

TRANSPORT – DEVELOPMENT:
IMPACT STUDY OF THE LONDON-STOCKHOLM CORRIDOR

by

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ABSTRACT

Large-scale transport infrastructure projects are designed to enhance the rate of economic growth and income distribution of regions they link. They are often constrained by various social, economic, environmental and financial considerations. Projects are usually evaluated by economic and financial cost-benefit analysis obtained by a typical cash-flow study. This approach makes projects' appraisal deficient because it does not involve multifactor impacts of the projects. Those impacts that are not included in cost-benefit analysis are referred to as socio-economic effects.

In the framework of the trans-European high-speed railway network, this thesis focuses on the London-Stockholm corridor that is only partially completed. Nowadays, one of the European Union's main objectives is a proper socio-economic integration of the different regions between themselves in order to foster regional development and sustainable mobility.

Large-scale infrastructure effects on regional development and evaluation methods of such effects are analyzed to study the importance of socio-economic impacts. In megaprojects' evaluation, socio-economic impacts are no longer negligible in comparison to the financial benefits. Furthermore socio-economic impacts drive regional development and thus are the essential justification for implementing the infrastructure.

Researchers are beginning to suggest that mega-projects should tend first to maximize the socio-economic benefits and second to being sound and profitable. The implication would be that governments should pay more attention to maximizing the socio-economic impacts and environmental standards and delegate to the private sector the task of making the projects profitable on a financial analysis basis.

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To my parents

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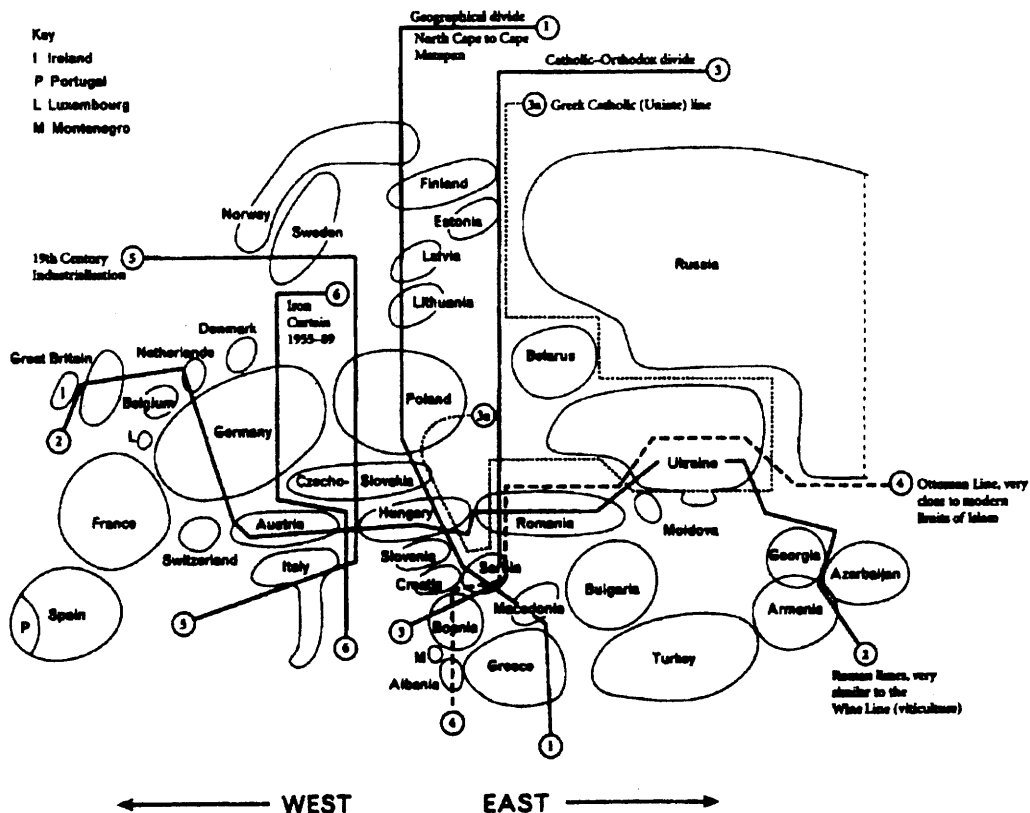
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INTRODUCTION

Historically, the European culture results from the merger of three currents that took place from the beginning of the Roman Empire to the XII century: Latin (Southern Europe), Celt (Central Europe), Viking (Northern Europe). All three are mixed. However there are three natural Regions to connect: the Viking route (under development, of which a North-European corridor and the Océane route), the Celt route towards the East (to be developed) and the existing Southern routes.

From the Roman Empire to nowadays, Europe has experienced many divisions in its development, and many of which have a North-South direction as shown in the map below. The only east-west division line finds its origins in the frontiers of the Roman Empire.

Map 1: East-West fault lines in Europe



As Europe was divided by East-West fault lines, regions have developed within the boundaries imposed by these cultural, industrial or geographical lines. Communication routes followed the same trend and expanded in a North-South direction over many centuries.

This trend is still visible in the end of the twentieth century, as many infrastructure projects show that up to now a lot of attention has been paid to linking the South of Europe to the North: the Rhine-Rhone waterway and many of the road-tunnels through Switzerland or Austria deal with this objective of linking the Mediterranean Sea with the North or the Baltic Seas.

In the 1990s, with increasing membership, the EU is entering a stage of expansion towards the East and the Baltic Sea. The Baltic Sea region is an example where the surrounding countries have cultural and economic incentives of coming together. This might create groups within the EU, which could create competition and tension between European regions. As Europe is stretching towards the Northeast, it is now time to provide infrastructure for East-West integration.

In the current stage of development of the European Union (EU), the main issue is a proper socio-economic integration of the different Regions between themselves; this concerns especially the peripheral Regions with the central continent.

In this perspective of development, the European Commission (EC) has realized that in order for Europe to become a Union where all countries would grow at the same speed, there is a need to bind them to one another through an efficient transport network. Transport infrastructure will contribute to regional development in reducing the disparities between the regions, and in linking islands, and peripheral regions with the central regions of the continent.

14 priority corridors have been identified and feasibility studies are being performed for missing key-links to be completed. The construction of corridors is important to include Peripheral Regions in the larger frame of the EU. Although all corridors are part of one single pan-European Network, each one taken separately needs to meet a precise objective.

The first of these corridors to have been built is the construction of the Channel Tunnel which has given birth to a whole new conception of transportation means in Europe. The United-Kingdom is finally bound to the continent by a fixed link and the European Union's goal of a marketplace where people goods and ideas are freer to move around has made a big step forward. More recently the Oresund Link has bridged the gap between Sweden and Denmark over the Baltic Sea. These two completed segments offer valuable benchmarks for further impact assessment of future large-scale infrastructure projects.

These two mega-projects are precursors of the arising of a new corridor across the North of Europe. This corridor will eventually include nine countries: Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France, the United-Kingdom and Ireland.

In the past the feasibility studies of such projects were limited to a cost-benefit analysis. Recently these have been extended to include also environmental impact studies. In addition, the issue of socio-economic effects has been raised and widely accepted, but they generally are only subject to a qualitative description and do not impact much on the decision making process.

Hence projects have been designed for a maximum profit and an acceptable socio-economic effect. In the current stage of development of the EU, with evolving needs, it is believed that now is time to set forth suggestions that mega-projects should tend first to

maximize the socio-economic benefits and as a secondary goal concentrate on having it sound and profitable.

The thesis will focus on a specific link within the corridor across Northern Europe: the Fehmarn Belt Link. Within the study of this link, the importance of the socio-economic effects in comparison with a cost-benefit analysis will be underlined and compared with other mega-projects. Methods of socio-economic effects evaluation are presented in Chapter three and then results of these methods for the Fehmarn Belt (between Denmark and Germany) are studied in Chapter four.

The analysis of large-scale infrastructure effects on regional development will help study the importance of their socio-economic impacts. The implication would be that Governments should pay more attention at maximizing the socio-economic impacts and environmental standards and delegate to the private sector the task of making the projects profitable on a cost-benefit analysis basis.

CHAPTER ONE

IMPACT OF INFRASTRUCTURE ON REGIONAL DEVELOPMENT

1.1 Transport policy and regional integration

1.1.1 The enlargement of the European Union

In the current stage of development of the European Union (EU), the main issue is a proper socio-economic integration of the different regions; this concerns especially the peripheral Regions with the central continent.

In this perspective of development, the European Commission (EC) has realized that in order for Europe to become a Union where all countries may grow at the same speed, there is an need to bind them to one another through an efficient transport network. The Commission expects the transport infrastructure to contribute in two main ways to regional development:

- In reducing the disparities between the regions. The strengthening of economic and social cohesion by the contribution which the development of transport infrastructure can make to reducing disparities between the regions and linking islands, land locked and peripheral regions with the central regions of the Community.

- In linking islands, and peripheral regions with the central regions of the Community. The transport service industry is essential for the integration of the Community, its economic performance and the mobility of its citizens. The problems of the more peripheral regions show that geographic disadvantages may be exacerbated by insufficient transport, resulting in lack of competitiveness and difficult market contacts of the economies concerned.

The European Commission mentioned in its White Paper of December 1992:

Transport efficiency requires that on the basis of a properly functioning internal market, the development of trans-European transport networks and the possibilities offered by best available technologies, citizens and enterprises should have access to means of mobility corresponding as closely as possible in quality and performance to their needs and expectations.

Up to now a lot of attention has been paid to linking the South of Europe to the North: the Rhine-Rhone waterway (linking two major rivers in Europe) and many of the road-tunnels through the Alps in Switzerland or Austria deal with this objective of linking the Mediterranean Sea with the North or the Baltic Seas.

With increasing membership, the EU is entering a stage of expansion towards the East and the Baltic Sea. The Baltic Sea region is an example where the surrounding countries have incentives for coming together in a more involved manner than with other countries. As Europe is turning towards the North-East, this is now the time to provide the right means for an East-West integration.

In this perspective the European commission recognizes that the construction of corridors is important to enable the inclusion of peripheral regions in the larger frame of the EU. Two examples are the following:

- The Paris-Brussels-Cologne/Amsterdam-London Corridor (PBKAL)
- The Paris-eastern France-southwest Germany Corridor (POS)

The international coordination of concepts also requires taking account of the new political situation in Central Europe. This means concentrating more on upgrading West-East lines. With this in mind, the two projects mentioned, PBKAL and POS, have been pushed ahead as basic links for East-West traffic.

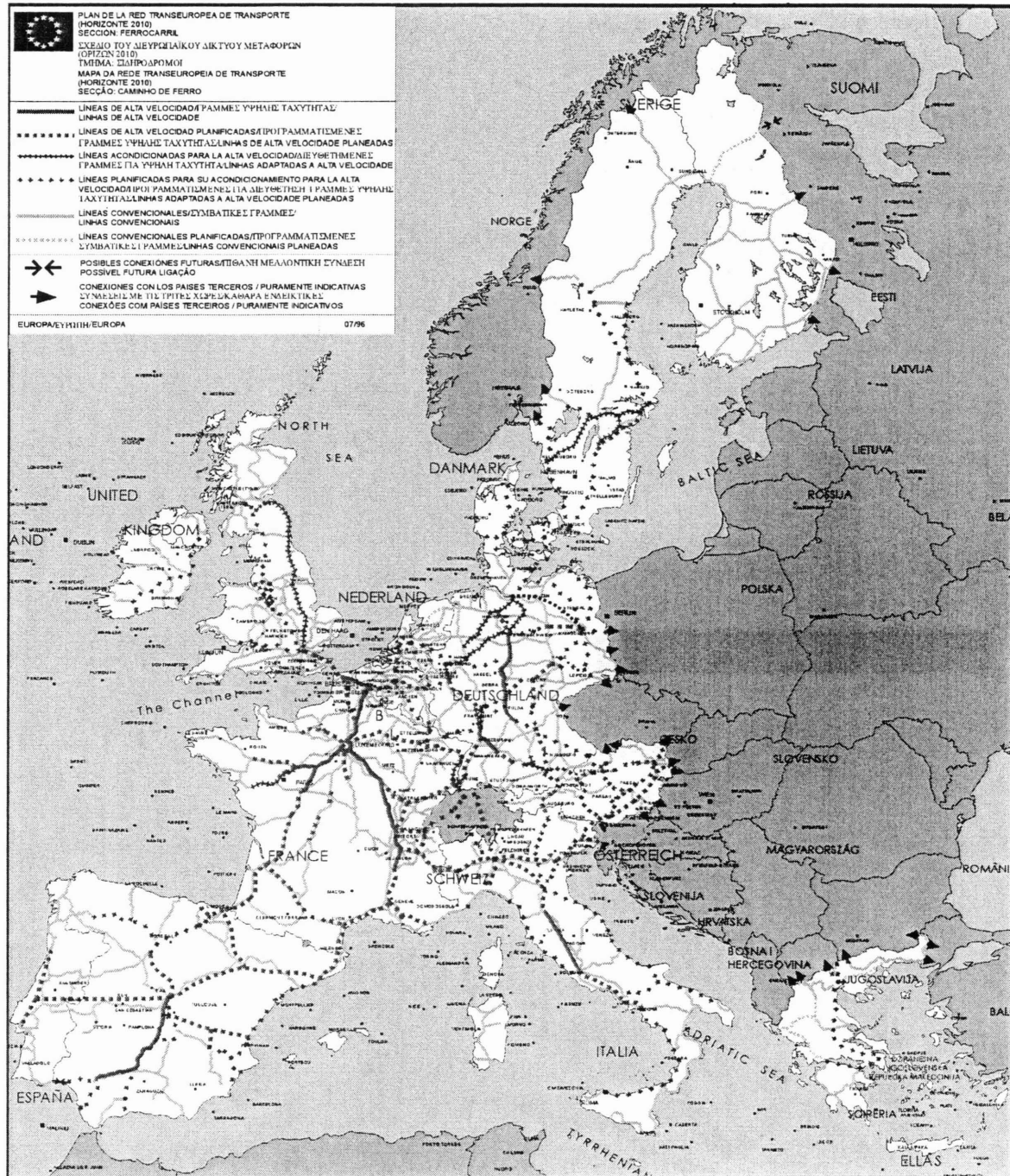
1.1.2 European Union transport policy for regional integration

Until the early 1990s, as growing congestion affected and still affects most economic centers of Europe, there had also been under-investment in peripheral areas. Nonetheless it was accepted that reliable transport systems are instruments capable of making an important contribution to the redressing of current center-periphery disparities. In addition, the functioning of a regional transport network has been negatively affected by several factors.

The reasons for the lack of investment were: the relatively low ranking of infrastructure investments in the periphery, mainly due to the difficulties in identifying and quantifying benefits from such schemes; and the high costs involved in overcoming the problems of isolation of these areas often related to the existence of natural barriers. The result was a failure to complete networks, which clearly acts to the detriment of the Community as a whole. Of course the regions most affected by this investment gap tend to be the least prosperous parts of the community. EU Commissioner Neil Kinnock saw a need for supporting these investments at EU level and was very active in promoting increases in the Trans-European Network (TEN) budget. Moreover, a major effort is now being made to prepare for the extension of the TEN to the accession countries.

Following is a map describing the outline plan of the European high-speed train network:

Map 1 - Outline plan of European high-speed train network¹



¹Source: Commission of the European Communities, "Les perspectives du territoire communautaire", Les actions communautaires: les liaisons manquantes dans les réseaux de transport de la Communauté, Europe 2000, 1991.

In the specific case of the high-speed railway there is a major problem of long distances for small countries. In particular, railway stations have to be located about 150 km apart, which means that there is barely enough scope for more than one stop in each country. This certainly applies to the scale of the European Community high-speed system, which is aimed primarily at conurbations of international city level. More stops might be tolerated at the end of the lines where traffic gradually falls off, but the problem then arises that poor traffic levels cannot justify new infrastructure.

It is already apparent, however, from a variety of forecast calculations, that it is precisely the small, peripherally located countries, or those with a limited potential area of influence, like Denmark and the Netherlands, which have a fairly modest volume of long-distance traffic. Despite this, these countries have shown great interest in linking up with a high-speed rail network, while it is also in the communal European interest.

Since the mid-1980s, the Community has been working on an ambitious policy to tie national transport infrastructures together into trans-European networks. For rail, the first priority is to complete the high-speed network and, in particular, realize the priority projects endorsed by the European Council at Essen (Germany). The emphasis so far has been on passenger transport and greater attention must now be paid to freight.

The Prague (Czech Republik) Declaration adopted by the Pan-European Transport Conference in 1991 emphasized the necessity of developing transport networks on a truly European scale and of integrating the greater European transport market.

Until the early 1990s, transport networks had been designed largely from a national point of view. Moreover, emphasis had frequently been placed on the

development of particular modal networks rather than on the relationships between them. This policy has led to major problems, including frequent absence of adequate interconnections between national networks, missing links and bottlenecks. Differences in the geographical situation and economic history of the member states have resulted in considerable divergence in the availability and quality of transport infrastructure.

The substantive goal of Community action is defined as the establishment and development of trans-European transport networks, through the promotion of interconnection and interoperability of national networks and access thereto. It takes particular account of the need to link islands, landlocked and peripheral regions with the central regions of the Community. The goal to be pursued is the integration of the Community's transport system through the completion and combination of its networks, taking particular account of the needs of its more geographically isolated regions.

1.1.3 Integration in an economic and social environment

The European Commission has looked towards high-speed technology to link regions; higher speed allows to overcome greater distance and bring towns and countries closer to one another. This focus on high-speed infrastructure is an essential step towards an integration of regions, but infrastructure serves no purpose if isolated.

Infrastructure has effect only if it is integrated into the economic and social environment. This means that back-up measures – ranging from investment in ancillary

transport systems to campaigns to improve the infrastructure's image – can increase its influence by strengthening its ties with the social fabric.

Among the measures that can be taken to strengthen the role of new infrastructure, the most obvious is the provision of back-up transport: links like the Channel Tunnel would not have been fully effective if it had not been properly linked to other rail and motorway networks at both ends in Kent and in Pas-de-Calais. For high-speed trains there is hence a need to upgrade the existing infrastructure of the neighboring regions. The *Conseil General des Ponts et Chaussees* (French administration) drew up (without being exhaustive) the following list of measures that can be taken to back up new infrastructure:

- ❑ Creation of development zones;
- ❑ Provision of start-up facilities for firms;
- ❑ Financial and tax incentives;
- ❑ Promotion of tourism;
- ❑ Urban and property development;
- ❑ Promotion of the local town, region or infrastructure;
- ❑ Construction of ancillary infrastructure;
- ❑ Modification of the local passenger services;
- ❑ Construction of highway systems.

Beyond the accompanying policies that are needed with the building of a new infrastructure, there are definite notions inherent to the infrastructure itself and that determine its range of impact. Within this continuous trend towards ever-higher speeds in

all transport modes, there are distinct thresholds: during certain periods and in certain places, journeys, which previously were not feasible, suddenly become so.

More recently, different researches have shown that distance is less and less the barrier it used to be. The very marked change in the volume of travel shows that passenger behavior has changed, and that people usually do not travel for the same reasons as they did before the high-speed link was introduced.

If the increase in speed is insufficient to shorten the journey time to below the critical threshold, its only effect will be to improve passenger comfort. If it does reduce it to below that threshold, it then manages to impact on firms' strategies and policies through the opening of a reach to a new market. The main effects of high speeds are on threshold journey times and frequency of service.

From the moment people can do the round trip within the same day, it creates the possibility for firms to conduct business with companies at the other end of the infrastructure. Through this new opportunity arises a greater interaction between the regions, their economy and development.

In the same way, with regards to railway services, open access to railway infrastructure would allow the entry of new operators offering new and better services. Open access would allow transport enterprises to develop the services needed in an area without frontiers and to find new markets.

The railways developed on national lines over a century and a half. This resulted in the difficulties we know today in operating across frontiers: inadequate planning of cross-border infrastructure and fragmentation of the supply industry and of research

activities. Although some progress has been made in breaking down national barriers, a desirable degree of integration is still a far-off goal.

At present a rail transport service is generally the sum of national services, hence it is limited through different issues linked with the change between two national networks. Therefore, even further improvement is attainable by linking all networks together, which will make the whole greater than the sum of its parts, allowing regions to widen their reach for economic development.

1.2 Transport and regional development

1.2.1. Infrastructure and the regional economy

Infrastructure effects

Traditionally when speaking of the relationship with economic activity in general infrastructure effects are divided into two types: construction effects and socio-economic effects, also called “structuring effects”.

Construction effects

They concern the multiplier effects of investment expenses in an infrastructure project. For this type of effect there is indeed a causal relationship between the implementation of a major construction project and the distribution of the benefits resulting from it.

The transport industry is one of the most important customers for a number of other industrial sectors, the most important being iron, steel and metal industries, mechanical engineering, the electrical, plastic and chemical industries. Through technical developments in all sectors, the transport equipment industry has become a pace-setting industry for technological innovation from which a wide range of other industries benefit. Hence the investment that goes into an infrastructure project spreads out to benefit the whole local economy through its impact on many other industries.

Like all effects connected with construction, these effects are only transitory since they vanish when the project is completed. These operations do not lastingly transform the economic structures of the region, and a few years after the completion of the infrastructure all economic traces disappear. The only persevering trace is related to works of maintenance, which seldom play a significant role. Infrastructure construction does not constitute a factor for take-off in the economy that disadvantaged regions look for through such projects in order to boost their economic development.

Socio-economic effects

Attempting to forecast the “structuring” effects connected with a transport infrastructure raises questions above the relevance of this approach. The main difference with the first type of effects is that socio-economic impacts are not directly linked with the introduction of a new transport infrastructure; they are induced by it and are subject to many other external parameters. The following statement made in a report of the SETEC²

² SETEC report : Etude d'impact du TGV Mediterranee, Volume2 Etude des impacts sur l'economie des departments traverses par la ligne nouvelle, December 1991, page 2.3

(French consulting engineering company) points out the role of transport infrastructure in structuring effects:

The fact is that transport infrastructures constitute an asset for regional development but it is to the regional decision-maker to take advantage of the opportunity and exploit this potential.

Here is an example of deterministic results of econometric estimates from the SETEC report studying the impact of the Mediterranean TGV. They formalize the relationship between the introduction of the TGV and employment:

$$\Delta E = 6.64 \times 10^{-8} \times GTEM \times E7_0$$

Where ΔE is the variation in total employment

$GTEM$ is the time saving brought by the HST for passengers using the stations of the local region concerned, expressed in (minutes x no. of passengers per day)

$E7_0$ is the number of jobs (excluding the building and public work sector) in the local region for the concerned year.

Such a method can give the impression of an automatic development of employment. Still there are examples of substantial improvements in accessibility where no regional development was induced (e.g. Station of Le Creusot on the Paris-Lyon TGV line).

Hence in the latest studies there has been a return towards approaches aimed at demonstrating the potentialities of the regions rather than expressing direct impacts.

For many economic activities the inertia of behaviors appears to be much greater than the momentum of mobility practices. The logic of enterprise evolution is more connected with the development of the branch or sector concerned than with that of transport.

Infrastructure and Firm Location

The idea that transport infrastructure does not suffice by itself to generate a new spatial pattern of economic activities is gaining ground. Factors like development strategies implemented by firms or authorities are recognized as being preponderant.

Indeed, a firm's choice of location is above all dictated by its business strategy- the market, the workforce, the sites available. Transport factors play a major role in the firm's decision to rule out locations that have poor transport facilities. Nonetheless an improvement in transport infrastructure will not be the reason for a firm to change location.

For productive activities, the share of transport costs in total costs has become so small – on average 2 to 3 % – that the need to keep them as low as possible is no longer the main factor that determines where a firm sets up. Transport-related factors are given roughly the same weight as the local environment and personal factors, but much less weight than labor-related factors such as the quality of the workforce, employer-union relations and the wage levels. In the final analysis, no matter how important the role of infrastructure might be, it is declining for, in the industrial countries, there are many locations with adequate infrastructure.

A new means of transport is of interest for an entrepreneur only to the extent that he uses it for some purpose, either simply to cut his transport times and costs or to penetrate a market that was previously inaccessible, or to establish new links with partners. Each entrepreneur has specific reasons for locating in a particular area and transport and communications carry less weight than business development strategies, the possibility of recruiting labor locally and the economic environment. While poor

transport facilities may be a reason for ruling out a location, good facilities are not a sufficient reason for choosing one.

Hence for transport infrastructure to have a visible impact it must make possible development strategies that would not have been feasible if it had not existed, that is create new patterns of behavior.

The question is then no longer that of the consequences of the new infrastructures, but rather that of their role as instruments of movement in the transformation of relations between industrial sectors.

1.2.2 Infrastructure and spatial pattern of activities

1.2.2.1 Historical trend

By making communications easier, high-speed services allow firms to remain in locations that would otherwise be no longer practical. Hence the changes in passengers' behavior do not reflect a change in the spatial pattern of activities: it is the people that move, not the activities. In the specific case of high-speed railways, we will see the consequences they may have. As has been developed above in the general case of transport infrastructure improvement, high-speed lines do not have a visible effect on the spatial pattern of activities. Still they may gradually remodel it via a few sensitive activities although the changes are not immediately reflected in the spatial pattern of activities.

The historical development of transport infrastructure shows a clear trend: as speeds increase, the distance between stops also increases; new networks are less dense and have fewer nodes.

- Air transport, particularly after the Second World War, shortened journey times even more than present innovations in transport: it became possible to fly from Paris to NY in ten hours, whereas by ocean took three days to do the same journey. The journey time by air was thus seven times faster than by ship. Air travel made possible journeys that had previously been impossible, shrinking the planet to the size of a continent.
- The construction of an efficient highway network in the United States raised road transport considerably. The same trend was observable in Europe with motorways. It may be estimated that highways have at least halved journey times. This has led to a fundamental separation between the former road network that used to serve every place in the country, and the highway network where a driver can enter or leave a highway only every thirty kilometers.
- In the railway network, three stages can be distinguished in the history of rail speeds. The first was the advent of the rail itself, which raised passenger transport speeds from 15km/h to about 50km/h, and freight transport speed from 5km/h to 40km/h. This revolution in transport made possible the growth of major industrial centers. The second stage involved steady improvements in commercial speeds leading to the introduction of electric traction. Finally, the introduction of high-speed trains (300 km/h) in Japan first and then in Europe; the TGV in France does at least 200 or 300 km without a stop.

Modernization of transport infrastructure has therefore gone through several stages, each time improving the mobility of the population. On the other hand modern infrastructure in all three modes mentioned above has increased the terminal effects on development, to the detriment of those on the area through which it passes.

1.2.2.2 The Emergence of a Dual Spatial Pattern

With regard to the effects of major transport infrastructure, one must distinguish between its “terminal” effects and the effects on the area through which it passes. This distinction is particularly important for regional development: either development would be concentrated at the ends of the infrastructure or at the nodes of the network as it is progressively built, or would be spread along the whole infrastructure.

Under the pressure of economic change, together with the coming into service of new infrastructures, the regions in Europe are seeing their space, which was formerly relatively continuous and homogenous, mutate into a discontinuous space, increasingly polarized, unless they simply belong to the spaces forgotten by both economic activity and high speed. The extension of links and the reduction of the number of nodal points in modern transport networks favor its concentration. The spatial pattern of activities would thus become discontinuous and increasingly polarized around a few centers. Each of the two types of space would function on entirely different principles from the other.

- First there would be an area formed by the set of nodes located on the major networks, by the major cities with an international vocation, and by a few regional capitals between which passengers, freight and information could travel rapidly. The

ease with which one could get from one to the other would depend solely on the means of transport used and not on the distance or features of the country traversed.

- Second, the areas between these nodes or major cities would consist of space in which travel time would still depend on the distance, and traditional notions of proximity would still bear some relation to the distance actually covered.

Europe is thus moving towards two types of space: one in which traditional notions of proximity still prevail and another equipped with a high-speed network. It is already easier to get from London to Paris or to Brussels than to travel within the same country.

The new lines, connecting only a few larger towns, promote the relative concentration of economic activities in those very towns, not only because their communications are much improved, but also because the quality of service offered to the smaller intermediary places tends to deteriorate after the opening of a new line.

Infrastructures like the Channel Tunnel or the Oresund Fixed Link combined with the high-speed lines have increased the importance of the major towns served by them. The regions through which they pass only benefit indirectly via the expansion of regional centers like Ashford (UK) or Lille (France). If the regions that benefit the most from the new infrastructure are also the most developed, it seems that the trend towards a polarization of Europe will increase.

1.3 Developing a trans-European network

1.3.2 Present situation

Most of the critical performance sectors of the European economy, namely services and high-tech manufacturing, tend to be located in congested environmentally sensitive areas. In the picture of a dual spatial pattern, these areas can be identified with the nodes of communication previously defined. Typically they are places where it is particularly difficult to implement supplementary infrastructure because of environmental and economic costs. From the European Union's perspective, these regional nodes of communication should be further developed to ensure the optimal efficiency of the connection between the network and the capillary, regional/local networks.

The fact is that inadequate capacity in some modes is producing congestion and environmental damage, while in others underused capacities exist. There is a general awareness of increasing environmental problems linked with congestion, traffic noise and with the unchecked development of new road infrastructure. In the present situation where road transportation is overwhelmingly used for inland communication, there is a call for a greater use of rail rather than road. The railway could do much to sustain mobility and reduce the social impact of transport problems both with regard to goods and passengers. However while unease is growing about the negative effects of transport, rail's market share still declines.

The trend in rail history has been the following: rail transport began in the first half of the nineteenth century and rose to be the primary means of transport by the

beginning of this century. Since the end of the Second World War, the role played by rail in the transport industry has been in constant decline and now, in the closing years of the twentieth century, rail's share of the passenger market is no more than 6% and that of the freight market 16%. The railways have even lost out in one market where they should be in a powerful position, long-distance freight.

This trend is alarming. It suggests serious increases in congestion, pollution and possibly accidents; it also suggests that the roads will carry increasingly heavy traffic, including highly dangerous goods.

The Community has been working on an ambitious policy to tie national transport infrastructure together into trans-European networks. Further enlargement of the Community will provide considerable opportunities to expand the role of rail. In the late 1990's many of these countries still have more extensive rail networks, offering opportunities for freight delivery and collection. In June 1994 in Corfu, the European Council approved a list of 34 transport infrastructure projects of which 11 were designated as priority projects. Then a group chaired by Mr. Henning Christophersen presented a classification of 14 projects at the Essen Summit in December 1994 following the criterion of the financing method used for the projects. Among those 14 projects, 10 are railway projects and 8 are high-speed train projects concerned with the construction of a trans-European high-speed line network.

As was set forth in the project list at the Essen Summit, the first priority for rail is to complete the high-speed network. The emphasis has been, for over ten years, on passenger transport and greater attention is now being paid to freight transport.

1.3.3 Integration of national systems

The railways developed over a long period of time to meet national needs. This has caused a fragmentation of both the railway system and the supply industry, a fragmentation that still exists. Differences in technical standards and operating rules in the member states of the European Union have complicated interoperability and helped split the supply industry into a set of national companies serving national markets. In the same way, initially viewed as a simple extrapolation from conventional rail technology in the 1980s, high-speed rail developed first from techniques specific to each country.

Interoperability

The fragmentation of the railways hindered the process of interoperability between the different national networks. Although much progress has been made in the last few years, great efforts are still needed to reduce the regulatory, technical and operational differences that could prevent trains circulating freely without stopping at frontiers. Not stopping at frontiers is one of the major substantial improvements that can be made for time-saving on international journeys.

In the case of high-speed rail, the European directive on its operability has established a process for setting technical specifications to allow interoperability on the high-speed network.

The technical standards characterizing one national network often differ from one member state to another. Following is a list of particular technical issues that show discrepancies within the European Union's Members.

Axle loads

The SNCF (Societe Nationale des Chemins de fer Francais, French railroad) limited the axle load on its TGV rolling stock to 17 tons. This has enabled SNCF to reduce maintenance costs and increase the lifetime of the track superstructure and moving parts of the rolling stock.

Other networks have adopted less stringent standards: for example the German ICE power units weigh 77.5 tons, which corresponds to an axle load of 19.4 tons. The ICE can run at 280 km/h. However, its normal cruising speed will be 250 km/h. The ICE3 (third generation) is expected to comply with the TGV standards of 17 tons on the axle load and will have a maximum speed of 330km/h.

Loading gauge

Because it has smaller loading gauge, the UK network cannot carry high-speed trains designed for continental services. Hence a specially designed rolling stock had to be developed for high-speed services through the Channel Tunnel.

Likewise, the DB (Deutsche Bahn, German Railroad) loading gauge is larger than the UIC (International Railway Union) standard gauge, and its ICE rolling stock cannot run on the French network.

Power supply

Broadly speaking, five electric power supply systems are currently in use on European networks, and three of them have been adopted for the new high-speed lines:

25kV 50 Hz (SNCF (France), RENFE (Netherlands), SNCB (Belgium)), 15 kV 16 Hz 2/3 (DB) and 3 kV dc (FS).

Signaling systems

There is an extreme diversity of signaling and speed control systems on the conventional networks. Moreover, additional signaling systems have been implemented for high-speed lines that are incompatible: TVM, LZB and Cab-Signal FS.

Track profile

The longitudinal section of track is determined not only by topographical requirements, but also by the operating policies adopted. For example, maximum gradients vary from 8 per mil (FS) to 12.5 per mil (DB) for lines designed to carry mixed traffic, and 35 per mil (SNCF) and even 40 per mil (DB) for lines that will be used solely by high-speed trains.

The main concern now is the necessity of a unified European train control system. It is not enough to establish standard specifications for the interfaces that will allow rolling stock to operate on several networks. It will also be necessary to design and to develop a comprehensive traffic management system that will form the nerve center of the railways' technical and commercial organization.

The new generation of control systems should make extensive use of information processing and data transmission technology. This would improve performance (line capacity, punctuality, operating speeds), reduce operating costs and make it possible to

extend to the conventional network, the level of safety that currently exists only on high-speed lines.

1.3.4 Introduction of market forces

Notwithstanding the obstacles that would have to be overcome, such a list makes it clear that there is a pressing need to harmonize the technical standards of the various national railways in Europe. At an exploitation level, there are two main reasons for coordinating technical concepts:

- First, it is necessary to make international through services physically possible, i.e. enable the same rolling stock to run on different networks;
- Second, these services will have to be efficient, i.e. in terms of operating costs and quality of service. Furthermore, it is reasonable to assume that, by simplifying standards for international rolling stock, by generating economies of scale at the manufacturing level and by promoting healthy competition between suppliers, the harmonization of technical concepts will lower investment costs significantly.

Internationalization of services

Obviously the technical and economic aspects are interrelated, if only by the impact on costs. But efficiency of operation will also depend on other factors that affect only performance and economic efficiency. These are the cinematic characteristics of the rolling stock (maximum speed, acceleration and braking characteristics) relative to the optimum carrying capacity of the line and to journey times.

The Commission believes that the further introduction of market forces is the most effective means of creating a railway that can compete with other modes of transport. The internationalization of services and operations is just as important as the harmonization of the technical standards. It is needed in order to make international rail services competitive and to promote the image of an efficient and well-managed rail system.

At the moment many railways are largely insulated from market forces. Some railways may focus entirely on their core business of operating trains; others may choose to enter into partnerships, for example with road haulers or logistics companies, and offer door-to-door intermodal services. Some may operate across Europe providing seamless services, while others may concentrate on local services. The extension of access rights to infrastructure would allow new railway enterprises to enter the market. To help ensure that access rights are effective, the commission will propose the separation of infrastructure management and transport operations into distinct business units.

Access rights

Open access to railway infrastructure would allow the entry of new operators offering new and better services; this competition would stimulate established operators to improve their performance. Open access would also allow transport enterprises to develop the services needed in an area without frontiers and to find new markets. At present a rail transport service is generally the sum of national services; rarely does a

single operator have responsibility for a whole international service from door to door terminal.

In the case of freight, an individual railway enterprise would not be able to develop a complete transport chain integrating international and domestic legs.

Open access for freight services will provide Community enterprises with the freedom to identify and exploit business opportunities, essential to halting the decline of rail's market share for freight.

The creation of these "freeways" would have a wide range of benefits. Infrastructure managers would gain experience of collaboration, which could lead to new thinking about infrastructure and its potential to provide different types of service, including the transport of dangerous goods. Open access should attract new operators and the single point of contact would vastly simplify obtaining train paths. The overall result would be an expansion of the total value of rail freight business with benefits for all operators.

Table 1: Railway Technical Standards³

Country	Railway	Train	Maximum Speed	Speed in Operation	Axle-load	Installed Power	Power Supply	Motive Power units
	Eurostar	Class 373	300	300	17	12240	h c b (f/a)	2
	SNCF/SNCB/NS	TGVThalys	300	300	17	8800	i / h f c b	2
Finland	VR	S220	220	200	14.6	4000	h	4
France	SNCF	TGV	300	300	17	8800	h f b	2
France	SNCF	Tilting TGV*	300		17	4500	h b	3
Germany	DB AG	ICE 1	280	250	19.4	9600	f	2
Germany	DB AG	ICE 3*	330		16	8000	h f c b	4
Italy	FS SpA	ETRY 500	300	250	19	8500	c	2
Italy	FS SpA	ETR 500	300	250	17	8800	h c	2
Norway	NSB	BM71*	210		16.5	2646	f	3
Portugal	CP	Penduloso	220	160	14.6	4000	h	4
spain	RENFE	AVE	300	300	17	8800	h c	2
spain	RENFE	Euromed	220	200	17	8800	h b	3
Sweden	SJ	X2-2	210	200	18	3260	f	1
Tchequie	CD	Class 680*	230		13.5	4000	h f c	4
UK	GNER	IC225	225		21	4540	h e d	1

Legend for the Power supply:

a = 750 V DC

e = 12,5 kV 60 Hz

b = 1,5 kV DC

f = 15 kV 16 2/3 Hz

c = 3 kV DC

h = 25 kV 50 Hz

d = 12 kV 25 Hz

i = 25 kV 60 Hz

³ Source: UIC International Union of Railways

CHAPTER TWO

A NORTH EUROPEAN BELTWAY

2.1 A North European beltway within the trans-European network

2.1.1 Building a trans-European network

In the early 1990's the challenge was to create a climate of stability supported by a sound and decentralized economy. Emphasis was placed on the relevance of developing trans-European networks for transport and telecommunications. In the framework for trans-European networks, 30 priority projects were endorsed by the working party led by Mr. Christophersen, Vice-President of the European Community at that time. Those projects were split up in three sub-sections and were then brought down to 14 projects at the Essen Summit (December 9-10 1997). Implementation of these projects was supported by a new financial framework: 24 billion Ecu (Euros) were attributed for the 1994-1999 period by the Cohesion Fund and the European Investment Bank.

In the scope of this thesis we will limit ourselves to the high-speed railway network. High-speed rail lies halfway between conventional train services (medium range speed of 160 km/h, and high capacity levels up to 1,500 seats) and air transport (high-speed, and low capacity up to around 300 seats). High-speed trains present significant speed levels of around 300km/h and an average capacity of up to 800 seats with an adaptable frequency. Hence the ideal market for the high-speed train is services between major cities with distances of several hundred kilometers.

Table 2: Christophersen 14 top priority projects¹

	Project denomination	States involved	Completion
Project 1	North-South high-speed link (the Brenner)	Germany/Austria/Italy	uncertain
Project 2	Paris-Brussels-Köln-Amsterdam-London (PBKAL) high-speed link	UK/France/Belgium/ Netherlands/Germany	around 2005
Project 3	High-speed train South	Spain/France	around 2005
Project 4	High-speed train East	France/Germany	around 2005
Project 5	Betuwe combined transport rail line	Netherlands/Germany/ <i>Switzerland/Italy</i>	around 2005
Project 6	high-speed train Lyon-Trieste	France/Italy	uncertain
Project 7	Greek motorways	Greece	around 2005
Project 8	Multimodal link Portugal/Spain with the rest of EU	Portugal/Spain	uncertain
Project 9	Cork, Dublin, Belfast, Larne conventional rail link	Ireland/UK	completed
Project 10	Malpensa Airport	Greece	completed
Project 11	Oresund fixed link	Denmark/Sweden	completed
Project 12	Nordic triangle multimodal corridor	Denmark/Norway/ Sweden	uncertain
Project 13	Ireland-UK-Benelux road link	Ireland/UK/Benelux	uncertain
Project 14	West Coast Main Line	United Kingdom	around 2005

¹ Source: European Commission Division VII report June 1998.

Map 2 – Mapping the high-priority projects²

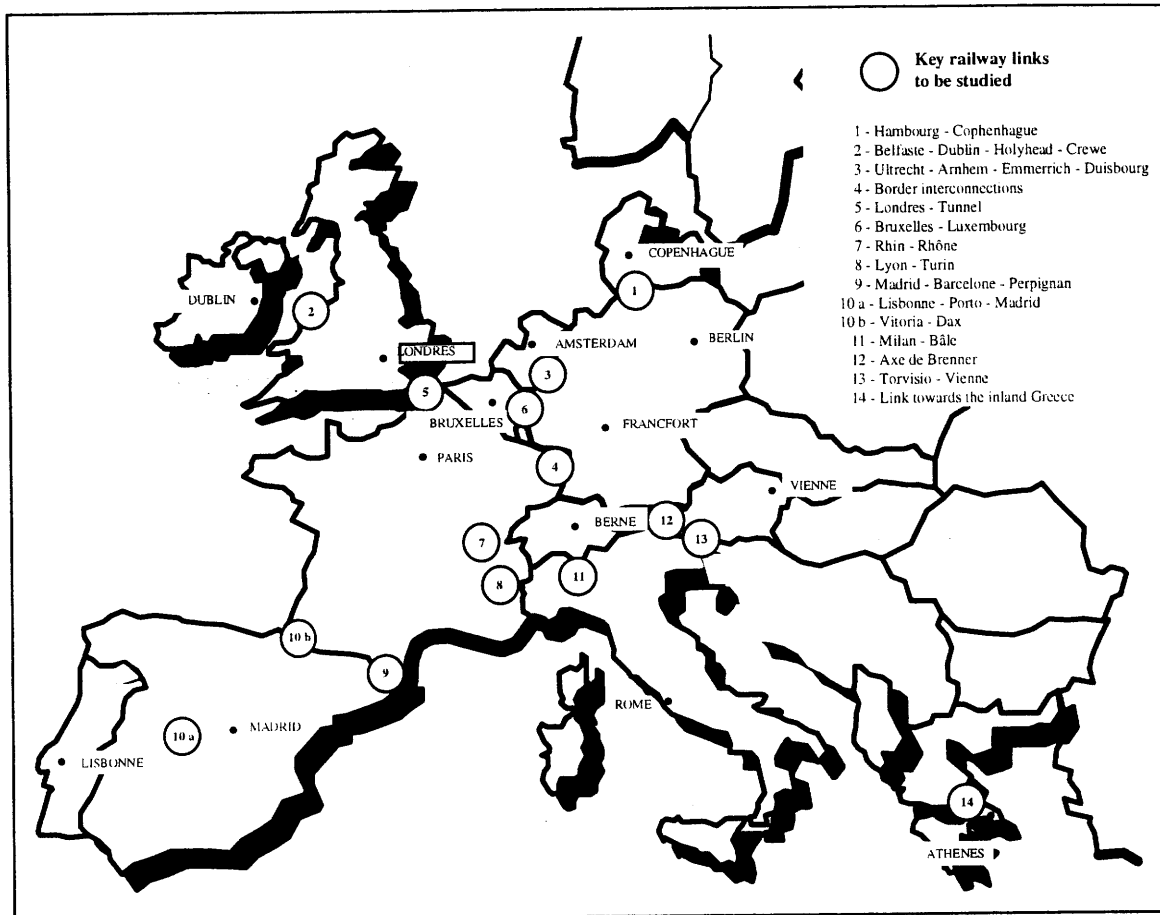


Schéma O. HEDDEBAUT - C. HYPACE (INRETS)

Europe presents favorable characteristics in demographic distribution for the development of high-speed rail transport:

- Strong demographic and economic concentration in cities with more than 100,000 inhabitants, which account for 40% of the population;

² Le Moniteur des Travaux Publics et du Bâtiment, "Europe le jour "J", January 1993.

- Average distances (between 100 and 400km) between many cities for which rail offers many advantages in comparison with other modes.

When building a new infrastructure, one needs to keep in mind that it is meant to fit into an existing environment with its own set of operating rules, and the reasons for building it are to be found in that prior environment. Hence a major issue is to define the physical boundaries of that environment; what is the scale we should set for the project? Many projects are justified economically on a national or bi-national basis. In the case of the Fehmarn Link in the North Sea area, the link has potential impacts on a greater zone than just Denmark and Northern Germany. In the same way, the Channel Tunnel has had an impact in a greater area than the one covered by the metropolises of London and Paris, it has extended to the whole of France, to Belgium, the Netherlands and Germany. It is through the integration of the infrastructure in a proper railway network that has enabled it to broaden its reach.

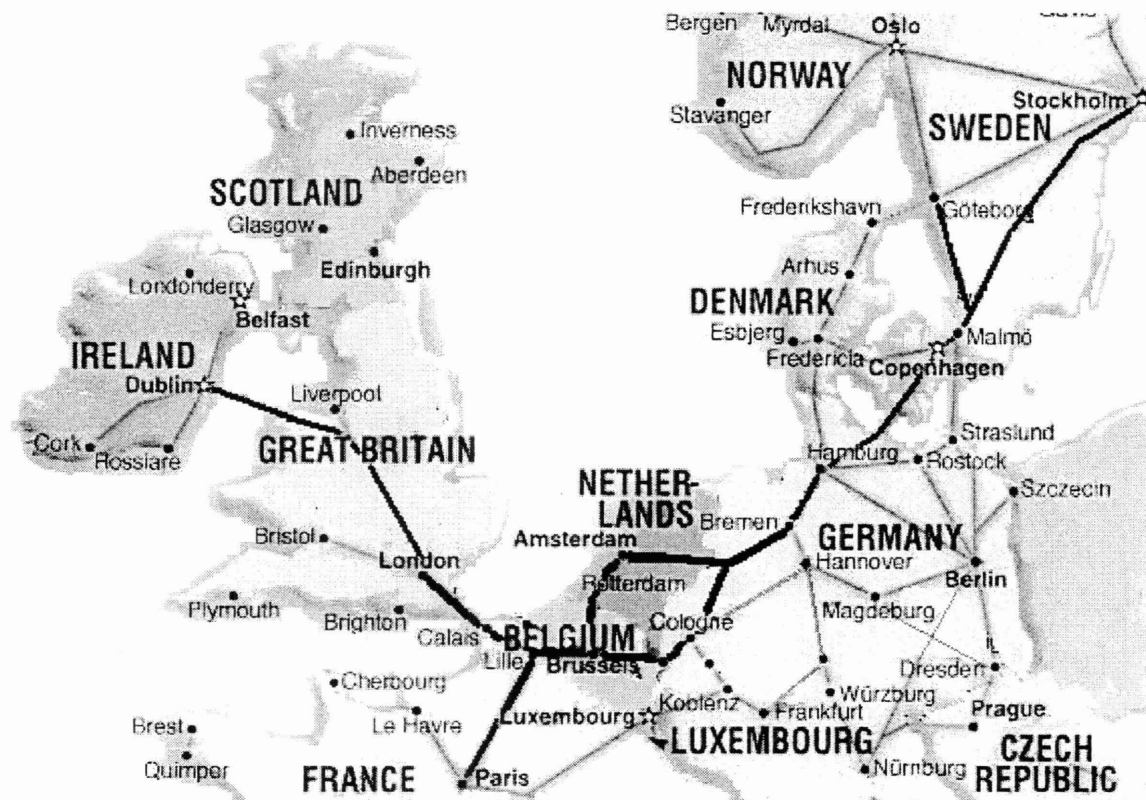
On the other hand, one cannot assess in an accurate manner the impact of a new infrastructure on too wide a region. Hence each infrastructure project taken separately needs to meet a precise objective. Moreover, while measuring the impacts of a project it is important to keep in mind, that in the case of a trans-European network that the whole has the potential of being far greater than the sum of its parts. Indeed, the underlying idea for EU Commissioner Neil Kinnock to promote a trans-European network was that the patchwork of European infrastructure would follow the rule where the product of the whole would be greater than the sum of its parts.

2.1.2 A North-European beltway

The construction of the Channel Tunnel was a precursor in the understanding of the need for an integrated trans-European network and has given birth to a whole new conception of transportation means in Europe. By means of this infrastructure the United-Kingdom is finally bound to the continent by a fixed link. The European Union's goal of a marketplace where people goods and ideas are freer to move around has taken a big step forward. More recently the Oresund Link has bridged the gap between Sweden and Denmark over the Baltic Sea. Hence the European Union's list of priority projects is under achievement. These two completed segments offer valuable benchmarks for further impact assessment of future large-scale infrastructure projects.

These two mega-projects are precursors of the arrival of a new corridor across the North of Europe. This corridor will eventually include nine countries: *Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France, the United-Kingdom and Ireland.* At this stage of the European union's expansion towards the East, there is a need to highlight and support West-East links rather than North-South links as was traditionally the case until recently. This corridor across the North of Europe is one of the main corridors that run through Europe from East to West. It is composed of different projects classified as high priority by the Christophersen group all justified on a national or bi-national basis. Including these projects within a corridor gives them greater impact since as a part of the whole, their interaction with one another adds up to the sum of the impacts of each project taken separately.

Map 3: The North European high-speed network



Due to the choice of such a framework, the analysis will ignore some important impacts with other regions, which are not included in the corridor. On the other hand, the North-European Belt presents the particularity of being unidirectional. Breaking down the trans-European network into linear components facilitates an analysis that covers several infrastructure projects and their interaction with one another rather than limiting oneself to impact studies of isolated components that do not reflect their real impact on a European scale.

The skeleton of this North-European beltway is a combined transport infrastructure: high-speed line railroads together with motorways on most of the corridor constitute the backbone of the corridor. Eventually over a dozen of main European cities

including eighth capitals out of the nine countries named above will be connected through high-speed line railroads: Dublin, London, Paris, Brussels, Rotterdam, Amsterdam, Cologne, Hamburg, Hannover, Copenhagen, Malmö, Stockholm Goteborg and Oslo.

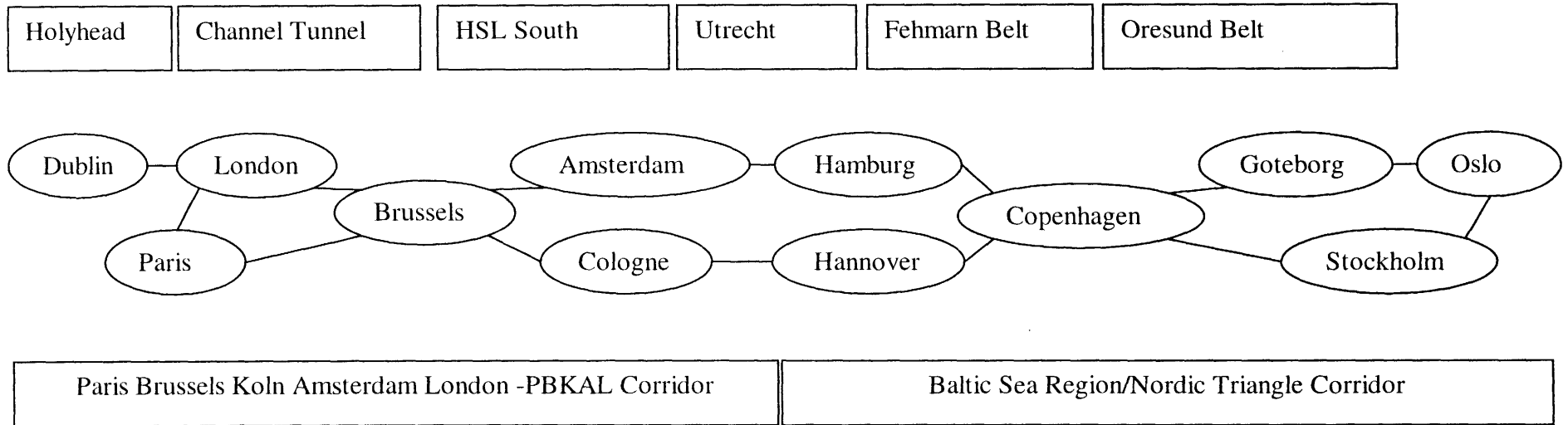
This beltway includes the PBKAL Corridor, and the Nordic Triangle Corridor. More specifically it includes six segments qualified as key links by the European Commission for the completion of the trans-European network:

1. The Ireland-United Kingdom link (scheduled for 2005)
2. The Channel Tunnel (completed in April 1995)
3. The High-Speed Line South link (under construction, scheduled for 2005)
4. The Betuwe link: Amsterdam-Duisburg (scheduled for 2005)
5. The Fehmarn link (studies underway)
6. The Oresund link (opened in July 2000)

The objective of this beltway is, by means of highly efficient communication, to make the corridor a dynamic growth center in Northern Europe, stimulating trade and development locally in the whole Baltic Sea, North Sea and the Channel regions. High-speed rail here plays an important role in bridging geographical gaps within a time lapse of time competitive with air transport and in minimizing the negative environmental impacts that road or air transport provoke.

Figure 1: A North European Belt

Infrastructure Projects
Main Metropolises
Corridors

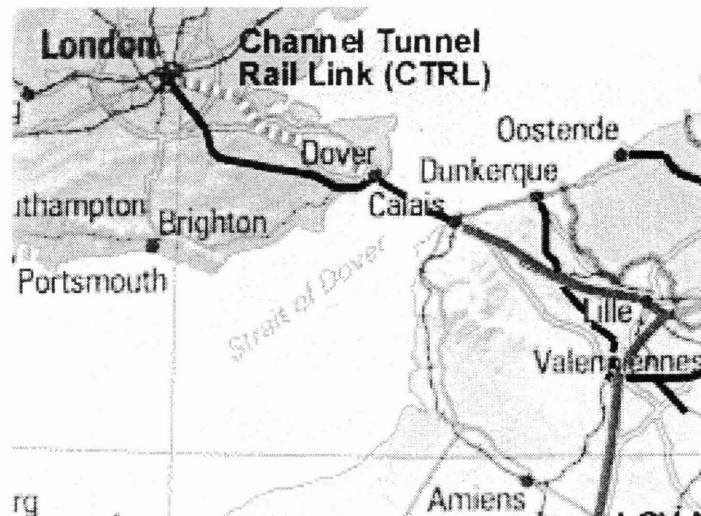


2.2 Links in place or under construction

2.2.1 The Channel Tunnel

A fixed link connecting Great Britain to the European Continent is a 200-year-old dream. In 1801, the French Emperor, Napoleon Bonaparte, made the first planning of the channel tunnel, and since then many attempts to build the fixed link have failed. In 1987 the French and English governments agreed on the notion of a fixed link between both countries. Today this project has finally been achieved and marks the beginning of a restructuring of the European communication network.

Map 4: Channel Tunnel region



Construction of the Channel Tunnel started late in 1987 and the Tunnel was completed in May 1994 and opened in March 1995, closely associated with the completion of the Single European Market.

The Channel Tunnel consists of two running tunnels for the traffic in each direction on either side of a service tunnel. Each tunnel is 49.9km long; the running tunnels have a diameter of 7.6m while the service tunnel's diameter is 4.8m. This project

has linked the British and French rail motorway networks and has reduced the travel time between London and Paris to three hours and between London and Brussels within two hours forty minutes.

The services provided by the Channel Tunnel have led to a considerable reduction in journey times for surface travel between the markets of Great Britain (55 million people) and mainland Europe. The basic justification for the construction of the Channel Tunnel was that the means of crossing the Channel at that time has led to a transport bottleneck. The fixed link helped reduce significantly these disruptions to the free flow of passengers and goods within the Single European Market.

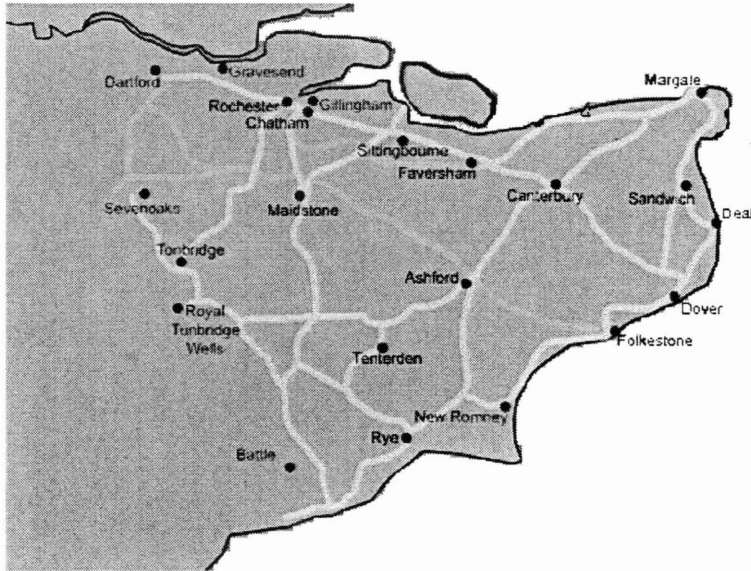
From its opening, Eurotunnel had a competitive advantage in the cross-channel traffic system because of its high speed and its independence of weather conditions. A further advantage is its integration in a growing European network, extending its reach at least to Amsterdam and Cologne.

Further improvement of the infrastructure is scheduled on the British side of the Tunnel with the Channel Tunnel Rail Link project (CTRL), which should cut the journey to the continent by half an hour.

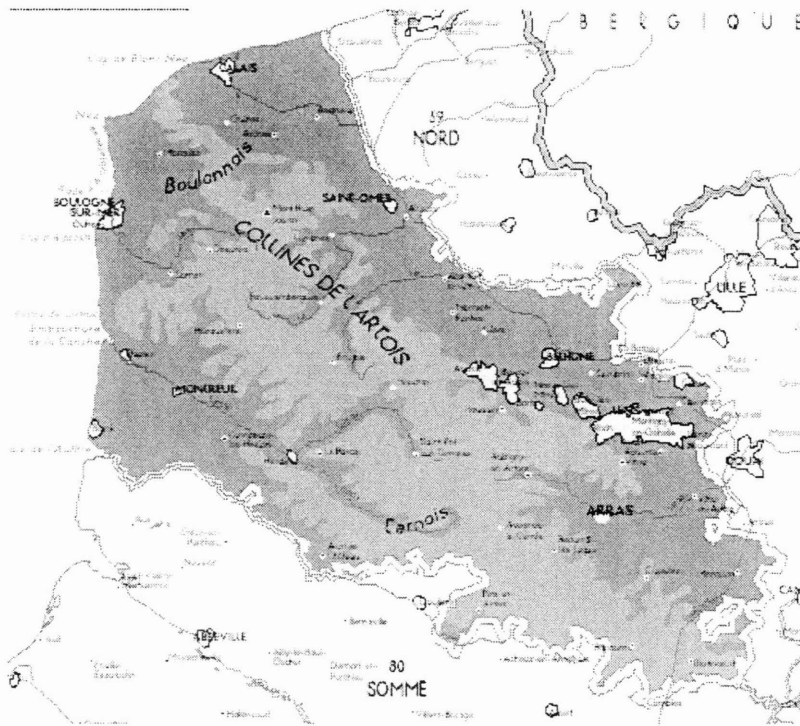
Local impacts

The British terminal of the Channel Tunnel is close to Folkestone in Kent, a county of 1.5 million people. On the French side the terminal is located close to Calais in the Nord/Pas-de-Calais region, numbering over 4 million people, including the major urban agglomeration centered on Lille.

Map 5: County of Kent (United Kingdom)



Map 6: Department of Pas-de-Calais (France)



In round figures, the channel was expected to capture 70 percent of the passenger/car market, but the ports were to retain 70 percent of the road freight vehicle trade. The following table shows the annual tunnel and ferry traffic in million of units

between 1995 and 1998. One can see that the ferry traffic started losing its share in 1998 after a three-year period of traffic increase because of improved service and lower prices.

Table 3: Annual tunnel and ferry traffic figures in million units, 1995-1998³

	1995	1996	1997	1998
Shuttle				
Cars	1.22	2.08 (+70%)	2.32 (+90%)	3.35 (+174%)
Coaches	0.23	0.58 (+148%)	0.65 (+182%)	0.96 (+317%)
Train Passengers	2.92	4.87 (+67%)	6.00 (+105%)	6.30 (+115%)
Pass. Ferry in Dover				
Cars	2.89	3.04 (+5%)	3.56 (+23%)	3.30 (+14%)
Coaches	0	0	0.17	0.15

The main impacts of the Channel Tunnel were the promotion of Ashford as a growth pole in Kent and of Lille as a European region center. On the other hand, towns like Dover and Folkestone in the UK suffer from being 'behind' the mouth of the tunnel while cities like Dunkerque and Calais in France still suffer of considerable restructuring since the mid-1980s and the Channel Tunnel has only emphasized the economic problems linked to restructuring.

A number of objectives were established on both sides of the Channel to make the most out of the introduction of the Tunnel. Firstly, through the establishment of new training and technology centers, the regions made sure they would profit from the

³ Source : « Long term impacts of the Channel Tunnel : Methodology and evidence, November 1999

construction effects: 50 percent of the construction jobs in Kent and 80 percent in Nord/Pas-de-Calais were filled within the region. Then other measures included restructuring their tourism and distribution industries and changing the image of the region.

In France the construction of the Channel Tunnel was accompanied by strategies focusing on including it in the coastal highway extending the A26 motorway to Calais and linking it to the E40 motorway from Brussels and proceeding further south-west, following the coast. Similarly, the railway infrastructure was upgraded to allow the Thalys to circulate with the optimum speed.

In England, the upgrading of the segment between Folkestone and London's St Pancras station is under way (CTRL project). The expected journey times and line usage are to be the following⁴:

Table 4: Journey times between London and the Continent

Origin	Destination	Journey times	Expected usage
St Pancras	Paris	2h20	8 trains per hour each way
St Pancras	Brussels	2h00	
Waterloo	Paris	2h35	4 trains per hour each way
Waterloo	Brussels	2h20	

⁴ Source: Channel Tunnel Rail Link. RLE & UNION, June 8, 2000

Regional impacts

A number of 'ex-ante' studies have been done to assess the expected impacts of the Channel Tunnel on surrounding regions.

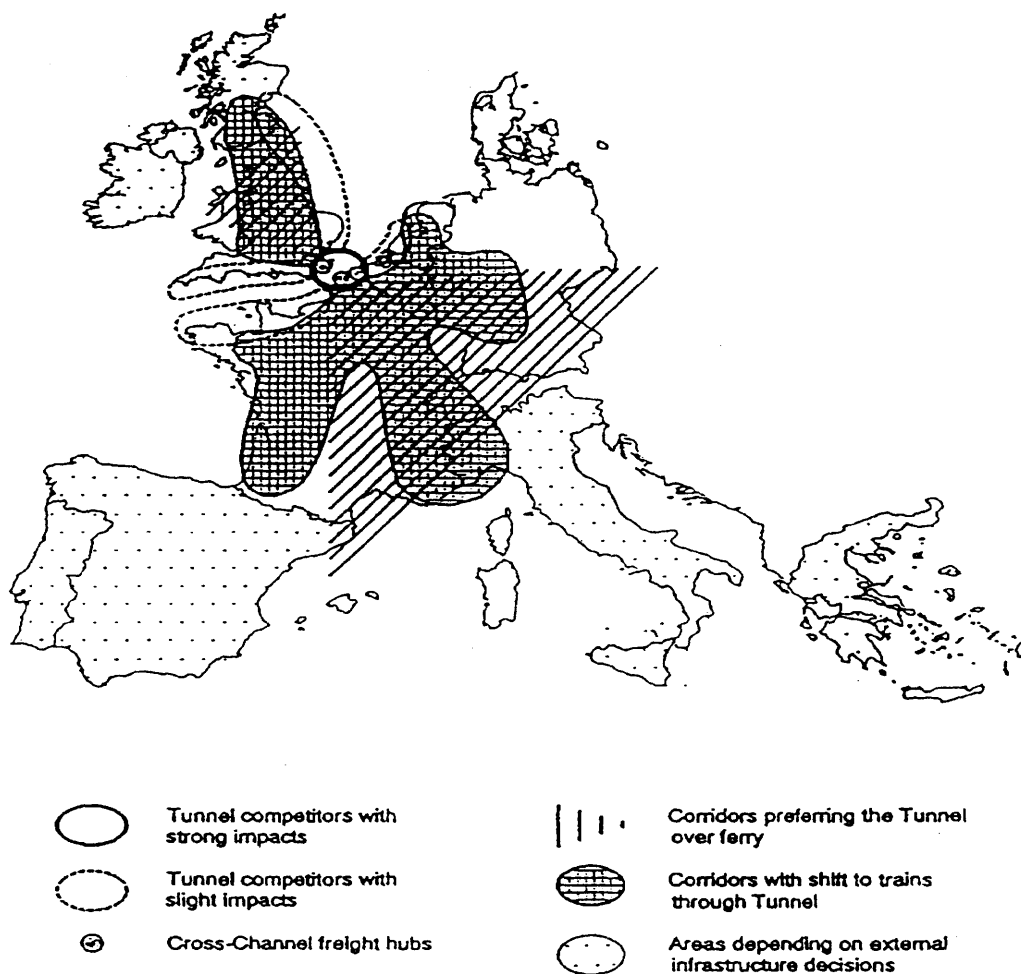
Table 5: Studies on the socio-economic impacts of the Channel Tunnel⁵

Study period	Working group	Objective	Results
Sept 1981/ April 1982	Braibant-Lyall	Examine different alternatives for fixed links, Assess the impact of proposed solutions for a fixed link on the economies of France and UK	The group opted for a twin bored rail tunnel with shuttles for motor vehicles
Dec 1984/ Sept 1985	SETEC/ SERETE-CODRA	Estimate traffic trends and identify the Channel tunnel impact on employment	Increase of passenger traffic for France Germany and Spain
End 1984/ 1st quarter 1985	BECHTEL France consultants	Identify impact on traffic and on employment by sector in the Nord/Pas-de-Calais region	Increase in regional employment, subject to implementation of back-up measures
July 1990/ April 1991	EEC	Analyze the effects of the Channel Tunnel on 33 areas of the EEC	The tunnel should have few effects except in those regions near the mouths of the tunnel

⁵ Data obtained from Mrs. Odile Heddebaut tables in the COST action 317 report « Socio-economic effects of the Channel Tunnel » February 1995.

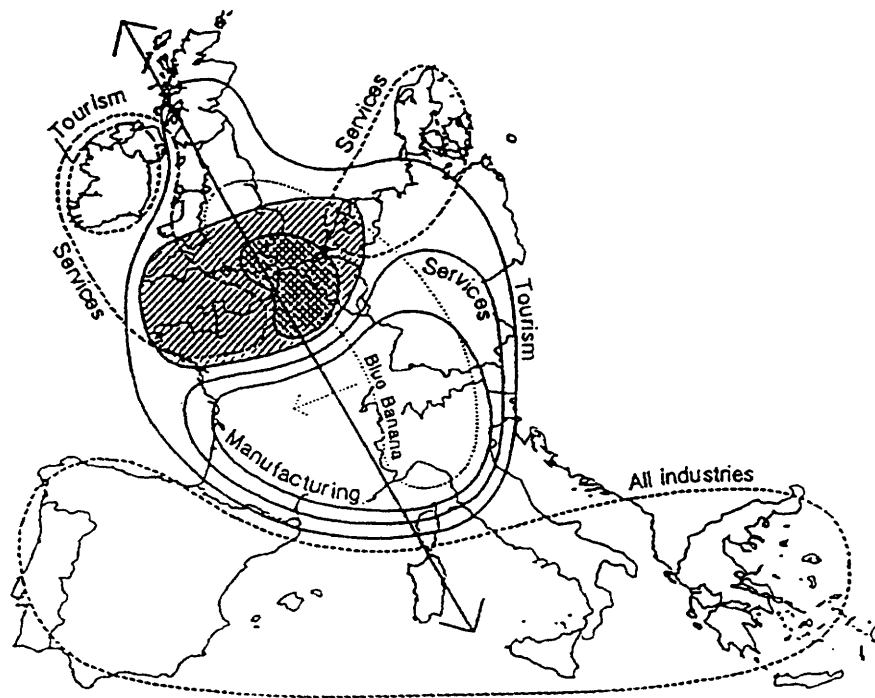
An overall impression given by these studies is the need to implement regional strategies supporting the introduction of the new fixed link. The study carried out for the EEC included the analysis of regional effects expected from the opening of the Channel Tunnel on both traffic flows and regional development. A quick overview of them is given in the two following maps.

Map 7: The impact of the Channel Tunnel and of the associated transport infrastructures on transport flows⁶








⁶ ACT, IRPUD, ECHENIQUE Marcial and Partners, "The regional impact of the Channel tunnel throughout the Community", Executive Summary for the DG XVI, February 1992.

Map 8: The impact of the Channel Tunnel and of the associated transport infrastructures on economic development⁷



Relative impact of the Channel Tunnel and the related infrastructure on value added

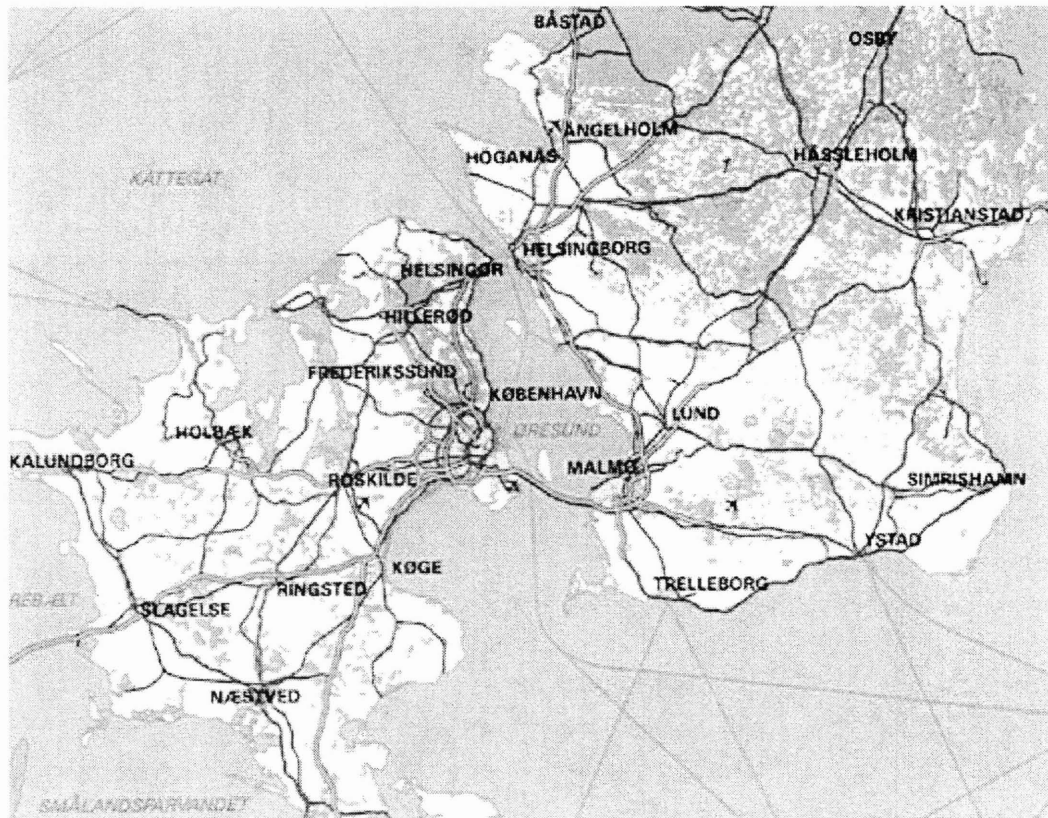
-  Positive, all industries
-  Positive, manufacturing
-  Marginally positive
-  Negative
-  Axis of central corridor

⁷ ACT, IRPUD, ECHENIQUE Marcial and Partners, "The regional impact of the Channel tunnel throughout the Community", Executive Summary for the DG XVI, February 1992.

2.2.2 The Oresund Link

The conception of a fixed link between Sweden and Denmark is also an old dream. In 1872, the Swedish company Skanska and Danish Højgaard & Schultz first proposed a tunnel under the Oresund. In 1991 both the Swedish and Danish governments came to a joint decision on a 16 km-long combination bridge/tunnel link incorporating an artificial island.

Map 9: The Oresund region



The Oresund Consortium awarded the construction of the two-level bridge to Sundlink Contractors. The upper level of the bridge would have four lanes of automobile

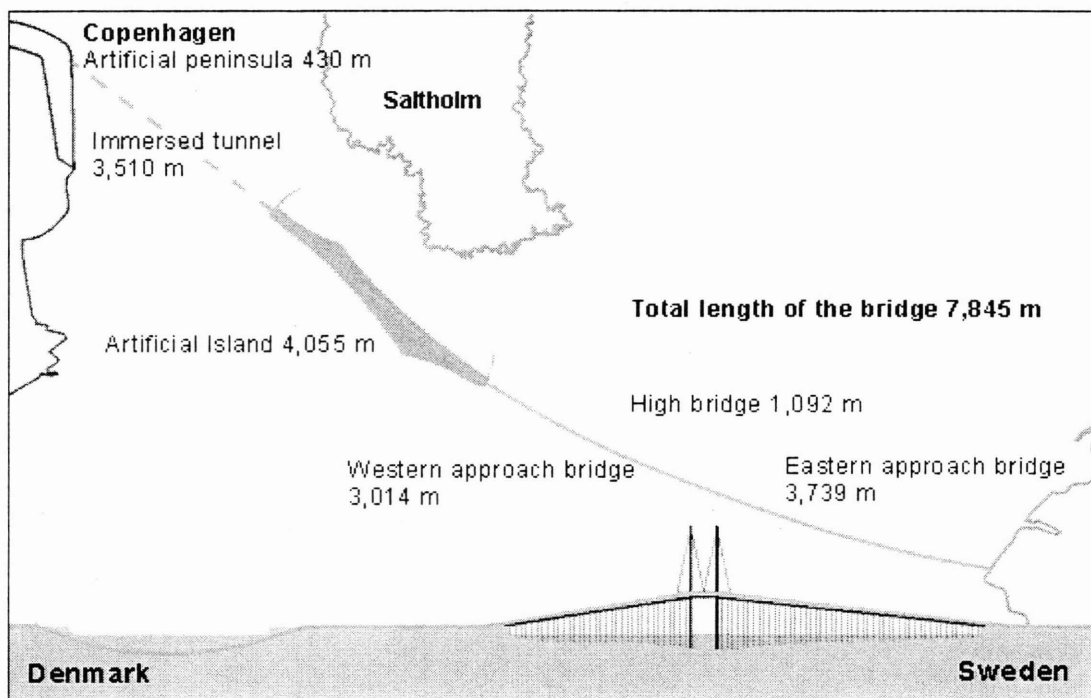
traffic, while the lower level would take trains. The completion of this project has enabled the linking Copenhagen to Malmö within two hours.

The bridge-island-tunnel system connecting Sweden and Denmark officially opened on July 1st, 2000. It includes the building of new motorways and railways in both Sweden and Denmark. From Sweden to Denmark, the system consists of six major parts:

1. Eastern Approach Bridge: It is 3,739 m long, comprising 22 spans. With a RC-structure, the bridge has a two-level superstructure- the upper deck for motorway and the lower deck for railway.
2. High Bridge: Above sea level by 204 m, four pylon legs support the cable –stayed bridge which is 1,092 m long with a 490 m main span and a navigation clearance of 55 m Pylons have protective islands surrounding them.
3. Western Approach Bridge: 22 spans form the 3,014 m-long western approach bridge. With gradual changes in the angles at the joints between the bridge spans, the bridge has a beautifully curved shape. Approaching bridges use about 15 m-dredged pits below sea level.
4. Artificial Island: The artificial island, Peberholm, is 4,055 m long and mainly made up of dredged material from the Oresund seabed. A total of 1.6 million m³ of stone and 7.5 million m³ of sand and dredged material were used.
5. Immersed Tunnel: Four side-by-side tubes form the 3,510 m-long tunnel which motorway and railways pass through. Consisting of 20 tunnel elements, the tunnel is the longest immersed tube tunnel for both road and rail traffic in the world.

6. Artificial Peninsula: The 430 m-long artificial peninsula is made up of dredged material from the Oresund seabed and covers 0.9 km². The purpose of the peninsula is to accommodate the portal of the Oresund tunnel.

Figure 2: Coast-to-coast outline



The environmental objectives for the project have been very closely observed; the construction of the fixed link must not cause any change in the Baltic Sea's physical, biological or chemical marine environment. In order to reduce the effect to the water flow through the Oresund, compensatory dredging in the Oresund is projected to reduce the effect of the fixed link. Therefore in terms of environmental impacts, this project has a rather small ecological footprint for its size.

However on October 10, 2000, about 1,000 migrating birds died of exhaustion after having been disoriented by the lights of the bridge. Hence environmental impacts cannot be assessed in a definite way for infrastructure mega-projects.

Denmark and the southern part of Sweden share a common culture as they constitute the Sound Region that marks the entrance to the Baltic Sea. Moreover, until the seventeenth century both regions were Danish, as is shown in the following map.

Map 10: The Baltic Lands around 1617

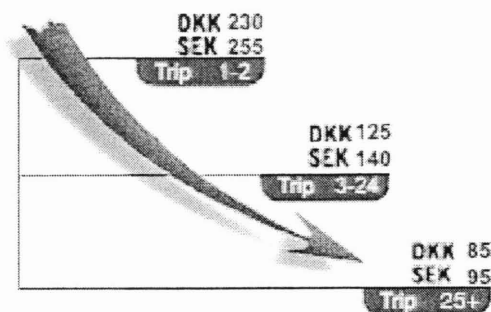


The Oresund fixed link supplies convenient connections between the Sweden and Denmark. The people and governments of both countries have high expectations for the

Oresund fixed link. Many believe that the fixed link will contribute to the creation in the region of a common housing market, a common labor market, positive development in education and research, increased economic activity, and increased investment. It is expected to improve the trade in this region, in particular through the amelioration of freight transport.

Another important infrastructure project, the Great Belt Bridge opened in June 1998 connecting Copenhagen to the continent. This project contributes to the integration of the Oresund Link in the European network rather than limiting it to a simple link between two countries. Nonetheless, almost a year after the opening of the link its success is not yet clear. Companies give incentives for their employees not to use the fixed link because of the high fares. The construction of a fixed link over the Fehmarn Belt would provide a more direct route to the continent for Sweden and might promote in a better way the Oresund link. The Oresund Consortium has implemented, therefore, a fare based on the number of trips made across the bridge following the policy shown in the following figure:

Figure 3: fare policy for private cars



Studies by the AKF, a local authority research institute, are in progress in order to answer the following questions:

- How is the cooperation between the Copenhagen region and the Sound to develop?
- How will the labor market react?
- What effects will be observed on trans-frontier trade?
- What will be the consequences of cultural collaboration?

2.2.3 Brussels-Amsterdam HSL South

This link is part of the Paris-Brussels-Cologne/Amsterdam-London Corridor also named the PBKAL Corridor. The construction started with the construction of the Green Heart Tunnel in July 2000.

The purpose of the HSL South project is the construction of a high-speed rail link between the Netherlands' principal urban agglomeration in the west of the country, known as the Randstad, to the other European economic centers through the trans-European network. Full integration with the European network will promote sustainable economic development in the Netherlands and will play an important role in facilitating rapidly growing international network.

The HSL South project is in particular the expression of the interest of "small" countries like the Netherlands in having high-speed rail services. One of the goals underlying the decision to built this line is to partly remove, on the one hand, the road and railway congestion of the Randstad and, on the other hand, the air congestion due to a substantial proportion of medium haul air traffic at Schiphol Airport.

Map 11: the HSL South region



The distance between two stops for a high-speed line needs to be distant of at least 100 km in order to have an effective gain in time. In a country of the size of the Netherlands this is a major issue. This issue has been addressed in the following way in the Netherlands: high-speed trains entering the Netherlands from the south will stop in Rotterdam, Amsterdam and at Schiphol Airport while cities like Breda and the Hague will be linked to the high-speed line through shuttle services.

Meanwhile, a 'Stations' project aims at the development of stations for the high-speed railway. The aim is to ensure that in 2005 every station offers a standard quality that reaches the quality provided by the high-speed rail services

Two economic arguments prevail for the construction of the HSL South, on one side the possession of a high-quality infrastructure which would generate significant reductions in journey time and on the other hand the improvement of the Randstad's attractiveness to businesses. However, environmental issues hold an important place in the Dutch culture. One major argument is that this link being exclusively a railway, it will

contribute to the process of replacing road and air transport by more environmentally friendly rail transport. Nonetheless, a sensitive segment of the project was the region of the Green Heart of Holland. The unspoiled character of that region is so important to Dutch society that the Parliament had to propose an alternative. The chosen solution was the option of building an 8 km long tunnel in order to preserve the region.

The expected journey time-savings are presented in the table beneath.

Table 6: Journey times in Europe

	London		Paris		Barcelona	
	1998	2005	1998	2005	1998	2005
Amsterdam	5h15	3h39	4h25	3h03	14h20	7h15
The Hague	4h36	3h27	3h56	2h49	14h11	7h00
Rotterdam	3h58	3h09	3h18	2h33	13h18	6h45

In 1994, an 'ex ante' evaluation by a consortium of three Dutch consultancy firms, funded by the Ministry of Transport, listed a number of effects with regard to the project⁸:

- Time savings and reductions in travel costs;
- Increased possibilities for single-day return trips, savings associated with such trips;
- Growth in imports and exports related to an increase in business trips;
- Additional employment;
- Improved accessibility and attractiveness to the areas served;

⁸ Source: The COST Action 317 report "The socio-economic effects of the Channel Tunnel" February 1995
ref: "Economische Effecten Hoge-snelheidslijn, Eindrapportage" February 1994

- Actual and potential values of high-speed connections.

The report also emphasized that substantial economic growth cannot be induced by the infrastructure without appropriate supporting policies that could influence regional development and spatial pattern.

2.3 The missing links

2.3.1 The Dublin-London Link

The project consists of upgrading the existing rail and road links between the three main cities in Ireland – Dublin, Cork (Eire) and Belfast (Northern Ireland). The network is connected to Scotland and Wales through the ferry links and further to England through rail and road networks. This T-shaped corridor includes two routes: Cork-Dublin-Belfast and Dublin-Holyhead-Crewe.

Map 12: The British Isles



Cork-Dublin-Belfast link

This project involves upgrading the existing line (449km) to allow for train operation at a maximum speed of 200km/h by 2000. This mixed-traffic line is a key route between the Republic of Ireland and Northern Ireland. It has been short-listed amongst the Christophersen Group projects, and was classified as a top priority project by the European Council during the Corfu Summit.

The sections of the railroad in the island of Ireland were completed in 1999. The rail route has been upgraded to support passenger trains at speeds of up to 200 km/h, and implementation of this project has shorten journey times between Belfast and Dublin by 30 minutes, and by 15 minutes between Dublin and Cork. The railroad is already well utilized in preference to road transport.

Dublin-Holyhead-Crewe link

This project involves electrification of the Holyhead-Crewe line on UK territory. No new measures are planned for the Dublin-Holyhead ferry link. Electrification work on the Crewe-Holyhead line will spread over two-three years. No starting date has yet been set for this project.

Electrification of the Holyhead-Crewe section will diminish the duration of the journey on this route by eight minutes. Moreover, the electrification of the link will get rid of the need for time consuming locomotive changeovers hence improving London-Dublin journey times in a more substantive way.

Traffic pattern

According to the report of the high level group “The European High-Speed Train Network” of February 1995 on this route, the introduction of the Cork-Dublin-Belfast project would generate 12% more traffic between Belfast and Dublin, and 16% more between Dublin and Cork.

For the Dublin-Holyhead-London route, according to the same report, traffic flows recorded in 1988 represented some 0.1 million passengers, and introduction of this project at a 2010 time horizon is expected to increase traffic by a coefficient of five.

In a more distant future, one might want to consider a fixed link across the Irish Sea from Dublin to Holyhead. Of course the technical complexity of such a project and the modest marketplace that Ireland represents make such a vision utopian today.

2.3.2 The Betuwe line

This corridor links up the Dutch Randstad (Amsterdam-Rotterdam-Utrecht) with the German Rhineland region and extends towards other destinations within the high-speed network: southwards towards Stuttgart, Frankfurt, Munich and north-eastwards towards Hamburg, Hannover, Copenhagen. These are densely populated regions separated by distances superior to 150 km corresponding to the appropriate efficiency standards of the high-speed rail network.

In October 1992 the Dutch and German Governments signed an agreement to implement this project. This included the upgrading of the Amsterdam-Duisburg line for train services up to a speed of 200 km/h. The implementation of the project will shorten the Amsterdam-Duisburg journey time by about half an hour.

In a corridor up to now mostly composed of road and inland waterway networks, the extension of the so-called Betuwe line will extend modal choice and hence benefit the environment. It will almost exclusively be reserved for freight traffic freeing thereby other lines from exceeding congestion. The capacity of the line is expected to be of over 300 freight trains per day across the Dutch-German frontier.

Linking by this Line the ports of Rotterdam and Amsterdam to the main European network is of extreme importance for the position of the country as a center of transport, production and distribution.

Pattern of traffic flows along the corridor⁹

Traffic flows exchanged between the Netherlands and Germany in 1988 currently represented 0.8 million passengers annually.

The upgrading of the Betuwe line is expected to generate a growth in traffic flows in the order of:

- 5% on the Amsterdam-Utrecht section;
- 8% on the Utrecht-Arnhem section;
- 30% on the Arnhem-Duisburg section.

Where Arnhem is the town on the Dutch-German frontier.

⁹ Source: Report "High-Speed Europe" February 1995 of the High-Level Group "The European High-Speed Train Network"

Economic evaluation¹⁰

The infrastructure investment package was evaluated at 884 M Ecus (Euros) in 1990 representing the part ascribable to high-speeds. From that assumption economic evaluation was made and provided the following results:

- The financial rate of return amounts to 1%
- The socio-economic amount to 4.4%.

2.3.3 The Fehmarn Link

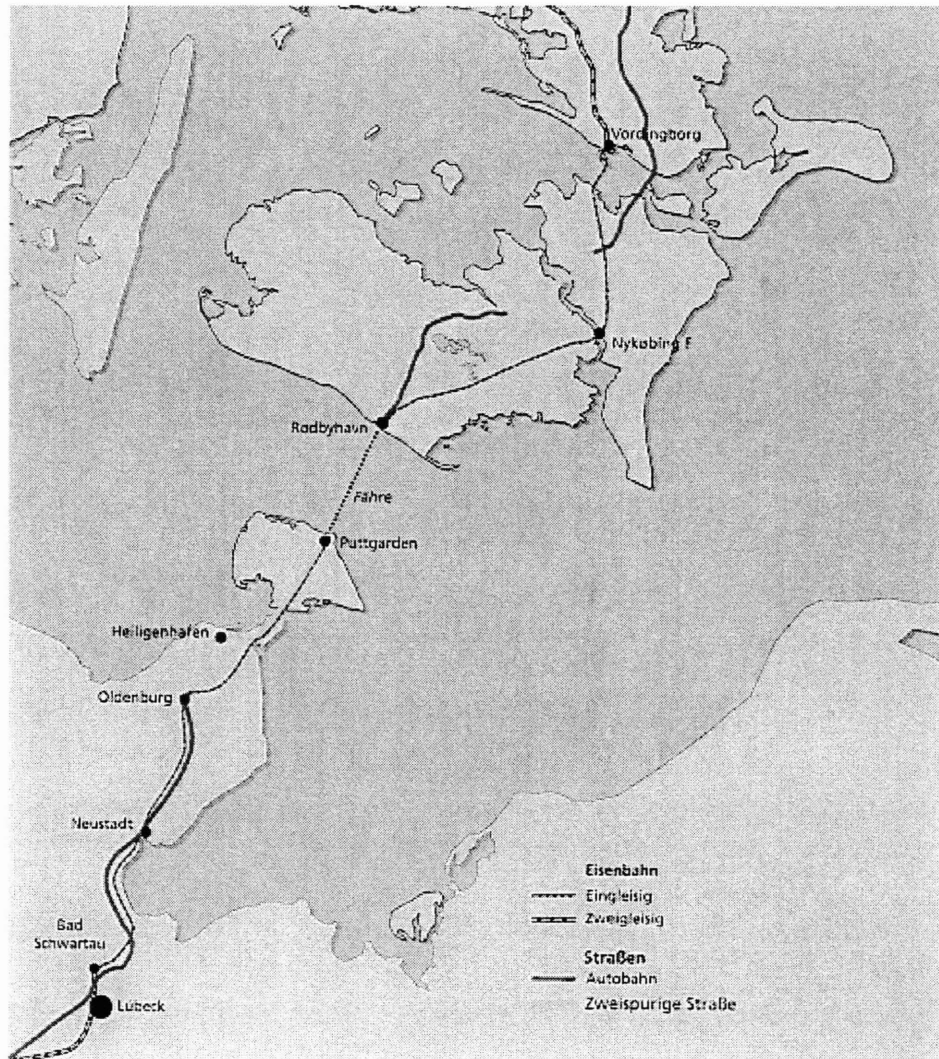
The Fehmarn Belt link might be the third major connection in Denmark after the Great Belt Link opened in 1998 and the Oresund Link opened in 2000. This fixed link between Denmark and Germany would provide the Scandinavian countries with a direct route to the Continent.

When the Oresund link was agreed upon between Sweden and Denmark, the latter agreed to work on a fixed link across the Fehmarn Belt if the project was proven to be sound economically and environmentally.

In 1987 a German consortium proposed the construction of a single-track tunnel and a two-lane road tunnel. The proposed tunnel has only one track on a distance of 23.6 km and is designed for speeds up to 250 km/h. The implementation of the link also requires the upgrading of the access railroads that are at present single-track railways and where speeds are limited to of 120km/h.

¹⁰ *ibid.*

Map 12: The Fehmarn Belt



The economic viability study of the project has shown an internal rate of return of 15.4% assuming that the Oresund bridge would be implemented. On the other hand, the traffic flow forecast suggests that capacity problems might be encountered as early as in 2020, especially for the road network.

The traffic forecasts indicate that the number of loaded wagons passing through the tunnel in 2020 will amount to 2,900 per day, corresponding to 58 freight trains and 33 passenger trains daily.

A major consequence of the fixed link is a diversion of traffic from the direct routes from Germany to Sweden. However only in the market share of rail freight transport would the Great Belt Link be affected by the Fehmarn fixed Link.

There have, recently, been several proposals under study inspired by the Oresund bridge.

Figure 4: The three alternative routes

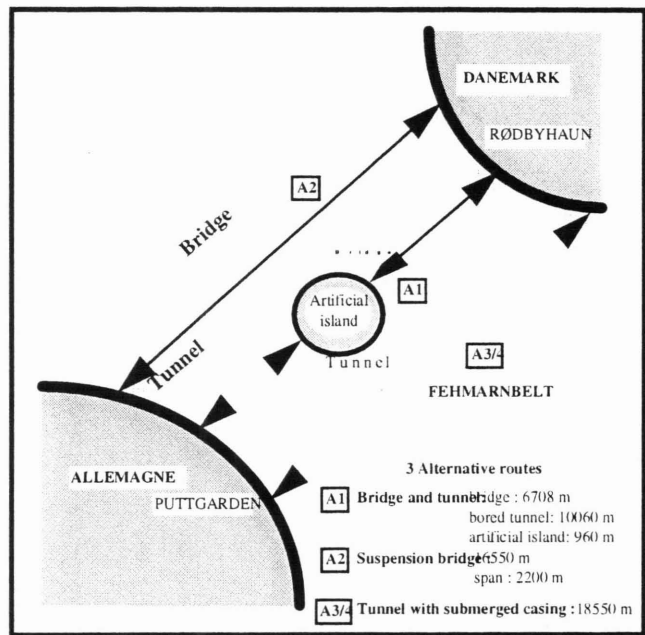


Schéma O. HEDDEBAUT - C. HYPACE (INRETS)

In terms of capacity, the following proposed solution are also being evaluated:

- Railway tunnel: two tracks railway
- Combined tunnel: two-lane road and one-track railway
- Combined tunnel: four-lane road and two-tracks railway
- Bridge: two-lane road and one-track railway
- Bridge: four-lane road and two-tracks railway

CHAPTER THREE

METHODOLOGY FOR PROJECT EVALUATION

3.1 Towards building a framework for megaproject appraisal

3.1.1 From cost-benefit analysis to empirical assessment

In the domain of evaluation of transport infrastructure projects' impacts, research, in the European union, has been under considerable pressure by political decision-makers. This pressure has been building up over the past fifteen years and is reaching an apogee with this present phase of great expansion of the European Union.

Greater light has gradually been thrown on the reasoning behind research on the effects of major transport infrastructure. The numerous research projects undertaken today are motivated by the curiosity which encourages all scientists to gain a better knowledge of the area in which they conduct their research; but the research is in fact, in the main, an attempt to meet a request by political decision-makers who ask themselves three questions:

- Should this infrastructure be constructed or not?
- If the decision is taken to construct infrastructure of this type, what technical solution should be adopted and what route chosen?
- If it is decided to construct the infrastructure, what will be the consequences for the regions crossed and the activity of the country as a whole?

The question of effects has therefore initially been an aid to decision which attempts to go beyond the logic merely of transport and infrastructure capacities. The attempts to integrate the indirect effects in the cost-benefit analytical methods, which serve as a basis for decisions, is a good illustration of this concern.

The more recent concerns to respect the environment and maintain a situation capable of allowing development which is sustainable in the long term, have complicated the debate on the effects of major infrastructure. It is now necessary to be in a position to predict what will be the damage to the environment which a new infrastructure project may cause and, furthermore, to predict the socio-economic effects it is likely to have on society.

The way in which the approach of scientists to this question has developed reveals the uncertainties over the use of methods. There is currently no agreement on definitions and the classification of the effects of major transport infrastructure, or on the methods to be used.

The diversity of the methods used in the various countries is a clear consequence of this scientific uncertainty. Instead of choosing a single method, researchers prefer to use a mixture of methods to try to scan all the possible and still poorly identified areas. Behind this wide variety of methods, three main approaches can be distinguished: methods of evaluation based on the cost-benefit analysis, econometric approaches and empirical approaches.

- cost-benefit analysis was the first conceptual framework developed to evaluate the effects of major transport infrastructure. The reason for this choice of a framework is linked to the fact that the aim then was mostly to evaluate the social utility of megaprojects. The analysis is effective in the short term for drawing up an overall picture of a situation for individuals or the community, although the assumptions on discount rates and utility functions are subjective and choices have to be made to weigh the various points of view. Although this type of method remains effective in a relatively limited number of specific cases, it cannot be the basis for an evaluation of the fundamental effects. Moreover, it depends totally on the methods used for forecasting effects, since it only values them and weighs them against other advantages or disadvantages.

- Econometric approaches have mainly sought to relate the variables governing an improvement in the supply of transport to indicators of regional growth. For transport variables, use is made of savings in time or reductions in the generalized cost and investment expenditure. With regard to the regional aspect, models are found which include as variables regional product, international or interregional trade, different employment levels etc.

- Lately, very empirical methods have been subjected to deeper research in an attempt to approach the effects of major infrastructure, mainly because of the difficulties met in the econometric approaches. All studies then become isolated cases which are

often of excellent quality but can no longer be compared one to another, due to the diversity of their approaches and area of interest.

3.1.2 Classification of megaprojects' impacts

Impact categories

Large transport projects comparable to the North European Beltway tend to have comparatively large external costs or benefits by virtue of their size or of their being part of a network, namely, here, of the Trans-European Network. It is in taking account of these external effects that megaprojects often distinguish themselves from others. By their nature, there are comparatively few large projects, and procedures for their assessment need to be tailor-made.

Transport infrastructure projects are traditionally divided into two main categories: short-term and long-term effects. It is worth introducing a further distinction, namely between additive and redistributive effects.

Redistributive effects are characterized by the absence of increase in overall production and involve relocation of activities or changes in conditions of endogenous production.

Additive effects mean that there are gains in production. These fall into three categories :

- Immediate effects arising from a cut in generalized transport costs and thus an improvement in productivity ;
- Benefits of reorganization, or secondary benefits, with economies of scale enabling a bigger market to be exploited by a drop in the cost of access to the market and integration of the markets. Firms can seek to profit from the new transport infrastructure by improving the production or distribution of their products. For example, "just-in-time" delivery practices require a good transport network. Firms will therefore adapt their production and distribution systems to the new conditions, with the intent of increasing margins as well as benefiting from lower transport costs.
- Stimulative effects which mean increased competition between regions, with firms obliged to increase their productivity. Moreover, competition improves the performance of firms (additive effect) and can lead to a redistribution of production among regions (distributive effect). An analysis of distributive effects is of special interest when the new infrastructure links regions which are unequally developed or have very different reserves in terms of potential.

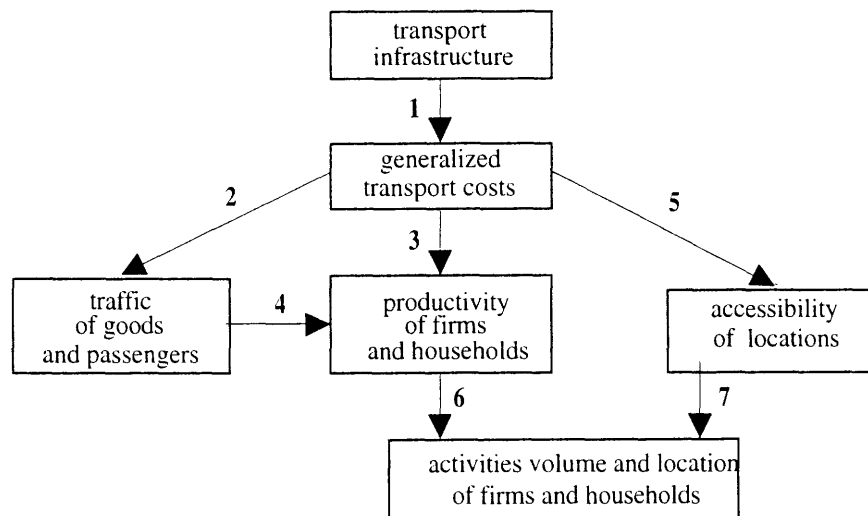
The relationships between transport infrastructures and spatial development are illustrated in a diagram by Mr. P. Rietveld, which is given below in figure 5.

Link 1 shows that an improvement in the transport infrastructure can lead to a drop in transport costs, with shorter distances or higher speeds resulting in a reduction in the number of vehicles and drivers for the same level of service, a cut in petrol consumption, etc.

The reduction in generalized costs, in turn, means an increase in the productivity of firms, either directly (link 3) or because of growth in transport flows (link 2) and greater accessibility promoting new locations (link 5).

All these effects combine to affect the levels of development and/or relocation of firms and households (links 6 and 7). This is a limited interpretation, however, since it assumes that all the effects are generated by the infrastructure and this is not affected by the changes which it has generated. A more detailed diagram has been developed by Mr. P. Rietveld including the feedback loops in his report “Spatial economic impacts of transport infrastructure supply” (1992).

Figure 5: Transport infrastructure and spatial development¹



¹ Rietveld P., "Spatial economic impacts of transport infrastructure supply", Vrije Universiteit, Faculty of Economics, Amsterdam, December 1992, 27 p.

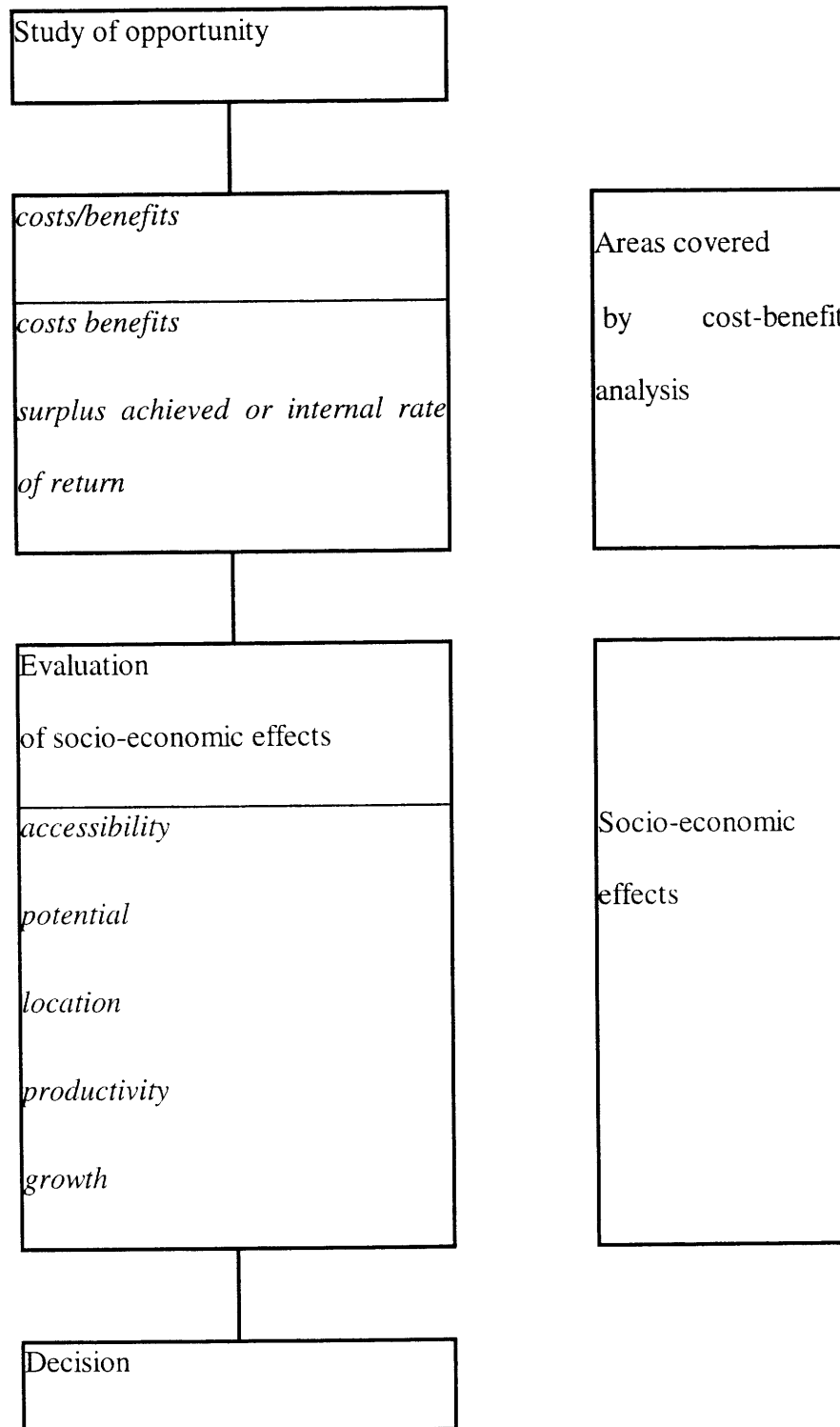
Non pecuniary impacts

While major transport infrastructures are designed with the aim of improving mobility for people and goods, they nevertheless have indirect repercussions which go far beyond the field of transport economics. Those indirect repercussions are what researchers refer to when speaking of the infrastructures' socio-economic effects or structural effects. All effects flowing from a new transport infrastructure have a social dimension, which include diverse concepts such as accessibility to regions and marketplaces, land value, firm's location and productivity and regional growth.

Within this context, the socio-economic effects will be set against the costs and advantages normally considered in a cost-benefit analysis, since this has been the tool traditionally used in evaluating major transport infrastructures. The special feature of cost-benefit analysis is that it sums up the positive and negative consequences of a project in terms of a single value - the surplus achieved or the internal rate of return.

However, because of their complexity and diversity, socio-economic effects are difficult to measure. Then, for the effects that it is possible to measure, there is the problem of how to aggregate them, since they are not all of the same type. Some represent real advantages (productivity gains, for example), while others are financial advantages (change in property prices through modification of access to a region). There are therefore good reasons for not including socio-economic effects in a cost-benefit analysis. But awareness of them when evaluating the project does give the decision-maker important additional information.

The following figure synthesizes the repartition of the effects in their categories.



3.2 Overview of cost-benefit analysis

3.2.1 Analytical principles

For projects of the size of the North European Belt, the megaproject needs to be broken down into its components. For the North European Beltway, these are the segments defined in Chapter two, each of them being a large-scale project by itself. A cost-benefit analysis is then carried out for each component independently, although we will then emphasize on the need to include each segment in the larger picture determined by the whole corridor.

Hence we will focus on the cost-benefit analysis of a single infrastructure project. The lifetime of large-scale infrastructure projects is around 100 years. In a cost-benefit analysis, the discounted values of the far future happen to be negligible in a financial evaluation because of the length of the project's exploitation duration. Usually the time horizon chosen for the cost benefit analysis is around 30 years, and increased with an additional perpetuity value calculated for the remaining time of its useful life. More recently, researchers have come up with the concept of discounting the far-distant future at its "lowest possible rate" (Pr. M. Weitzman 1998)².

With the new evaluation methods now available, the field covered by cost-benefit analysis has widened considerably. It is therefore possible to quantify in money terms almost all the non-commercial advantages - especially the environmental impact - and so to integrate them in the cost-benefit analysis.

² Source: «Why THE Far-Distant Future Should Be Discounted at Its Lowest Possible Rate», August 1998.

3.2.2 Components

Costs

As regards costs, these concern not only the resources used in constructing the project but also the impacts (mostly negative) on man and his environment, that is, the internal and external costs.

In the cost-benefit analysis method, these include the construction costs on the one hand, and the operation and maintenance costs, on the other hand. They are categorized into capital costs, fixed costs and variable costs.

The method used for the estimation of costs is often a combination of survey and engineering approaches. The former centers on the interviewing of experts, while the latter bases its assessment on the adjustment of data on the expected or documented cost functions of similar and previously developed projects.

Other types of costs are the foregone benefits or opportunity costs, which are the benefits that would have been received had the project not taken place. These are considered in the evaluation when their evidence is perceived to be strong and clear.

Benefits

Cost-benefit analysis considers all the benefits (as distinct from the pecuniary benefits), whether they are enjoyed by the users of the new infrastructure ("user benefits") or by other groups ("non-user benefits").

For infrastructure project evaluation, the cost benefit analysis includes mainly the user benefits, which are those benefits obtained from the direct use of the infrastructure and can in a straightforward manner be assigned a monetary value.

The input for the quantification of both the direct and indirect benefits comes from demand studies. These studies need to be tailored for each specific infrastructure project.

Real benefits	Real costs
<p>to the user:</p> <ul style="list-style-type: none"> • reduced generalized transport cost (reduced cost of use of vehicles; time saving; reduced accident risk; improved comfort, etc.) 	<p>Commercial resources:</p> <ul style="list-style-type: none"> • construction, maintenance and operation of the infrastructure • reduced output of agriculture and forestry
<p>to other groups:</p> <ul style="list-style-type: none"> • gains in money or time for users of another transport mode 	<p>Non-commercial resources:</p> <ul style="list-style-type: none"> • damage and risks to environment • damage and risks to health

3.2.3 Shadow pricing

Shadow pricing is the process of deriving the “true” prices of goods, services and productive factors by adjusting the market prices of cost and benefit items for project appraisal. More appropriate prices exist whenever there are opportunity costs or restrictions that entail a shadow price different from the market price.

Distortions observed can be of an economic nature. In particular, the way of handling prices of land and labor factors and the prices of traded and non-traded goods should be carefully considered for the evaluation of the megaproject.

Land is probably the one factor that is very abundant in the megaproject's area of influence. Land along the motorways or railroads will lose value, whereas land and property at the nodes of the network will tend to gain value. Because of the nodal regions being already very developed in this case, the gain in value in those areas is expected to be marginal in comparison with the regions crossed.

There are also issues of social shadow pricing, which comprise two kinds of adjustments:

- the change in consumption of a poor man is given a higher weight than the same change in consumption of a rich man;
- savings, investment and government income are given some premium over consumption in those countries where investment levels are considered suboptimal.

In the context of the European Union, shadow pricing can be considered negligible as it is more appropriate for developing countries rather than for developed countries.

3.3 Non-pecuniary effects evaluation

By definition, socio-economic effects present an indirect cause-and-effect relation, which makes them difficult to evaluate. Usually, socio-economic effects are

measured with the means of indicators such as production, employment and the departure or arrival of firms.

Other main characteristics of socio-economic effects are:

- changes are not immediately perceptible but are spread over long periods;
- the effects are mostly commensurate with the potentialities (economic, tourist-related, human) of the regions served;
- finally, these effects depend to a great extent on the supporting measures taken by the local authorities.

3.3.1 Overview of methods for socio-economic effects evaluation

In view of the uncertainty surrounding the "effects" of major transport infrastructures, various methodologies have been used in the different countries faced by this question. The choices made in trying to evaluate these consequences reflect both the methods available and the political decisions governing the development of the infrastructure project.

Methods used to determine socio-economic changes related to infrastructure projects include the following:

- Modeling: Traditional transport models analyze traffic flows and volumes and can observe changes in their composition, distribution, choice of mode and mobility induced by the infrastructure. Changes in travel costs and journey time affect personal mobility and improve reliability of delivery of goods. This can lead to changes in

economic activities, production processes and the location of industries, offices and homes. In time this can affect spatial and urban structures.

- Descriptive studies: These qualitative studies based on interviews with experts are often undertaken to study the factors behind choices of location, to prepare mental maps of what firms or individuals intend to do, and to examine the decision-making processes in response to transport improvements. Surveys are also used in these studies.
- Case studies: These use statistics and analysis to determine changes in rates of economic activity such as employment levels, floor space used in various sectors, income and expenditure of residents, profitability of companies, property rents and land values in adjacent areas where accessibility has improved. The difficulty is to measure the effects that can be attributed to the transport infrastructure project when the local economy is being affected by other changes in the same period.
- Graphic representation: This allows observation of changes in spatial structure and urban form. The relationship between the large-scale transport project and socio-economic changes is represented but not explained. However, this technique gives information on changes in a visual form which is easy to absorb.

There are several methods for evaluating the relationship between the transport infrastructure and regional development. Standard methods of evaluation for transport investment projects focus on the benefit side on:

- time savings and journey quality improvements (e.g. comfort, frequency, interchange convenience) captured in the fare;

- time savings and other benefits not captured in the fare (consumer surplus), either for users of the project or non-users (e.g. users of parallel roads which are decongested);
- savings in operating costs (again, either to operators or users of the project itself or to others affected).

The choice of method will depend on the aim in view, on the scale of the project (regional, inter-regional or international link) and on its type (road or rail link, priority for passenger or goods transport, etc.).

Obviously the presented methods – socio-economic evaluation and cost-benefit analysis – each have their strengths and weaknesses. In the evaluation of the impacts of a megaproject we cannot limit ourselves to one single method, which would be qualified of being the reference method and the only correct method for project appraisal. Furthermore, each one of the methods brings its added value to the understanding of the projects effects. Even though all methods are not always appropriate for a specific project, a combination of the above-described methods will give a much better overview of the project's impacts. The question then arises as to what relative importance should be attributed to each method knowing that they measure different parameters on scales that are not comparable from one method to another. Researchers, who have started to adopt this approach, are now confronted to this problem that cost-benefit was meant to solve but which limits have been brought to light as we try and evaluate socio-economic effects.

In the case of the Fehmarn Belt project, described in Chapter two, 2.3.3., and which impacts we will analyze more particularly, we focused on two main methods for socio-economic impact assessment, the economic potential one and the scenario literary analysis.

3.3.2 The economic potential method

The evaluation of socio-economic effects is reached through indirect methods that first assess impacts on other parameters that will give us information on the plausible socio-economic impacts of the infrastructure.

Changes in travel costs and journey time are one kind of the variables that reflect socio-economic impacts. Indeed they affect personal mobility and also improve reliability of goods delivery. This can lead to changes in economic activities, production processes and the location of industries, offices and homes. Furthermore it can in time affect spatial and urban structures.

Isochrones and iso-cost graphs are graphic representations that allow to present in a visual way large-scale transport effects and socio-economic changes. Isochrones and iso-cost graphs are purely descriptive in that they are not based on a model of how the economy operates and of how economic activity relates to transport. Hence these methods can be combined with qualitative studies based on interviews with experts that study the factors behind choices of location, to prepare mental maps of what firms or individuals intend to do, and to examine the decision-making processes in response to transport improvements.

Isochrones and iso-cost graphs allow a comparison of accessibility starting from a given center before and after the creation of a new link, and description of the accessibility provided by a project. There are specific disadvantages in these methods and, namely, isochrones and iso-cost graphs tell us about the variation in absolute accessibility, whereas relative accessibility is more important when evaluating attractiveness and regional growth. A further disadvantage: these methods do not take account of relative mass.

More advanced analyses like the gravity model or the economic potential method integrate an econometric or statistical model. In these models the transport infrastructure is also viewed as a factor affecting the location of firms, and the emphasis is put on improving accessibility. Cities or economic centers are identified as points with an associated mass.

The gravity model enables to analyze the effects of economic development on transport, through a dependent variable, which is referred to as interaction. In the case of the implementation of a large-scale infrastructure we look at the effect of transport on regional development. For that purpose the model of gravitational potential or of economic potential is more appropriate. The potential V_i is obtained as follows:

$$V_i = I_{ij} / M_{ij} = \sum \sum M_j f(d_{ij}) \quad (1)$$

Where

- ij : starting centers and destinations
- I : interaction
- M : mass
- f : function to be estimated
- d : distance

The potential is an indicator of the attraction of point i as a function of the attraction of masses in space. Attraction corresponds to the sum of the masses weighted by their accessibility. Some authors speak of an accessibility indicator. They then multiply the sum in (1) by M_i .

One major assumption underlying the economic potential model is that growth in a region depends on the relative distance of its firms both from current or potential markets and from sources of supply and inputs.

When interpreting isochrones or iso-cost graphs for the economic potential method the following mechanism is at stake: a reduction in transport costs leads to intensified competition between regions, and entails an increase in inter-regional trade and a growth of firms in regions with low production costs at the expense of firms in less efficient regions.

However, this mechanism makes the assumption that a region's economic development depends only on the growth of the firms in the region; interregional displacement of firms is not envisaged, which limits the validity of the model.

3.3.3 Scenario literary analysis

The former method presents the advantage to be visual and easy to absorb. At the same time it is a static description for regional development and does not propose any perception of the nature of the changes in the spatial distribution of activities or other socio-economic impacts. When one uses such sophisticated models, the analysis is strongly dependent on the assumptions that have been made since the degree of detail to which the model goes requires more data than is available. Hence a scenario analysis may

come and correct this trend. Nevertheless scenario analysis can only propose guidelines without giving concrete figures.

The literary method for scenario analysis is an informal procedure, based on reflection and reasoning, which comprises a series of logical stages. One of the advantages of the scenarios method is that it compels the analyst to situate the new transport link within a wider system, to analyze the inter-relationships between the different variables of the system (the new transport link is only one of the determinants of the possible development of the regions studied, among many others). It should be noted that this method lends itself especially well to taking account of accompanying policies (the region exercises control over its future and its policies can therefore modify the effects of a new infrastructure).

The existence of a causal link between investment in transport and regional development is not clear and in this regards the importance of back-up policies is undeniable. A good strategy for accompanying policies will increase the probability that the investment in the new infrastructure will promote the development of the region. Taking the tourism industry as an example, the introduction of a fixed link has marginal negative effects on that industry and presents at the same time great potential for positive ones.

The scenarios method is of special interest when evaluating the long-term effects of a transport infrastructure. While traditional prediction methods are based on the use of quantitative and determinist models and are supposed to yield a single result, the prospective method uses qualitative or stochastic procedures and enables us to envisage

several possible futures. Among the realizable ones, it is a matter of choosing those which best meet the needs of the population concerned.

As regards the evaluation of the economic situation and the production conditions of firms located in the regions most directly affected by the project, it is necessary to bring together economic and demographic data (the labor market in particular), as well as information on the quality of the infrastructure and of the natural environment. The transport infrastructure is never a sufficient condition for the development of a region, but is one element among others in decisions on the location of investments. An investment in the transport field has more chance of having a positive effect in a region where the other conditions for location are favorable.

3.3.4 Environmental impacts

Environmental impact analyses for megaprojects involve so many criteria that each project requires a tailor-made assessment methodology. In all European countries explicit considerations are also given in project appraisal on the effects to the environment. Denmark in particular has a rigid policy of sustainable mobility.

For large-scale infrastructure projects, we identify some environmental effects which have an impact on policy objectives, but do not arise through an effect on accessibility:

- (usually) negative impacts on the visual environment (but which may include the opportunity to improve derelict or polluted land which otherwise would not be financeable out of public funds);
- reduction in emissions (usually), e.g. from motor vehicles as a result of a rail project.

This may refer to noise as well as CO₂ or other gases. The diversion of flows of

dangerous or heavy vehicles (e.g. across the Alps, where important security improvements have been implemented after the fire of the Mont-Blanc tunnel in 2000) may also be a consideration, and an objective in terms of the numbers of such vehicles may be set.

The environmental effects are generally divided into biotic effects and abiotic effects.

- Biotic effects analyses include assessment on the fauna and flora – fish population, bird population, protected wildlife areas.
- Abiotic effects analyses include issues about gas emissions, water quality, hydrology, geomorphology and soil contamination.

Obviously these lists of concerns are not exhaustive and also not appropriate for every infrastructure project, depending on the location and the technical solutions proposed for the infrastructure, the impact evaluation will focus on different issues.

CHAPTER FOUR

FEHMARN BELT: PROJECT APPRAISAL FOR A MISSING LINK

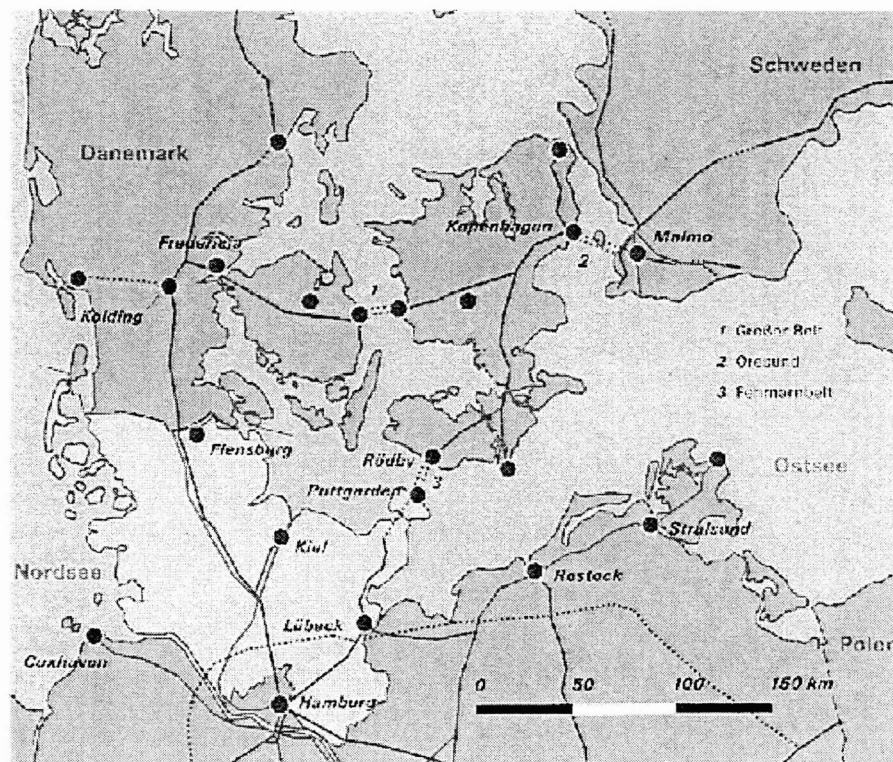
In this chapter we go through the application for the Fehmarn Belt project of the previously described project evaluation methods.

4.1 Economic evaluation

4.1.1 Status quo

Contrary to the Channel Tunnel or the Oresund link, the Fehmarn Belt is not the sole route linking by land Germany to Denmark and to Sweden. The construction of the great Belt in 1997 has already opened the path for a road and rail connection between the three countries. This path goes north from Hamburg to Kolding and then eastwards across to Copenhagen and Malmo.

Map 14: Railway network around the Fehmarn Belt



As a consequence of its implementation, all freight trains that used to go over the Fehmarn Belt have been rerouted through the Great-Belt despite an increase in distance of about 200 km. For a train going from Hamburg to Copenhagen this increase can be evaluated to an increase in travel distance of 60%.

4.1.2 Improved ferry system

The economic and financial evaluation of the scenario of an improved ferry system across Fehmarn Belt is important for the decision-making on whether or not to build a Fixed Link. Indeed, the evaluation of the introduction of a fixed link should not confine itself to the present situation, but should cover the of all existing ferry services.

- In a report on the “Economic Evaluation of an Improved Ferry System across the Fehmarn Belt” (May 2000) the Scandlines AG company presented the following scenario for an improved ferry system;
- A capacity extension of the current four-ferries system by the introduction of a additional ferry in 2010 and a sixth one in 2020;
- An increase in the cruising speed of the ferries;
- A reduction of the ferries’ docking time;
- An extension of sea access channels.

Consequently, total transit time would be reduced from 62 minutes to 54 and 52 minutes in 2010 and 2020 respectively. The expected benefits are estimated to be comparable with the railway tunnel 0+2 solution, which provides a total transit time of 55

minutes (15 minutes transit and 40 minutes access and egress time). The main features of the improved ferry system are shown in the following table:

Table 8: Main features of the improved ferry system¹

Item	Reference case	Improved ferry system	
		Year 2010	Year 2020
Number of ferries (passenger-cars per hour)	4	5	6
Transport capacity	1072	1608	1930
Frequency of departures (hour ⁻¹)	2	3	3.6
Departure per day (day ⁻¹)	48	72	86
Round trip time (minutes)	120	104	100
Time at docks (minutes)	16	11	9
Cruising time (minutes)	44	41	41
Average transit time of passengers (minutes)	44+16+2 = 62	41+11+2 = 54	41+9+2 = 52
Cruising speed of ferries (knots)	16.5-18.5	18.5-19.5	18.5-19.6
Maximum cruising speed (knots)	20	20	21

4.1.3 Solutions for a fixed link across Fehmarn Belt

In a first phase seven different technical solutions have been proposed for a Fehmarn Belt fixed link and have been analyzed in the following capacity options:

A two-track railway (0+2) for models 1 and 2;

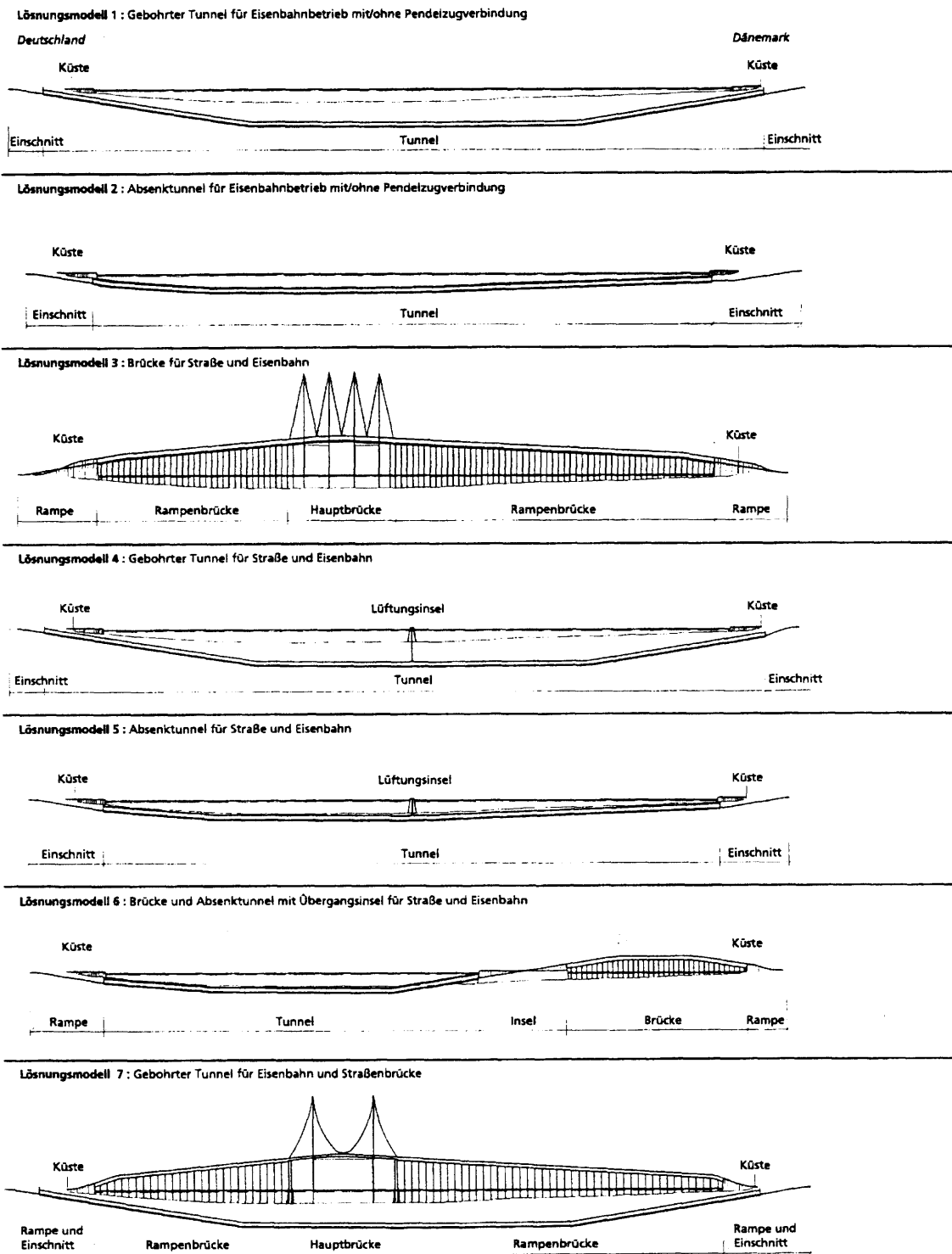
A four-track motorway plus a two-track railway (4+2) for models 3 to 7;

A two-track motorway plus a one-track railway (3+1) for models 3 to 7.

The models are presented in the following graph.

¹ Source: final report of PLANCO Consulting GmbH for the Danish and German Ministries of Transport: "Economic Evaluation of an Improved Ferry System across the Fehmarn Belt", May 2000.

Figure 6: Technical solutions for a Fehmarn Belt fixed link²



Die sieben grundlegenden Lösungsmodelle

² Source: "Die Verbindung ueber den Fehmarnbelt – Voruntersuchungen", for the Transport Ministry of Schleswig –Holstein, March 1999.

After a further examination of the proposed solutions, some have been ruled out, namely models 6 and 7, mainly because of the scale of the infrastructure they implied.

4.1.4 Cost-benefit analysis

The following results have been obtained for the different solutions described until now. The figures given in the two right-hand columns of the table are the results of the environmental impacts study, which will be discussed later in this chapter. Those results have been added in order to give an insight of the environmental impacts of each solution compared to their financial value.

Table 9: Comparison of evaluation results³

Solution Model			Net Present Value (r=3%)	Cost/Benefit Ratio	Environmental impact	Energy consumption
No.	Description	Capacity	Million Euro			PJ per year
1	Bored Tunnel	0+2	-2111	0.42	1.3	0.03
2	Immersed Tunnel	0+2	-2138	0.42	2.2	0.03
3	Cable Stayed Bridge	4+2	787	1.22	2.5	0.01
3.1	Suspension Bridge	4+2	348	1.09	3.2	0.01
4	Bored Tunnel	4+2	192	1.04	1.5	0.03
4.1	Bored Tunnel	3+1	2111	1.76	1.5	0.03
5	Immersed Tunnel	4+2	811	1.2	2.5	0.03
5.1	Immersed Tunnel	3+1	2232	1.85	2.3	0.03
Improved Ferry System			414	5.22	0*	0.5

* corresponding to the criteria presented in the table in Part III of Chapter three.

³ Source for NPV and C/B ratio: final report of PLANCO Consulting GmbH for the Danish and German Ministries of Transport: "Economic Evaluation of an Improved Ferry System across the Fehmarn Belt", May 2000.

The results given show a high cost-benefit ratio for the improved ferry system. This reflects the fact that this solution is very efficient with respect to the investment in the proposed solution. On the other hand, the calculated Net Present Value of the improved ferry system is far from the ones realized by the 3+1 tunnel solutions. From these figures, the immersed tunnel solution 3+1 presents the best financial return for an average environmental impact in comparison to the other solutions.

The underlying question for a decision on a financial reasoning is the following: are we looking for the most efficient return on the investment or do we want the maximum benefits? A high cost-benefit ratio can be attained by minimizing the investment and ensuring a consequent benefit. Hence it does not reflect fully the absolute worth created by the project. The first concern for the government is to maximize the profits; the investment that needs to be made is another issue, although not negligible. Hence the net present value is a better indicator to compare the projects with one another.

Another concern would concern the validity of these financial figures. The net present value of the immersed tunnel 3+1 solution does not reflect the fact that as soon as 2015 this infrastructure will be congested and a need for another infrastructure will become urgent whereas the immersed tunnel 4+2 solution, although less sound financially, will suffice for a far longer period of time. Here is where the valuation of far-distant future as proposed by Pr. Weitzman, becomes an important issue.

4.2 The economic potential method⁴

Here are presented the results of a socio-economic study carried out by the PRODEC Planning Consultants in January 2000. PRODEC carried out an analysis to characterize the impact of the construction of a fixed link across Fehmarn Belt on road traffic and hence on accessibility to some major cities in the region.

The methodological approach is of the type of a potential model following the main arteries of the network. Two types of maps were established: isochrones and iso-cost graphs for particular locations. Both reflect the accessibility of a location respectively through journey time and travel cost.

The reference scenario used is the present one with ferry services, the other scenario being that of the implementation of a Fehmarn fixed link.

Isochrones

The timesaving is composed of the following components:

	Basic scenario (Ferry)	Fixed Link scenario	Time saving
Crossing	75	10.1	64.9
Network upgrade in Denmark	12.2	9	3.2
Network upgrade in Germany	26.6	16.4	10.2
Total time saving			78.3

⁴ Source : « Accessibility study for road traffic in the STRING area », PRODEC report, January 2000.

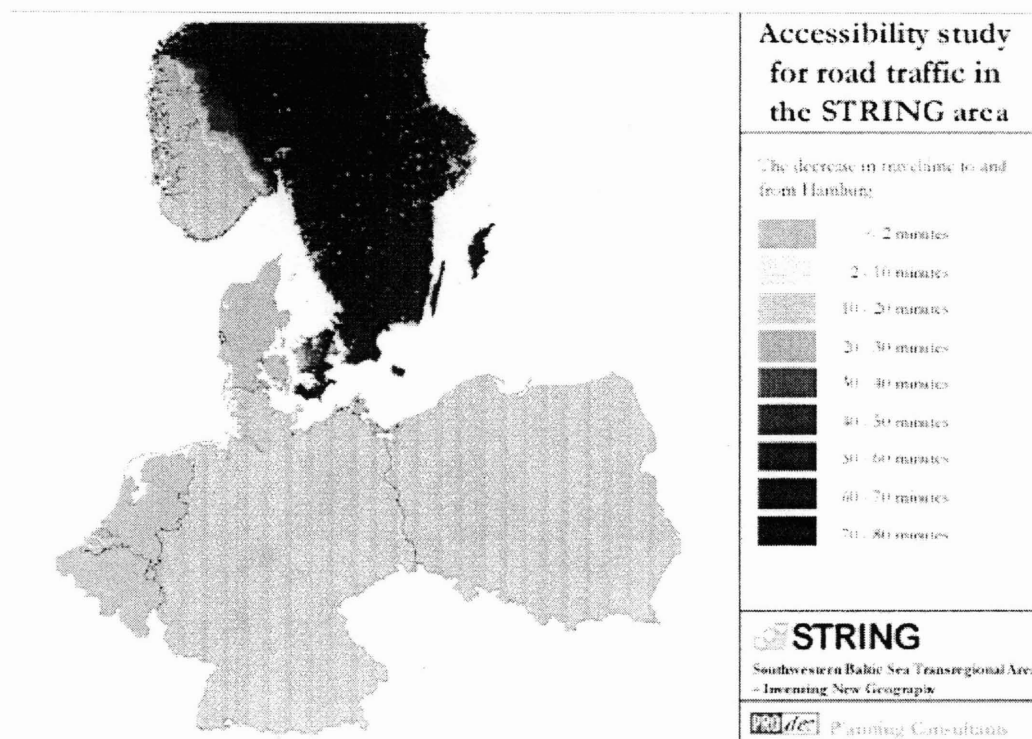
The crossing time in the reference scenario has three components:

	Time
Crossing time	45
Meeting time before departure as demanded by Scanlines	15
Terminal time	15

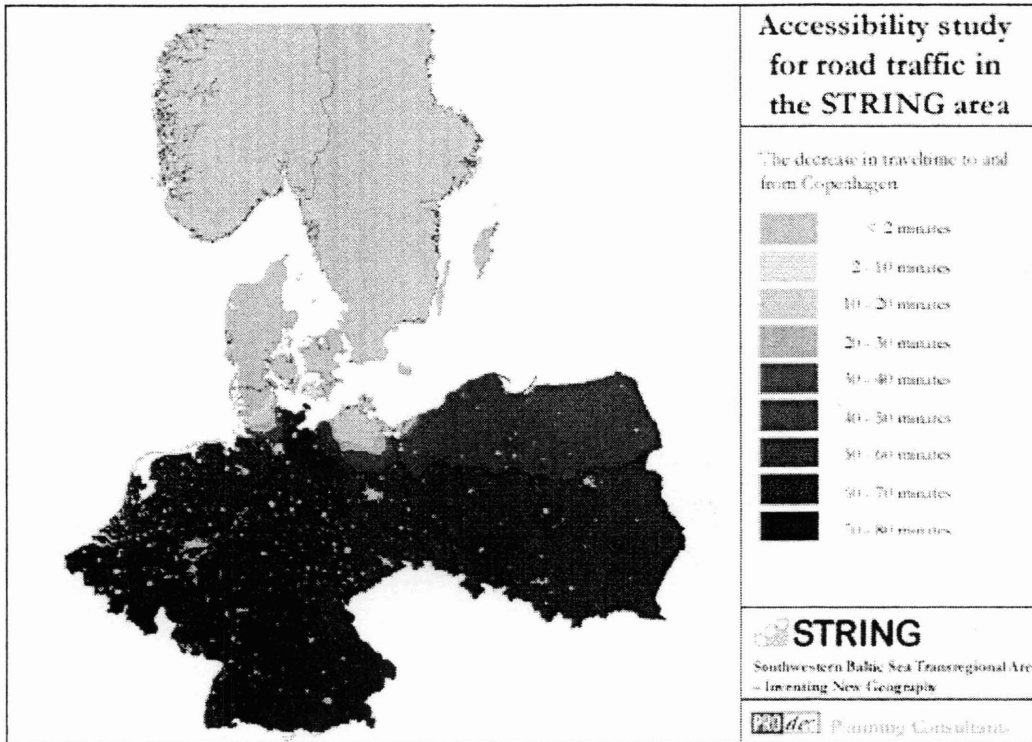
The study defines the terminal time as follows:

Normally travelers do not know the exact travel time to the ferry (traffic situation etc), so they add some extra time to be on the safe side. This 'hidden' waiting time is terminal time. With a fixed link, you can of course start your journey whenever you like.

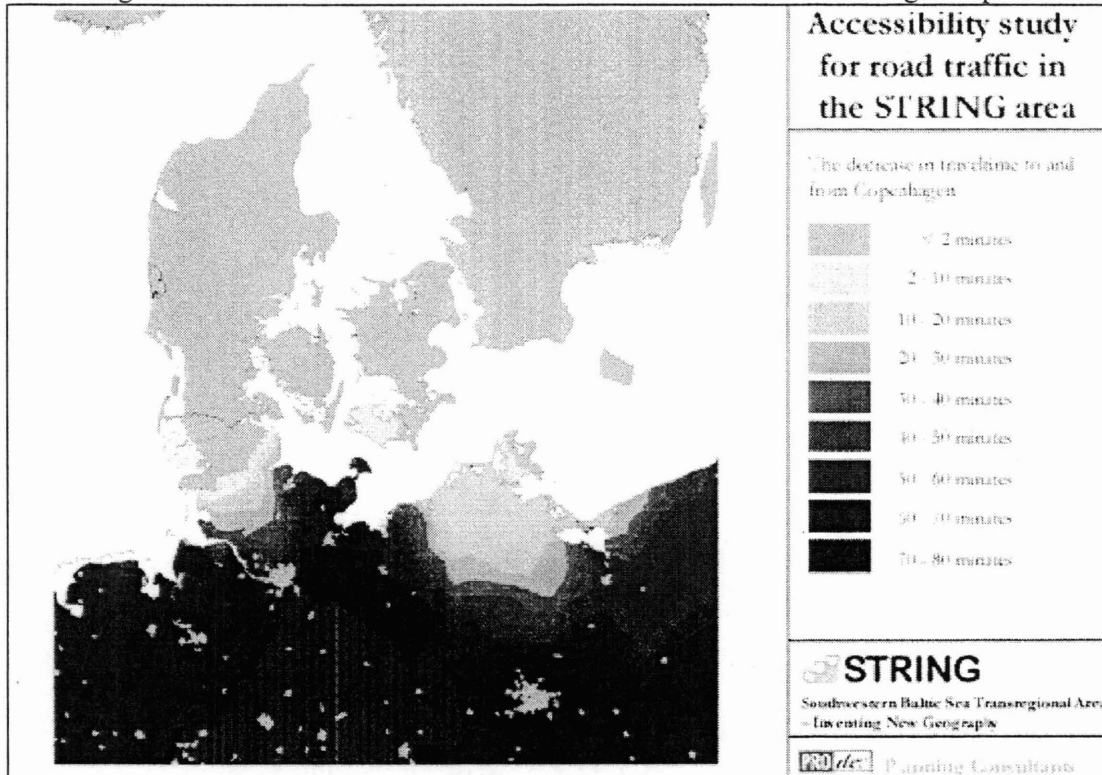
Isochrones to and from Hamburg. Decrease in time travel of 70 minutes to Sweden.



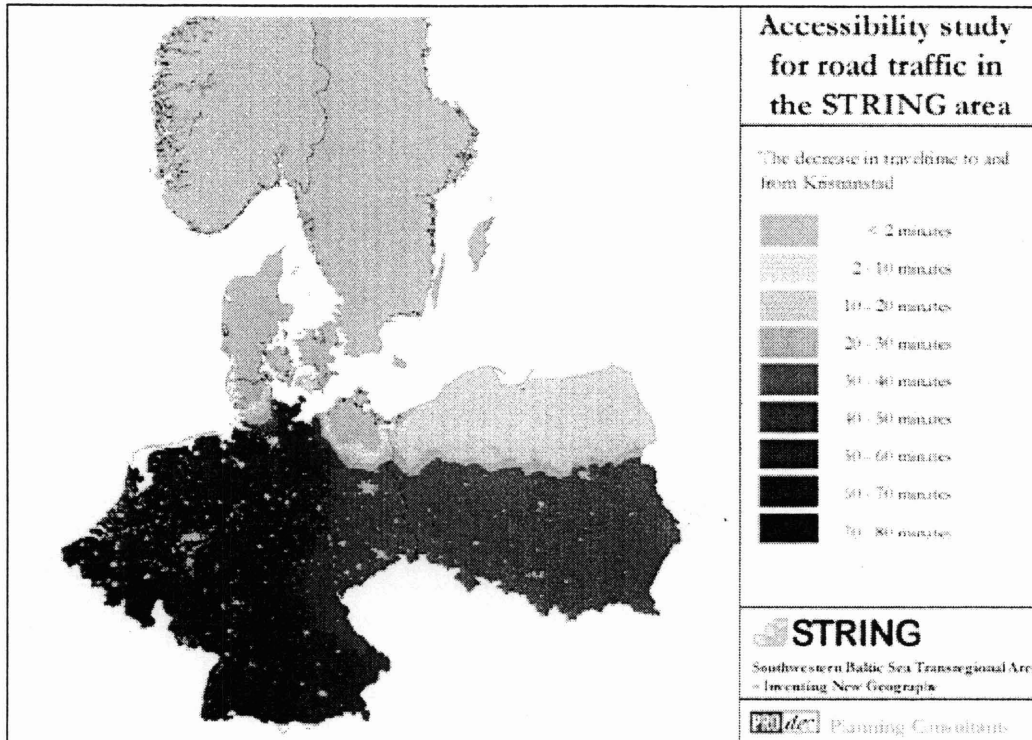
Isochrones to and from Copenhagen. Decrease in time travel of 70 minutes to Benelux.



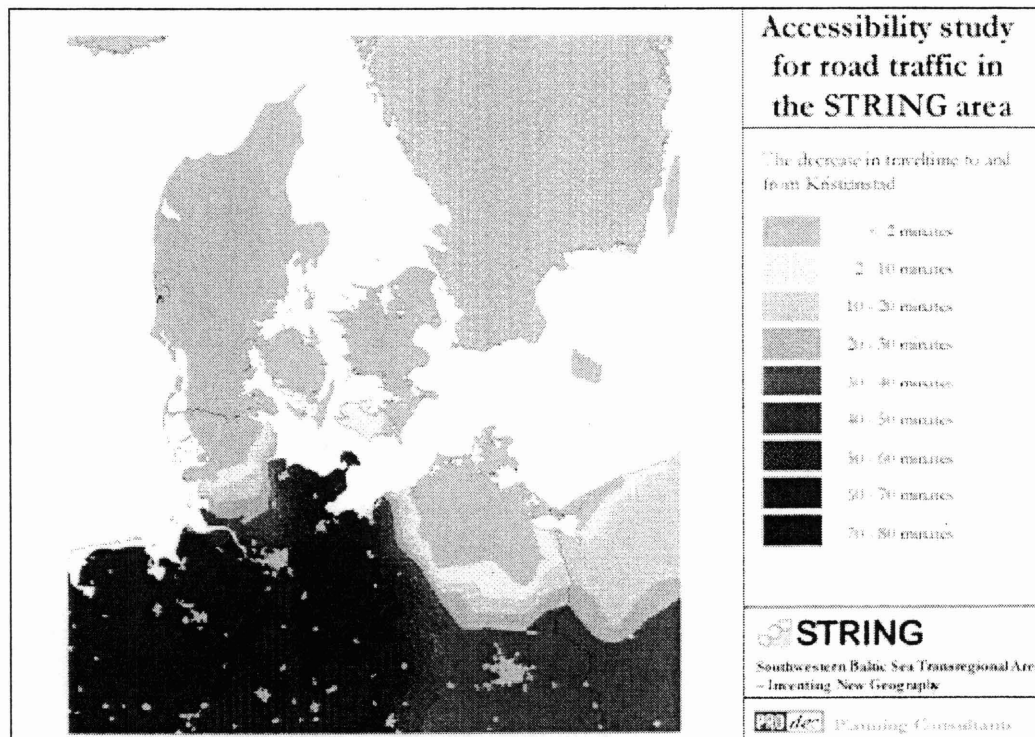
This close-up emphasizes the competition with the Great Belt for access in northern Schleswig-Holstein and with ferries for access in northern Mecklenburg-Vorpommern.



Isochrones to and from Kristianstad (Sweden). Decrease in time of 70 min. to Benelux.



This close-up shows the same competition issues as for Copenhagen. Again, competition with ferries impacts only on the access to the Polish and eastern markets.



From the observation of this set of maps, it appears that the direction, which benefits most from the introduction of a fixed link, is the southwest North-East direction, i.e. following the Hamburg Kristienstad axe. This shows up more when one analyzes the isochrones centered on Hamburg and on Kristienstad. Hence, the consumer surplus of the introduction of the fixed link reaches to France, England and the Benelux countries.

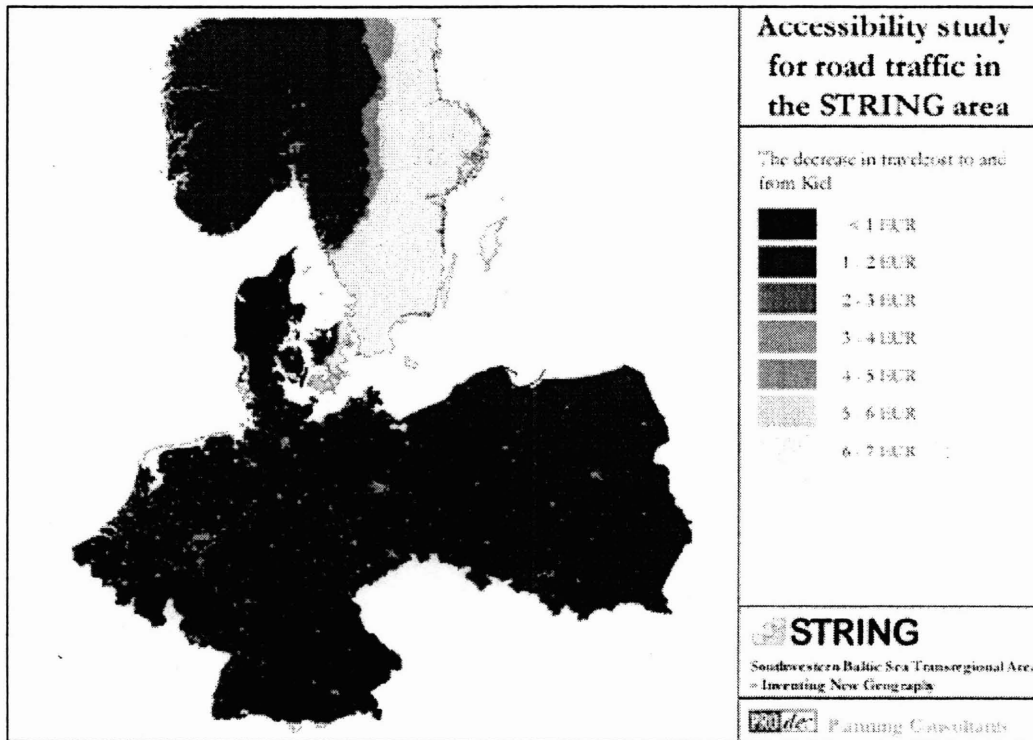
Iso-cost graphs

They show the distance in cost relative to a location. In this analysis the iso-cost graph is the same whether one travels to or from the location. In order to calculate the iso-cost bands, the study went through the calculation of a generalized cost (GC_{car}) which is a function of time (T travel time; V_T value of time), length of the link (L), driving cost (V_L) and tolls: $GC_{car} = T \times V_T + L \times V_L + Toll$.

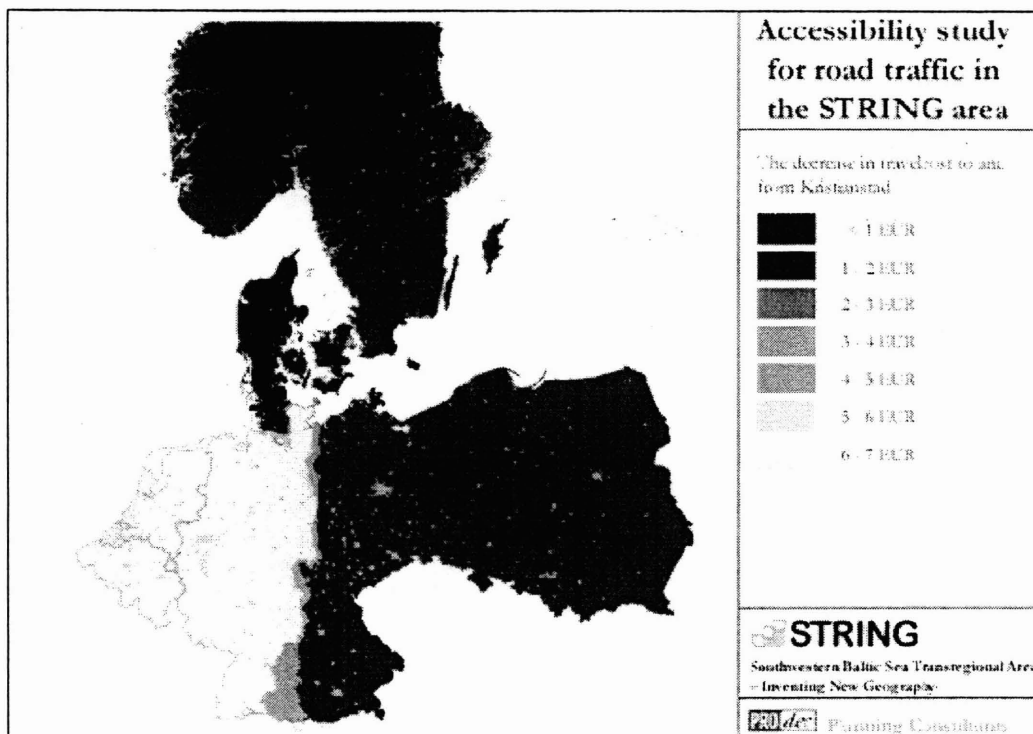
The figures used are shown in the following table:

	Basic scenario	Fixed Link scenario
Toll	41.55 EUR	58.31 EUR
Time cost	25.14 EUR	3.35 EUR
Driving cost	0 EUR	1.50 EUR
Total	66.69 EUR	63.16 EUR
Assumptions	$V_T = 20.11 \text{ EUR/h}$ $V_L = 0.15 \text{ EUR/km}$	

Iso-cost graphs to and from Kiel (Germany). The decrease in travel cost is apparent for the eastern cost of Sweden, still including also Goteborg, which lies west from Malmo.



Iso-cost graphs to and from Kristienstad (S). Decrease in travel cost clear for Benelux.



The results of the iso-graphs tend to emphasize the trend observed in the analysis of the isochrones. Indeed it appears that the southwest-northeast route from Benelux to Sweden is the one that presents the maximum profit from the introduction of a Fehmarn Belt fixed link. The profits are expected to be even greater for rail services and this tends to promote the idea of an efficient communication mean linking the Nordic Triangle Corridor to the west-European continent.

Moreover the models show that regions further away from the infrastructure, countries like Sweden and, less obviously, France, England and the Benelux countries, also profit in journey time and in travel cost from the introduction of the link. It is important to capture the value created to those regions. This can be done either by charging at a higher rate long distance users, or another way of capturing this added value it is to set high fares for the use of the infrastructure and offer advantages to the closer regions as it has been implemented for the Oresund Bridge in their fare policy.

4.3 Scenario literary analysis

The former method has the advantage of being visual and easy to absorb. At the same time, it is a static description for regional development and does not propose any perception of the nature of the changes in the spatial distribution of activities or other socio-economic impacts.

4.3.1 Regional transport pattern

The introduction of a fixed link over Fehmarn Belt has the potential to alter the whole transport pattern of the Northern-Europe region, in particular in the perspective of modal split. Other than the local modal split from ferries to cars or train shuttles, high-speed rail is likely to impact on a far larger region, especially on a South-East North-West route extending from the Benelux region to Stockholm in a coherent way with the results given by the isochrones and iso-cost graphs.

4.3.1.1 Inland transport

The construction of the Great Belt Link, opened in 1997, attracted the entire rail freight transport system across the Fehmarn Belt. Indeed, rather than transferring wagons onto the ferries, the Great Belt offered the possibility to do without a modal transfer in order to reach Zealand. Following the same trend that has been shown for road transport by the isochrones and iso-cost graphs, the implementation of the Fehmarn fixed link increases notably the accessibility of cities like Copenhagen and Hamburg on each side of the link. Furthermore, a resulting impact would be to get back the traffic share it held before 1997. On the other hand, it is not expected to impact on the passenger traffic of the Great Belt since the Great Belt traffic is mostly local.

4.3.1.2 Sea transport

In a more global perspective than merely the freight going from Germany to the Copenhagen island, a Fehmarn fixed link would provide a modal alternative for freight originating from all around the world that has the Baltic Sea for a final destination.

The port of Hamburg is known to be the port of the Baltic Sea. The Danish straits and the harbors of the Baltic Sea lack the necessary depth to allow the ships carrying international cargoes to dock. International cargoes are therefore unloaded in Hamburg for the goods to be transferred onto smaller ships that can sail to the final destination in the Baltic Sea.

The construction of a fixed link over Fehmarn Belt would provide a straight road from Hamburg to Stockholm and other destinations in Sweden. The main advantage for the railway is that in this particular situation the modal transfer that is needed from cargoes to railway does not require any extra time than in the present situation, since the goods have to be transferred anyway. Moreover, Hamburg as an international harbor offers efficient infrastructure for intermodal transfers. Hence this railway route over the Fehmarn Belt offers an extremely competitive alternative to the sea services to Sweden for freight transportation.

4.3.1.3 Air transport

The construction of a high-speed line linking Stockholm and Copenhagen to the Trans-European Network is expected to provoke the same modal transfer as the Eurostar and the Thalys have provided between London-Paris-Brussels.

Indeed, high-speed trains will make Stockholm accessible from Hamburg within five hours. Copenhagen will be about two hours from Hamburg, four hours from Amsterdam, 5 hours from Brussels. Such journey times are competitive with air-transport services, especially since the high-speed lines provide services from city center to city center.

The relationship between air services and high-speed rail services should not be seen as competitive, but rather as complementary. Indeed high-speed train services competing with local air services will help lighten the air traffic and airport congestion. Hence greater availability will be created for long distance international traffic with the present airport infrastructure. This issue is critical as airports like Heathrow and Frankfurt have reached their maximum capacity and no further expansion projects are on their way. Only the Charles-de-Gaulle airport in France has capacity for further expansion.

4.3.1.4 Consumer surplus

Efficient connection of the major European airports to the high-speed rail network is essential to foster this complementarity between the two transport modes. The Charles-de-Gaulle airport has been well connected to the trans-European network and the airports of Heathrow (UK), Schipol (Netherlands) and Copenhagen (Denmark) are about to be integrated in the network. In the first quarter of 2001, Air France and Thalys have agreed on a partnership: Air France will no longer ensure flights from Paris to Brussels, instead all Air France's passengers for Brussels will be transferred to the rail transportation insured by Thalys.

This complementarity among modes creates a consumer surplus for the users of air services as airports' congestion decreases. Hence the construction of high-speed train infrastructure has an impact that spreads out both geographically as the economic potential shows and across transport modes. Here again there is an important issue of capturing this added value enjoyed by users of other transport modes. The solution here is

far less obvious than for geographical reach of the project's impacts, it requires cooperation between the different transport modes.

4.3.2. Regional development

In the present situation the crossing of the Fehmarn Belt is a bottleneck. This is economically inefficient and hinders the development not only of Denmark and Schleswig-Holstein, but also the development of the European Community. The implementation of a fixed link would reduce significantly the disturbances occurring and improve the flow of passengers and goods. Thereby the infrastructure would stimulate economic activity by bringing the markets of Denmark, Sweden and, less so, Norway (about 15 million people) closer to those of mainland Europe.

From this statement follows the fact that the principal regional markets of production and consumption will benefit most from the removal of this bottleneck, namely, on the Danish side, Copenhagen within Zealand and, on the German side, the key beneficiary region is likely to be Hamburg, while Luebeck would hold a strategic location just like Lille for the Channel Tunnel region. On the other hand, the areas closest to the Fehmarn Belt link, whose economies have gained from the growth of port and ferry activities during the past twenty years, will loose out after the removal of the transport bottleneck.

For a sensitivity analysis, different scenarios have been studied to quantify the socio-economic impacts of a fixed link on local regions. The three following solutions have been studied:

- A shuttle solution: no road and a 2-track railway: 0+2
- A combined solution: a 3-way road and a 1-track railway: 3+1
- A combined solution: a 4-way road and a 2-track railway: 4+2

A reference scenario corresponding to the actual ferry service was used for benchmarking. Those scenarios have been examined in two different phases: construction, on the one hand, and operation and maintenance, on the other, for the combined regions of Schleswig-Holstein, Lolland and Zealand. The results present the average effect on employment.

Table 10: Regional employment during the construction phase⁵

Employment	Combined Solution (4+2)	Combined Solution (2+1)	Shuttle Solution (0+2)	Reference Scenario
due to the construction of the fixed Link	5800	4300	3800	900
Due to investing in hinterland	1900	760	1860	
Total	7700	5060	5660	900

⁵ Source: report of the Ministerium fuer Wirtschaft, Technologie and Verkehr des Landes Schleswig-Holstein. "Feste Fehmarnbeltquerung", January 2000.

Table 11: Regional employment during the operation phase⁶

Employment in	Combined Solution (4+2)	Combined Solution (2+1)	Shuttle Solution (0+2)
Germany	920	660	645
Denmark	820	650	635
Total	1740	1310	1280

In both phases, construction and operation, positive results have been obtained hence illustrating how regional studies tend to assess that, in the global picture, the introduction of such a link presents less risks than opportunities.

Among others, the tourism industry was not included in the calculations since it is very dependent on the policies that are at the local governments' initiative. Benefits related to that industry are not to be underestimated and the local authorities should take measures to promote the image of their region, just like the region Nord/Pas-de-Calais did starting in 1985 before the construction of the Channel Tunnel.

4.3.3. Accompanying policies

The existence of a causal link between investment in transport and regional development is not clear and in this regard the importance of back-up policies has for long been recognized. If the accompanying policies are well targeted, the probability that the investment in the new infrastructure will promote the development of the region will increase.

⁶ Source: *ibid.*

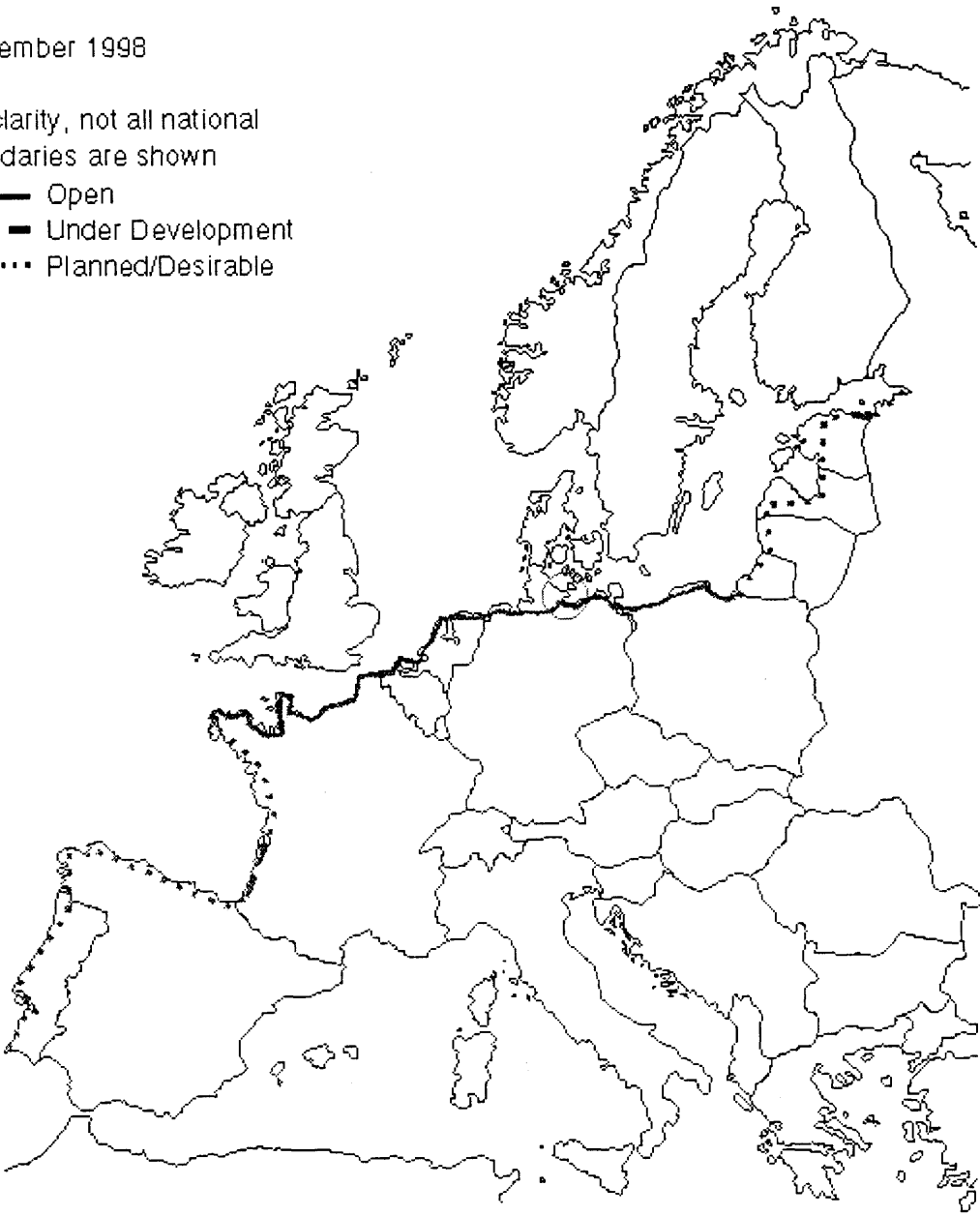
In the previous evaluation of fixed-link impacts on employment, a conservative method was used by the German specialists. The impacts on industries highly influenced by regional policies have not been considered. As was mentioned previously, the tourism industry is one of them. The introduction of a fixed link has marginal negative effects on that industry, and presents a great potential for positive ones.

Luebeck is on the European Coast Path E9, which is one of the European long-distance paths and goes across the whole of Europe from Portugal all the way beyond Poland. Just as Calais ensured the link from the mouth of the Channel Tunnel, the region of Schleswig-Holstein, and especially the coastal town of Puttgarden, could build appropriate infrastructure to link the Fehmarn Belt to this European Coast Path E9. This might have a very positive impact on the tourism industry of the region by bringing tourists a little further North than the E9 would lead them. The region concerned is circled on the map below.

Map 14: European long distance paths-European Coast Path E9

September 1998

- For clarity, not all national boundaries are shown
- Open
 - - - Under Development
 - Planned/Desirable



Following the strategies implemented in advance of the construction period in Kent and Nord/pas-de-Calais for the introduction of the Channel Tunnel, interventions aimed at establishing new training and technology centers to raise the skills of the local workforce would help to ensure that a maximum of the infrastructure construction jobs

would be filled from within the region. Other policies would reveal themselves useful, such as:

- Stimulation of cultural activities, which hold an important place, with entertainment in economic development;
- Promotion of sustainable development, which is Denmark's policy and would promote maximum mobility without causing damage to the environment
- Implementation of balanced planning for urban development;
- Accommodation for new firms, facilities, financial incentives.

4.4. Environmental impacts

4.4.1. Coastal ecosystem

In order to assess the environmental impact of a fixed Fehmarn link, many studies have been carried out on several aspects. These studies have been limited enough to enable an evaluation of the impact of the introduction of a fixed link. No global impact study can assess all the impacts the fixed link will have.

Hydrographic behavior

The water exchange between the saltwater of the North Sea and the less salty water of the Baltic Sea takes place in the Oresund and in the Fehmarn Belt. This water exchange is of high importance for the hydrographic and ecological composition of the Baltic Sea.

The collected data shows a more complex distribution of streams in the Fehmarn Belt than in the Oresund or the Great Belt straits. In the Fehmarn Belt friction has a smaller impact on the streams and hence leaves place for other factors such as the earth rotation to play a greater role. Hence, water can at the same time inflow on one side of the Belt and outflow on the other side. This complex exchange system makes it more difficult to estimate the impact of the construction of a fixed link.

Nevertheless, the conclusion of the studies is that the long-term effects of any type of fixed-link proposal are very limited. Strategy for protection of the environment requires optimization of the infrastructure in order to minimize its impacts.

Bird population

Another environmental concern of main importance for the region is its bird population. The Fehmarn Belt is an important refuge during winter for several bird species. From October to March, eleven species of international importance find refuge in the Belt region. Moreover, the Belt is also on the path of many migration routes. Hence there are many protected natural areas.

As has been observed in the case of the Oresund, a technical solution implying a bridge can impact on birds. In particular by night or in stormy weather, it can provoke collision with the bridges poles or disorientate migrating birds and cause their death by exhaustion.

Table 12: Comparison of the environmental impacts of the proposed scenarios⁷

	Lasting effects					Time dependent effects					Weighted average	ranking
	Hydrographic impacts	Migrating routes for birds	Sediment deposit	Consumption of raw material	Land Environment	Vegetation	Fauna	Mussels	Fish	Birds		
Scenario	Weight factor											
	60	15	10	10	10	10	5	5	5	10	140	
Bored tunnel 0+2	1	1	3	2	6	0	0	0	0	0	1.3	1
Immersed tunnel 0+2	1	1	4	3	6	5	3	2	2	2	2.2	4
Cable stayed bridge 3+1	2	4	2	4	5	4	1	1	1	1	2.5	6
Suspension bridge 3+1	3	4	2	5	5	5	3	1	2	1	3.2	8
Bored tunnel 4+2	1	1	4	3	4	1	1	0	1	1	1.5	2
Bored tunnel 3+1	1	1	3	3	4	1	1	0	1	1	1.5	2
Immersed tunnel 4+2	1	1	6	4	4	6	3	3	2	3	2.5	6
Immersed tunnel 3+1	1	1	5	4	4	6	3	3	2	2	2.3	5

⁷ Source : « Die Verbindung ueber den Fehmarnbelt », Zusammenfassender Bericht, March 1999.

The precedent table presents a comparison of the different technical solutions proposed. It is no surprise that the ranking shows the bored tunnel solution as being the less harmful for the environment. It needs to be pointed out that the proposed solutions all have a same range of impact on the environment. Moreover, the few impacts that are evaluated between 4 and 6 need to be minimized through appropriate changes in the technical conception of the concerned solutions.

4.4.2 Impact on energy consumption and CO₂ emissions

The introduction of the Fehmarn link will also have a positive environmental impact, especially as regards energy and gas emissions. The implementation of a fixed link will promote a change in the traffic modes from ferries and planes to cars and trains. The study on the impacts of the introduction of a Fehmarn Belt fixed link on the modal split, highlights that, in particular, the high-speed rail services will have a regional impact on the other transport modes used between Germany and Sweden. This is a change from heavy energy-consuming modes towards less energy-consuming ones, thus leading to a decrease in the CO₂ gas emissions and in the green-house effects

With the implementation of the infrastructure, there will be an increase in the number of passenger km from the reference case (the ferry service), in the cable-stayed bridge case of 630 million and in the immersed tunnel solution of 380 million. The results of the thesis report give the following average energy consumption for the different transport modes:

Table 13: Energy consumption per mode⁸

	Energy consumption in MJ per passenger km
For cars	0.85
For trains	0.5-1.0
For planes	2.75
For bus	0.35
For ferries	10

The calculations have been made for the following solutions: the tunnel 0+2 and the bridge 4+2. The other proposed scenarios are expected to be within the same range.

Going from the reference case to the cable-stayed bridge, the energy consumption is reduced by 3.8% from 71.0 to 68.3 PJ. For the immersed tunnel solution, the reduction in energy consumption amounts to 3.3% to 68.7 PJ. These results show that despite an increase in traffic, a fixed link reduces the energy consumption over the corridor.

The report uses the life-cycle analysis (LCA) to estimate the energy consumption due to the construction of a fixed link. The results are summarized in the following two figures: The energy consumption to build the link was found to be 27PJ (equivalent to about 0.7 M tons of fuel) for a bridge scenario, and 14.3 PJ (equivalent to about 0.4 M tons of fuel) for a tunnel scenario.

⁸ Source: report "Fehmarn Belt. Green House effect", Sund & Belt, Knud Mose Poulsen, 1999.

Figure 14: Mass balance, in-output, for constructing a cable-stayed bridge, 4+2⁹

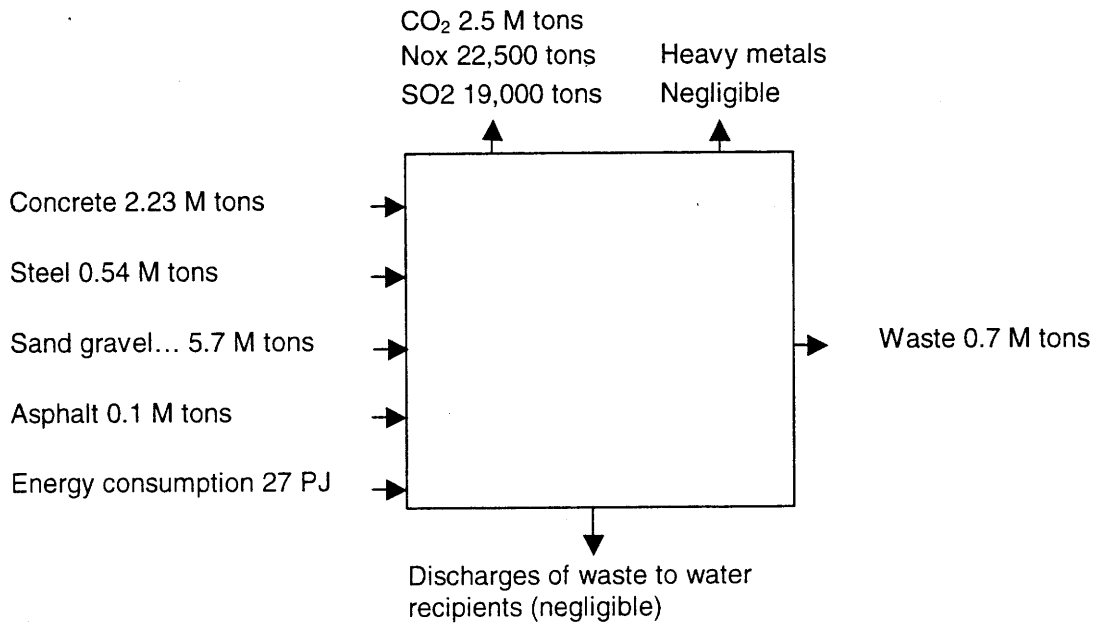
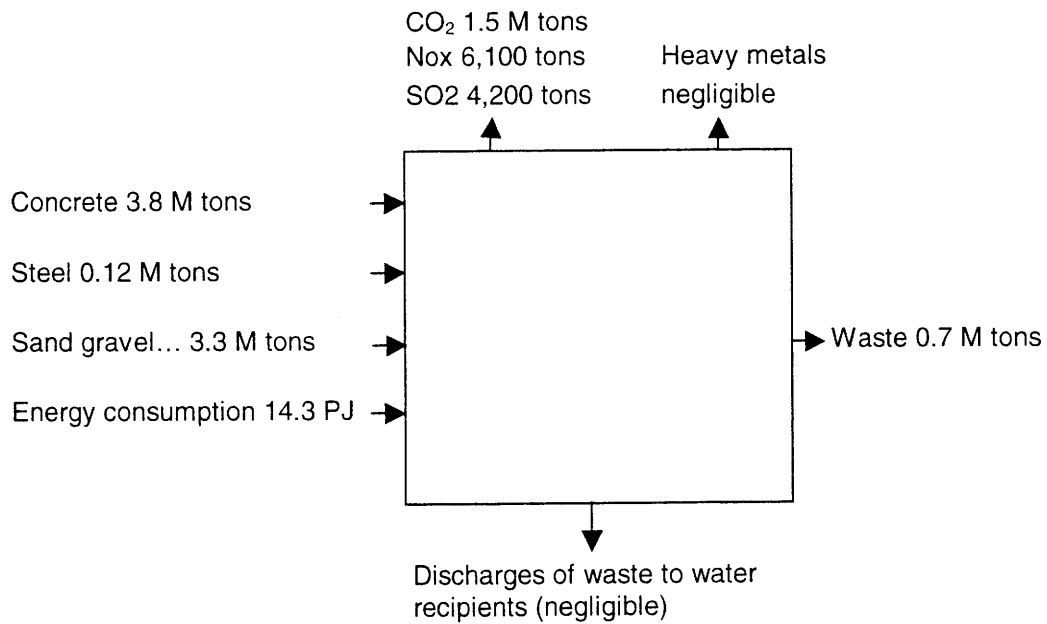


Figure 15: Mass balance, in-output, for constructing an immersed tunnel, 0+2¹⁰



⁹ Source: report "Fehmarn Belt. Green House effect", Sund & Belt, Knud Mose Poulsen, 1999

¹⁰ Source: *ibid.*

For operation and maintenance, the annual consumptions of energy for the 4+2 solution and the 0+2 solution are 0.01 and 0.03 PJ respectively, and the repayment periods for the two solutions are five years and one year respectively under the following assumptions that the annual energy consumption for a ferry link is 0.5 PJ and the theoretical energy consumption for building ferries is 13 PJ for a comparable lifetime of a fixed link hence 100 years. Similar results are obtained for CO₂ emissions.

This thesis estimates that the construction of a fixed link will lead to an annual energy saving of about 60,000 tons of fuel and 225,000 tons of CO₂ emissions.

Results of a similar magnitude had been presented in a report by the Great Belt Company for the Great Belt Link, namely, the reduction was estimated to be 75,000 tons in fuel consumption and 250,000 tons in CO₂ emission. Those results happened to even underestimate the energy savings that were observed. Hence these results may be seen as a conservative estimate of the actual benefits arising from the introduction of a fixed link.

The tunnel scenario appears to have a shorter pay-back period because of a low initial consumption level associated with construction. On the other hand, the bridge solution has a lower consumption energy for operation and maintenance and creates more energy savings per year, 2.7 versus 2.4, which makes it more efficient in energy consumption than a tunnel solution after 43 years of operation. Following are the energy savings calculation:

$$E_{\text{bridge}} = 27 - 2.7 \times 43 = -8.91$$

$$E_{\text{tunnel}} = 14.3 - 2.4 \times 43 = -8.89$$

If the lifetime of the infrastructure is 100 years then a bridge solution happens to be more ecological than a tunnel. On the other hand, 40 years is a long time period that leaves time for new technologies and solutions to arise and supplement today's decisions.

Studies on coastal environment impacts and on CO₂ emissions and energy consumption all present a tunnel solution as being less harmful than a bridge solution. Although the results show that all solutions stand within the same range for the damage caused to the environment, tunnel solutions are to be preferred to bridge ones since, compared to the bridge solutions, they combine advantages on all environmental issues.

CHAPTER FIVE

IMPLEMENTING THE LONDON-STOCKHOLM CORRIDOR

5.1 Public-private partnership in infrastructure investment

After the project evaluation and when all risks, costs and benefits are assessed, the next step is the decision-making process as to whether the project should be undertaken or not and if yes then what solution should be implemented. This decision is combined with another concern that deals with how the design building and operation phase should be managed.

The decision to construct the Fehmarn Belt fixed link would be the third occasion in Denmark, after the Great Belt and the Oresund Link, that a major transport infrastructure project would be constructed independently of existing public' transport bodies, subject to the requirement that the project be self financing.

Such an organizational structure was already chosen for the Oresund Link and many other projects in Europe to ensure clear project responsibility, which I believe is key to the involvement of all the parties to achieve the project.

Public-private partnership is the concept that has gained great support recently for addressing these issues. It can offer benefits to all parties but each party must remain realistic and accept the level of risk that each of them has to bear in order to balance properly the partnership.

The concept of public-private partnership (PPP) ensures an overall approach of the project. The most advanced stage of a PPP is that of a concession where the concession holder is responsible for both construction and operation of the infrastructure project.

5.1.1 Risk allocation

PPPs also require that the risks associated with the project are shared with the public sector and the private companies involved. Risk analysis is an essential component of any PPP and its allocation to one or the other of the parties must be done depending on which party has the means to mitigate the identified risk. The main risk categories are the following:

Political and legal risks

Although these risks are considered typical of developing countries, they are also a concern in developed countries, the Channel Tunnel experience brought a few lessons with this respect. Such risks in European countries correspond to possible changes in government policy, although the governments apply themselves to mitigate them once the private sector has been involved. For a private investor the risk is very large during the period when the project characteristics and political and economic requirements are determined.

This category of risks also includes those involved in the implementation of back-up policies that will enhance profit. It is not possible to determine in advance whether the necessary infrastructure projects abutting to the fixed link in the two countries will be

realized. It is not possible to evaluate whether the initiatives to coordinate between the two parts of the region will be taken in due time or even at all by the two states. A private sector would never be able to assume this risk without tangible guarantees from the two states.

Organization and design risks

The work of organization and project design also includes an element of risk since there will be uncertainty concerning the details of the actual performance, and with regard to the authorities' acceptance and approval of the performance of the work. The responsibility for the choice of method relating to the detailed design technology would be placed where the technical competence is held (by the contractor).

On the other hand, the governments regulate and may change the previously mentioned acceptances, which rely on this conformity to environment-related requirements, for example. Hence the corresponding risks have to be calculated according to precise definition of the risks namely compliance with pre-set requirements, increase in the government's quality standards etc.

Technical risks

These risks are associated with construction and also with maintenance and operation. Most of these can be well assessed and the contractor is the party, most able to mitigate them. Hence, during the construction phase these risks are held by the contractor, apart from 'force majeure' situations.

Operation of the infrastructure in terms of maintenance, etc. does not entail any great variations in risk.

Commercial risks

Commercial risks resulting from tariff, and traffic levels.

- Tariffs are subject to political risk, thus the authorities are the most likely to be able to estimate and mitigate the risk, but they are not the only ones to bear that risk;
- Traffic level is difficult to control. A distinction needs to be drawn between commercial risks that should be borne by the holder, and risks related to external random events that should be shared.

The two states, Germany and Denmark, are the only factors that can influence the development in the economy, should it be only on a modest scale. Another kind of state intervention would be some form of subsidy that might be inevitable to promote the use of railway versus road, for example. Indeed, the terms of competition between railway and motorway capacity utilization of the railway, among others are not under the control of the private sector and therefore impose an element of risk in relation to the earnings basis of the company.

5.1.2 Funding of the project

The final cost of investment for these sized projects can be reimbursed by two different means, namely through tax collected from the whole population or through tolls collected from the beneficiaries.

Hence the funding, in the first place, would be insured by the authorities or by the infrastructure holder in the second case. The ways of exploiting these two resources are: public or private sector borrowing, public funding and private capital.

Due to the nature of the infrastructure, there is a need to secure long-term sources of funding. The maturity of loans is an even more determining factor than the rate of interest. There is in fact more to it since the maturity of loans directly impacts on the length of the concession, hence on the time-period during which the marketplace will present no competition, hampering an effective use of the infrastructure. On the governments' side there is a compromise to be made between risk and the concession period; the longer the concession period, the lower the risk for the private sector, but the smaller the socio-economic benefits. Hence a key issue in infrastructure financing is the sharing of risk between the governments the concession holder and the lenders.

In addition, as mentioned by Mr. Alain Fayard from the French Ministry of Public Works, Transport and Housing, in the "Seminar on Public-Private Partnerships in Transport Infrastructure Financing":

Changes in tax regulations relating to loans for infrastructure could help foster the creation of a 20-30 years long-term capital market, a market that in Europe is currently extremely small if not non-existent.

Nonetheless the national governments are the basic principals for the project and have to show their unconditional commitment by issuing state guarantees for the debt established at any time.

5.1.3 Public sector – private sector: one project, two concerns

In this partnership framework, the private sector applies itself to making the project financially sound. All environmental and socio-economic constraints are given and are to be respected in order to comply with the requirements set forth by the public sector. With the little margin of maneuver the private companies need to come up with a profitable project. Because of the governments' requirements, this project is thus not a maximum profit project from a financial point of view.

As for the public sector, the states need to focus on creating the highest socio-economic and environmental benefits. The main criteria for investment in the infrastructure project are the environmental, social and economic benefits, which will improve the welfare of society. In this regard it is the responsibility of the public authorities to set plans for transport infrastructure and services development. This is achieved by taking into account the socio-economic benefits of the project leaving the financial profitability issue to the private sector.

Still the governments must make sure that the project is bankable. Namely the states need to give sufficient guarantees so that banks and finance institutions are inclined to invest in the project at reasonable interest rates. There is a need to match the risk borne to the expected financial profitability that the private sector will managed to reach. The governments can impact on risk through financial guarantees, as well as legal and political facilitations.

In addition, the authorities may intervene to ensure social and spatial solidarity since the benefits of a fixed link are not uniformly spread out to the population and regions. Moreover, for projects of such a scale one might want to consider solidarity

between generations. Indeed several generations will benefit from the fixed link, and the way such links are generally considered is at cost for only the first of the three or four generations that will benefit from the link.

At the same time, there is a need to promote the project's impact on a European regional scale in particular including the trans-European network.

Capacity is an important aspect to take into account. Indeed, the 3+1 solutions, which have been proved to have the greatest net present value, correspond to solutions of a fixed link that will be congested as soon as in the year 2020. Hence the link between Denmark and Germany will again appear to be a bottleneck for international transport. In 20 years there will thus be a need for another fixed link implying additional infrastructure and additional impacts on the environment. The sum of the impact of two infrastructure projects of such a scale is obviously far greater than the one of a single infrastructure with double the capacity. Where the private sector would go for a 3+1 solution, the governments might want to enforce a 4+2 solution in order to ensure that, at the same time, local and international transportation are satisfied.

Accompanying the construction of a fixed link, the governments must also implement a complete road and railway network to integrate the link in a global pattern, rather than keeping it isolated. This includes major investments in the local infrastructure, but also a global understanding from the deciding authorities of the traffic flows within Europe, the reciprocity of the impact between them and the infrastructure project.

5.2 Exploitation of the corridor

The implementation of the Fehmarn Belt fixed link would mark the completion of this genuine corridor from London to Stockholm. As presented in Chapter two, the Fehmarn Belt is the main missing link of this particular route. Its completion is expected to help the whole corridor to have a greater impact on development than the sum of its parts taken individually, as it covers the last natural gap to complete the chain of projects. Indeed, looking at the map of Europe all these projects link up in order to give birth to one entity, a continuous bimodal rail and road route from London to Stockholm. Hence, in their partnership with the private sector, the governments need to keep in mind the impact of such a corridor not only on a bi-national scale, but even more so on a regional scale where seven and more countries are involved.

5.2.1 Completing the corridor

The completed corridor presents tremendous potential for regional development. It is a main prime network in the dual spatial pattern arising in Europe in that it provides high-speed links between European regional centers, hence permitting an efficient exchange of freight technology and people. The corridor will facilitate the transfer of concrete technology and perhaps, even more, the transfer of tacit knowledge through the increased movement of people with experience and competences.

The concretization of this potential depends on back-up policies enforced at a multinational level. Local accompanying policies are necessary to promote local development, but that is only one marginal effect of the potential impacts of such a link.

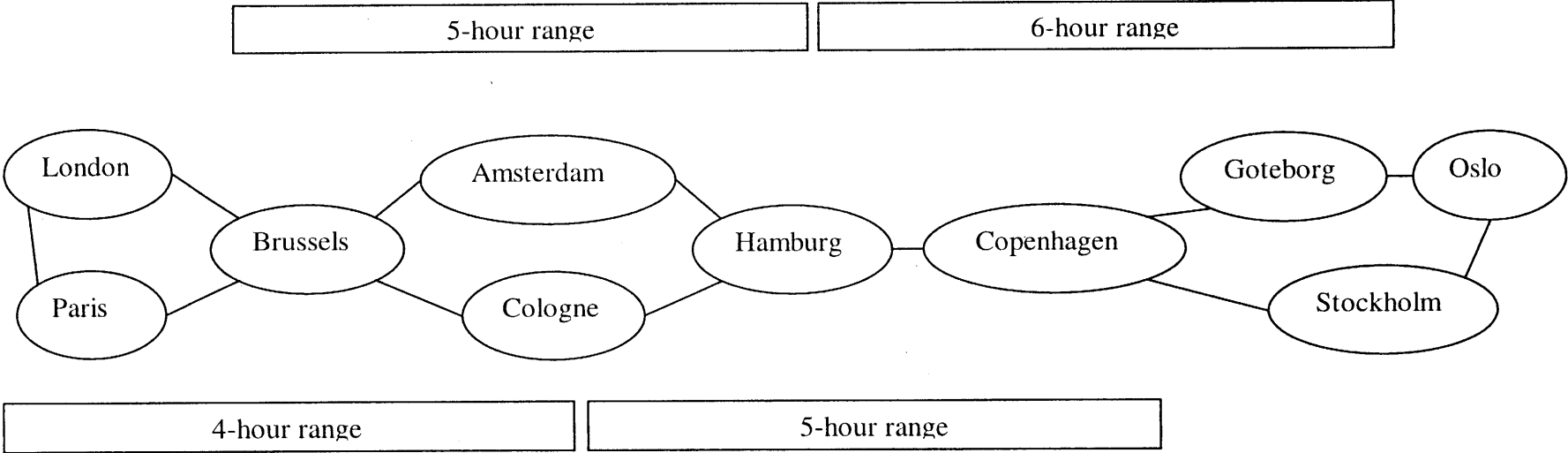
Indeed, in order to optimize a transport corridor crossing seven countries the introduction of international policies is crucial.

The following figure presents the expected journey times before and after completion of the Fehmarn Belt and the other projects. The bottom-left triangle of the matrix presents the journey times on January 1, 2001, whereas the top-right triangle presents the expected journey times after completion of the missing links mentioned in Chapter two.

Table 14: Journey times after and before the completion of the transport network

	London	Paris	Brussels	Amsterdam	Cologne	Hamburg	Copenhagen	Goteborg	Stockholm
London		2:30	2:00	3:30	4:00	7:00	9:30	13:00	14:00
Paris	3:00		1:30	3:00	3:30	6:30	9:00	12:30	13:30
Brussels	2:30	1:30		1:30	2:00	5:00	7:30	11:00	12:00
Amsterdam	5:00	4:00	2:30		2:30	4:00	6:30	10:00	11:00
Cologne	5:00	4:00	2:30	2:30		3:00	5:30	9:00	10:00
Hamburg	8:30	7:30	6:30	5:00	3:30		2:30	6:00	7:00
Copenhagen	13:00	12:00	10:30	9:30	8:00	4:30		3:30	4:30
Goteborg	17:00	16:00	14:30	13:30	12:00	8:30	4:00		
Stockholm	19:00	18:00	16:30	15:30	14:00	10:30	6:00		

Figure 16: Time range across the North European Corridor



Cities that are within a range of 4 hours of one another:

London Paris Brussels Amsterdam Cologne

Cities that are within a range of 5 hours of one another:

Brussels Amsterdam Cologne Hamburg

Cities that are within a range of 6 hours of one another:

Amsterdam Cologne Hamburg Copenhagen

Cities that are within a range of 7 hours of one another:

Hamburg Copenhagen Goteborg Stockholm

These figures have been computed with the assumption that the time spent in the different towns is negligible. Hence, one could go from Amsterdam to Copenhagen in six and a half hours instead of nine and a half. Still, if the company operating the Amsterdam-Hamburg line is different from the one operating the Hamburg-Copenhagen one, then there might be additional time added to the journey, since passengers would have to change trains and take correspondences.

5.2.2 Operating the corridor

Hence, although the chain might be complete physically, the beltway is only a juxtaposition of infrastructure projects and not a continuous corridor, in that it is not possible for the same train of a same company to go from one end to the other. This implies technical interoperability between the different rail systems, but also implies the possibility for one single company to exploit the whole corridor. This last point raises concerns about the operation of the projects. Each project is usually operated through a concession, should it be the Channel Tunnel by Eurostar or the Oresund Link by Oresundskonsortiet, or the HSL South in the Netherlands that is about to be operated under the regulation of a concession contract.

From the moment it is not the same company that wins the concessions, the exploitation of the whole infrastructure is not possible. Hence there is an important question about how long these concessions should last. As long as they last the socio-economic benefits of the infrastructure are not maximized, since there is no competition

once the concession is given away, and, on the other hand, the whole network cannot be exploited as such but only as sums of its parts. Here again, it appears that the whole is expected to incur greater benefits than the sum of its parts.

Considering the way the concessions are given, in particular that a single company does not win all contracts, it appears that monopolies are arising on specific segments of the beltway, and a continuous exploitation of the beltway therefore seems impossible in the near future. Thus, in this perspective, alternatives to the “concession” method might gain more interest. In particular, franchising would allow two or more companies to operate on a same infrastructure, hence this would increase the chances of having one company being able to operate the whole corridor. But for this to become realizable there is still a final step which would have to be taken and this is the establishment of interoperability between the different systems.

5.2.3 Concept of a “European company”

When we look at the issue of giving the possibility to an operator to run services along the whole track, franchising as mentioned above might be an answer on the other hand the concept of a European company might also well address this issue. One must keep in mind that, for the implementation of one operator to run the services from one end of the corridor to the other, there are other important concerns that need to be addressed.

One of the major concerns that may rise for a company operating the whole route is the social regulation. The route is an international one and hence in each train station the operator would be under different social regulations. If strikes go on in one country, the whole beltway communication is affected. Such events as strikes can have great impact. In April 2001, strikes broke out in two of the European railway services: the first one was that of the SNCF in France that took place from the 2nd to the 6th of April 2001, the second is the strike of the RENFE in the Netherlands, which started on April 15, 2001. In the context of the north European route, this could have paralyzed the whole railway services for a full month. The exposition of companies to these risks is important. Hence there is a need to create a new status for “European” companies in order to mitigate this kind of risks. The so-called “European” company would be under a community regulation and not submitted to the regulations of each country it operates in.

The operation of the link needs to be supranational in order to promote the regional development at the European Community’s scale. There should not be a need to create national entities where the social legislation is dictated by national regulations. Indeed, companies would then be shrunk to the sum of national entities instead of working as a global firm. Furthermore, this global firm and the different states involved need to form a partnership so that the technical operational standards may be enforced in order to be compatible with the exploitation of the railway corridor.

The European Union is about to enlarge itself drastically with the entry of the Eastern Europe countries. Hence the notion of a European company as a supranational company should receive particular attention. Taking the large American companies for a

model would bring some insight into this perspective. Indeed, large American companies are not seen as companies of a particular state, but as one of the whole of the United States.

Another example of supranational regulation is the one jointly created in South America by Argentina, Bolivia, Brazil, Paraguay and Uruguay for the exploitation of their water transport system: the "hydrovia" waterway project.

Map 16: The "hydrovia" Project¹



¹ "Critical environmental costs of the Parana-Paraguay Waterway project in South America" by Enrique H. Bucher, 1995

This project is planned for the physical integration of the Southern Common Market (MERCOSUR) through a 3,442-kilometer river route linking the ports of Caceres in Bolivia with Nueva Palmira in Uruguay. After 25 years of negotiation the five countries agreed on a set of international laws to regulate the waterway.

In the context of the trans-European network for high-speed rail, supranational legislation is key for a homogeneous exploitation of the total capacity of the link, as well as for optimal regional development impacts.

Further research would lead to thinking about what kind of company would be appropriate for the operation and exploitation of an international route linking seven different countries. Should it be a company created as a joint venture of the different states, or could it be a privately held company and in such case is there a need for a European institution to supervise it and to mediate with the states concerned in order to adapt the demand with the supply?

CONCLUSION

The evaluation of socio-impacts of the Fehmarn Belt has shown how benefits appear not only locally around the infrastructure but spread out geographically as well as across the different modes of transport.

Models have shown that a consumer surplus is created for users located in countries next to the North European Beltway, but still quite distant from the project of a Fehmarn Belt fixed link. Simultaneously, through efficient connection of airports to the high-speed rail network, air services benefit from a decrease in congestion as more and more intermodal partnerships take place, following the recent example (since January 2001) of Air France and Thalys for the Paris-Brussels connection from the Charles-de-Gaulle Airport.

Both of these results deal with consumer surplus and benefit regulation, which the governments need to handle. Governments need to cooperate and focus on creating the highest socio-economic and environmental benefits on an international scale. Cooperation is needed between different regions, transport modes and generations for the cost and the payment of the infrastructure. The public sector is the main agent to foster such cooperation, since the benefits of a fixed link are not uniformly spread out to the population and regions. On the other hand there is a need for competition in the transport industry in order to gain efficiency.

For project appraisal, public-private partnership is a great mean to make a project successful through risk mitigation, government guarantees and private funding. For the public sector, the main criteria for investment in an infrastructure project are social and economic benefits and the environmental impacts, which will improve the welfare of society. Then it is the private sector's objective to make a project financially sound. In this perspective, an important issue is to capture consumer's surplus created by the project for remote regions or other transport modes.

The operation of the London-Stockholm corridor needs to be ensured in a supranational manner in order to promote the regional development at the European Community's scale. This is statement is true for the whole trans-European network.. The public sector should help companies to work as global firms on a European scale. Companies operating the network should not be divided in national entities submitted to social legislation dictated by national regulations.

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