Norway High Speed Rail Assessment Study: Phase III

Estimation and Assessment of Investment Costs

Final Report

25 January 2012

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Executive Summary

Overview

This report provides the 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 of Phase III, Work Stream B.2 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, prepared by Faithful + Gould, 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.

The cost reports identify and price the various route scenario alternatives being considered by route corridor based on alignment data provided by other consultants. The data and cost reports have been presented and reported in a manner to feed and support the Full Economic Appraisals.

This Report covers in detail the 12 number Alternative Routes considered for Full Economic Appraisal.

Capital Cost Model & Report (CAPEX)

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 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 Scenario being considered.

It should be noted that the route option specifications have not been defined in detail at this stage, but is sufficient to support the cost model and includes 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 the 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 cost 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.

Life Cycle Cost Modelling

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 a ‘dummy’ run through exercise a life cycle cost analysis period of 40 years post commencement of operation was used For the Phase III cost modelling a life cycle period of 25 and 40 years will be provided. In addition sensitivity tests for other assessment periods, such as 60 years, could be provided if required.

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 refurbishment and operations.

Sources of information that have been used in the development of the life cycle methodology includes the UK HS2 data, ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE PRICES AND COSTS IN THE RAILWAY SECTOR J.P. Baumgartner Professor - January 2001 and Jernbaneverket METHOD HANDBOOK JD 205 Economic analysis for Norwegian Railroad - June 2006.

Risk and Uncertainty

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 projects 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 – Option 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.

This Report considers risk 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 will be undertaken.

Table 1. HSR Alternatives – Summary of Total Costs (MnNoK @ 4Q 2011 prices)

	MNoK				
	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**
FEA Routes					
Northern Corridor					
G3:Y	156,378	29,114	**185,493**	**54,378**	**115,877**
O2:P	121,580	23,776	**145,356**	**47,522**	**99,382**
Western Corridor					
N1:Q	131,041	27,852	**158,893**	**43,262**	**95,221**
Ha2:P	131,604	36,396	**168,000**	**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**
Southern 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**
Eastern 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**

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, improved passability 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 study has been divided into three phases.

- In Phase 1, which was completed in July 2010, the knowledge base that already existed in Norway was collated, including outputs from previous studies. This included the studies that already were conducted for the National Rail Administration and the Ministry of Transport and Communication, but also publicly available studies conducted by various stakeholders, such as Norsk bane AS, Høyhastighetsringen AS and Coinco North;
- In Phase II a common basis and models were identified 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 have been developed to help assess the costs of HSR; and
- In Phase III the tools and guiding principles established in Phase II have been used to test scenarios and alternatives within 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.

The principles established in Phase II and used in Phase III are used to test the following scenarios:

- Scenario A – reference case. This is a continuation of the current railway policy and planned improvements, with relatively minor works undertaken shown in the National Transport Plan from 2010-2019. This forms the ‘do minimum’ scenario to which the other scenarios will be compared;
- Scenario B – upgrade. A more offensive development of the current infrastructure, looking beyond the ‘InterCity’ area to achieve a stated improvement on timetabled journey times;
- Scenario C – major upgrades achieving high-speed concepts. This is to be based on an aggressive upgrade of the existing network to provide a step change in journey times, and
- Scenario D – new HSR. This involves the implementation of newly built, separate HSR lines

The improvements are being considered on six corridors:

- Oslo – Bergen;
- Oslo – Trondheim;
- Oslo – Kristiansand and Stavanger;
- Bergen – Stavanger;
- Oslo – Stockholm (to Skotterud in Norway); and
- Oslo – Gothenburg (to Halden in Norway).

The scenarios will be considered in relation to the long distance travel market, for example for journeys over 100km in distance. The Scenarios considered in this report are a combination of Scenario C & D, with route speed alternatives D1, D2 and 2*, within a particular route. For each route, for the Full Economic Appraisal, two principle speed conditions are considered - 330 and 250 kph using a combination of D1, D2 and 2*.

In addition Sensitivity Route Analyses were completed for comparison purposes using similar criteria.

For each scenario it will be necessary to assess conditions related to income and costs, environmental concerns, energy consumption, maintenance under winter conditions and the procurement and operational organisation of the services and infrastructure.

1.2. 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 2. 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.***

1.3. Overall Context of the Financial and Economic Analysis Contract

To complete Phase III of the study, Jernbaneverket has commissioned Contracts:

- Technical and Safety Analysis;
- Rail Planning and Development;
- Environmental Analysis;
- Commercial and Contract Strategies;
- Market Analysis, and
- Financial and Economic Analysis.

WS Atkins International Ltd (Atkins) and Faithful + Gould are assisting Jernbaneverket in two of the contracts: Market Analysis and Financial and Economic Analysis. This report, prepared by Faithful + Gould, is part of the Financial and Economic Analysis Contract.

The Financial and Economic Analysis Contract consists of five Subjects:

- Subject 1 Impact on Road and Aviation Sectors;
- Subject 2 Cost Estimation;
- Subject 3 Funding and Operating Structure Analysis;
- Subject 4 Financial and Economic Analysis, and
- Subject 5 Uncertainty Analysis.

The purpose of the Financial and Economic Analysis Contract is to establish an assessment framework to use to evaluate potential HSR alternatives against the objectives stated in the Ministry's mandate. Outputs of the assessment framework will show the financial impact and affordability of the interventions, including an evaluation of alternative financing alternatives. Socio-economic impacts of the improvements will also be demonstrated and together with forecast generated revenue will be considered in relation to the expected costs. The uncertainty around the results will be assessed. Together the outputs will provide a basis for HSR investment decisions in Norway.

This Report provides the outputs for Subject 2 (Estimation and Assessment of Investment Costs) of the Financial and Economical Analysis Contract.

1.4. Purpose of the Estimation and Assessment of Investment Costs Report

The High Speed Rail Assessment Project aims to assist Jernbaneverket in the decision-making process by analysing the costs and benefits of constructing a High-Speed Railway in Norway.

The primary purpose of the Subject 2 Workstream: Estimation and Assessment of Investment Costs, is to develop and report on definitive Capital & Life Cycle Costs for each of the identified High Speed Rail Route Alternatives for Full Economic Appraisal. The outputs, together with other related reports and studies will enable JBV to make informed decisions and recommendations.

The methodology and cost model developed as part of Subject 2 identifies Capital (CAPEX) and Life Cycle Costs (LCC) which are considered necessary to input into a financial model to enable confident decision making on route alternatives.

The methodology and associated excel based cost models will enable the comparison by route of alternative HSR scenarios.

1.5. Organisation of report

The report has been structured into the following Chapters:

- Chapter 2 - Assessment and Quality Assurance of Previous Estimates;
- Chapter 3 – Route Alignment Appraisal data;
- Chapter 4 – Capital Cost Modelling;
- Chapter 5 – Life Cycle Cost Modelling (including Maintenance & Renewals, Operational & Occupancy costs);
- Chapter 6 – Risk Review;
- Chapter 7 - Cost and Risk Analysis – Scenario B; and
- Chapter 8 – Conclusions / Summary of Results and Reports.

1.6. 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, January 2012;
- High Speed Rail Assessment Project, Corridor North Oslo – Trondheim: Delivery 2 – Phase 3 Alignment study, 2011-11-25, Ramboll
- 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
- Norwegian High Speed Railway Assessment, Phase3 Corridor East: Corridor specific analysis main report, 2011-11-25, Norconsult

2. Assessment and Quality Assurance of Previous Estimates

2.1. Introduction

As part of the Phase II study Faithful + Gould carried out an assessment of a previous cost reports prepared for JBV together with those for similar projects within Norway and Northern Europe.

For completeness the results are briefly described below.

2.2. Studies reviewed

In addition to the High Speed Railway Lines in Norway: Concept Evaluation, Cost Estimate and Uncertainty Analysis Report (2007) prepared for JBV we studied further High Speed Cost Reports including:

- Nuremberg – Munich High Speed Line;
- Mannheim – Stuttgart High Speed Rail;
- HS1 – Channel Tunnel Rail Link;
- HSL Zuid;
- ICE Frankfurt – Cologne;
- Hanover – Wurzburg; and
- COWI Report on High Speed Rail in Norway.

2.3. Key findings and recommendations

In reviewing the various cost models the first exercise was to regularise the costs to a common base date. This done the contents of each report can be aligned by the major elements (i.e. track, power, signalling and property).

Using the various published data we prepared a Regression Model, reflecting the weighted average unit rates and elemental costs. These figures were used to develop the unit rates in the F+G Cost Model and also to assess rates against the previous Cost Report prepared for JBV.

The key findings of JBV's Cost Report were:

- The Cost Model appeared incomplete as it excluded costs for Power and Signalling elements;
- The level of detail was low. The figures were reported at a high level, an all inclusive rate per kilometre, without any further supporting backup. This prevented any detailed analysis of unit rates;
- The Track (permanent way) base costs, having allowed for structural works (embankments, cuttings, tunnels, etc) appeared high compared to other projects and the weighted average; and
- It would appear that the cost estimate exercise was based on minimal data and therefore it would be fair to assess that this was a Pre-Feasibility Order of Magnitude Cost Report, and therefore any data extracted should be considered with that in mind.

Further references and considerations are made of the JBV (2007) report and other cost data throughout the rest of this report.

A comparison between the historical project data and cost models under review are represented in a graph in Appendix A.6

3. Route Alignment Appraisal data

3.1. Introduction

A more detailed study and report of each route alignment will be presented within the separate Alignment Engineers' Reports. However as background to this report a brief outline of the presentation of Appraisal data is given here.

At a joint Client and Consultant workshop in August 2011 the Alternative Route Scenario Alternatives for each corridor were determined. They were further split into two groups for analysis - 1) Full Economic Analysis and 2) Sensitivity Analysis.

The data used to populate the cost model for each route scenario was provided by four Alignment Engineering Consultancies. Each Consultant was designated a Route Corridor, North, West, South and East. Following a number of further workshops the parameters were set and route alignments determined for the various scenarios.

3.2. Full Economic Analysis Scenarios

Each Route Corridor was to be considered by the Alignment Engineer and they were tasked to present what they considered the best route alternative for speeds of 330 and 250 kph, combining route speed options D1, D2 and 2*, for a Full Economic Appraisal. The cost model was prepared and submitted for input into the detailed Financial Assessment**.**

3.3. Alternative Sensitivity Analysis Scenarios

In addition to providing the data for a full Economic Analysis the Alignment Engineers were also asked to consider Alternative Route Scenarios for a lesser analysis. Using the same parameters and principles they were to offer alternative Scenario C&D Alternatives for Sensitivity Analyses. (These studies have not been reported within this document).

3.4. Presentation of data

Both sets of alignment data were to be presented to Faithful + Gould in an agreed format. The alignment was shown by way of a route map, identifying existing, upgrading and new lines and indicating the potential final speed there on. The mapped route alignment was then to be presented in a tabular format on an Excel spreadsheet identifying elements and quantum calculated at 0.50km stages. This data had to align with the Work Breakdown Structure identified in the Cost Model. In addition an assessment of additional stations, based on the Demand Modelling, was scheduled and included in the cost data.

In deriving the element and quantum certain criteria, parameters and assumptions had to be agreed and established for all routes. These qualifications and assessed unit rates to reflect same were discussed and agreed with the alignment consultants at various workshops throughout the Phase III process. These outputs and qualifications are collated and contained within the full Route Cost Models which are summarised within the Appendices with detailed reports available at http://www.jernbaneverket.no/no/Prosjekter/Hoyhastighetsutredningen.

The Elements identified were as follows

- Track
- Electrification (power)
- Signalling
- Earthworks
  - Cuttings and / or Embankments (categorised into depth/height and difficulty of construction)
  - Tunnels (categorised into difficulty of construction)

Structures

- Bridges (categorised into types and size)
- Viaducts (categorised into span and lengths)
- Crossings
- Special construction by location

Stations (and other buildings)

4. Capital Cost Modelling

4.1. Introduction

4.1.1. Background to Capital Cost Modelling

The purpose of the Capital Cost Modelling 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.

Several studies were taken into account for the development of the High Speed Rail Cost Model. The most relevant studies are the following:

- "Concept Evaluation, Cost Estimate and Uncertainty Analysis", Metier, Oslo, 2007
- "Comparison of High Speed Lines' CAPEX", BSL, Hamburg, 2009
- "HS2 Cost and Risk Model", HS2, London, 2009
- "High-Speed Rail Development Programme", Systra and MVA Consultancy, 2009
- The Model will enable the comparison by route of alternative scenarios reflecting different levels High Speed Rail.

4.1.2. Aims, Scope and Limitations

The Cost Model developed within Phase II of this study is now used, together with the alignment input data to define the cost of a particular route or alignment as determined within the study strategy. This in turn will be used to make an informed financial assessment for appraisal and presentation. The cost model is based on delivering a high speed rail infrastructure. The specification is fundamental for the creation of a solid and reliable cost model. Although at this early stage of the study a detailed specification would not have been defined, a high level specification, compliant with European and Norwegian standards, and agreed with the Consultants was used to compile the Cost model.

The key outline specifications are:

Permanent Way:

- Standard Gauge - 1,435 mm
- Rail – CEN60 CWR
- Sleepers – Concrete, spacing of 700 mm
- Track Support – 7.5 track bed width comprised of 300 mm of bottom ballast; 300 mm of top ballast; Geotextile layer and 200 mm of sand blanket

Electrification:

- 15kV 50HZ overhead line equipment
- Auto-Transformer system

Signalling & Telecoms:

- The model can accommodate both traditional signalling and ERTMS level 2
- The system adopted for telecoms is the FTN/GSMR system

The High Speed Rail Cost Model compiled consists of two cost models: an estimating cost model and a regression cost model. The first generates cost 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 estimating model produces the estimated cost and is then benchmarked against the regression model to verify the reliability of the resulting data.

The data is then split into different cost breakdown structures and benchmarked against data collected from different studies available to further increase the degree of reliability of the model.

Though the model offers the user a great degree of reliability, it strongly relies on the background data of both cost and specification which require updating when changes are made to either. In addition, the same applies when the total length of rail infrastructure to be built is in the region of 25 kilometres or lower as the model does not interpret skewing or distortion to the unit rates due to small quantities.

The model allows for a risk contingency uplift. This has been assessed and added following a QCRA workshop. More information on the risk appraisal is contained within Section 6 – Risk Review.

4.1.3. Acknowledgements

- The base date for the cost model is 4th Quarter 2011(4Q2011) in accordance with JBV economic analysis guideline. The model can include for inflation to a specific date.
- The currency is to be the Norwegian Kroner. The model can also express costs in Euros, USD and GBP
- The model is used to calculate costs for differing scenarios for each route as described earlier.

4.2. Methodology

4.2.1. General

This section of the report provides a description of the methodology used in developing the CAPEX Estimate Cost Model. It also identifies and describes the data that has been used in this exercise and the contents of the model.

4.2.2. Estimating Model

The estimating model has been developed using simple calculations to arrive at a series of high level elemental costs applied to quantities that can either be generated from statistical data or input manually, namely:

- The route length – base data being at Grade level
- The extent of the route being carried on elevated structures and type
- The extent of the route running in cuttings and embankments, plus type
- The extent of the route running within tunnels and type
- The number of stations by type
- The number of depots and sidings
- The number of grade separated and flat junctions by type
- The number of crossings between rail and roads, other rail lines and water courses

To these quantities, a series of "all-in" elemental rates have been applied to arrive at an overall scheme cost. These rates have been developed from a variety of methods but generally from first principles, benchmarked against "all-in" rates from available studies and actual costs from High Speed Rail projects in Europe. In addition a series of Workshops were held with the corresponding Alignment Engineers to obtain their views on unit rates, criteria and assumptions. Taking the input from the Consultants the Unit rates have been "Harmonised" to reflect Scandinavian factors in high speed rail construction.

4.2.3. Regression Model

This exercise has also included a benchmarking estimate, resulting from processing outturn cost data of other comparable high speed rail schemes on an overall route-wide per km basis. This data from similar projects was processed and normalised to enable a logarithmic regression of the relationship between cost per route Km and total length of construction. The logarithmic regression of the Northern Europe data sets a threshold for the estimating model which, at each iteration, is benchmarked against the historical data.

In addition historical data for the proportion of cost per asset (Permanent Way, Signalling, Power, etc.) and indirect costs has been included in a number of checks. These test the model for discrepancies and errors. This greatly assists the user by displaying the expected (historical) splits against the estimating cost splits.

4.2.4. Unit Rates

The unit rates by element have been derived from historical and published cost data. We have determined bench marked rates by taking the mean of a number of similar published Northern European Inter City and High Speed Rail projects.

Generally such data can be drawn from a number of sources:

- In house historical data (From previous scheme outturn costs and estimates) at elemental or work item level
- Published data from previous schemes – country and system related, normally at elemental level
- Specific client based/supplied data
- “Bottom up” rate build-ups prepared on a resource led basis

At this stage of project development the first two categories are most relevant. Where the client has provided data this is noted in the assumptions register.

The Unit Rates reflect the considered mean Northern European rates as described above. As described earlier the rates have then been “harmonised” by working with the other Study Consultants. Having identified and acquired such cost data it needs to be checked for accuracy and reliability. Particularly with published data, we need to understand what is, and more importantly, isn’t included within each item, and what further allowances or adjustments will be necessary in order to normalise the data to a common denominator, with particular regard to the following:

- Location (with particular regard to local labour and material costs)
- Base date at which the data is priced. (in order that this can be adjusted to a common baseline date)
- Programme (where delivery targets or restraints may influence productivity or other contributory factors)
- Site specific factors (access, restraints on economic working etc)
- Market or other economic conditions

Having reviewed these factors in each case, commonly described as assumptions, rates have been adjusted as necessary to a common “base” either manually or by utilising a statistical analysis over a range of alternative rate sources to establish a common ground to account for these assumptions. These “Generic” Assumptions and Qualifications are described in Section 4.6

4.2.5. Harmonisation

In determining the unit rates as described above a further exercise of harmonisation was carried out in conjunction with the Alignment Engineers.

Due to the intricate geography of Norway and the high level nature of this study certain criteria in relation to quantum and cost had to be addressed. With the Alignment Engineers, Faithful + Gould reviewed the quantum and rates of the significant cost elements, i.e Groundworks and Tunnelling.

By a process of definition and detailing unit rates were determined for the key infrastructure elements. These rates are also qualified by default assumptions contained within the “Generic” Assumptions and Qualifications (Section 4.6)

4.3. Process

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 model is broken down into elements as defined in Section 4.3.2. The elemental unit rates can be applied to the quantities derived by either method.

4.3.1. Format

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. It is based on best practices used within the construction industry and is recognised by major professional bodies. The stages of this cycle are set out below:

- Output definition
- Pre-feasibility
- Option selection
- Single option selection
- Detailed design
- Construction test & commission
- Scheme hand back
- Project close out

4.3.2. Cost Breakdown Structure

For reporting purposes, the resulting costs have been split into three main categories and respective sub-categories:

Contractor's direct costs

- Signalling & Telecoms
- Electrification & Plant
- Track
- Operational Property
- Structures
- General Civils
- Utilities
- Stations

Contractor's indirect costs

- Preliminaries
- Design
- Testing & Commissioning
- Training
- Spares
- Other - Possession Management, Isolations, etc

Client's indirect and other costs

- Client's Project Management
- Compensation Charges (to Train Operators, etc)
- Planning & Transport Act Charges
- Land / Property Costs & Compensation

4.3.3. Required Inputs

Whilst determination of elemental quantities by percentage of route length will provide a good order of cost estimate up to pre feasibility a more detailed and reliable cost model would depend on the input of measured quantities based on a defined route. The level of quantum will be determined by the level of design details and outputs.

For this report the cost model relied upon route data provided by the Alignment Engineers. The data was to be presented within a given format, by way of an Excel spreadsheet.(An example of the data sheet is provided in Appendix A2). The data broken down into key Elements includes the following:

- Length of new single and double track (new corridor) (including “normal” signalling, electrical, telecoms)
- Length of upgrading existing single track (existing corridor)
- Length of new single track and upgrading existing track (existing corridor)
- Other railway systems (overall signalling centre/system, overall electrical system, GSMR masts, etc)
- Earthworks cuttings
- Earthworks embankments
- Length of tunnels and proposed construction methodology
- Number of railway bridges (single/double track) and outline geometry

- Number of passenger terminal stations (categorised by size, including track, platforms, switches/turnouts) – taken from Demand modelling data
- Number of passenger intermediate stations (categorised by size, including track, platforms, switches/turnouts) - taken from Demand modelling data
- Number of crossings, passing loops and track junctions
- Number of level crossings (road bridges) (small, medium, large)
- Other types of concrete structure/works
- Environmental actions (noise reduction)
- An estimate of the proportion of urban/agricultural/forest land along the route as a % of the route
- Type of traffic (mixed, freight, passenger)

For each of these inputs assumptions and qualifications have been determined, as described earlier. This enables the estimator, together with Alignment Engineers to derive an appropriate Unit rate per element.

4.4. Sources of Information

The schedule of information resources utilised in the compilation of the cost model are listed below:

- “Concept Evaluation, Cost Estimate and Uncertainty Analysis”, Metier, Oslo, 2007
- “Comparison of High Speed Lines' CAPEX”, BSL, Hamburg, 2009
- “HS2 Cost and Risk Model”, HS2, London, 2009
- “High-Speed Rail Development Programme”, Systra and MVA Consultancy, 2009
- “Feasibility study on Rail, Baltica railways” COWI, 2007
- “Economic Analysis of High Speed Rail in Europe” Fundacion BBVA, Bilbao, 2009
- “High Speed Rail: International Comparisons”, Steer Davies Gleave, London, 2004
- “Prices and Costs in the Rail Sector”, EPFL, Lausanne, 2001

4.5. Base Data

Previous studies noting the limitations of them

- In house historical data
- Client based data
- Published data – country related
- Sense checks of data for accuracy and reliability and coverage
- Rates are reviewed and adjusted as necessary for: location; market conditions, economic conditions, programme, definitions, etc

4.6. Working (Generic) Assumptions and Qualifications

In preparing the Cost Model, and developing the unit rates, the following “Generic” assumptions have been made:

(Route Specific assumptions have been included separately within each Route Cost Model)

4.6.1. General

- Base date – the date all construction and life cycle prices are based at, (i.e. 4th Quarter 2011)
- Construction programme dates include lead in time for planning & approvals
- Construction programme profiles are assessments only and assume more than one contractor per route.
- Due to interpolation of route data input the route lengths calculated and stated within the cost reports are within +/-5% of the lengths within the Alignment Engineers reports.
- Cost sensitive elements which will have the most impact in the decision making.
- The model is set up to show an Order of Magnitude Estimate based upon input route alignment data for the various route option scenarios

- Prices are expressed in Norwegian Kroner
- The prices are at a base (point) estimate level. A small allowance has been made for measurement accuracy.
- No firm design proposals have been prepared, therefore the scope of works is deemed to be based on typical working standard specifications.
- The Unit rates, in general, are based on rates derived from similar High Speed European railways. They are high level unit rates and have been benchmarked against similar rates provided by Systra, BSL and Metier studies
- Unit rates have been “Harmonised” with Alignment Engineers input to reflect Norwegian working practices and environment.
- The rates reflect the assumption that the works will be carried out by an experienced international railway contractor and the works shall be competitively tendered
- No allowance has been made for operation or maintenance costs within the CAPEX figures. Reference for these should be made within the OPEX Summaries
- An adjustment factor has been added - This is for rate adjustment for factors such as:- Unmeasured Items, Development, Complexity, Location - all of which are NOT included within the Risk Contingency
- Specific project risks were determined through a Quantitive Cost Risk Assessment workshop The %age output calculated per route has been added to the estimates

4.6.2. Permanent-Way

Parameters used in deriving the Unit Rates are as follows:

- Ballast Density 1.6 t/m3; Spoil Density 1.7 t/m3
- Track Bed Width 7.5 m for single track and 12.5m for double track ; Sleeper Spacing 700 mm
- Ballast Depth 600 mm; Sand Blanket 200 mm
- Ballast width 3.8 m; Rail UIC60, R65 CWR"
- Rates priced at cost/linear km and assume a 7.5 metre wide track bed
- The rates are based on a slab-track solution similar to the Rheda 2000 system. Adjustment has been made to match the project specifications
- The rates were built from first principles and include plain line, site clearance, shallow depth excavation and formation preparation, fencing, signage, drainage, allowance for UTXs. We have assumed that 30% of the spoil resulting from the formation works is contaminated
- Passing Loops have been assumed and included within the costs for new stations only. No additional allowances have been included at this stage
- Switches and crossings have been measured and priced as extra over the plain line track and allow for: additional excavation; formation; ballast; configuration of the fitting, points heating, clamplocks and backdrives, testing and commissioning
- All S&C units are full depth, built on site. The S&C units were divided into two categories, low, and high speed. Unit rates built from first principles
- Allowances for land reclamation or flood relief work are measured as an extra over the base trackwork rate

4.6.3. Structures

- Tunnel rates are based on two methods a) bored and /or drill & blast (no differentiation) and b) cut & cover ,measured extra over trackwork. Slab tracking is included in rates
- Tunnel rates assume single track tube construction
- Tunnel pricing assumes the acquisition of 2nr Tunnel Boring Machines. Rates are based on recovered data and information from approximately 50 separate structures completed as part of actual projects.
- Bridge unit rates include excavation, reinforcement, formwork, concrete, bearings, expansion joints, deck waterproofing, deck finishes, P1 parapet and lighting.
- Viaduct construction assumed to be simply supported span sections in steel and/or concrete. at varying span lengths. (In addition a cost model was developed to determine cost as a function of the variation in height of the viaducts)
- The rates for viaducts have been derived from cost /m2 deck area. Bridges have been enumerated and defined by road size. Rail over rail bridges /crossings have been specifically identified. Where bridges, spans exceed economical length over 80 metres, viaducts have been assumed. Bridge construction assumed to be simply supported span sections in steel and/or concrete. Bridges have been categorised according to location and circumstance - road, river, etc and priced in span ranges accordingly.

- Special constructions, i.e. bridges over fjords, are enumerated and priced separately

4.6.4. Earthworks

- Embankments & Cuttings have been measured and priced as extra over the trackwork
- Cuttings and Embankments cross-sections assumed a 7.6 m single track bed width and slopes graded at 45° (assumed below natural angle of repose). It was assumed that 70% of the earthworks grading is adequate. For the remainder 30% an allowance was made for earth stabilisation methods, in particular, soil nailing and rock netting
- A cost model was developed to express cost as a function of depth/height of the cutting/embankment and split into three categories dependant on height/depth and ground difficulty. An allowance was made for utility diversions in urban areas only
- Any specific geological constraints to be identified by route
- Environmental and Nature considerations included as a cost per km of route

4.6.5. Signalling & Telecommunications

- The signalling system is ERTMS level 2
- The telecoms system is GSM-R

4.6.6. Electrification & Power

- 15kV 50HZ overhead line equipment
- The system priced is an Autotransformer system
- There will be 30 km between every feeder station
- An allowance was made for SCADA remote monitoring

4.6.7. Buildings

- Allowance was made for Electrical Control Centre, Signalling Control Centre, Administration Buildings, etc
- Stations have been categorised into 3 main types and costed accordingly and include for passing loops and car parking appropriate to station category

For the purpose of this exercise the full station construction cost was assumed and included in the cost model instead of a major refurbishment/upgrade cost. The difference in overall cost, taking into account the magnitude of the final overall cost is negligible

- No allowance has been included for Depots as deemed to be provided within the Rolling Stock lease costs included in Life Cycle Cost figures.

4.6.8. Quantities

- The route lengths are defined by the Alignment Engineers. From this the Engineers have determined the infrastructure elements by quantification of the route detail. The elemental breakdown determines the quantities of bridges, viaducts, tunnels and earthworks

4.6.9. Sundry Items

- Acoustic barriers – assumed in urban areas only, both side of route. Rolling Stock is included within the Life Cycle Cost Model on an annual rental basis.

4.6.10. Indirect Costs

- Prices are inclusive of Contractor's overheads & profit
- Preliminaries & Professional Design & Management Fees have been shown separately as a percentage of the base construction figures
- Client indirect costs have been added as a percentage of the Total Construction cost (Base cost plus Contractor’s indirect costs)
- Land costs are approximate assessments for temporary land take during the construction works and permanent land take for the immediate construction works

4.7. Exclusions

In arriving at the unit rates and preparing the Cost Model the following have specifically been excluded at this stage:

- Value Added Tax & other taxes
- Escalation during the lead in and construction periods (i.e. all costs are therefore based at 4th Qtr 2011 price levels)
- Capital Allowance costs, finance charges etc (added in the financial model)
- Track access and operational charges (included in the life cycle cost model)
- Existing track upgrade cost
- Development Study costs (i.e. project development studies from 2010 onwards)
- Legal & Parliamentary/ Governmental Fees
- Estate, Local Planning Fees
- Public Consultation costs
- Third party compensation
- Professional & other Adviser Fees to Feasibility stage
- Environmental, Ecological & Geotechnical studies
- Project Contingencies (added in the financial model)
- Consequential costs in improving connections with or upgrading of existing passenger routes. The cost model reflects the extra over\enhanced cost on providing the HSR only

4.8. The Cost Model

The Cost Model composed in an Excel Spreadsheet format contains the following data sheets for each route scenario:

- Summary & Inputs – This section is to be populated to reflect the Route option by selecting a number of basic parameters to define the rail route to be estimated. These parameters include route option length, number of tracks, type of tunnelling, type of signalling, currency (default is Norwegian Kroner) and base date (default is 4th Qtr 2011). By completing the Inputs a Cost Summary is generated in total and by Route Alternative.
- CAPEX Report – The report section offers a number of total cost summaries that include the estimate broken down following different criteria. The first summary is by key elements for direct and indirect costs. The remaining summaries report on both the statistical and estimating aspects of the model and offers comparisons with a number of studies and actual costs of similar projects
- Unit Rates – The unit rates selected as described in Section 4.2.3 are nett rates. In this section the rates are converted to gross rates and the individual elements converted to unit rate per Km or Sums
- QTO – The topography is defined in this section. The quantum data is manually input to generate costs for different topography profiles. By default the model selects historical data for the typical Northern Europe topography (extracted from several similar schemes in this area). The selection between the two alternatives is made by switching the cells “Earthworks, Tunnels & Viaducts Quantities” and the “Crossings” lines, in the Input section, from “statistical” to “input”
- Input data – Route alignment data provided by the Alignment Engineers recorded at 0.5km stages. Data identifies the key route elements from which all quantum is measured or derived.
- Cost Profile – An assessed construction time line and spend profile. This is derived from historical data providing typical out turn construction periods on a km per year basis. It assumes that there will be more than one contract per route. This profile is hypothetical and used purely as a means to assist in the Financial Modelling.
- Alignment & Journey Times – Route table identifying stations, route distance an journey times together with route map identifying the Scenarios per route

4.9. Output & Results

4.9.1. Cost Outputs

The Feasibility Study involves the preparation of Route Capital Cost Models in providing the infrastructure to deliver a combination of 2 route scenarios

Scenario C – Provide new alignment to allow operational speeds up to 250 kph, by upgrading existing or providing new route alignment.

Scenario D - Provide new alignment to allow operational speeds up to 330 kph, by upgrading existing or providing new route alignment

Twelve number route alternatives were considered for a Full Economic Alternative Analysis. This involved preparing a Capital and Life Cycle Cost Estimate for each alternative which would be used to develop the Financial Appraisals. In addition a further eight number route alternatives were considered for Sensitivity Analysis. This also involved preparing a Capital and Life Cycle Cost estimate for each alternative for sensitivity testing only.

The Outputs of each alternative are summarised below with Route Summary results included within Appendix A1

4.9.2. Economic Alternative Analysis results

4.9.2.1. North Corridor – Key Issues

G3:Y – 250 kph – via Gudbrandsdalen

- Northern corridor route runs through large tracts of National Parks
- Significant costs related to Geographical & Environmental constraints
- Total route length of 525 km of which 448 km is upgraded
- 60% of route in tunnels
- Special Bridge over Imsroa river valley
- Length of track between Stange & Tangen is and remains existing
- Estimated Construction period 10 years

O2:P – 330kph – via Osterdalen

- Northern corridor route runs through large tracts of National Parks
- Significant costs related to Geographical & Environmental constraints
- Total route length of 483 km of which 409 km is upgraded
- 42% of route in tunnels
- Estimated Construction period 9 years

4.9.2.2. West Corridor – Key Issues

The western routes generally involve a greater extent of tunnelling and earthworks due to the geography and terrain. This is reflected in the higher sectional cost for these routes.

N1:Q – 250 kph – via Numedal

- Excluding section from Oslo to Drammen (assumed existing is compatible)
- Total route length of 399 km of which 339 km is upgraded
- 43% of route in tunnels
- Some special bridge locations required.
- Estimated Construction period 7 years

Ha2:P – 330kph – via Hallingdal

- Excluding section from Oslo to Sandvika (assumed existing is compatible)
- Total route length of 367 km of which 355 km is upgraded
- 56% of route in tunnels
- Special Bridge at Geillo river valley and special tunnelling under the Hardangerjøkulen glazier
- Estimated Construction period 7 years

H1:P – 330kph – via Haukeli

- The infrastructure costs include for a combined “Y” route from Oslo to Roldal and branching north to Bergen and south to Stavanger
- Excluding section from Oslo to Drammen (assumed existing is compatible)
- Significant costs related to Geographical & Environmental constraints
- Total route length of 563 km of which 531 km is upgraded
- 66% of route in tunnels
- Special Bridges at Hardangerfjorden and Skudenesfjorden crossings
- Estimated Construction period 10 years

BS1:P – 330kph – Bergen to Stavanger, via Stord

- Significant costs related to Geographical & Environmental constraints
- High proportion of bridge crossings and tunnelling
- Total route length of 230 km of which 230 km is upgraded
- 63% of route in tunnels, high proportion over 50 km in length
- Complex fjord crossing or tunnelling
- Estimated Construction period 6 years – subject to tunnelling constraints

4.9.2.3. South Corridor – Key Issues

S8:Q – 250 kph – via

- Southern corridor route follows the existing coastal route
- Excluding section from Oslo to Drammen (assumed existing is compatible)
- Significant costs related to bridges, crossings and the like
- Total route length of 538 km of which 421 km is upgraded
- 48% of route in tunnels
- Special Bridges over fjords at Kjevik and Flekkefjord
- Estimated Construction period 9 years

S2:P – 330kph – via Osterdalen

- Southern corridor route follows the existing coastal route
- Excluding section from Oslo to Drammen (assumed existing is compatible)
- New direct line from Drammen to Porsgrunn
- Significant costs related to bridges, crossings and the like
- Total route length of 498 km of which 440 km is upgraded
- 58% of route in tunnels
- Special Bridges over fjords at Kjevik and Flekkefjord
- Estimated Construction period 9 years

4.9.2.4. East Corridor – Key Issues

GO3:Q – 250 kph – to Gothenberg

- Eastern corridor route runs through relatively open countryside
- Access is relatively easy
- Total route length of 337 km of which 184 km is upgraded

- 25% of route in tunnels
- The Oslo to Ski section is excluded as deemed part of a new independent project.
- The route from Oxnered to Gothenberg remains as existing and assumed adequate to support new proposal
- Estimated Construction period 5 years

GO1:S – 330kph – to Gothenberg

- Eastern corridor route runs through relatively open countryside
- Total route length of 308 km of which 195 km is upgraded
- 30% of route in tunnels
- The Oslo to Ski section is excluded as deemed part of a new independent project.
- The route from Oxnered to Gothenberg remains as existing and assumed adequate to support new proposal
- Estimated Construction period 5 years

ST5:U – 250 kph – to Stockholm

- Eastern corridor route runs through relatively open countryside
- Total route length of 510 km of which 331 km is upgraded
- 17% of route in tunnels
- The Oslo to Ski section is excluded as deemed part of a new independent project.
- The route from Vasteras to Stockholm is upgraded to 250 kph speed limits. As no information is available, this section is estimated on a pro rata basis of the Norwegian element
- Estimated Construction period 7 years

ST3:R – 330kph – to Stockholm

- Eastern corridor route runs through relatively open countryside
- Total route length of 492 km of which 319 km is upgraded
- 13% of route in tunnels
- The route from Vasteras to Stockholm is upgraded to 250 kph speed limits. As no information is available, this section is estimated on a pro rata basis of the Norwegian element
- Estimated Construction period 7 years

Table 3. Summary of Economic Alternative Analysis Results

Route (speed in kph)	Total Length	Length Upgraded	Capital Cost (Bn NoK)	Construction Period (years)	Number of New Stations
G3:Y (250)	525	448	185.49	10	6
O2:P (330)	483	409	145.36	9	4
N1:Q (250)	399	362	158.89	7	6
Ha2:P (330)	367	355	168.00	7	4
H1:P (330)	563	531	262.05	10	6
BS1:P (330)	230	230	114.71	6*	4
S8:Q (250)	538	421	218.88	9	10
S2:P (330)	498	440	222.06	9	8
GO3:Q (250)	337	184	66.32	5	5
GO1:S (330)	308	195	69.02	5	2
ST5:U (250)	510	331	129.33	7	2
ST3:R (330)	492	319	114.24	7	2

5. Life Cycle Cost Modelling

5.1. Introduction

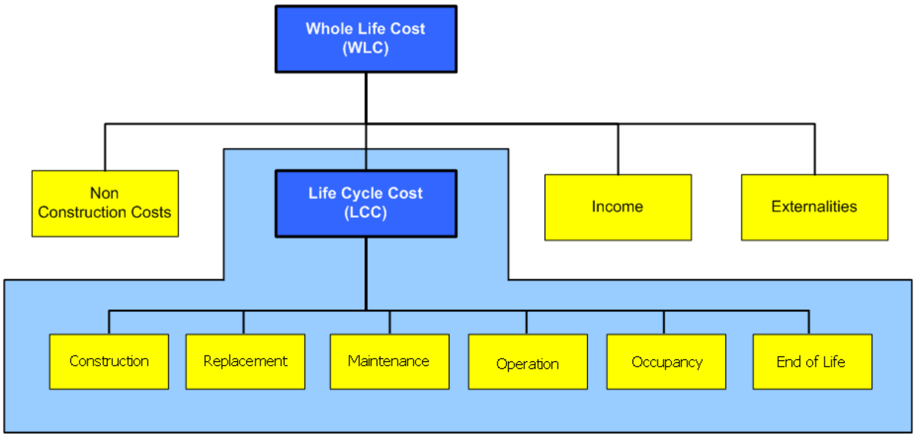
The purpose of the life cycle cost modelling is to provide JBV with order of magnitude cost estimates for maintenance (which covers asset renewals) and operation to ensure that the life cycle costs (LCCs) together with the capital costs over the long-term are included as part of the overall economic assessment for each of the route options at Phase III.

The aim is to provide a robust and workable high-level life cycle costing appraisal model that can test the different high speed rail full economic appraisal and sensitivity alternatives for a period of 25 and 40 years from commencement of operation. The LCC model conforms to the capital cost data structure and provides inputs into the economic and financial models.

5.2. 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 option 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:



The SMLCC definitions for life cycle are as follows:

Replacement costs - Scheduled replacement and refurbishment 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.

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
- Rolling stock leasing costs

NB other costs such as finance and strategic non-construction cost 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

5.3. Form of Analysis and Reporting Requirements

The LCCs are reported in accordance with the construction cost data structure and the proforma detailing the costs on an annual basis for financial input.

The LCCs have followed the same Work Breakdown Structure (WBS) as for the capital costs:

- Lifecycle maintenance costs
  - Signalling & Telecoms
  - Electrification & Plant
  - Track
  - Operational Property
  - Structures
  - General Civils
  - Utilities
  - Depots
  - Rolling Stock
- Life cycle operating costs
  - Station Staffing
  - Train staffing & management
  - Energy Consumption

The period of analysis is 25 and 40 years from commencement of operation.

The base date used for the Capital Construction Cost Estimate is 4Q 2011

The base date used for the Life Cycle Cost Estimate is 4Q 2011

5.4. Methodology

Generally

The life cycle costing methodology conforms to the BS ISO 15686-5:2008 Buildings & 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.

Life Cycle Replacement

The life cycle replacement (LCR) cost estimate utilises the descriptions, quantities and cost rates for each of the assets as given in the latest capital cost plan.

Benchmark replacement frequencies and percentages from our database that have been factored to the Norwegian environment are then applied to the given quantities and costs for the asset. Percentage uplifts from our database are applied to the installation cost rates to reflect the predicted replacement costs of each asset. The replacement frequencies and assumptions for each of the assets have been included in the LCR Assumptions sheet.

The service life expectancies for the asset components are drawn from our own databank of information which has evolved from our in-house knowledge and data; and from the following published sources:

- BS ISO 15686-5:2008 Building & constructed assets - Service life planning - Part 5: Life cycle costing
- Standardized Method of Life Cycle Costing for Construction Procurement - A supplement to BS ISO 15686-5:2008
- CIBSE Guide M - Maintenance engineering and management 2008
- BCIS Life Expectancy of Building Components 2006
- HAPM, BPG and BLP Component Life Manuals
- BRE The Green Guide to Specifications 2008
- Research Organisations such as CIBSE, CIRIA, TRADA
- Test Houses and Certification Bodies
- Published research and conference papers
- Project agreed life expectancies

The LCR costs relate to and have been estimated from the cost rates given to the assets in the capital cost plan. The annual LCR cost estimates for each element are calculated together to give an overall total for the 25/40 year period of analysis.

The life cycle replacement costs have been derived without benefit of a procurement, renewal and replacement strategy. It has been assumed that the life cycle assets will be controlled by a comprehensive asset register and asset renewals plan that will seek to minimise asset replacement whilst offering best value over the 25/40 year concession period.

Maintenance

The infrastructure and equipment is assumed to have been designed to minimise the necessity for maintenance intervention and maximise reliability. Heavy maintenance work will have to be carried out within a fairly short 'shutdown' period each night due to the intensity of service and separation required which will limit access for maintenance. The maintenance costs have also been factored to take in to account the limits caused by the Norwegian environment. It has been assumed that the system will be designed with a high degree of redundancy, for the modular exchange of equipment and ease of major maintenance tasks.

It has been assumed that inspection and maintenance cycle will follow manufacturer's recommendations modified in accordance to experience and actual service performance.

The maintenance cost estimate covers the following:

- Inspection & testing of assets
- Routine Maintenance – activities carried out at regular intervals generally less
- Planned Preventative Maintenance – work activities which are planned on a time, utilisation or condition basis
- Reactive Maintenance – unplanned corrective work undertaken to put right faults, damage or premature failure of an asset

Maintenance costs for different activities are estimated from either the time taken to undertake a task, labour rate, spares and consumables, plant or equipment required to undertake each activity or from annual labour requirements with allowances for spares and consumables.

The staffing levels and all inclusive labour costs used in the maintenance estimate are given in an Organogram for each of the line alternatives.

In the maintenance cost estimates for each route we allowed for the following:

- personal protective equipment
- tools and equipment for general use
- spares and consumables
- maintenance vehicles

The maintenance costs have been derived without benefit of a procurement, renewal and maintenance strategy but it is assumed that the life cycle assets will be controlled by a comprehensive asset register and asset maintenance plan that will detail all the maintenance activities and operations to be carried out on a planned basis. The whole emphasis it assumed to be on planned preventative maintenance according to comprehensive maintenance schedules undertaken by a trained and motivated workforce.

Operations

The incremental operational costs are derived from benchmark operational organogram and staffing levels for similar High Speed Rail operatives, adjusted to the assumed performance and operational requirements of the trains and stations for Norway HSR. The operation costs allow for management and administration during the operation period.

The operational energy costs are derived from assumed energy consumption levels and rates for the trains, stations and depots for Norway HSR.

The leasing costs for the rolling stock have been derived from benchmark costs from other European HSR services. This includes for procurement, planned and reactive maintenance, mid-life refurbishment, replacement and all associated first response costs to the rolling stock.

Baseline annual salaries and on-costs for key staff have been reviewed and agreed with Jernbaneverket.

5.5. Sources of Information

Schedule of Information Sources includes:

- High Speed Rail London to the West Midlands and Beyond HS2 Cost and Risk Model - December 2009
- ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE PRICES AND COSTS IN THE RAILWAY SECTOR J.P. Baumgartner Professor - January 2001
- Jernbaneverket METHOD HANDBOOK JD 205 Economic analysis for Norwegian Railroad - June 2006

5.6. Assumptions

- Our detailed assumptions for each route option have been included within each LCC report.
- Refer to Appendix B for examples of the Life Cycle Replacement, Maintenance, Operation and Organagram Assumptions for the Route O2:P Oslo – Værnes.
- Each LCC estimate has been prepared using the following general assumptions:
- It has been assumed that the rolling stock will be "off the shelf" TGVs for passenger use only and standard freight locomotive and wagons.
- Train Journey Times CORE hourly departures 06:00 to 22:00 hrs
- PEAK hourly departures 07:00 to 11:00 and 16:00 to 20:00 hrs
- Train turn-around 15 mins generally required
- No adjustments have been made to changes in peak train services at weekends as it has been assumed that any differences will be offset by additional late night services.
- Assumed 2 drivers, 1 conductor and 2 on-board staff per train.
- No allowances have been made for on board catering staff as these will be provided by the buffet concessionaire.
- We have assumed revenue protection and train cleaning will be carried out by the OBA staff.
- We have generally assumed a 35 hour working week.
- Station cleaning has been allowed for new stations only.
- No LCC allowances have been made for car parks as it has been assumed that these costs will be covered by the revenue generated.

5.7. Risk & Sensitivity

An overall risk & contingency allowance of 20% has been applied to the total LCC estimate for each route at this stage.

These LCCs are 'base-line' estimates at this stage. No sensitivity analysis has yet been carried out. The LCC risks will be estimated for the significant items highlighted in the risk register.

6. Risk Review

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.

6.1.1. Route Specific Risks

Route specific risks were established following a series of risk workshops held in Norway, to analyse the Northern, Western, Southern and Eastern 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.

6.1.2. Pricing Risks

Faithful+Gould has applied a 5% pricing risk allowance.

6.1.3. Design Risks

Faithful+Gould has also applied a 12.5% design risk allowance to the Eastern and Western Corridors a 10% design risk allowance to the Northern and Southern Corridors.

6.2. Optimism Bias

The use of Optimism Bias is best practice in the United Kingdom. It is applied during the economic appraisal of any public sector capital spend project. Optimism Bias 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 Optimism Bias to apply to the Anticipated Final Cost for each corridor. They are as follows:

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

6.3. Findings

Faithful+Gould has summarised the appropriate risk allowance and Optimism Bias uplifts in the table below.

Table 4. Application of Risk and OB to HSR Alternative Capital Costs (MnNoK @ 4Q 2011 Prices)

	Base Cost	Pricing Risk Allowance (5%)	Design Risk Allowance	QCRA (P80)	Total Risk Allowance (%)	**Anticipated Final Costs (AFC)**	Optimism Bias (OB)	**AFC + OB**
	BC	A	B	C	(A+B+C) / BC	**BC+A+B+C**		
FEA Routes								
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**

7. Cost and Risk Analysis – Scenario B

7.1. 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 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 chapter presents the results for Scenario B Route Upgrade Alternatives and follows the same methods and procedures as 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
- 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 the Route Upgrade Alternatives carried out for Scenario B.

7.2. Capital Costs (CAPEX)

7.2.1. 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 option 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.

7.2.2. Outputs & Results

Tables 4 and 5 below present the headline and summary capital cost estimates derived from the cost modelling process. Costs are presented in BnNOK and are in 4Q 2011 prices. 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 5. Route Upgrade Alternatives Anticipated Final Costs – Capital Costs (BnNOK, 4Q 2011 prices)

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 base capital costs, excluding risk, range from between 28 BnNOK for the Western corridor to 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 to 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 Route Upgrade Scenario B Alternatives clearly shows the impact of tunnels, earthworks and structure cost components on option costs, even for track alteration works. 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 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

- The existing line would be closed whilst upgrade works continued

7.3. Life Cycle Costs

7.3.1. 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 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 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
- 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.

7.3.2. Outputs & Results

Tables 5 and 6 below present the LCCs at 4Q 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 6. LCC Scenario B - 25 Year Headline Summary (BnNOK 4Q 2011 prices)

25 Year	Life Cycle Replacement Costs (NOK 000,000)	Life Cycle Maintenance Costs (NOK 000,000)	Life Cycle Operating Costs (NOK 000,000)	On Costs (NOK 000,000)	Total (NOK 000,000)
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 7. LCC Scenario B - 40 Year Headline Summary (BnNOK 4Q 2011 prices)

40 Year	Life Cycle Replacement Costs (NOK 000,000)	Life Cycle Maintenance Costs (NOK 000,000)	Life Cycle Operating Costs (NOK 000,000)	On Costs (NOK 000,000)	Total (NOK 000,000)
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

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

Additional night train service to run once in each direction on all routes except East

7.4. Risk and Uncertainty

7.4.1. 7.4.1 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 applied as for Scenarios C/D and 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 in Chapter 7 of this report.

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

Table 7 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 8. Application of risk and OB to Route Upgrade Alternatives Capital Costs (MnNOK 4Q 2011 prices)

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

7.5. 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 Route Upgrading 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 9. Scenario B Route Upgrade Alternatives – Summary of Total Costs (MnNOK 4Q 2011 prices)

	MNoK				
	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**
FEA Routes					
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. Conclusions

This report details the work that has been undertaken to use and develop the cost estimation models to provide a financial assessment of each of the alternative scenarios for high speed rail improvements in Norway. The “Cost Model” contains methodologies for providing CAPEX and Life Cycle cost estimates. These models and methodologies are employed in this stage (Phase III) of the study to estimate costs using outputs from the detailed route alignment studies and more detailed scenario specification. The cost estimations will be used in the financial and economic assessment to show the performance of alternative scenarios on each route under consideration.

8.1. Capital Cost Modelling (CAPEX)

The client brief noted that there were a number of scenarios that need to be considered such as minimal upgrades to the existing network, mixture of upgrade of existing and cut-off, new high speed route plus the possible requirement for freight. The model at Phase II has been developed in such a way that it has the flexibility to cope with the majority of these scenarios.

In Phase III we have taken the Cost Model, input the data for the various route alternative scenarios, as provided by the Alignment Engineers to deliver a high level Capital Cost Estimate. Each estimate is presented in the same format so to enable fair comparison between routes. A combined summary of all Full Economic Appraisal route alternatives is attached at Appendix A1.

An example of a detailed Cost Model Reports for a typical scenario is included in Appendix A3.

The CAPEX results show in summary that the geography, geology and environment of Norway has a great influence on costs. Earthworks, structures and tunnelling combine to form the greatest proportion of the costs for all routes. Taking this into account the average costs per km are still comparable to Northern European averages.

The CAPEX figures for each scenario have been handed to the Economic Analysis Team for full economic analysis and reporting. The outputs of which are contained within a separate report.

8.2. Life Cycle Cost Modelling (Life Cycle)

During Phase III the Life Cycle model was developed in line with the Capex cost model and aligned with the established WBS. Each life cycle estimate is presented in the same format so as to enable fair comparison between routes. A combined LCC summary of all Full Economic Appraisal route alternatives is attached at Appendix B1. An example of a detailed life cycle cost model report for a typical route option is included in Appendix B2 with all associated assumptions (Appendices B3-B8). The model is proven by reference to published and recognised guidelines and the review of similar costs for High Speed Rail schemes.

The Life Cycle costs for each scenario have been given to the Economic Analysis Team for full economic analysis and reporting, the output of which are contained within a separate report.

Appendix A. Capital Cost Model Reports

A.1. Scenario C/D - Economic Appraisal Route Summary Report (MnNOK at 4Q 2011 prices)

	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**	**355**	**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**

A.2. Engineering Input Data (Example)

NORWAY HSR	ROUTE ALIGNMENT SCHEDULE
	ROUTE: Route 3
	SCENARIO: Alternative D Osterdalen

Østerdalen Prioritized Variant

					Trackwork					Electrification		Signalling	Earthworks - Cuttings & Embankments						Crossings (Bridges)				
Stretch	Grid Point				A1	A2	A3	A4	A5	B1	B2	C1	D1	D2	D3	D4	D5	D6	F1	F2	F3	F4	F5
Homogeneous stretches	from	to	Length	Single(S) or Double(D) New(N) or Existing(X) Track	Plain Line (Ballast track)	Slab Track in Transition/ Open ground	Slab track in Tunnels orViaducts	Extra over for Turn Outs	Check	per km of track	Extra Over for Additional Sub Station	per km of track	Cat 1- **EASY** (0 - 10m dp/h) Good gd Cdns	Cat 2 **Medium** (10-20m **dp/h**) OR >10m dp/h with soft Gd	Cat 3 **Difficult** (<20m dp/h) OR > 20m dp/h with "special Measures"	Extra over wide crossection	Extra overSpecial Ground Cdns	Ekstra over Urban community Areas+ utility diversions	Class 1 Road (motorway)	Class 2 Road (double lane)	Class 3 Road (single lane, footpath and minor roads)	Rail over Rail	Specials
Indicative Cost (MNOK/Route Km) Rates **at 3rd Qtr 2011**													48	120	190	+30%	20	TBA	100	40	15	80	
Nr	Km	Km	Km	S/D/N/X	Km	Km	Km	Km	Km	Km	Km	Km	Km	Km	Km	Km	Km	Km	Qty	Qty	Qty	Qty	LS
0	0.000	61.967	61.967	X					61.967														
1	61.967	64.756	2.789	D/N	2.789				0.000	2.789		2.789	2.321	0.159	0.009						4.000		
2	64.756	64.856	0.100	D/N			0.100		0.000	0.100		0.100			0.100		0.100						
3	64.856	64.976	0.120	D/N		0.120			0.000	0.120		0.120	0.120			0.120							
4	64.976	65.975	0.999	D/N			0.999		0.000	0.999		0.999											
5	65.975	66.000	0.025	D/N		0.025			0.000	0.025		0.025	0.025			0.025							
6	66.000	66.358	0.358	D/N			0.358		0.000	0.358		0.358											
7	66.358	66.421	0.063	D/N		0.063			0.000	0.063		0.063	0.063			0.063					1.000		
8	66.421	68.463	2.042	D/N			2.042		0.000	2.042		2.042											
9	68.463	68.598	0.135	D/N		0.135			0.000	0.135		0.135	0.093	0.042		0.135							
10	68.598	68.770	0.172	D/N			0.172		0.000	0.172		0.172											
11	68.770	68.812	0.042	D/N		0.042			0.000	0.042		0.042	0.042			0.042							
12	68.812	77.217	8.405	D/N			8.405		0.000	8.405		8.405											
13	77.217	78.207	0.990	D/N		0.990			0.000	0.990		0.990	0.864	0.126		0.990							
14	78.207	78.533	0.326	D/N			0.326		0.000	0.326		0.326											
15	78.533	81.119	2.586	D/N		2.586			0.000	2.586		2.586	2.116	0.400		1.000					2.000		
16	81.119	82.967	1.848	D/N			1.848		0.000	1.848		1.848											
17	82.967	83.028	0.061	D/N		0.061			0.000	0.061		0.061	0.061			0.061							
18	83.028	83.230	0.202	D/N			0.202		0.000	0.202		0.202											

A.3. Scenario C/D - Economic Route Appraisal Summary – Route O2:P

Jernbaneverket
Norway High Speed Rail - New Lines Northern O2:P
Oslo - Værnes Capital Cost Estimate
24th November 2011
CAPEX Report

FAITHFUL GOULD CONSTRUCTIVE EXPERTISE

O2:P Oslo-Gardermoen-Elverum Parkway-Tynset-Trondheim-Værnes

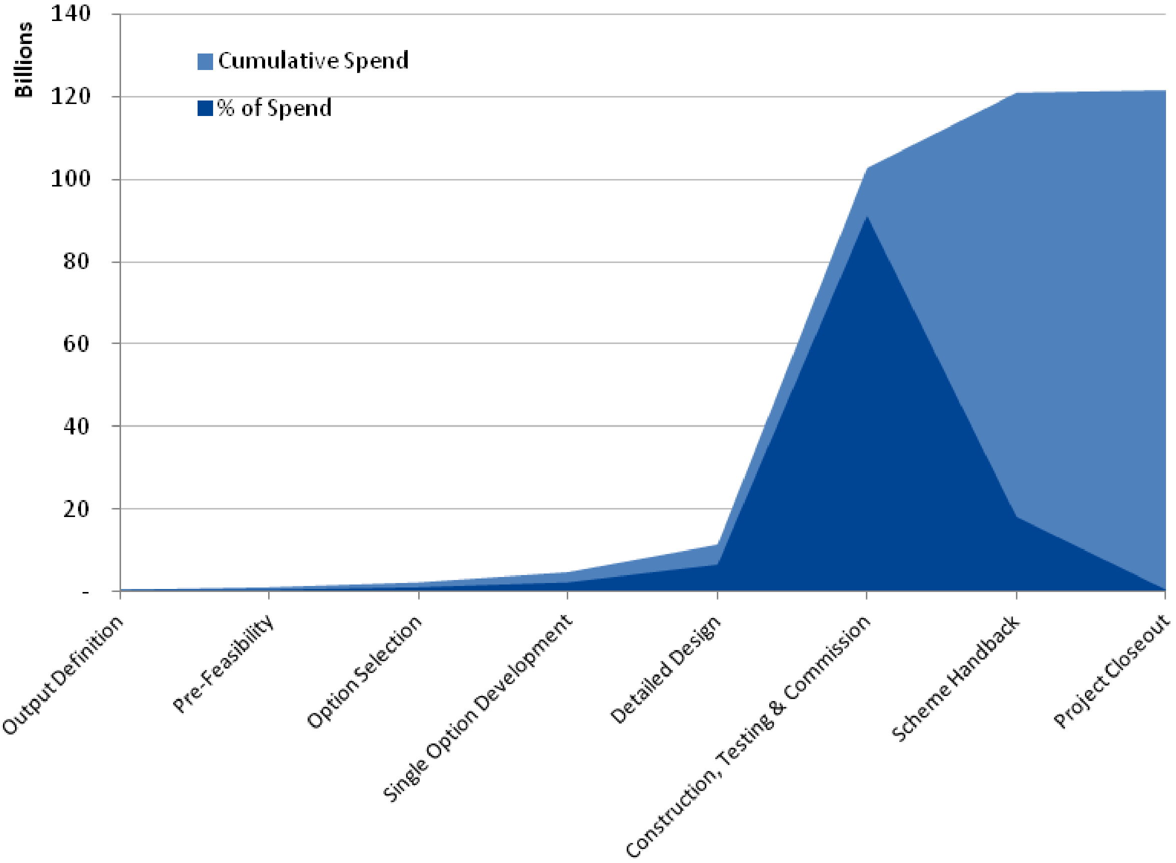
Estimate Summary Report

Estimate No	**001**	**Revision**	**0**
Estimate Date	**24-Nov-11**	**Base date**	**2011**
Project Title / Location	**O2:P Oslo-Gardermoen-Elverum Parkway-Tynset-Trondheim-Værnes**		
Total Route Length (km)	**483**	**Upgraded Route Length (km)**	**409**

Estimate Breakdown	Value	%
Contractor's direct costs		
Signalling & Telecoms	2,430,446,127	2.8%
Electrification & Plant	5,164,225,260	6.0%
Track	9,264,905,751	10.7%
Operational Property	1,073,134,862	1.2%
Structures	54,706,031,331	63.1%
General Civils	12,210,323,561	14.1%
Utilities	31,587,803	0.0%
Depots	1,876,519,977	2.2%
Sub-Total i	**86,757,174,671**	
Contractor's indirect costs		
Preliminaries	17,340,697,858	20.0%
Design	4,702,425,653	5.4%
Testing & Commissioning	770,260,924	0.9%
Training		0.0%
Spares		0.0%
Other - Possession Management, Isolations, etc	4,333,536,435	5.0%
Sub - Total i	27,146,920,869	31.3%
Total Construction Cost (i+ii)	**113,904,095,541**	
Client's indirect and other costs		
Client's Project Management	4,337,858,734	3.8%
Compensation Charges (TOC & FOC)	-	0.0%
Planning & Associated Costs	2,315,130,693	2.0%
Land / Property Costs & Compensation	1,022,654,642	0.9%
Sub - Total iii	7,675,644,068	
	121,579,739,609	
Uplift for Risk and Contingency		
Price, Design and Development Risk	23,775,831,757	
Project Anticipated Final Cost (AFC)	**145,355,571,366**	
Upgraded Cost per km Excluding Client Indirect Cost and Contingency (MNok/km)	**278.164**	
Optional Extra cost of the provision of Category 3 Stations including indirect and on costs (3 nr)	**369,439,871**	

A.4. Spend Profile

Typical spend profile graph



A.5. Unit Rates

Example of Unit Rate build up

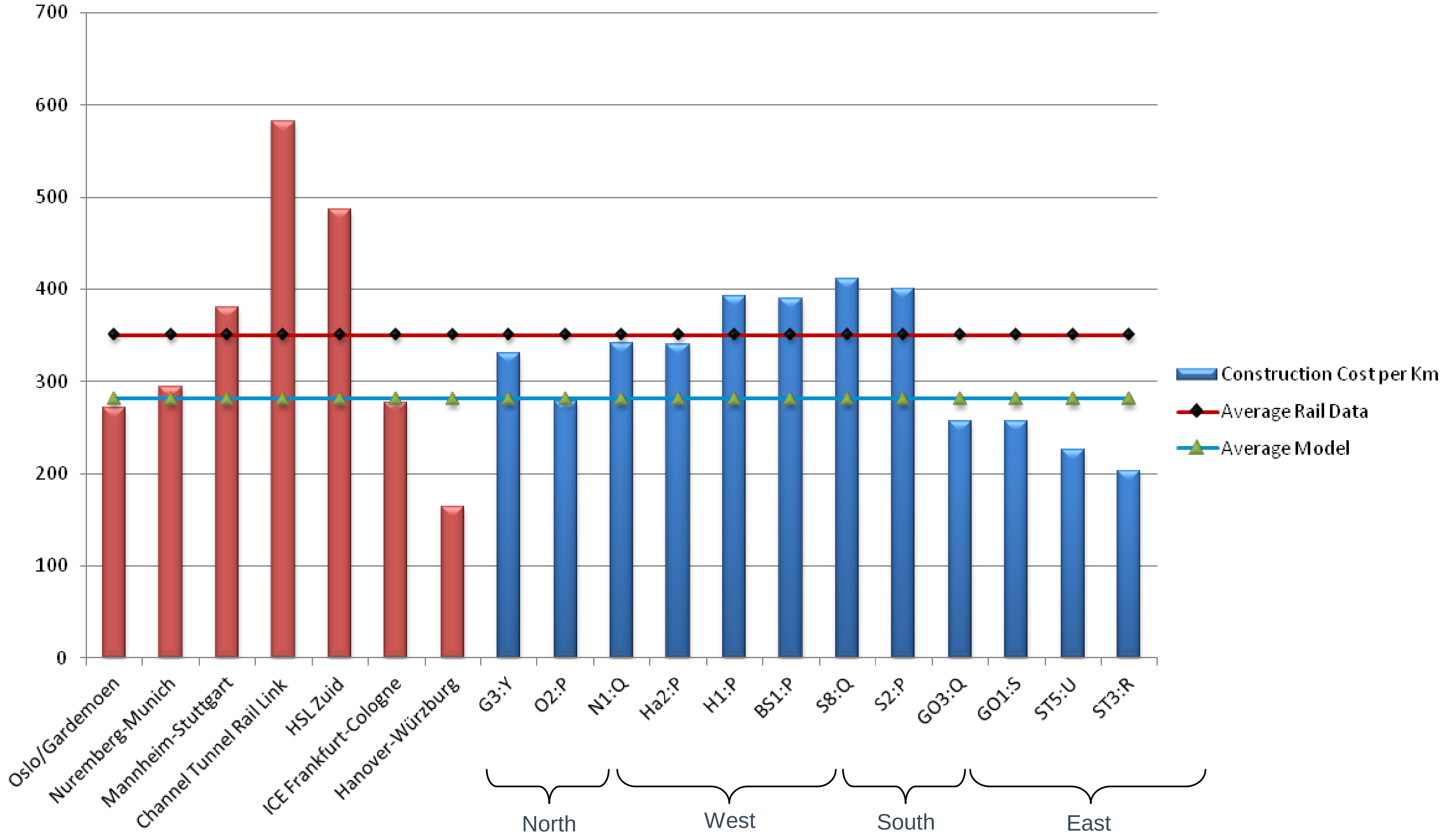
Permanent Way

Track		Unit	Quantity	Rate	Total
	Formation	single track km	2	1,247,212	2,494,424
	Drainage - twin track	single track km	2	1,918,788	3,837,575
	Rail, Sleepers & Ballast	single track km	2	3,837,575	7,675,150
	Delivery of Materials & Tamping	single track km	2	959,394	1,918,788
	Lineside fencing -pallisade fencing	single track km	0	1,266,400	-
	Track Renewal	single track km	2	7,675,150	15,350,300
					15,925,937

S&C		Unit	Quantity	Rate	Total
	Crossovers	number	30%	5,660,423	1,698,127
	Crossovers (Emergency / Low speed)	number	10%	4,317,272	431,727
	Turnouts	number	30%	3,252,345	975,703
	Turnouts (Low speed)	number	10%	2,398,484	239,848
	Twin track tie in of new to existing route - normal operations	Number	0%	13,431,513	-
	Twin track tie in of new to existing route - emergency use	Number	0%	7,195,453	-
					3,345,406

A.6. Cost Benchmarking (MnNOK/km at 4Q 2011 prices)

Comparison between Average of Route Scenarios and Example of Northern Projects analysed



A.7. Parameters

Parameters

Nr of Tracks	2		Nr
Signalling System	ERTMS 2		Type
Tunnelling Method	Cut & Cover		Type
Earthworks, Tunnels & Viaducts Quantities	Statistical		Data
Crossings	Statistical		Data
Topography Factor	0		[0:5]
Track Bed Width	12		m
Nr of Intermediate Stations	3		Nr
Nr of Terminus Stations	2		Nr
Length - Route Option 1 - New High Speed Line	753		Km
Length - Route Option 2 - High Speed Upgrade	0		Km
Length - Route Option 3 - Double Tracking + High Speed Upgrade	0		Km
Length - Route Option 4 - Do Minimum	0		Km
Total Route Length	753		Km
Currency Factor (excludes PPPs) - Jan 2010	8.15		NOK
Base Year	2006		Year
Standard Error	16.2%	41.07	0.02%

A.8. Scenario B – Economic Appraisal Route Summary Capital Cost Report (MnNOK at 4Q 2011 prices)

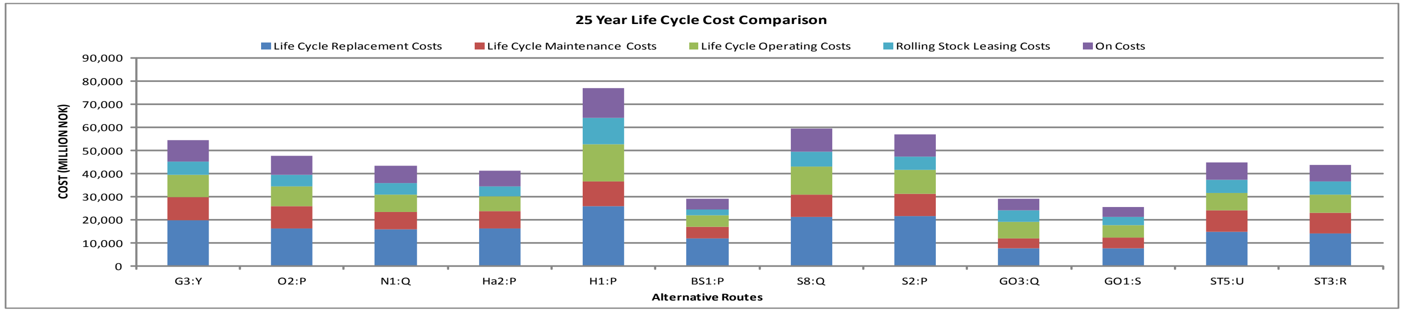
SCENARIO B	Northern	Western	Southern	Eastern
Route ID	**(MNoK)**	**(MNoK)**	**(MNoK)**	**(MNoK)**
Notes				
Scenario Speed (Kph)				
Total Route Length (Km)	**397**	**526**	**518**	**97***
Upgrade Length - Construction (km)	**163**	**77**	**165**	**60**
Total Construction Cost E (MNoK)	**50,202**	**27,712**	**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**

Appendix B. – Life Cycle Cost Model

B.1. Scenario C/D - Life Cycle Cost Summaries for Full Economic Appraisal Route Alternatives

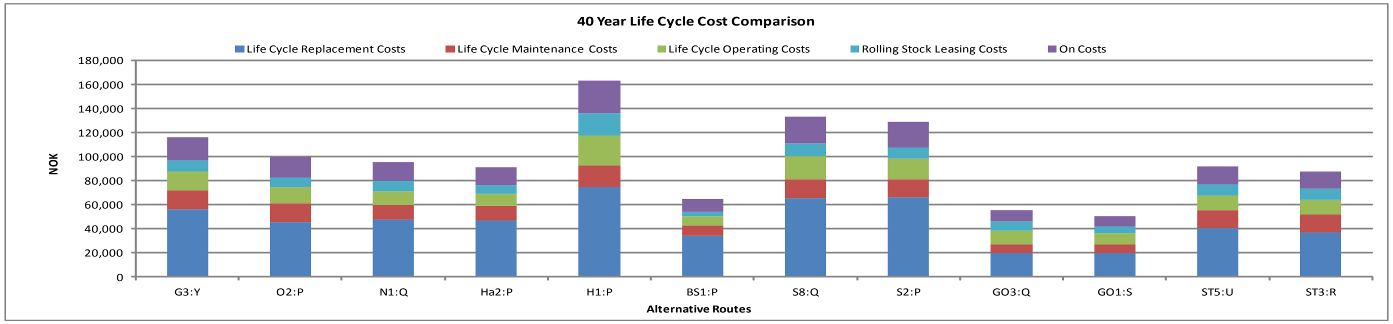
B.1.1 25 Year Life Cycle Cost Summary for Full Economic Appraisal Routes (MnNOK at 4Q 2011 prices)

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



B.1.2 40 Year Life Cycle Cost Summary for Full Economic Appraisal Routes (MnNOK at 4Q 2011 prices)

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



B.2. Scenario C/D - Life Cycle Cost Estimate Summary – Example Route O2:P Oslo - Værnes

Jernbaneverket
Norway High Speed Rail - New Lines Northern 02:P
Life Cycle Cost Estimate
24th November 2011

LIFE CYCLE COST ESTIMATE SUMMARY

Life Cycle Cost Estimate Breakdown			Total Cost Over 25 years (NOK)	%	Total Cost Over 40 years (NOK)	%
Life Cycle Replacement Costs						
Signalling & Telecoms			1,742,167,826	3.67%	4,485,058,471	4.51%
Electrification & Plant			138,967,331	0.29%	6,374,654,166	6.41%
Track			7,004,455,666	14.74%	11,360,073,446	11.43%
Operational Property			354,662,276	0.75%	866,389,274	0.87%
Structures			5,314,637,156	11.18%	19,384,712,437	19.51%
General Civils			218,326,867	0.46%	555,789,194	0.56%
Depots			1,563,704,097	3.29%	2,561,449,769	2.58%
		Sub-Total A	**16,336,921,220**	**34.38%**	**45,588,126,756**	**45.87%**
Life Cycle Maintenance Costs						
Signalling & Telecoms			2,201,972,819	4.63%	3,522,383,291	3.54%
Electrification & Plant			699,376,776	1.47%	1,118,371,642	1.13%
Track			5,201,965,631	10.95%	8,329,257,992	8.38%
Civil Engineering Works			503,026,494	1.06%	807,560,819	0.81%
Mechanical			955,488,672	2.01%	1,528,308,476	1.54%
Maintenance Overheads			111,755,376	0.24%	178,808,602	0.18%
		Sub-Total B	**9,673,585,769**	**20.36%**	**15,484,690,821**	**15.58%**
Life Cycle Operating Costs						
Organisation Management			365,289,955	0.77%	584,463,929	0.59%
Operational Management			121,763,314	0.26%	194,821,303	0.20%
Operational Staff	- Cleaning Staff		400,317,750	0.84%	640,508,400	0.64%
	- Train Staff (OBS)		4,143,288,452	8.72%	6,629,261,523	6.67%
	- Station Staff		2,148,371,734	4.52%	3,437,394,775	3.46%
Exterior Train Cleaning	- Train Washer		2,548,000	0.01%	4,076,800	0.00%
	- Shunt Driver		133,439,250	0.28%	213,502,800	0.21%
Energy Consumption	- Infrastructure		179,318,003	0.38%	286,908,804	0.29%
	- Traction Rolling Stock		1,056,740,996	2.22%	1,690,785,593	1.70%
Cost Of Sale			0	0.00%	0	0.00%
Rolling Stock Leasing Costs			5,040,000,000	10.61%	8,064,000,000	8.11%
		Sub - Total C	**13,591,077,455**	**28.60%**	**21,745,723,927**	**21.88%**
Total Life Cycle Cost Estimate excl. on-costs (A+B+C)			**39,601,584,443**	**83.33%**	**82,818,541,504**	**83.33%**
On Costs						
- Risk/Contingency @ 20.00%			7,920,316,889	16.67%	16,563,708,301	16.67%
Total Life Cycle Cost Estimate incl. on-costs			**47,521,901,332**	**100.00%**	**99,382,249,805**	**100.00%**
Average Cost per annum			1,900,876,053	4.00%	2,484,556,245	3.00%

B.3. Life Cycle Replacement Assumptions – Example Route O2:P Oslo - Værnes

Jernbaneverket
Norway High Speed Rail - New Lines Northern 02:P
Life Cycle Cost Estimate
24th November 2011

Life Cycle Replacement Assumptions

F+G Aggregated Description	% of Capital	% Uplift	% Replaced	Service Life	Delay to starting year	Renewal spread	Notes
Acoustic barriers (civils - rail)	100%	20%	10%	1	20	1	
Anchors	100%	30%	100%	30		1	
Cantilevers / gantries	100%	30%	100%	30		1	
Control centres; electrical							Aggregated
Substructure	13%	15%	100%	100		1	
Superstructure	31%	15%	50%	40		1	
Finishes	5%	15%	100%	20		1	
Fittings & Furnishings	5%	15%	100%	15		1	
Mechanical	9%	15%	20%	5	10	1	
Electrical	20%	15%	20%	5	15	1	
External Works	18%	15%	20%	20		1	
Earthing bonding; major	100%	15%	100%	30		1	
Electrification; AC distribution; power monitoring system (routewide)	100%	15%	100%	20		1	
Electrification; neutral sections						1	Aggregated
Substructure	0%	15%	100%	100		1	
Superstructure	0%	15%	50%	40		1	
Finishes	0%	15%	100%	20		1	
Fittings & Furnishings	0%	15%	100%	15		1	
Mechanical	50%	15%	20%	5	10	1	
Electrical	50%	15%	20%	5	15	1	
External Works	0%	15%	20%	20		1	
Electrification; overlaps						1	Aggregated
Substructure	0%	15%	100%	100		1	
Superstructure	0%	15%	50%	40		1	
Finishes	0%	15%	100%	20		1	
Fittings & Furnishings	0%	15%	100%	15		1	
Mechanical	50%	15%	20%	5	10	1	
Electrical	50%	15%	20%	5	15	1	
External Works	0%	15%	20%	20		1	
Electrification; traction power; feeder station	100%	20%	100%	40		1	
Electrification; wiring	100%	15%	100%	40		1	
Elevated structures; viaduct; twin track							Aggregated
Substructure	30%	20%	100%	100		1	
Superstructure	60%	20%	50%	40		1	
Finishes	6%	20%	100%	20		1	
Fittings & Furnishings	0%	20%	100%	15		1	
Mechanical	2%	20%	20%	5	10	1	
Electrical	2%	20%	20%	5	15	1	
External Works	0%	20%	20%	20		1	
Rail crossings; carriageway							Aggregated
Substructure	30%	20%	100%	100		1	
Superstructure	60%	20%	50%	40		1	
Finishes	6%	20%	100%	20		1	
Fittings & Furnishings	0%	20%	100%	15		1	
Mechanical	2%	20%	20%	5	10	1	
Electrical	2%	20%	20%	5	15	1	
External Works	0%	20%	20%	20		1	
Rail crossings; motorway							Aggregated
Substructure	30%	20%	100%	100		1	
Superstructure	60%	20%	50%	40		1	
Finishes	6%	20%	100%	20		1	
Fittings & Furnishings	0%	20%	100%	15		1	
Mechanical	2%	20%	20%	5	10	1	
Electrical	2%	20%	20%	5	15	1	
External Works	0%	20%	20%	20		1	
Rail crossings; over rail bridge (twin track)							Aggregated
Substructure	30%	20%	100%	100		1	
Superstructure	60%	20%	50%	40		1	
Finishes	6%	20%	100%	20		1	
Fittings & Furnishings	0%	20%	100%	15		1	
Mechanical	2%	20%	20%	5	10	1	
Electrical	2%	20%	20%	5	15	1	
External Works	0%	20%	20%	20		1	
Rail crossings; special							Aggregated
Substructure	30%	20%	100%	100		1	
Superstructure	60%	20%	50%	40		1	
Finishes	6%	20%	100%	20		1	
Fittings & Furnishings	0%	20%	100%	15		1	
Mechanical	2%	20%	20%	5	10	1	
Electrical	2%	20%	20%	5	15	1	
External Works	0%	20%	20%	20		1	
Rail crossings; under track							Aggregated
Substructure	0%	20%	100%	100		1	
Superstructure	90%	20%	50%	40		1	
Finishes	0%	20%	100%	20		1	
Fittings & Furnishings	0%	20%	100%	15		1	
Mechanical	0%	20%	20%	5	10	1	
Electrical	10%	20%	20%	5	15	1	
External Works	0%	20%	20%	20		1	
Security fencing (civils - rail)	100%	20%	7%	1	15	1	Palisade - after 15 years renew 7% each year

(Cont'd)

Jernbaneverket
Norway High Speed Rail - New Lines Northern 02:P
Life Cycle Cost Estimate
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Life Cycle Replacement Assumptions

F+G Aggregated Description	% of Capital	% Uplift	% Replaced	Service Life	Delay to starting year	Renewal spread	Notes
Signalling; control centre							Aggregated
Substructure	15%	20%	100%	100		1	
Superstructure	35%	20%	50%	40		1	
Finishes	5%	20%	100%	20		1	
Fittings & Furnishings	5%	20%	100%	15		1	
Mechanical	10%	20%	20%	5	10	1	
Electrical	10%	20%	20%	5	15	1	
External Works	20%	20%	20%	20		1	
Signalling; lineside train protection equipment; axle counters	100%	30%	100%	10		1	
Signalling; routewide cabling & cable routes	100%	30%	100%	20		1	
Signalling; routewide cable ducts	100%	30%	100%	40		1	
Signalling; trackside control equipment	100%	30%	100%	20		1	
Signalling; signalling control system and equipment	100%	15%	100%	20		1	
Signalling; control panel	100%	15%	100%	20		1	
Stations; intermediate						1	Aggregated
Substructure	15%	20%	100%	100		1	
Superstructure	35%	20%	50%	40		1	
Finishes	5%	20%	100%	7		1	
Fittings & Furnishings	5%	20%	100%	15		1	
Mechanical	10%	20%	10%	2	10	1	
Electrical	10%	20%	20%	5	15	1	
External Works	20%	20%	20%	20		1	
Stations; terminus						1	Aggregated
Substructure	15%	20%	100%	100		1	
Superstructure	35%	20%	50%	40		1	
Finishes	5%	20%	100%	7		1	
Fittings & Furnishings	5%	20%	100%	15		1	
Mechanical	10%	20%	10%	2	10	1	
Electrical	10%	20%	20%	5	15	1	
External Works	20%	20%	20%	20		1	
	100%	30%	100%	30		1	
Telecommunications; digital PABX	100%	20%	10%	10		10	Assume that capital cost is equipment only
Telecommunications; fibre optic network							Aggregated
Fibre Optic cables	75%	20%	100%	40		1	
Equipment (control, booster stations etc)	25%	20%	100%	15		1	
Telecommunications; GSM-R communications system	100%	20%	10%	10		10	Assume that capital cost is equipment only
Telecommunications; control centre equipment	100%	20%	50%	5	10	1	Assume 50% of control equipment replaced every 5 years from year 10
Telecommunications; master clock	100%	20%	100%	25		1	
Telecommunications; station control rooms equipment	100%	20%	50%	5	10	1	Assume 50% of control equipment replaced every 5 years from year 10
Telecommunications; TETRA Line Station	100%	20%	10%	10		10	
Telecommunications; TETRA Repeater Stations	100%	20%	10%	10		10	
Telecommunications; TETRA Masts	100%	20%	10%	40		10	
Track; ballasted track system; plain line							Aggregated
Ballast	25%	30%	100%	22		10	Average service life @ 12 MGTpa.
R150-R250				18			
R250-R500				21			
=>R500				25			
Concrete Sleeper	23%	30%	100%	36		10	Average service life @ 12 MGTpa
R150-R250				31			
R250-R500				36			
=>R500				42			
Rail	52%	30%	100%	23		10	Average service life for CWR FB 113A rail @ 12 MGTpa and 0.01 gradient
R150-R250				14			
R250-R500				23			
=>R500				31			
Track; slab track system; plain line							@ 12 MGTpa - Aggregated
Slab track	26%	30%	5%	36		10	Replace 5% every 20 years
Rail	60%	30%	100%	23		10	Average service life for CWR FB 113A rail @ 12 MGTpa and 0.01 gradient
R150-R250				14			
R250-R500				23			
=>R500				31			
Track S&C; crossovers	100%	30%	100%	23		23	@ 12 MGTpa
Track S&C; tie in	100%	30%	100%	23		23	
Track S&C; turnouts	100%	30%	100%	16		16	@ 12 MGTpa
Transformer 200kva 400V/11Kv	100%	20%	100%	30		1	
Tunnels; blast & drill (twin track)							Aggregated
Superstructure	65%	30%	100%	100		1	
Finishes	5%	30%	100%	40		1	
Fittings & Furnishings	5%	30%	50%	30		1	
Mechanical	10%	30%	50%	15		1	
Electrical	5%	30%	50%	20		1	
External Works	10%	30%	0%	100		1	
Tunnels; special (twin track)							Aggregated
Superstructure	65%	30%	100%	100		1	
Finishes	5%	30%	100%	40		1	
Fittings & Furnishings	5%	30%	50%	30		1	
Mechanical	10%	30%	50%	15		1	
Electrical	5%	30%	50%	20		1	
External Works	10%	30%	0%	100		1	

B.5. Life Cycle Maintenance Assumptions – Example Route O2:P Oslo - Værnes

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Norway High Speed Rail - New Lines Northern
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Life Cycle Maintenance Assumptions

Asset type	Work type	Description of Work
Track		
Ballasted track	Reactive maintenance	Wet bed rectification
Ballasted track	Planned maintenance	Prevention of buckling measures
Ballasted track	Reactive maintenance	Track Geometry maintenance following TRV, inspection etc.
Ballasted track	Planned maintenance	Adverse weather precautions
Plain line	Inspection	Track visual inspection
Plain line	Inspection	Rail ultrasonic inspection
Plain line	Planned maintenance	Manual track cleaning and signage maintenance
Plain line	Inspection	Manual rail head profile measurement
Plain line	Incident response	Failed rail replacement
Plain line	Incident response	Failed weld replacement
Plain line	Incident response	Fault rectification works (plain line)
Routeway	Planned maintenance	Track walkway maintenance
Routeway	Planned maintenance	Drain and Trough cleaning and rodding
Routeway	Planned maintenance	Weed killing (manual backpack)
Routeway	Reactive maintenance	Fencing/ Boundary repairs
Routeway	Planned maintenance	Maintain Expansion switches @ bridge / embankment interface
Switches & crossings	Inspection	Visual inspection
Switches & crossings	Inspection	Rail ultrasonic inspection
Switches & crossings	Planned maintenance	Manual Fettling
Switches & crossings	Planned maintenance	Hand grinding
Switches & crossings	Planned maintenance	Switch Cleaning and Lubrication
Switches & crossings	Planned maintenance	Welding up of crossings
Switches & crossings	Planned maintenance	Welding up of stock rail & switches
Switches & crossings	Incident response	Emergency response - switches
Civils		
Earthworks	Inspection	Visual Inspection
Earthworks	Reactive maintenance	Local re-grading, repair of animal burrows etc
Earthworks	Planned maintenance	Veg clearance
Acoustic Barriers	Inspection	Visual Inspection
Acoustic Barriers	Reactive maintenance	Repair following inspection
Viaduct	Inspection	Detailed Examination
Viaduct	Inspection	Visual Examination
Bridge	Inspection	Detailed Examination
Bridge	Inspection	Visual Examination
Tunnel	Inspection	Detailed Examination
Tunnel	Inspection	Visual Examination
Viaduct	Planned maintenance	Vegetation removal, minor repairs, drainage clearance etc.
Bridge	Planned maintenance	Vegetation removal, minor repairs, drainage clearance etc.
Tunnel	Planned maintenance	Surface repairs, prevention of water ingress measures
Category 1 Station - New	Inspection	Detailed Examination
Category 1 Station - New	Inspection	Visual Examination
Category 2 Station - New	Inspection	Detailed Examination
Category 2 Station - New	Inspection	Visual Examination
Category 1 Station New	Planned maintenance	Minor repairs, drainage clearance etc.
Category 2 Station New	Planned maintenance	Minor repairs, drainage clearance etc.
Signalling & Telecoms		
Signalling	Inspection	Visual & detailed examination
Signalling	Planned maintenance	PPM
Signalling	Reactive maintenance	Repair following inspection
Telecoms	Inspection	Visual & detailed examination
Telecoms	Planned maintenance	PPM
Telecoms	Reactive maintenance	Repair following inspection
Power & Electrification		
Power	Inspection	Visual & detailed examination
Power	Planned maintenance	PPM
Power	Reactive maintenance	Repair following inspection
Electrification	Inspection	Visual & detailed examination
Electrification	Planned maintenance	PPM
Electrification	Reactive maintenance	Repair following inspection

B.6. Life Cycle Operation Assumptions – Example Route O2:P Oslo - Værnes

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Norway High Speed Rail - New Lines Northern 02:P
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Life Cycle Operation Assumptions

Station Staff - Assumptions

Number of stations per station manager	10	nr

	No of shifts req per day	Number of staff per station / office										Establishment allowance for shift working, weekends, holidays, training and rostering inefficiencies
		Cat 1 - New	Cat 1 - Refub	Cat 2 - New								
Station manager (assumed 1 per 10 new stations)	1											0.00%
Category 1 station staff	3	10	2	0								100.00%
Category 2 station staff	2	0	0	5								100.00%
Category 3 station staff	2	0	0	0								100.00%
Gate line / platform attendant	3	0	0	0								100.00%
Other modal transfer staff	3	0	0	0								100.00%

No operational staff present during the night

Train Staff (OBS) - Assumptions

Number of terminus stations	2	nr
Number of OBS managers per terminus stations	1	nr

	No of Shifts req per day	Number of OBS per train	Number of train sets	Establishment allowance for shift working, weekends, holidays, training and rostering inefficiencies
OBS Managers (assumed 1 per terminus stations)	2			0.00%
Driver	3	1	12	100.00%
OBS / Conductor	3	3.5	12	100.00%
Catering crew	3	0	12	100.00%

Cleaning Staff - Assumptions

Number of stations per cleaning manager	10	nr
Number of cleaners per stabling facility	3	nr

Station	No of shifts req per day	Number of cleaners per station										Establishment allowance for shift working, weekends, holidays, training and rostering inefficiencies
		Cat 1 - New	Cat 1 - Refub	Cat 2 - New								
Cleaning manager (assumed 1 per 10 new stations)	0											0.00%
Cat 1 station cleaners	3	2										50.00%
Cat 2 station cleaners	2			1								50.00%
Daytime train cleaners	3	0	0	0								0.00%
Night time train cleaners (3 per stabling facility)	1											0.00%
Shunt train drivers	1											0.00%
Exterior train washing @ €20 per train per day	1											0.00%

B.7. Life Cycle Operation Assumptions (Cont'd)

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Norway High Speed Rail - New Lines Northern 02:P
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Life Cycle Operation Assumptions

Energy infrastructure - Assumptions

Stations, including CER & SER, PIS, escalators and lifts, HVAC, lighting, general LV power

Asset Description	MW/hr used per unit	Rate per MW (NOK)
Cat 1 - New	1.50	236.70
Cat 2 - New	0.75	236.70
Cat 3 - New	0.38	236.70

Energy Traction Rolling Stock - Assumptions

Asset Description	MW/hr	Rate per kW (NOK)
HV traction power (assume 200m trainset = 28kWh/km @ €0.03/kWh) 1 trainset =	28.00	0.24

Cost of Sale

Asset Description	NOK per annum
Cost of sale	0.00

Rolling Stock Leasing Costs

Asset Description	NOK per annum per car
Rolling Stock Leasing Costs	1,800,000.00

B.8. Life Cycle Organogram Assumptions – Example Route O2:P Oslo - Værnes

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Organogram - Assumed additional staff for Jernbaneverket	No of Staff	Salary including on-cost (NOK)	Total Cost (NOK)	Notes
Director	1	NOK 2,268,467	NOK 2,268,467	Organisation Management
Integrated Management Office Manager	1	NOK 934,075	NOK 934,075	Organisation Management
Control Room Staff	19	NOK 600,477	NOK 11,409,056	Organisation Management
Maintenance Manager	1	NOK 934,075	NOK 934,075	Maintenance Management
Head of Discipline Civils	1	NOK 867,355	NOK 867,355	Maintenance Management
Civils Supervisor	5	NOK 667,196	NOK 3,335,981	Maintenance Staff
Civils Inspector	20	NOK 600,477	NOK 12,009,533	Maintenance Staff
Head of Discipline Track	1	NOK 867,355	NOK 867,355	Maintenance Management
Track Supervisor	52	NOK 667,196	NOK 34,694,205	Maintenance Staff
Track Maintenance Team	260	NOK 600,477	NOK 156,123,928	Maintenance Staff
Head of Discipline M&E	1	NOK 934,075	NOK 934,075	Maintenance Management
Mechanical Supervisor (HVAC. Plant, L&E)	10	NOK 800,635	NOK 8,006,355	Maintenance Staff
Mechanical Technicians (HVAC. Plant, L&E)	50	NOK 600,477	NOK 30,023,832	Maintenance Staff
Electrical Supervisor (LV and Electronics)	4	NOK 800,635	NOK 3,202,542	Maintenance Staff
Electrical Technicians (HV, LV, AFC)	20	NOK 600,477	NOK 12,009,533	Maintenance Staff
Head of Discipline Signalling & Comms	1	NOK 867,355	NOK 867,355	Maintenance Management
Signalling and telecomms Supervisor	13	NOK 667,196	NOK 8,673,551	Maintenance Staff
Signalling and Telecomms Technicians	126	NOK 600,477	NOK 75,660,057	Maintenance Staff
Operational Staff Manager	1	NOK 1,467,832	NOK 1,467,832	Operational Management
Station Cleaners	24	NOK 333,598	NOK 8,006,355	Operational Staff
Night time train cleaners	24	NOK 333,598	NOK 8,006,355	Operational Staff
Train Crew Manager	4	NOK 667,196	NOK 2,668,785	Operational Management
Driver	72	NOK 667,196	NOK 48,038,130	Operational Staff
Shunt Driver	8	NOK 667,196	NOK 5,337,570	Operational Staff
On-board Staff	252	NOK 467,037	NOK 117,693,408	Operational Staff
Stations Manager	1	NOK 733,916	NOK 733,916	Operational Management
Category 1 Stations Staff	144	NOK 467,037	NOK 67,253,376	Operational Staff
Category 2 Stations Staff	40	NOK 467,037	NOK 18,681,493	Operational Staff
	1,156		**NOK 640,708,551**	

B.9 Scenario B Alternatives 25 Year Life Cycle Cost Report – (MnNOK, 4Q 2011 prices)

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 Staff	150	0	75	75
	- Train Staff (OBS)	230	230	230	0
	- Station Staff	1,401	0	701	701
Energy Consumption	- Infrastructure	179	0	90	90
	- Traction Rolling Stock	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

B.10. Scenario B Alternatives40 Year Life Cycle Cost Report – (MnNOK, 4Q 2011 prices)

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 Staff	240	0	120	120
	- Train Staff (OBS)	368	368	368	0
	- Station Staff	2,242	0	1,121	1,121
Energy Consumption	- Infrastructure	287	0	143	143
	- Traction Rolling Stock	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

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