial basis.

9.7. Additional considerations

- The fit with the Inter-City project does offer potential to enhance the business case of both projects and the opportunity exists now at a marginal cost to optimise this fit, through, for example, the adoption of 250 kph as a speed standard (rather than 200 kph). It is recommended that examination of this opportunity be mandated at the earliest juncture and a strategy be produced detailing how the projects can be optimised.

- The Inter-City project and the opportunity to phase in different high speed corridors, presents different network opportunities and potentially an improved business case by, for example, allowing high speed passengers from Trondheim to connect with Inter-City services to Vestfold. Examination of these opportunities would be worthwhile before any final decision regarding which high speed route should be taken forward is confirmed. In addition the use of the existing line and the handling of the existing services will have a significant impact on the business case.

- Further consideration should be given to dedicated HSR links to Gardermoen Airport, particularly with respect to South and West alternatives, as this will offer the potential for significant additional demand and revenue, possibly enhancing the economic and financial performance.

- Alternative structures to procurement and delivery of HSR in Norway could have significant implications for scheme costs, risk and financial outcomes and there is scope to examine and better understand the feasibility of HSR delivery in this respect.

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