Oslo-Stockholm High Speed Railway: An up in the air project

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Abstract

The objective of this paper is to shed a light on a High-speed Railway (HSR) study project in the corridor Stockholm-Oslo, and investigate the global context in which it has grown. Priority Project 12 (PP12), commonly named “The Nordic Triangle”, is a project within the Trans-European Transport Network (TEN-T) program, a European program aiming at establishing an efficient transport network, for competitiveness and employment in Europe. The Nordic Triangle aims at linking the Nordic countries, Sweden, Norway, Denmark and Finland and their capitals to each other and improving passenger and freight transport, both rail and road, between the central Europe, the Baltic countries and Russia. The cornerstone of this program in Sweden is the development of three main axes: Stockholm-Katrineholm-Laxa-Swedish-Norwegian boarder; Katrineholm/Jarna-Norrköping-Malmö; and Malmö-Gothenburg-Swedish-Norwegian border. Of course, this extension to the Swedish-Norwegian boarder targets to reach Oslo, the Norwegian capital.

What was expected in theory mismatches with the current situation and the future expectations on this project. It proves that Sweden, throughout the PP12, has concentrated its railway upgrades to the two other axes and has made few efforts to improve the Oslo-Stockholm line. Political decisions in terms of railway network development are more focused on the North-South axes, which represent an undeniable opening to Central Europe.

At the same time the Norwegian Ministry of Transport has launched in 2010 an overall High Speed Rail Assessment to study different route alternatives for the creation of a first new HSR system. Among them is the Stockholm-Oslo route. It is curious to see that Norway focuses on a project that is not on the agenda of the European Commission and it is important to try to understand why and to know if such a project is economically viable.

The conclusion is that this current implementation reflects the Swedish willingness to develop its railway network, and especially its high-speed network, to the South, which embodies a front door to Central Europe. Thus, since the beginning of the development of the Nordic Triangle, it seems probable Sweden had in mind not to upgrade all the line to Oslo, but only half the way.

As regards the viability of the HSR line, it could not be economically viable because the revenue generated could not offset these former costs. An insufficient demand would be the main problem. Investing in a HSR on this corridor is certainly not the most reasonable decision, neither for Norway nor for Sweden.
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1. Introduction

1.1 Stockholm-Oslo: a planning puzzle

In 2006, the Trans-European Transport Network Executive Agency (TEN-T EA) was created to implement and manage the TEN-T program on behalf of the European Commission. This program, based on the proposals from the Member States, is composed of 30 Priority Project whose their completion will improve the economic efficiency of the European transport network and bolster competitiveness and employment in the European Union. Among them, Priority Project 12 called “Nordic Triangle railway/road axis” deals with the Nordic countries. The Nordic Triangle links the countries of Sweden, Denmark, Norway and Finland and their capitals to each other and improves passenger and freight transport from the region to central Europe, the Baltic countries, and Russia. Three main corridors, all situated in the Swedish territory, make up the Triangle. At each vertex of the Triangle are Stockholm, Oslo and Copenhagen, the three respective capitals of Sweden, Norway and Denmark, linked each other by three main axis. On each routes, upgrading of the current railway and road network and new infrastructure constructions have been scheduled.

During 2011, the European Commission has carried out a revision of the TEN-T guidelines. Pointing out the fragmentation of the program but also the lack of coherence and connection between the 30 Priority Projects, a new planning methodology has been developed. The new TENT-T policy leads the “Core Network” approach, which better takes into account the multimodal dimension and aims at addressing the objectives set out by the Treaty and by the Europe 2020 strategy. Henceforth, the implementation will focus on 10 core network corridors, each composed of several pre-identified projects. According to the European Commission, the continuity of current Priority Projects should not been affected by this revision because inclusion on the core network outlay plan concerns the prioritization of future funding decisions.

If we take a deeper look at all the sub-projects included in PP12, we notice that many of them deal with railways. But surprisingly, the implementation planning maps that represent the progress of TENT-T railway project in Sweden clearly show that the prioritized axes are not those that were expected initially by the Nordic Triangle. The development of the high-speed network does not take into account the whole part of the Stockholm-Oslo corridor. Therefore, it seems that the Triangle in Sweden is somewhat warped. Of course, the upgrading on this section scheduled in the PP12 is completed by now, but the improvements made are quite vague and remain light. The Stockholm-Oslo corridor that, however, links two important capitals of Northern Europe, is sidelined to the detriment of the others. With this policy, it seems the Stockholm-Oslo corridor has been substituted by the Gothenburg-Stockholm axis in the Swedish prioritisation. We already see there is a mismatch between the planning of the PP12 and its implementation.

1 European Commission, Impact assessment on Union Guidelines for the development of the trans European Transport Network
Although the TEN-T program has not, to a certain extent, focused its priorities on the development of the Oslo-Stockholm corridor, Norwegian feasibility studies and reports have been published aiming for future HSR development on this line. This interest from Norway for this axis is surprising on two grounds. First, it deals with a corridor that is low prioritized by Sweden and that is not on the prioritized agenda of the TEN-T program. Then, much more than a conventional railway, it is about a high-speed railway, a technology which has so far partly been introduced in Sweden and that Norway has not got yet.

This study project is part of a two years consultation program undertaken by Jernbaneverket, the Norwegian National Rail Administration, which has been mandated by the Norwegian Ministry of Transport to assess the development of high-speed long distance passenger train transport in the southern part of Norway and to provide recommendations for the long-term transport strategies. Considering the current railway development prospects in Sweden and the clear orientation taken by Sweden in relation to the PP12, Norway is alone on this project, all the more so it concerns a HSR line. In the PP12, only one is related to the development of HSR; a pre-study for the railway line on the section Boras-Jönköping-Linköping.

There is however EU policies and agreements on how to extend TENT-T outside EU in which Norway is mentioned explicitly. Some strategic cross border points with Northern Dimension have been defined, whose some of them are situated in the Swedish-Norwegian border, along the Stockholm-Oslo rail line. However, it seems these agreements have not changed Sweden decision-making about this line.

Sweden has traditionally been reluctant regarding the operation of high-speed trains, claiming an uncertain economic viability. But this does not prevent research papers on the economic evaluation of HSR to be published. However, the line Stockholm-Oslo is almost never mentioned and if Sweden decide on getting high-speed railways, it might prefer, for political reasons, extending its railway network up to Central Europe.

However, such investments are not topical since the Swedish government does not believe in the viability of HSR in Sweden, an opinion supported by some scholars. Lately read in the newspaper, professor Per-Olov Johansson from Stockholm School of Economics and Umeå University natural resources and economics professor Bengt Kriström who have worked with a Spanish colleague on the economic evaluation of HSR, a report commissioned by the Ministry of Finance stated that there is “too few Swedes to motivate high speed rail” (Per-Olov Johansson and Bengt Kriström, Svenska Dagbladet newspaper, 03/06/12)

To conclude, there is on the one hand Norway, which by its status of non-member of the European Union is not a direct stakeholder of the TENT-T program but nonetheless investigate the Stockholm-Oslo corridor under a HSR alternative, and on the other hand Sweden, which has moved this route away from its priorities throughout the PP12 of the TENT-T and which despite some studies about the implementation of high-speed trains is not really convinced about the profitability and sustainability of such projects.
1.2 Research questions

First of all, it is important to understand why, despite the first orientation given to the Nordic Triangle, Swedish authorities have shown very little interest in the corridor Stockholm-Oslo and have preferred to focus on the two others axis of the Nordic Triangle. Then Norway, motivated by a firm willingness to get an HSR network, has among others carried out a feasibility study on the Stockholm-Oslo line as part of an overall assessment of HSR in Norway. It is surprising to see Norway dealing with a cross-boarder project, whose the main part is on the Swedish side, without any other major supporter. It is clear that Norway cannot assume alone the financing and the implementation of this line, especially if it is a HSR one.

But if the Norwegian approach was right and that a HSR line on the Stockholm-Oslo route was a good thing, needed by the crossed regions and also profitable? Whereas some analysts and scholars claim there are too few Swedes to make HSR investment profitable, what about the implementation of a high-speed line between Oslo and Stockholm? Is it an unrealizable project that only few people cling on?

This is analyzed through:

- A description of the TEN-T program and the Priority Project 12: the Nordic Triangle
- A comparison between what was expected and what has been done
- An overview of the existing conditions along the corridor Stockholm-Oslo
- An understanding of Sweden position and expectations in the Nordic Triangle
- An overview of the costs and benefits of an HSR line
- Economic and financial appraisal provided by ATKINS in a consultancy report

1.3 Scope and limitation

About the ATKINS calculations and results; I will not go back in detail on the procedures used and the different hypothesis set by the company. I will just explain briefly the calculation principles and I will only take a deep interest in the results. Being aware that the calculation methods can be criticized and commented, which has already been the case by KTH researchers', the goal of this paper is not to question the ATKINS 's work. The use of these ATKINS results aim at showing the long-term economic viability or not of a HSR line between Oslo and Stockholm, even though I stay prudent about their veracity.

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2 TEN-T POLICY REVIEW, Ten-T Extension outside the EU
3 Øskar Froïdh, Nils Olsson, Bo-Lennart Nelldal (2012), Some comments of the Norwegian High-Speed Rail Assessment according to the economic appraisal
Furthermore, it is important to stress that this paper deals with the Oslo-Stockholm HSR under a financial and economic approach. However, I am entirely aware that decision-making process on such project is complex and cannot be limited to financial issues. An important question is the cultural aspects of the project, including the historic legacy of each country and the relations they gather. Beyond the investment cost of the project and its potential profitability, the involvement in major cross-boarder project might embody the countries’ willingness to strengthen their relations, as well economic and politic as cultural.

All things considered, it seemed difficult to capture and analyse these other decision-making key points in such a short period that is the Master’s Thesis. That’s why I preferred to tackle this topic under a financial and economic approach.

1.4 Methodological approach
These two diagrams embody the thinking that has led me to identify the worthwhile questions exposed below.

The starting point was the TEN-T program, developed on behalf of the EU members. 30 Priority Projects were defined, all with the same goals and expectations. Even though a revision of the EU TEN-T guidelines was undertaken by the late 2011, the ongoing projects from the Priority Projects are still on the agenda. PP12, commonly named “Nordic Triangle”, deals with Nordic countries and aims at improving both railway and road passenger transport. Three main axes were defined whose the Stockholm-Oslo corridor, which is the subject of this paper.

A description of the current state of the line has followed, trying to point out the expected upgrades along the line and what has been really implemented. A mismatch was observed and some probable explanations were exposed. At the same time, the Norwegian HSR assessment is studying the Stockholm-Oslo route. Explanations about this interest were carried out and the existence or not of a understanding

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4 HSR category I : average speed 250kph, maximum speed 320kph  
5 HSR category II : average speed 120-150kph, maximum speed 250kph
between the two countries was questioned. Finally, the economical viability of this HSR line was studied, in order to check the relevance of such a project and to work out if it could be worthwhile.

2. The Trans-European Transport Network (TEN-T)

2.1 What is the main purpose?

The Trans-European Transport Network is an important key element of the of the Lisbon Strategy relaunch for competitiveness and employment in Europe. The Lisbon Strategy, which was an action and development plan set out by the European Council in March 2000, aimed at making EU the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion*, by 2010.

Mobility is a cornerstone in the fulfillment of this plan. An efficient transport network system, which allows people and goods to commute fast and handily is part of the ways to regain attractiveness in the European cities and bolster their economy. In the framework of this European action plan for struggling against the low productivity and the stagnation of economic growth in the EU, the Trans-European Transport Network Executive Agency (TEN-T EA) was created in 2006 to implement and manage the TEN-T program on behalf of the European Commission.

As a whole, TEN-T projects aim to:

- Establish and develop the key links and interconnections needed to eliminate existing bottlenecks to mobility
- Fill in missing sections and complete the main routes - especially their cross-border sections
- Cross natural barriers
- Improve interoperability on major routes

Transport infrastructure is essential for the effective operation of the internal market, for the mobility of people and goods. The long-term consequences of such improvements are difficult to measure, but there are at least easy to comprehend: they facilitate freight transport and so improve the performance of the economy, they allow cities and also other place to be more accessible and so can attract people, companies and industries. Finally what is at stake in the TEN-T program is the economic and social health of the European partner countries. With transport infrastructure investments, a country can promote its economic growth, mainly in urban and regional level.

The TEN-T program is composed of 30 Priority Projects, namely 342 projects, which include the guidelines of development priorities, which have been established based on the proposals from Member States. They cover all the transport modes and all the Member States.
TEN-T infrastructure in figures (existing and planned)

- 96,000 km of roads
- 106,000 km of railways which 32,000 km will be high-speed
- 13,800 of inland waterways
- 411 airports
- 400 international ports
- 3000 domestic ports

The 30 Priority Projects have been assessed to €154 billion whose €7.2 are granted by the European Commission.

Share on current TEN-T contribution by transport mode

100% = €7.2 billion

Legend

ATM: Air Traffic Management
ERTMS: European Rail Traffic Management System
ITS: Intelligent Transport System and Services
MoS: Motorways of the Sea
RIS: River Information Service
IWW: Inland Waterways

Figure 1: Share on current TEN-T contribution by transport mode
Source: TEN-T EA

The Priority Projects were chosen both according to their European added-value and their contribution to the sustainable development of transport. Their completion - planned for 2020 - will improve the economic efficiency of the European transport system and provide direct benefits for European citizens. Of these 30 key projects, 18 are railway projects, 3 are mixed rail-road projects, 2 are inland waterway
transport projects and one refers to Motorways of the Sea. This choice reflects a high priority to more environmentally friendly transport modes, contributing to the fight against climate change. The Rail part accounts for 61% of the EU contribution whereas the other development fields share the 39% remaining. There has been a firm commitment on behalf of the Member States and the European Union to deliver these key Priority Projects and they have been at the centre of the European Union's efforts - both financially and in terms of coordination. In July 2005 the European Commission has designated a group of nine senior European Coordinators to evaluate the progress of certain TEN-T Priority Projects, to make recommendations for the effective implementation of these projects and to play a major role in advancing the works.

![Map of the Nordic Triangle](image)

**Figure 2: Map of the Nordic Triangle**  
*Source: TEN-T EA*

### 2.2 PP12: Nordic Triangle railway/road axis: what has been done so far?

#### 2.2.1 Implementation and characteristics

Northern Europe is concerned to the TENT-T throughout the Priority Project 12 (PP12) named the Nordic Triangle. The Nordic Triangle links Sweden and Finland and their capitals to each other and improves passenger and freight transport from the region to central Europe, the Baltic countries, and
Russia. Three main corridors, all situated in the Swedish territory, are the cornerstone the Triangle. At each vertex of the Triangle are Stockholm, Oslo and Copenhagen, the three respective capitals of Sweden, Norway and Denmark, are linked to each other by three main axis. On each routes, upgrading of the current railway and road network and new infrastructure implementations have been scheduled. More precisely, the TENT-T project consists in 1,500 kms of railways, mostly double track. Double-tracking are prioritized on the main line Malmö-Gothenburg-Norwegian border to address a severe bottleneck. Today, many projects aiming at the elimination of bottlenecks as well as increasing capacity are still in preparation phase. Below are some of the planned projects:

<table>
<thead>
<tr>
<th>Rail Section</th>
<th>Status</th>
<th>Cost estimate (million €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malmo city tunnel</td>
<td>Completed</td>
<td>1,275</td>
</tr>
<tr>
<td>Malmo yard</td>
<td>Under construction</td>
<td>109</td>
</tr>
<tr>
<td>Malmo Flackarp</td>
<td>In preparation/Under construction</td>
<td>260</td>
</tr>
<tr>
<td>Angelholm-Maia</td>
<td>In preparation</td>
<td>130</td>
</tr>
<tr>
<td>Ängelholm-Förlöv</td>
<td>In preparation/under construction</td>
<td>87</td>
</tr>
<tr>
<td>Förlöv-Båstad (Hallandsås tunnel)</td>
<td>Under construction</td>
<td>1,083</td>
</tr>
<tr>
<td>Varberg</td>
<td>Under construction</td>
<td>230</td>
</tr>
<tr>
<td>Gothenburg – Trollhättan</td>
<td>In preparation/under construction</td>
<td>712</td>
</tr>
<tr>
<td>Double tracking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port of Gothenburg</td>
<td>Under construction</td>
<td>23</td>
</tr>
<tr>
<td>Stockholm City Tunnel</td>
<td>In preparation</td>
<td>1,800</td>
</tr>
<tr>
<td>Nyköping-Östergötland link</td>
<td>In preparation</td>
<td>1,320</td>
</tr>
</tbody>
</table>

Table 1: Ongoing and planned major Nordic Triangle rail projects in Sweden. (Estimated costs at 2009 prices; prices today are higher due to currency strengthen)
Source: TEN-T EA

In Annexe 1, an overview of the outline plan scheduled by the PP12, horizon 2020, is represented. We clearly see that the development of the Swedish rail network is focused on Southern Sweden, to Gothenburg Malmo and Copenhagen. The discussed high-speed lines are mainly on both the Malmö-Gothenburg and Stockholm-Gothenburg corridors. Rails journeys from Stockholm to Malmö will be cut to less than four hours and between Gothenburg and Oslo, where tilting trains could be used, from four hours to two hours and 20 minutes. As regards the axis Stockholm-Oslo, very few improvements have been done. Half the way, from Stockholm to Karlstad is an upgraded conventional line but from Karlstad
to Oslo, trains run on a single-track conventional line, which make the all trip very long.

The total cost of this Priority Project amounts to €12,738.61 million for the two member states involved, namely Sweden and Finland. So far the TEN-T support for the implementation of all the projects add up to €189.5 million, only approximately 2%.

In the different project planned by the PP12, only one deals with the HSR issue, even thought it is only a pre-study for the railway line on the section Borås-Jönköping-Linköping.
2.2.2 A mismatch between the planning and the implementation of the Nordic Triangle
Above is the expecting Swedish High Speed Railways at the horizon 2015. High-speed trains in Sweden are category II, which means their maximum speed is 200 km/h and they run in average 120-150 km/h. The network is mainly focused on southern Sweden, structured between the cities of Stockholm, Gothenburg and Malmö, the three biggest cities of Sweden. This development pattern is somewhat different and so far from what the Nordic Triangle should have looked like. Indeed, the main upgrades and improvements on the network have been implemented along the two other axes of the Triangle, sidelining the corridor Stockholm-Oslo that was however a part of the project. Actually, only half the way of this line has been upgraded, allowing now trains to run up to 200km/h between Stockholm and Kristinehamn. It seems the initial development prospects to the Norwegian border have been given up to focus instead on the corridor Stockholm-Gothenburg. The Nordic Triangle does not really look like it was expected at the beginning. Now, the triangle is distorted and half the way of the line to Oslo has not been upgraded.
Figure 4: Nordic Triangle: Railway/Road axis
Source: TEN-T EA

Figure 5: Expected Nordic Triangle (black) / Implemented Nordic Triangle (red)

3. The Corridor Oslo – Karlstad – Stockholm
3.1 Existing conditions: Poor standards of infrastructure between Karlstad and Oslo

The travelling time between the two endpoints is in 2012 more than 6 hours with Intercity trains with a lot of stops along the way. Shorter timetable timings was in use in 2003-2004 when the NSB-SJ joint company Linx operated X2000 tilting trains with much less stops, thus reducing the travel to 4:50 between Stockholm and Oslo. This time can be seen as the limit allowed by the present infrastructure standard with such trains. Today, it is possible to go from Stockholm to Karlstad using the SJ2000 and then change for an Intercity train to Oslo, for a travel time of 05:40.

The shortest line to reach Oslo from Stockholm is via the Kongsvinger Line in Norway, the Värmland Line and the Western Main Line in Sweden. The line, 570km long, has variable standards and maximums permitted speeds range between 130 and 210 km/h. Speed restrictions can be observed at the close proximity of some cities.

The most important drawback of the line are the 325 single track kilometers, between Lillesøm and Kristinehamn. The crossings take a lot of extra time and considerably extend the time travel. Whereas it takes round 2:30 to cover the 345 km between Stockholm and Karlstad with frequent departures (approx. 1 per hour), going on till Oslo take almost 4 hours for only 225 km. This is for sure the main drawback of the line. On this 225km stretch, the top speed is only 130km/h and around 70 % of the track has speeds equal to or lower than 100 km per hour. The boarder-crossing railway is very sinuous and the curvature on the stretch between Lillesøm and Karlstad is narrowed; thus, for safety reasons and especially due to a lack of upgrading infrastructures, running speed on this section is very slow. In
addition to that is the long detour by Kongsvinger considerably extends the travel time. The current track layout is therefore not competitive at all.

Improvements on the line must be focused on this stretch so as to the service be deemed to be satisfactory. Journey times by train have been significantly reduced in the other corridors in the Triangle in the last 20 years. The train between Malmø and Stockholm now takes two hours less and covers the distance in just over 4 hours than 20 years ago. However no improvements have been observed to journey times between Oslo and Stockholm since a travel time of 05:30 has been reached.

3.2 Stockholm-Oslo axis: a downgraded corridor or a voluntary limited interest?

Among all the documents and reports published by the TENT-EA (Trans-European Transport Network Executive Agency), very few deal with the Stockholm-Oslo corridor. This fact is merely surprising because this axis takes part, as much as the two others, to the Nordic Triangle in Sweden. Whereas it is clearly specified “the Nordic Triangle in Sweden extends from Øresund fixed link (PP11) in Malmø to Stockholm and the Swedish-Norwegian border, and from Stockholm to the Swedish-Norwegian border east of Oslo” (Progress Report 2010: Implementation of the Priority Project; Trans-European Transport Network Executive Agency), it seems like it has been totally downgraded from the list of projects in Sweden in favour of a development priority to the North-South axes.

Important efforts have been done on these axes: the connection Gothenburg-Copenhagen has been reduced from 4½ to 3½ hour, Gothenburg-Oslo from 5 to 4 hours and Gothenburg-Malmö will be upgraded to speeds over 200 km/h. Furthermore, a planned high speed link Järna-Nyköping-Norrköping-Linköping passing outside Mjölby, thus making it possible to completely separate slow and high speed trains, especially

Such a low priority given to this axis within the PP12 in Sweden does not find justifications in the official follow up report from EU. All that is specified is that “the lines to the Norwegian border from Karlstad or Trollhättan will remain single track since traffic is quite low” (Progress Report 2010: Implementation of the Priority Project; Trans-European Transport Network Executive Agency) and that “the occurrence of many curves limit the speed to 160km/h” (The Nordic Triangle; Swedish Ministry of Industry, Employment and Communication).

However, do we have to speak about a downgrading or a voluntary limited interest from Sweden? Since upgrades have been done to allow SJJ2000 high-speed train to run to 200km/h from Stockholm to Kristineham, it would not be right to state that Sweden has downgraded the entire line. Improvements have been implemented on the half way that rejects the idea of any negligence. According to me, it is more likely that Sweden has not really planned to improve all the line from Stockholm to Oslo. Since the development of the Nordic Triangle, the expectations of Sweden about the Stockholm-Oslo axis were
clear and did not concern the second section. The Nordic Triangle as presented in Brussels was a selling point to highlight the Swedish willingness in transport improvements. Finally, Nordic Triangle as Priority Project 12 was perhaps a “branding project name” used by politicians to make it attractive.

It seems almost clear that the current implementation of PP12 reflects the Swedish willingness to primarily develop its railway network to Central Europe, a front door to the most powerful European countries.

However, the regions of Orebro and Karlstad do not totally agree with these priorities from the government (The Growth Corridor Oslo – Karlstad – Stockholm, Tilveskt Korridoren), which finally gives the final orientation to the infrastructure development plans. For some local politicians, these two regions are worth not only to be better connected to the main capitals of Scandinavia (Copenhagen, Oslo, Stockholm) but also to each other. Since they cannot assume the cost of construction of new infrastructures, they remain dependent from the superior authority. If nothing moves at this level, nothing will happen on site.

### 3.3 A Stockholm-Oslo HSR?

Considering all the arguments developed above, it proves that throughout the PP12, Sweden expresses its willingness not to considerably improve the rail connection between Oslo and Stockholm. However, in the same time, a lot of Norwegian feasibility studies and report have been published handling the question of HSR development on this line. This sudden interest for this axis from Norway is surprising since on the one hand, it deals with a corridor that is partly abandoned by Sweden and that is not on the agenda of the TEN-T program any more, and on the other hand, much more than a conventional railway, it is about a high-speed railway, namely a technology which struggle to set up in Sweden and whose Norway has not got yet.

This study project is part of a two years consultation program undertaken by Jernbaneverket, the Norwegian National Rail Administration, which has been mandated by the Norwegian Ministry of Transport to assess the development of high-speed long distance passenger train transport in the southern part of Norway and to provide recommendations for the long-term transport strategies.

At first sight, it is very surprising to see a Non Member State dealing with a HSR project on a route which has been neglected by the TEN-T program. Of course, this project assessment is part of a national consultation program and is therefore not the only project undertaken. But its mere presence among all the other possibilities reveals from Norway a certain interest in this connection. However, considering the current railway development prospects from Sweden and the clear orientation taken by the PP12, it proves that Norway is alone on this project, all the more so it concerns a HSR line.

So what could be the reasons of such a study project? If the Norwegian government has decided to investigate this corridor, it is probably because it has seen some interest in this project.

#### 3.3.1 A legitimate idea: reaching new markets, bolstering economic growth
The cities of Copenhagen and Stockholm have among the highest concentrations of population in Scandinavia; Oslo is rank three. Considering the constant growth in passenger by rail in Sweden (Evolution of rail passenger transport, Eurostat), upgrades of the railway serving the different towns in this corridor could also lead to a significant increase in local travel, especially for people who travel daily.

The potential in term of economic development is growing along the line, especially within the Värmland region. The Swedish region of Värmland is located at the boarder to Norway, approximately 300 kilometers west of Stockholm and 200 kilometers east of Oslo. It is populated by 274 000 inhabitants and the regional capital Karlstad has 80 000 inhabitants. This region is thriving thanks to many industries such as pulp and paper, steel and trade. The trade with is Norway important and a considerable number of people from Värmland commute to Oslo to work.

Figure 7: Commuting to and from Värmland per day
Source: Norconsult consulting engineering company

Recently, the region, in cooperation with other partners has launched a so-called regional growth program which aims at promoting growth in the region, and is mainly focused on the economic opportunities in the so-called “Growth Corridor”. The “Growth Corridor”, which stretches from Olso in the west to Stockholm in the east form, in a wider perspective, a central position in the link between Glasgow - Oslo - Stockholm - Helsingfors - St. Petersburg. Some 4 million people live within the whole sphere of influence between Oslo and Stockholm, whose the two capitals comprise the largest concentrations of
population. The development in recent years in population numbers and in the number of jobs in the Growth Corridor indicates a positive trend in large parts of the corridor. The large and medium sized cities have known a significant growth in the number of inhabitants, while the smaller towns have stagnated or gone backwards. Growth has been greater in Norway than in Sweden in the corridor.

![Population in the Growth Corridor](source)

**Figure 8: Population in the Growth Corridor**

*Source: The Growth Corridor Oslo – Karlstad – Stockholm, Tilvesk Korridoren*

A better east-west train service would provide shorter travelling times and make it would become more attractive to use the train than other means of transport. Today, there is an important lack of demand despite the strong established relations between Oslo and Stockholm and the emerging growth area. However, the implementation of a new transportation system, faster and more efficient, would bolster the economic development of this region. Adding to that the people switch who travel directly between Stockholm and Oslo from plane to train could be part of the new market.

### 3.3.2 Political decision-making not in favour: A non-understanding between Norway and Sweden

It is now more evident why Norway has taken an interest to this corridor: two main capitals closely linked, a crossed dynamic region with high economic potential and a possible increase in demand. But despite all these elements that could justified the creation of such a line, the realization of a high-speed line between Stockholm and Oslo seems very unlikely. Indeed, it seems difficult to give credibility to a project which is not supported neither by the European Commission nor Sweden, one of the main stakeholders. Even thought an agreement has been signed between these two countries, fixing a common methodology of setting up infrastructure project, it is
unlikely to say it Norway can rely on the cooperation with Sweden in this HSR project. But if Norway ends up alone, it is unlikely it assumes the total financing of such a line. Cross-border projects require a perfect understanding between the concerned countries, notably because a costs sharing is often necessary. The Swedish railway development strategies are now focused on the north-south link and the Swedish government has so far never mentioned a start in official discussion with Norway.

The negotiation game on this project is thus complex between Norway and Sweden. The table below, where current arguments from each side are clarified, allow us to better understand the tricky situation:

<table>
<thead>
<tr>
<th></th>
<th>Norway</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pros</td>
<td>▪ First HSR line in Norway</td>
<td>▪ Bolster Varmland’s economic growth</td>
</tr>
<tr>
<td></td>
<td>▪ Strong link between two main Nordic capitals</td>
<td>▪ Improve Swedish network</td>
</tr>
<tr>
<td></td>
<td>▪ A symbolic partnership</td>
<td>▪ A symbolic partnership</td>
</tr>
<tr>
<td>Cons</td>
<td>▪ Government might decide to develop others lines among several in competition</td>
<td>▪ It is not a part of the Nordic Triangle’s projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>▪ It is not the Swedish strategic development plan of railway network</td>
</tr>
</tbody>
</table>

Table 2: Arguments from both sides about the Oslo-Stockholm HSR

Finally, it proves that the leeway from Norway for this development project is almost zero. Even though the decision-making processes appear against a future HSR between Stockholm and Oslo, it is still worthwhile to take a look at the sustainability of this project. Full-term, can it be economically viable and socio-economically efficient?

WS Atkins & Partners, a consulting company in construction, design and engineering, has provided a Cost-Benefit-Analysis (CBA) and a Financial Appraisals of the different HSR routes, whose the Stockholm-Oslo one. These results give us an idea of both the economic viability and the socio-economic efficiency of the project. In order to clearly understand them, it is necessary to first go through the HSR decision factors. The analysis and comments will follow after.
4. Challenges of HSR: the HSR decision factors

4.1 What are high-speed trains?

High-speed train stands out from the conventional trains by their running speed. Conventional railways are the most common lines and they were mainly built in the 1900th century all over the world. They were designed both for passengers and freight and restricted to a maximum speed of 200km/h. Fastest speeds can nevertheless be reached by upgrading the track and using tilting trains, namely trains able to tilt to one side or the other to counteract the centrifugal force.

High-speed lines are defined as able to allow fast passengers trains to run more than 250 kph. Such speeds can be reached, on the one hand because of the use of a new technology of trains, and on the other hand by the use of special tracks with a specific power supply and signaling system, much more efficient and powerful than those used for conventional railways. We can notice the average speeds for High-Speed railways are 200-250 kph. Indeed, there are still few lines in the world designed for high-speed trains only. In many cases, most of the high-speed are running of both conventional and high-speed tracks and maximum speeds can only be reached on specific sections. In addition, their speed commercial speed is often limited due to proximity to densely urbanized areas (to reduce the impact of the noise and avoid the risk of accidents) or the existence of viaducts and tunnels on the line, for safety reasons.

The table shows below the main characteristics of conventional and high-speed railway:

<table>
<thead>
<tr>
<th></th>
<th>Conventional railways</th>
<th>High-Speed railways</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition</strong></td>
<td>Old, new or upgraded track for passenger and freight trains</td>
<td>Newly built railway designed for fast passenger trains</td>
</tr>
<tr>
<td><strong>Maximum speed</strong></td>
<td>200-250 km/h</td>
<td>250-350 km/h</td>
</tr>
<tr>
<td><strong>Average speed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(long distance)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>120-160 km/h</td>
<td>200-250 km/h</td>
</tr>
<tr>
<td><strong>Train types</strong></td>
<td>Express trains, Local and regional trains, Light and heavy freight</td>
<td>Express trains, fast regional trains, fast freight trains</td>
</tr>
<tr>
<td><strong>Track geometry</strong></td>
<td>Modest curve radius</td>
<td>Big curve radius</td>
</tr>
<tr>
<td></td>
<td>Modest grades</td>
<td>Steep grades</td>
</tr>
<tr>
<td><strong>Level crossings</strong></td>
<td>Existing</td>
<td>None</td>
</tr>
<tr>
<td><strong>road-rail</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Characteristics of railways
Source: Ginés de Rus (2009), Economic Analysis of High Speed Rail in Europe
Although the high-speed technology is based on the same engineering principle as conventional railway, namely that the tracks provide a smooth and hard surface on which the wheels can roll with a minimum of friction and energy consumption, they have some technical differences. From a signaling point of view, the system used by high-speed trains differs from conventional trains: whereas traffic on conventional tracks is still controlled by external (electronic) signals together with automated signaling systems, the communication between a running HSR train and the different blocks of tracks is usually fully in-cab integrated.

As regard the power supply, running a high-speed train requires 25,000 volt to achieve enough power, whereas conventional line may operate at lower voltage. Other technical specificities exist regarding the track curve and gradient slope design as well as the exploitation of services.

All these differences considered, the decision of investing in HSR infrastructure can be revolved on 4 different exploitation model, as explained below:

1) The exclusive exploitation model characterized by a complete separation between high speed and conventional services, each one operating with its own infrastructure. This is the model adopted by the Japanese HSR since 1964, mostly due to the fact that the existing conventional lines had reached their capacity limits and it was decided that the new high-speed lines would be designed and built in standard gauge (1,435 mm).

2) The mixed high-speed model where high-speed trains run either on specifically built new lines, or on upgraded segments of conventional lines. This corresponds to the French model, whose high-speed trains (TGV) have been operating since 1981, mostly on new tracks, but also on re-electrified tracks of conventional lines in areas where the duplication was impractical. This reduces building costs, which is one of the main advantages of this model.

3) The mixed conventional model has been adopted in Spain, where some conventional trains run on high speed lines, and where most of the Spanish conventional network was built in broad gauge (1,676 mm), whereas the rest of the European network used the standard gauge (1,435 mm). Talgo trains can run at higher speed on specific HSR infrastructure (built in standard gauge). The main advantage of this model is the saving of rolling stock acquisition and maintenance costs, and the flexibility for providing ‘intermediate high speed services’ on certain routes.

4) The fully mixed model allows for the maximum flexibility, since this is the case where both high speed and conventional services can run (at their corresponding speeds) on each type of infrastructure. This is the case of German intercity trains (ICE) and the Rome- Florence line in

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6 Ginés de Rus (2009), Economic Analysis of High Speed Rail in Europe
Italy, where high speed trains occasionally use upgraded conventional lines, and freight services use the spare capacity of high speed lines during the night. This wider use of the infrastructure leads to a significant increase in maintenance costs.

The choice of one of these models highly affects the construction and the maintenance cost of the HS line, as well as the upgrading degree of conventional railway network. Finally, it seems speed does not only become a technical question but also an economic one. The future economic viability of a new HSR line is based on the development model which is chosen. In the Norwegian assessment for the Stockholm-Oslo HSR, option 2 is adopted.

### 4.2 Why HSR?

The High Speed Rail’s story in Europe begun three decades ago with the operation of the first high speed train in Europe. On 22nd September 1981, the French National Railway Operator (SNCF) commenced regular high-speed services between Paris and Lyon with its TGV (Train à Grande Vitesse). Since its first commissioning, the French high-speed train traffic volume has increased continuously until reaching in average 4.037 millions passengers on the year 2011 (INSEE, SNCF passenger traffic on TGV network). Face to this French breakthrough in railway transportation and taking into account its economic, social and environmental viability, France’s European neighbors have also invested in HSR. Today, HSR systems are in operation in Belgium, France, Germany, Italy, The Netherlands and Spain as well as the UK, where London is connected to continental Europe via the channel tunnel. Thus, the European HSR network encompasses 6,600 km of rail currently in operation, 2,350 km under construction and a further 8,700 km planned to complete the network.

For the last thirty years, high-speed trains have proved to be an attractive way of traveling. There are several relevant reasons that confirmed the utility for countries to invest in HSR.

“Investing in HSR infrastructure is associated with lower total travel time, higher comfort and reliability, reduction in the probability of accident [only on separate tracks], and in some cases the release of extra capacity which helps to alleviate congestion in other modes of transport.”

( Ginés de Rus, The Economic Effects of High Speed Rail Investment, 2008)

First of all, implementing new high-speed railway lines makes possible to shorten traveling times and to allow people to commute easily within the country or beyond the boarders: it is a way to considerably reduce the generalized cost of travel. The generalized cost of travel is defined as the sum of the monetary and non-monetary costs of a journey. They are mainly related to total time costs, including access, egress, waiting and travel time invested, reliability, probability of accident and comfort. Below is a detailed table of the monetary and the non-monetary costs.
Contrary to car and plane, HSR are much more independent from some externalities (accidents, traffic congestion, delays), which make them a reliable mode of transport, comfortable, accessible and competitive.

HSR technology is also able to entail a real switch in people’s habits in matter of transport. In a corridor where people are used to travelling by car, conventional train or plane, the introduction of an HSR line can really change the market shares distribution and rapidly take a position of leader. High-speed trains compete with road and air transport and this is especially true over distances of 400 to 600 km.

Thus, if this new public transport alternative can gain ground on other transport possibilities, it is likely that the travels by car and by plane are going to decrease. In a sensitive worldwide energy context, which announces the beginnings of a future energy crisis, the reduction of gas consumption is a step forward to an environmentally friendly transport. That’s why the HSR’s development seems to be a sustainable solution for traveling, concerned by supply of energy and environmental issues.

Table 4 shows the direct and indirect benefits associated with the investment in transport infrastructure. In the case of HSR, some of them are indisputable, as happens to be the case with time savings and new users’ willingness to pay. Other are less clear, but however reachable, such as the spatial effects or the agglomeration benefits. The list of potential benefits can now be discussed in more detail. It is important to point out that these expected benefits are more or less important depending on countries and regions. In Sweden where population densities are low, these benefits must be considered with precaution.

Table 4: Monetary and Non Monetary values of social benefits

<table>
<thead>
<tr>
<th>Monetary cost</th>
<th>Non Monetary cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price ticket</td>
<td>Access and egress time</td>
</tr>
<tr>
<td>Public transport fare</td>
<td>Waiting time due to:</td>
</tr>
<tr>
<td>Fuel</td>
<td>road congestion</td>
</tr>
<tr>
<td>Parking charge if necessary</td>
<td>security controls at airports</td>
</tr>
<tr>
<td></td>
<td>baggage carrousel</td>
</tr>
<tr>
<td></td>
<td>Travel time</td>
</tr>
<tr>
<td></td>
<td>Risk of accident</td>
</tr>
<tr>
<td></td>
<td>Comfort</td>
</tr>
</tbody>
</table>

*Source: Ginés de Rus (2009), Economic Analysis of High Speed Rail in Europe*
### Table 3.1 Benefits of transport investment

<table>
<thead>
<tr>
<th>Transport market (derived demand)</th>
<th>Primary markets (using transport)</th>
<th>Secondary markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Time savings</td>
<td>• Effects already measured in the transport market (except leisure and commuting time savings)</td>
<td>• Complement and substitutes in markets with distortions (indirect effects - Intermodal effects)</td>
</tr>
<tr>
<td>• Higher reliability</td>
<td>• Wider economic benefits</td>
<td>- Taxes</td>
</tr>
<tr>
<td>• Higher frequencies</td>
<td>- Agglomeration</td>
<td>- Subsidies</td>
</tr>
<tr>
<td>• Reduction in operating cost</td>
<td>- Higher competition</td>
<td>- Externalities</td>
</tr>
<tr>
<td>• Reduction in operating cost</td>
<td>• Spatial effects and regional development</td>
<td>- Unemployment</td>
</tr>
<tr>
<td>• Generated passenger-trips</td>
<td></td>
<td>- Market power</td>
</tr>
<tr>
<td>• Reduction of accidents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Environmental impacts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 5: Benefits of transport investment**

*Source: Ginés de Rus (2009), Economic Analysis of High Speed Rail in Europe*

Even if HSR infrastructure development seems to have a great deal of benefits, both economic and social, the cost of such investment often discourages governments. All the type of founds invested are essentially irreversible and the investment decision is often based on uncertain costs, demand, willingness to pay and revenue. This tricky decision-making must be support by relevant and trustworthy analysis, which thereafter could justify or not the realization of the project. The economic analysis of HSR investment as well as a financial analysis is a necessary tool that provides both information and estimation of the viability of this public investment.

### 4.3 Social benefits

Investment in transport infrastructures is generally an area for governments and not for private companies aiming for profit. Improvements in the domestic and international transport networks aim above all at making people life easier. Of course, all the people concerned and targeted by these new implementations are likely to represent market niche that will be essential to assess for the project’s economic viability. However, in this social benefits part, only people wellbeing is taken into consideration.
The social benefits commuted to the implementation of a new high-speed line are generally triple:\n\begin{itemize}
  \item a time saving
  \item a mobility improvement
  \item a higher reliability and comfort
\end{itemize}

The gains in traveling times are the most expected results from a new HSR. From the beginning of the railway story, speed has always been at the core of the development. Traveling faster and faster, being able to reach an other place in the shortest way: these are expectations that high-speed trains can meet.

The time users invest in a trip must include access and egress time, waiting time and in vehicle time. It includes all the time spent from the starting point to the arrival, that’s why we do speak about “door-to-door-time”. The time the user can save is also closely dependent with the transport mode used to reach either the railway station or the airport.

The results in time savings are useful and essential both for business and touristic travels. Enabling a return trip the same day for business proposes is a real breakthrough for business people. As regards the touristic travels, shrinking the travelling times allow people to better use their spare times and vacations, hence an increase in mobility.

### 4.4 Economic benefits

In order to make the heavy investment on railways viable and profitable, it is generally necessary to both gain market shares and to increase the current demand. This main goal, which is in a way one of the most important for the future decision-making proves to be a competition between the other transport modes namely: air, car and other modes as boat for example.

Thus, the direct benefits of HSR investment come from existing passenger-trips using conventional railway services in the corridor, the deviated demand from other transport modes and the induced passenger-trips after the reduction of the generalized cost of travel.

It is logical to expect that he existing passengers using conventional lines will be transferred to the new high-speed railway. Saving time is of course one of the first attempts of the railways users. However, this demand is not enough to recoup the cost of the investment and new market shares must be found to ensure the viability of the project.

Over longer distances, travelling by car is relatively slow compared to air and high-speed. Since speed is essential for most journeys, the car is not the first choice for a certain distance and it is very uncompetitive when faster public transport alternatives are available. Moreover, if we take into

\footnote{These benefits are in most cases observed, but depend on countries and technology}
consideration the price of gas and the fact that many highways are toll roads, which means extra fees for the drivers, the car option is not competitive. It is important to point out that it is not the case for Sweden and Norway, whose highways access is free. However, the reason given for travelling long distance by car is it is cheaper for a family, since a lot of luggage needs to be transported and that a car is needed once arrived. In this case, calculations can suggest taking the car. In the case of a 500 km length HSR line, car passengers shifting to HSR benefit from travel time and money savings but they lose with respect to access, egress and waiting time. Anyway, for long distance over 400km, travel time spent in car is not competitive at all compared to high-speed trains or air, as it is explained on Figure 8:

![Diagram of travelling time in the Swedish long distance market, connecting journeys included](image)

As regard long distance journey, car market shares are not really significant since the travelling time quickly grows up from 250 km.

The new demand a new high-speed train can entail comes from the deviated demand of air transport. Over long distance, the market share of air transport is very high, especially with the development of the low-cost model, which are companies that compete in the travel market with low fares. But, it is interesting to notice that from a specific travelling distance, HSR can compete with air transport. This distance has been estimated to about 500km according to Ginés De Rus. From this length, the travelling time with the HSR becomes really competitive for air transport where access and egress time is the most inconvenient on short distance. However, a 500km HSR project is not enough to justify a relevant users shift from air to high-speed train.
4.5 The cost of a High-speed rail line

Building new HSR infrastructure requires preliminary studies to plan and evaluate its implementation, both from a technical and economic point of view. As mentioned before, the setting-up of a high-speed line is a process with strict specifications. Therefore, all the different steps must be tackled before the construction of the project. Although the design features are almost the same among all the HSR projects - roadway level crossings, frequent stops or sharp curves unfitted for higher speeds, new signaling mechanisms and more powerful electrification systems – it seems difficult to establish a stable and reliable cost evaluation since most of the HSR projects mainly differ from the topography and geography of the country.

The main costs of the implementation of a high-speed line can generally separate in three parts:

- Construction
- Maintenance and reinvestment
- Operating (short-term costs)

4.5.1 Construction costs

According to the International Union of Railways (IUC, 2005b), the construction of a HSR line involves three major costs:

- Planning and land cost
- Infrastructure building costs
- Superstructure cost

It is crucial to notice how much the construction costs differ according to the countries. In Europe, there are two groups of countries: France and Spain, which have slightly lower construction costs in average than Germany, Italy and Belgium. Such a difference cannot only be explained by the geography of these countries and the existence of less densely populated, but also by differences in construction procedures. France for instance often adopts steeper gradients, which allows the construction costs to be minimized. Thus, the construction cost are spread from €4.7 to €23 million per kilometer. However, these cost levels cannot be reached in all countries. It is especially the case of Italy, whose construction costs amount to €65.8 million maximum. Indeed HSR lines can be really expensive in fragmented or high relief areas, which is notably the case in the North of Italy.
Thanks to the existence of the less populated areas outside the major urban centers, but also by construction procedures. In France, for example, the cost of construction is minimized by adopting steeper grades rather than building tunnels and viaducts. Because the TGV lines are dedicated to passenger transport, grades rather than building tunnels and viaducts. The only exception in graph 1.3 is Italy. This is because the lines under construction are mostly placed in the areas, without those economies of space.

In Europe, there are two groups of countries: France and Spain have slightly lower building costs (€4.7 million in construction costs), whereas the costs included in the construction costs of the projects in operation. It is interesting to note that there is no evidence of increasing the cost of labor, energy and other materials consumed by maintenance and do-to-day operations of the guideways, terminal, stations energy supplying and signaling system as well as traffic management and safety systems” (Javier Campos, Ginés de Rus, Ignoccio Barron, Economic Analysis).

Thanks to a database based on projects in five European countries, it is possible to split this general infrastructure operating cost into five sub-categories, as shown in Table 5 below:

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8 Economic evaluation of the High-Speed Rail, REGERINGSKANSLIET Finansdepartementet
since its estimated price vary from the demand. This explains why trains have different technical specificities. This development prospect is f
situation are based on the planning and land costs excluded and km. Hence the fixed cost of a 500km HSR line are for five European countries (Belgium, France, the carrier that supplies HSR services are not dis-
the infrastructure provider and those related to the pro-
lated to the exploitation and maintenance of the infrastructure itself, and those related to the pro-
Once the infrastructure is built, the operation of the carrier that supplies HSR services are not dis-
All these different features and characteristics strongly affect the acquisition cost of the rolling cost,
since its estimated price vary from €33, 000 to €65, 000 per seat (2002) as it is shown in Table 6:

| Source: Ginés de Rus (2009), Economic Analysis of High Speed Rail in Europe |
|-------------------------------------------------|----------------|--------------|--------------|----------------|
| **Km, of single track** | Belgium | France | Italy | Spain |
| Maintenance of track | 13,841 | 43.7% | 19,140 | 67.3% | 5,941 | 46.0% | 13,531 | 40.4% |
| Electrification | 2,576 | 8.1% | 4,210 | 14.8% | 2,455 | 19.0% | 2,986 | 8.9% |
| Signalling | 3,248 | 10.3% | 5,070 | 17.8% | 4,522 | 35.0% | 8,654 | 25.9% |
| Telecommunications | 1,197 | 3.8% | 0 | 0 | 0 | 0 | 5,637 | 16.8% |
| Other costs | 10,821 | 34.2% | 0 | 0 | 0 | 0 | 2,65 | 7.9% |
| **Total maintenance cost** | 31,683 | 100% | 28,420 | 100% | 12,919 | 100% | 33,457 | 100% |

The maintenance cost of tracks amounts to between 40 and 67 % of the total maintenance cost. Although HSR technology is high advanced technology, there are no so much differences between HSR and conventional railways. Regarding the signaling cost, a slight difference is observed: this cost ranges from 10 to 35 % for HSR, whereas it is usually 15-45 % for conventional railways.

Based on the data provided in Table 5 the total maintenance costs of an HSR are around €30, 000 per km. Hence the fixed cost of a 500km HSR line are roughly both €15 billion for the construction (planning and land costs excluded) and €30 million for the maintenance per year for the entire line.

**4.5.3 Train operating and maintenance costs**

The operation costs of HSR services include train operations, maintenance of rolling stock and equipment, energy supply, sales and administration. Such costs differ according to the train operators and are closely related to the traffic volumes and the technology used by the trains, but also to the market situation. In the European experience, each country has traditionally chosen and developed its own technology specificities. This development prospect is first based on the type of trains bought. Nowadays, different suppliers are sharing the train market and have developed their own products in order to meet the demand. This explains why trains have different technical characteristics in terms of length, composition, seats, weight, power, traction, tilting features, etc.

All these different features and characteristics strongly affect the acquisition cost of the rolling cost, since its estimated price vary from €33, 000 to €65, 000 per seat (2002) as it is shown in Table 6:
An average train operating and maintenance is difficult to estimate since it mainly depends on the number of kilometers run per year, the number of seat and the type of trains used. These parameters considered, it proves that this cost can be, in one country, twice expensive than in an other one.

4.6 A tricky decision-making

Investing in a new HSR project is an irreversible decision that needs to be carefully analysed. The involved costs are so high that it often leads governments to be reluctant to these investments, or at least very uncertain. Considering the average domestic budget of Ministries of Transport is roughly €4 billion in Europe, it is easy to understand how difficult such a decision must be.

In the decision-making process, the socio-economic performance and the economic viability of the project are the most important points. Assessment methods have been developed to estimate them. Although these key points are similar and interdependent, they do not quantify the same result.

4.6.1 Cost-Benefit Analysis

CBA (Cost-benefit analysis) is a tool that can be used to evaluate HSR investments. The aim is to consider all the significant impacts and to compare the value of costs and benefits, to identify a net social economic impact on society. The general principle of cost benefit analysis is to assess whether or not the social and economic benefits associated with a project are greater than its social and economic costs. To this end, a project is deemed to be desirable where the benefits exceed the costs.
The outputs considered are both long-term benefits and long-term costs of the project. This is an important consideration because of the long time-frame of the project. It will likely take 25 or more years to implement a HSR plan, and the value capture from the new infrastructure may not be the same now and in 25 years. Thus, the cost-benefit analysis considers the time value of money in its evaluation.

For an HSR project, the benefits that can be quantified include the operating revenue of HSR, user benefits such as travel time savings and improved safety, and nonuser benefits such as carbon emission reductions, highway decongestion, improved capacity of other transportation modes, and wider economic benefits. Costs that can be quantified include infrastructure construction, rolling stock, operations and environmental remediation costs.

While this analysis should consider all the possible benefits from the project, many of these benefits are qualitative and difficult to quantify. Impacts that cannot be assigned a monetary value are assessed qualitatively, either by assignment of scores to indicate performance.

As said above, the cost-benefit analysis takes into consideration the time value of money. Thus, all the different costs and benefits are Present Values, calculated thanks to a discount rate. The discount rate is used to convert costs and benefits to present values to reflect the principle of time preference. The proper discount rate should represent the opportunity cost of what else the firm could accomplish with those same funds. If instead of investing in the project, the money is used to invest for example in the private sector and yield 5% a year, and that is the best alternative for the company to use this money, then 5% would be the social discount rate. A time period for the appraisal must also be defined.

Once all the different Present Values of each cost and benefit are calculated, they are summed to provide the NPV (Net Present Value). NPV is an indicator of how much value the project adds to society. Depending on the value of NPV,

If NPV> 0 (the benefits exceed the costs), the project could add value to society and then may be accepted.
If NPV< 0 (the costs exceed the benefits), the project would subtract value to society and then should normally be rejected.
If NPV=0 (the benefits offset the costs), the investment would neither gain nor lose value to society and then could be either accepted or rejected. The decision must be based on other criteria (strategic positioning, privileged relations...)

CBA is a decision making tool that helps to determine the more economically viable project among a range of different alternatives. Therefore, in financial theory, the one yielding the higher NPV should be selected.
4.6.2 Financial appraisal

Financial appraisal is a method used to evaluate the viability of a proposed project by assessing the value of net cash flows that result from its implementation. Financial appraisals differ from economic appraisals in the scope of their investigation, the range of impacts analysed and the methodology used. A financial appraisal essentially views investment decisions from the perspective of the organization undertaking the investment. It therefore measures only the direct effects on the cash flow of the organization of an investment decision.

In contrast, an economic appraisal considers not only the impact of a project on the society, but also considers the external benefits and costs of the project for other government agencies, private sector enterprises and individuals regardless of whether or not such impacts are matched by monetary payments. Financial appraisals differ from economic appraisals since market prices and valuations are used in assessing benefits and costs, instead of measures such as willingness to pay and opportunity cost. A financial analysis of a project is undertaken to assess whether it will be commercially profitable for the company to implement it. Governments and international agencies will also undertake a financial analysis, as well as an economic analysis, of any project in which the output will be sold and a financial analysis will therefore have some meaning.
5. ATKINS analysis

The ATKINS consulting company has carried out estimations and assessment of investment costs but also economic and financial analysis of potential corridors and associated routes. Four different corridors have been considered and each of those corridors contains one or more ‘routes’ that have been studied:

- Corridor North: Oslo - Trondheim
- Corridor West: Oslo – Bergen /Bergen Stavanger
- Corridor South: Oslo – Kristianad – Stavanger
- Corridor East: Oslo – Gothenburg / Oslo – Stockholm

Several infrastructure scenarios were developed from the less to the more offensive in matter of high-speed technology. Thus, four different scenarios have been shortlisted to provide a wide set of representative alternatives. However, only two of them have been considered for the technical appraisal:

- Scenario C: major upgrades to the current infrastructures achieving high-speed concept, providing new alignment to allow operational speeds up to 250 kph
- Scenario D: building of new separate HSR lines, providing new alignment to allow operational speeds up to 330 kph

The cost outputs for the infrastructures have been calculated and estimated by delivering a combination of two route scenarios. As regards the corridor Stockholm-Oslo, here are the different routes with their associated assumptions:

- Route ST5:U – 250 kph to Stockholm
  Eastern corridor route runs thought out relatively open countryside
  Total route length of 510 km whose 331 km are upgraded
  17% of route in tunnels
  The Oslo to Ski section ois excluded as deemed part of a new indepent 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
- **Route STR3:R** - 330 kph to Stockholm
  
  Eastern corridor route runs thought out relatively open countryside
  
  Total route length of 492 km whose 319 km are 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

In this part, we will show the results of the route STR3:R, which is an exclusive high-speed line, whose the operating speed is 330kph from Oslo to Vasteras, and 250 from Vasteras to Stockholm.

In the following data, project GO3:Q and GO1:S are mentioned. These are their descriptions:

- **GO3:Q** - 250 kph - to Gothenberg
  
  Eastern corridor route runs through relatively open countryside
  
  Total route length of 337km of which 184 km is upgraded
  
  25 % of route in tunnels

- **GO1:S** - 330 kph - to Gothenberg
  
  Eastern corridor route runs through relatively open countryside
  
  Total route length of 308km of which 195 km is upgraded
  
  30 % of route in tunnels
# 5.1 Investment costs

Below is the detail of the total investment cost of the route STR3:R, assessed by ATKINS consultancy:

<table>
<thead>
<tr>
<th>Route ID</th>
<th>ST3:R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MnNOK</td>
</tr>
<tr>
<td>Scenario speed (kph)</td>
<td>330</td>
</tr>
<tr>
<td>Total Route Length (Km)</td>
<td>492</td>
</tr>
<tr>
<td>Upgrade Length (km)</td>
<td>319</td>
</tr>
<tr>
<td><strong>Total Construction Costs E (MnNOK)</strong></td>
<td>87,927</td>
</tr>
<tr>
<td><strong>Project Anticipated Final Cost (AFC)</strong></td>
<td>114,236</td>
</tr>
<tr>
<td>Construction Period (Years)</td>
<td>7</td>
</tr>
<tr>
<td>Route Tunnel Percentage</td>
<td>13%</td>
</tr>
</tbody>
</table>

**Detail**

<table>
<thead>
<tr>
<th>Contractor’s direct costs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Signalling and Telecoms</td>
<td>1,894</td>
<td>248</td>
</tr>
<tr>
<td>Electrification &amp; Plant</td>
<td>4,158</td>
<td>545</td>
</tr>
<tr>
<td>Track</td>
<td>7,079</td>
<td>927</td>
</tr>
<tr>
<td>Operational Property</td>
<td>537</td>
<td>70</td>
</tr>
<tr>
<td>Structures</td>
<td>15,835</td>
<td>2,074</td>
</tr>
<tr>
<td>General civils</td>
<td>17,036</td>
<td>2,232</td>
</tr>
<tr>
<td>Utilities</td>
<td>603</td>
<td>79</td>
</tr>
<tr>
<td>Depots</td>
<td>1,877</td>
<td>246</td>
</tr>
</tbody>
</table>

**Sub – Total 1**

<table>
<thead>
<tr>
<th>Contractor’s indirect costs</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminaries</td>
<td>9,712</td>
<td>1,272</td>
</tr>
<tr>
<td>Design</td>
<td>2,735</td>
<td>358</td>
</tr>
<tr>
<td>Testing &amp; Commissioning</td>
<td>613</td>
<td>80</td>
</tr>
<tr>
<td>Other</td>
<td>2,448</td>
<td>321</td>
</tr>
</tbody>
</table>

**Sub – Total 2**

<table>
<thead>
<tr>
<th><strong>Total Construction Cost E (1+2)</strong></th>
<th>64,526</th>
<th>8,453</th>
</tr>
</thead>
</table>

**Swedish Route Total (SR)**

<table>
<thead>
<tr>
<th><strong>Client’s indirect and other costs</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Client’s Project Management</td>
<td>2,451</td>
<td>321</td>
</tr>
<tr>
<td>Planning &amp; associated costs</td>
<td>1,938</td>
<td>254</td>
</tr>
<tr>
<td>Land / Property Costs &amp; compensation</td>
<td>887</td>
<td>116</td>
</tr>
</tbody>
</table>

**Sub – Total 3**

<table>
<thead>
<tr>
<th><strong>Total (1+2+3+SR)</strong></th>
<th>93,203</th>
<th>12,210</th>
</tr>
</thead>
</table>

**Uplift for Risk and Development Risk**

| Price, Design and Development Risk | 21,033 | 2,755 |

**Project Anticipated Final Cost (AFC)**

|  | 114,236 | 14,965 |

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**Table 8: Investment costs**

*Source: ATKINS, Norway High Speed Rail Assessment: Economic and Financial Analysis*

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<sup>9</sup> Conversion made with an average exchange rate based on the period October-Mid August: 0,1310
According to the calculation made by ATKINS, the total price on the investment costs, namely the Project Anticipated Final Cost (AFC) amounts to €14.965 billion. It has been seen previously that the average cost for a 500km high-speed railway is about €15 billion, assessment based on a wide number of HSR European projects.

With an investment cost of €14.965 for 492km, this a price totally fits with the benchmark prices for HSR lines.

The investment price is reasonable and seems to be an argument in support of the construction of the line. However, this only information is not enough to assess the long-term economic viability of the project. To decide of the profitability of the line, we have to go through both the Cost-Benefit Analysis (CBA) and the Financial Analysis.

5.2 Economic and Financial Analysis

To really know if it is worth or not to invest in this line, it is necessary to take a look at its economic and financial appraisal.

As detailed previously, the CBA identifies the likely impacts of a new transport system on society through time and compares their net value with the forecast cost of construction, operation and maintenance. The aim is to point out all the significant impacts and to compare the value of costs and benefits, to identify a net impact on society.

Contrary to the CBA, the financial appraisal focuses on the monetary costs and benefits (or revenue) generated by the line during operation. It is intended to help the extent to which each option could be considered commercially viable once the costs of construction are committed.

The explanation of the reasoning and the assumptions taken by ATKINS are explained in Appendix 2.
Figure 10 shows that the alternatives to Stockholm generate more user benefit and revenue than the alternatives to Gothenburg. This observation confirms the strong link that exits between these two capitals, and above all their narrowed economic relations. Indeed, on both alternatives, benefits are more focused on business trips than in the other corridors, accounting for just over 50% of demand but around 80% of benefits.

The Net Benefit for the Stockholm alternatives is higher relative to the Gothenburg ones. However, when the benefits are combined with the costs, there is a important difference between the routes to Stockholm and Gothenburg. This highlights the fact that the NPV is more influenced by the costs. Go1:S, the equivalent in speed of ST3:R but to Gothenburg is considerably shorter and less expensive than ST3:R and therefore generate less negative NPVs despite generating fewer benefits.

STR3:R, as the other alternatives, involves important construction work which will be expensive. Thereafter, monetized benefits cannot offset the costs across the appraisal time period and so generates a significant negative NPV.

Beyond the high construction costs, this economic performance reflect the small scale market available both in Norway and Sweden from which benefits and additional revenues can be derived, compared to the heavy overall investments costs that a new HSR required. To this small scale market is added the fact that on this corridor, the current market is well served by existing modes and especially air, meaning that the operation of a HSR does not reduced considerably journey costs and times. As it is underlined by...
ATKINS, the resulting negative NPV was to be expected.
This economic appraisal results described above are interesting in the consideration of the life of the line across society. However, this only information cannot reflect its commercial viability. Thus, considering the project in the perspective of financial performance proves to be valuable. The decision-making tool considers the extent to which the financial costs are covered by the revenue generated by the operation of the line. This aims at providing information whether the line could be commercially viable once the construction costs committed.

As expected by the economic appraisal, there are strong differences between the performance of the Gothenburg and Stockholm alternatives.
The Stockholm alternatives generate more revenue but also have higher costs. Consequently, although both are able to cover the operating and maintenance costs, neither alternative is able to completely recoup renewals.

Finally, a HSR from Oslo to Stockholm generates sufficient revenue to more than cover the associated service and infrastructure operating and maintenance costs. This reflects the difficult topography of Norway and Sweden, especially along the border. The relief is fragmented and presents in some areas high altitude peak, which explains the great estimated quantity of bridge and tunnel along the line (13% of route in tunnels). There is so a strong likelihood that such a line could operate as commercial and financially sustainable operations if costs of infrastructure, renewal and taxation are excluded.
5.3 An up in the air project

These ATKINS Economic and Financial appraisals show that an HSR line is not a reasonable decision for improving the Stockholm-Oslo line. Despite the fact that a high-speed line could be run on a commercially viable basis, it cannot however be economically viable, mainly because the construction costs cannot be recouped, even after a 25 years period. The revenue generated by the operation of the line would not be high enough to offset the construction costs, which however match with the average cost of a 500 km HSR line, namely €15 billion. Thus, the main weak point of this project is the lack of demand. Sweden and Norway are both little populated countries and have the smallest density population of all Europe: respectively 23 and 17 hab./km² (Statistics Sweden, Statistic Norway 2012). It is difficult with such parameters to expect the Stockholm-Oslo HSR to be profitable. Thereafter, Sweden and Norway would probably never invest in an exclusive HSR on this line. If major improvements have to be done, it would be better to think about a mixed high-speed model, just as it has been implemented on the Stockholm-Kristinehamn section, but on the remaining part to Oslo.

Finally, these results tell us we do not have to take too seriously the Norwegian investigation of a High-Speed line from Oslo to Stockholm. This route alternative takes part of a national HSR assessment which has studied all the different options for the development of a HSR. Even though this assessment reflects the Norwegian willingness to develop its railway system by the construction of high-speed lines, it does not convey a specific interest for this corridor. If Norway decides to invest in HSR, it will probably choose first only one of all these alternatives. According to the Norwegian National Rail Administration (Jernbaneverket) website, it seems Norway is already decided: “The project has shown it would be natural to prioritise the development of lines that will be utilised by the greatest number of people. In this respect, the line most obviously in demand is Oslo-Kristiansand-Stavanger.”

10 http://www.jernbaneverket.no/en/Startpage/Projects/High-speed-rail-services-can-be-run-on-a-commercially-viable-basis/
6. Conclusion

In this work, Sweden’s expectations of the Stockholm-Oslo corridor in the Nordic Triangle have been clarified. The comparison of the expected Nordic Triangle and its implementation has shown a clear mismatch along the corridor linking the two capitals. From Stockholm to Kristinehamn, improvements have been done and allow now trains to run to 200 km/h. However, the remaining section to Oslo is a sinuous single track with low speed operation. Therefore, what has been presented in Brussels, i.e. improvements along the three main axes of the Nordic Triangle has not been respected. It seems like Sweden has sidelined and neglected a part of this East-West line. In reality, we have conclude this current implementation reflects the Swedish willingness to develop its railway network, and especially its high-speed network, to the South, which embodies a front door to Central Europe. Thus, since the beginning of the development of the Nordic Triangle, it seems probable Sweden had in mind not to upgrade all the line to Oslo, but only half the way.

Whereas a total upgrade of the line is definitely not on the agenda of Sweden and the Nordic Triangle, Norway is investigating the introduction of HSR throughout different route alternative, whose the Stockholm-Oslo one. Such a huge gap between the current condition of the line, the Swedish expectations and this HSR project was very surprising. Results of the Economic and Financial appraisal point out the line could be operated as commercially and financially sustainable operations if costs of infrastructure, maintenance, renewal and taxation are excluded. The line could however not be economically viable because the revenue generated could not offset these former costs. An insufficient demand would be the main problem. Investing in a HSR on this corridor is certainly not the most reasonable decision, neither for Norway nor for Sweden, at least in a financial point of view.

If such an upgrade of the line to Stockholm wants to grow, Norway and Sweden should clearly discuss and find common long-term solution to improve the way from Kristinehamn to Oslo, which remains the main drawback of the line. Steady upgrades on the least updated sections seem to be the most reasonable solution. Perhaps, a 250kph railway might make the project more viable and might be an alternative to investigate. However, such an understanding cannot probably be concluded in the framework of the Nordic Triangle, especially because a core network has been defined lately to reconsider priority projects and regain coherence in the implementation. Ten corridors have been identified and as regards Sweden, the Stockholm-Oslo corridor is no longer mentioned”. It is probably assumed that all the required upgrades have been done on this axis and it is not necessary to include it in this new European core network.
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Appendix 1
Appendix 2

The impacts captured in socio-economic appraisal include effects on transport providers, the public sector, transport users and third parties, and can be grouped into the four categories of:

- **Economy**: including:
  - Construction costs (including risk allowances, costs of financing through taxation and an allowance for residual values of assets)
  - Operating, maintenance and renewal costs
  - Revenue
  - Journey improvements for users (including journey time savings, changes in fare, improvements in journey quality for passenger and freight users)
- **Environment**: impact on the physical (natural and built) environment. These impacts are typically externalities, i.e. affecting third parties rather than those using the transport scheme directly.
- **Safety**: impact on transport accident numbers and severity, typically also treated as an externalities
- **Social distribution/equity**: the extent to which impacts are distributed evenly between different geographical areas and social groups.

In its CBA, the ATKINS company has used two different Passenger Services Scenarios. The CBA stage is based on assumptions that are still uncertain and these two approaches reflect different rationales for HSR service provision which might be adopted later if the project is launched. Thus, we are distinguishing the PSS1 and the PSS2; whereas PSS1 better meet to demand thus target the market shares, PSS2 is more revolved on the delivery of commercial operational performance:

- **HSR Passenger Service Scenario 1 (PSS1)**: In this scenario, it is assumed that an hourly core HSR service that serves all the larger and significant towns and cities on the route is provided (about 18 trains a day in each direction), supplemented by an additional hourly limited stop, and therefore faster, during the morning and afternoon peak periods, targeting the end-to-end market (4 trains a day in each direction both the morning and afternoon). In this scenario it is assumed that rail fares are approximately 60% of air fares.

- **HSR Passenger Service Scenario 2 (PSS2)**: This scenario secures revenue while keeping the associated costs for service delivery down. Thus, it is assumed that only the hourly core HSR service is provided (18 trains a day), reducing the cost of service delivery, while the rail fare is assumed to be higher than in PSS1.\(^\text{12}\)

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\(^\text{12}\) Based on *Norway High Speed Rail Assessment Study: Phase III (2012), Economic and Financial Analysis: ATKINS*