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The Swedish Road System on the Threshold of the 21st Century

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Summary

Most transports will be by road for a long time to come. A well developed and efficient infrastructure contributes to economic growth and social well-being. The 1990's witnessed in Sweden an extensive expansion of both the road system and of the overall infrastructure in society.

Compared to many other countries, Sweden is relatively sparsely populated. This places great demands on a well developed and extensive road system while simultaneously necessitating substantial investments in metropolitan areas. Competition for land in these areas is intensive, rendering it difficult to find solutions for the design and alignment of the traffic system placed above ground. This fact, in combination with environmental requirements, has increasingly led to the consideration of tunnel alternatives. It is now time to consider directing the road system underground as well as to cope with traffic and environmental policy. Such civil works projects have been started in both Gothenburg and Stockholm.

In Stockholm, after many years of preparation and political discussions, works have now been initiated on the Southern Link (Södra Länken) of the motorway ring around Stockholm.

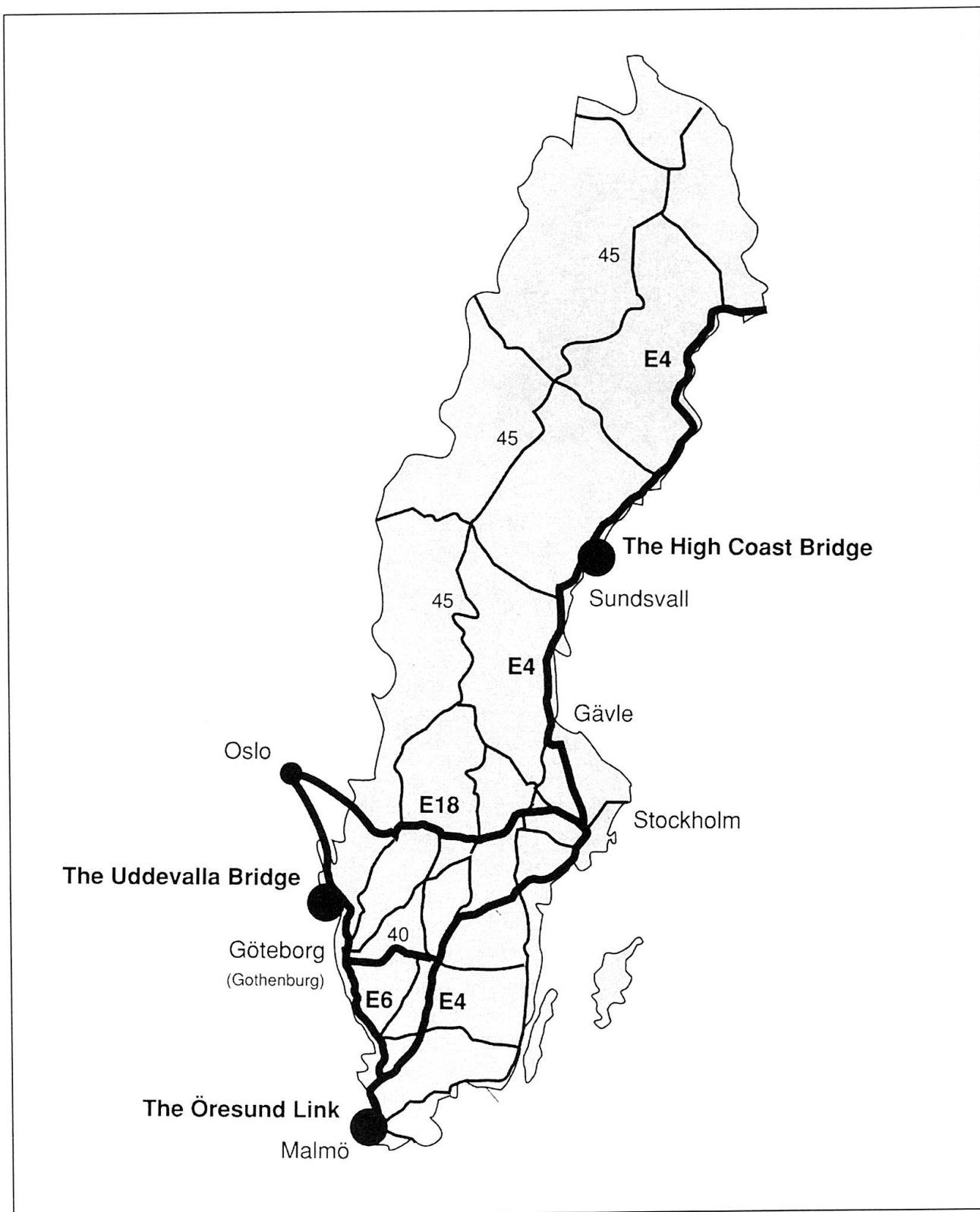


Figure 1 The Swedish main national trunk road system

1. General considerations

The mobility and transportation possibilities emanating from contemporary means of transport are today closely integrated with social development in general. The car, in combination with other means of transport, and a modern, widely ramified road network have created a transport system that provides good mobility and accessibility with great flexibility.

We now find ourselves in a new phase of development. The premise on which the road transport system of the future is based, rests on the creative interaction between different modes of transport, the vision that no one shall be killed or seriously injured in traffic accidents, and a conscientious policy on a road transport system which does not jeopardize a sustainable development of the society. Moreover, public transport shall be available to everyone in society.

The road transport system shall satisfy both the individual's need for mobility and accessibility as well as industry's need for efficient transports. The over-riding goal is that the user shall be able to find an optimal transport solution for every specific situation.

Most transports will be by road for a long time to come. Access to cars enhances the possibility of choosing where to live, of developing a richer social life and enjoying a wider range of recreational activities. Each one of us expects that this freedom of mobility will continue to grow. The road network will therefore continue to be the most important transport network.

A well developed and efficient infrastructure contributes to economic growth and social well-being. The 1990's witnessed in Sweden an extensive expansion of both the road system and of the overall infrastructure in society. In 1993, the Swedish Parliament passed a ruling on a national trunk road network comprising roads considered essential to the promotion of national economic and social growth. This trunk road network was also chosen on grounds that would assure its immunity from any foreseeable changes in the structure of society or from any temporary swinging of the political pendulum.

During the 1990's, the trunk road network of Sweden has been steadily up-graded and strengthened. Between 1993 and 1997, SEK 18,500 million (USD 2,300 million) has been invested in such undertakings. Amongst the larger road investments, the following can be mentioned: the upgrading to motorway standard of the European Highway E4 between Stockholm and Malmö as well as European Highway E6 between Malmö and Gothenburg. See map shown in Figure 1. Further, extensive civil works projects are in progress on up-grading the E6 from Gothenburg to the Norwegian border and the E4 north of Stockholm.

To this can be added three major bridge structures:

- *The High Coast Bridge*

This bridge was opened on December 1, 1997. It is a 1,800 metres long suspension bridge with a main span that is 1,210 metres long. This bridge crosses the Ångermanälven river and is the main connection between northern Sweden and Stockholm.



- *The Uddevalla Bridge*

In 1997, construction was started on a 1,712 metre long cable stayed bridge across the inlet to Uddevalla. The bridge is part of the E6 and will considerably shorten the land route between Gothenburg and Oslo.

- *The Öresund Link*

A permanent connection between Malmö and Copenhagen across the strait of Öresund is under construction. The works were started in 1995 according to an agreement signed in 1991 between the governments of Sweden and Denmark. The connection which is about 18 kilometres long consists of a high bridge on the Swedish side, a man-made island and a tunnel on the Danish side. Added to this are the requisite land connections. The project comprises both a dual track railway and a motorway. It is expected that the construction will be completed in the year 2000.

The Öresund Link is owned by a Swedish / Danish Consortium, and 50% of it is owned by a Swedish company of which 50% in turn is owned by the Swedish National Road Administration (SNRA). The SNRA is sole owner of the other two bridges mentioned above.

2. Future Swedish Investments

The future focus of road policy was decided by the Swedish Parliament in the spring of 1998. New investment plans for the period 1998-2007 have been established. In the continued development of the road transport system, the importance of improving the quality of the road infrastructure and making it more efficient is emphasised. With respect to transports, emphasis is placed on improving accessibility and mobility, enhancing road traffic safety, reducing the environmental impact and stimulating an increased use of the public transport system. The road transport system shall be designed so that it contributes to the sustainable development of society.

These new investment plans are the result of a comprehensive planning process based on prior strategic planning. This strategy determines the distribution of funds between the different types of traffic as well as the overall focus in the development of the road transport system. The government has thereby emphasised a holistic approach to the transport system. A more efficient utilisation of the existing road network and the potential for undertaking other measures - either as an alternative or in supplement to conventional road measures - are concepts that have been considered in the new investment plans in a more unbiased way than in the past. For instance, developments within the field of road informatics provide new possibilities for travel and transport planning, traffic control and traffic management. Of course a more efficient utilisation of the existing road network asks for proper actions with respect to maintenance, repair and strengthening of bridge and tunnel structures.

The investments planned for the national trunk road network amount to approximately SEK 30,500 million (USD 3,800 million). Of this, SEK 23,700 million (USD 2,950 million) have been allocated for new constructions and re-construction measures and the remainder for physical road traffic safety measures, traffic surveillance, road informatics, etc.

The overall strategy is to gradually up-grade the national trunk road network at the pace and to the geometrical standard that is motivated by the traffic conditions on each respective part. The following road systems have been prioritized. See Figure 1.

- *E4, Helsingborg - Stockholm; E6 (Trelleborg) - Malmö - Gothenburg and National Road 40, Gothenburg - Jönköping*

The three largest metropolitan regions in Sweden will be linked by a first-class road network. European Highways E4 and E6 are included in the Trans-European Transport Network (TEN) in what is referred to as the Nordic Triangle. This triangle is one of fourteen projects assigned priority within TEN.

- *E18 westbound from Stockholm to Örebro-Karlstad-Oslo*

The highway E18 between Stockholm and the Norwegian border is part of the Nordic Triangle.

- *E4 northbound from Stockholm to Gävle - Sundsvall*

This is the important connection between Stockholm region / Mälardalen and northern Sweden (Norrländ). It is a matter of national interest that the entire E4 is given the standard motivated by its traffic flow.

- *Improvements on National Road 45*

Road 45 is the most important trunk road for central and northern Sweden. The traffic flow is, however, not extensive. Substantial investments are being planned within the framework for the overall regional policy, beyond which only gradual improvement measures will be undertaken.

3. Need for Tunnel Structures in Metropolitan Areas

Compared to many other countries, Sweden is relatively sparsely populated. This places great demands on a well developed and extensive road system while simultaneously necessitating substantial investments in metropolitan areas. The number of these is, however, limited and primarily concentrated to the areas around Stockholm, Gothenburg and Malmö with heavy traffic. Competition for land in these areas is intensive, rendering it difficult to find solutions for the design and alignment of the traffic system placed above ground. This fact, in combination with environmental requirements, has increasingly led to the consideration of tunnel alternatives. Up until now, it has been the rail-bound traffic that has been housed in tunnels. It is now time to consider directing the road system underground to cope with traffic and environmental policies. Such civil works projects have been started in both Gothenburg and Stockholm. However, tunnel structures are often regrettably looked upon as harmful to the environment. It appears that in the eyes of the public, as well as in the political debate, longterm benefits to society and environment are often overshadowed by shortterm inconveniences during the period of planning and construction. Different activities have to be undertaken in order to find solutions that take into account the longterm needs of future transport systems and the demands of a sustainable development of society. Planners, technicians, politicians as well as media must all take responsibility for achieving this.

The Lundby tunnel in Gothenburg was opened to traffic this year. This is a two kilometre long rock tunnel on the north side of the Göta älv river, constructed at a cost of SEK 700 million (USD 90 million). This tunnel serves to relieve the surrounding residential areas from both through-traffic and from the heavy loads being transported to and from the harbour. This tun-

nel project, as many others, is mainly intended to achieve a better environment for those living nearby.

Construction is planned to begin this autumn on another rock tunnel in Gothenburg - this time south of the river. The intention is to leave the quays lining the river free from through-traffic. This Göta tunnel, at an estimated cost of SEK 2,000 million (USD 250 million), will be about 1.6 kilometres long. The southern shore of the river will subsequently become a central part of the city of Gothenburg increasing the environmental qualities of downtown Gothenburg.

In Stockholm, after many years of preparation and political discussions works have now been initiated on the Southern Link (Södra Länken) of the motorway ring around Stockholm. See Figure 2.



Figure 2 The planned motorway ring around Stockholm

4. Investments in the Traffic System of Stockholm

Background

Stockholm was founded in the 13th century at the intersection between the Lake Mälaren / Baltic sea route and the north/south land route through Sweden. This excellent geographical location contributed to the rapid expansion of the city. The benefits reaped from good communication links were thus the basis for both the origin and growth of the city.

Stockholm is situated on a large number of islands. Rail-bound traffic and motorised vehicles created new prerequisites while at the same time, the limitations imposed by waterways became increasingly apparent. During the thirties and forties it was principally the road network that was developed. Several important traffic infrastructure structures were built during this period; e.g., the interchange at the Slussen locks, Tegelbacken, and the Tranebergs-, St. Eriks- and Västerbro bridges. These were all designed and constructed in such a way that they still constitute the back-bone of the Stockholm road and rail traffic system.

The Essingeleden city motorway was opened to traffic in connection with the switch-over to right-hand traffic in 1967. This represented the first component of a system intended to relieve the central parts of Stockholm from traffic. It was built on bridges west of the heart of the city and has since then been extended with a connection to E4 northbound. See Figures 1 and 2.

Stockholm has extensive experience in constructing underground facilities. The Stockholm Metro, distance heating plants, telecommunication tunnels, sewage treatment plants and stormwater reservoirs are examples of facilities that have already been built.

Planning activities throughout the years

The first plan that predicted the need for an extended traffic route network was the 1952 master plan. Amongst other things, this plan included a ring route around the city to relieve the inner city area from traffic, although with a different alignment than what is now at hand. The 1952 master plan was followed by revised traffic route plans in 1960, 1977 and so on.

By the mid-eighties it was all the more evident that the traffic system risked becoming untenable in the long run. Immigration to Stockholm had been in the range of 15,000 persons per year for a great number of years. And so it still continues. It was nonetheless an impossibility for the Stockholm city and region on their own to determine how the necessary investments could be implemented both as far as financing and planning were concerned. The region consists of twenty-four independent municipalities, several county bodies and a large number of state authorities, all with different tasks and objectives as far as future development is concerned. The Government therefore appointed a special negotiator, former Governor of the Swedish Central Bank, Mr. Bengt Dennis. His commission was to work together with the parties concerned to elaborate a proposal for a sustainable solution to Stockholm's traffic system.

This work resulted in a political agreement, the so-called Dennis Agreement of January 23, 1991, to co-ordinate measures to improve the environment, increase accessibility and create better conditions for development within the Stockholm Region. In addition, these measures were to encourage increased housing development. A supplement was written to this Agreement on September 29, 1992. All in all, more than SEK 40,000 million (USD 5,000 million)



was to be invested in public transport facilities, rail lines and roads. Roads were to account for SEK 22,700 million (USD 2,825 million) at the January 1992 price level.

The Dennis Agreement

The Dennis Agreement of 1992 meant that Essingeleden was to be extended into a complete ring road around Stockholm. This was to be comprised of fourteen kilometres of urban motorway, housed primarily in tunnels. The new parts were to be Norra Länken (Northern Link), Södra Länken (Southern Link) and Österleden (Eastern Link). In addition, a so-called Outer By-Pass Route was to be constructed in order to link the southern and northern suburbs via a by-pass west of the city. This represented a total of 90 kilometres of road, of which the major part was to be built at motorway standard. Traffic hitherto forced to drive through the heart of the city would by these projects be afforded alternative routes.

The cost for the road system in the Dennis Agreement was to be financed through road user charges. Toll stations were to be placed outside the ring road.

The Swedish National Road Administration (SNRA) is responsible for the overall road system in the Stockholm Region and has, since the signing of the Dennis Agreement, been commissioned to implement the road investments. Three initial projects within the Outer By-Pass Route have been completed at a total cost of SEK 840 million (USD 105 million). These are now open to traffic.

In May 1997, the Government proposed a changed scope in the road component of the Dennis Agreement. This change meant that Österleden (the Eastern Link) of the ring road as well as Västerleden (the Western Link) of the Outer By-Pass Route were to be deleted. Further, a change in financing was also proposed. Instead of a road toll system, the road constructions were to be financed by special agreements, on the understanding that there was a common national and regional interest.

The Stockholm City, the Stockholm County Council and the Swedish Government finally reached an agreement in December 1997 in which the Government and the Stockholm City Council assumed shared responsibility for financing Södra Länken (the Southern Link). The Government would pay most of the cost. This agreement was submitted to the Swedish Parliament on February 19, 1998. The construction of Södra Länken (the Southern Link) as well as Häggviksleden (the Häggvik Link) and Haningeleden (the Haninge Link) included in the Outer By-Pass Route has thereby been assured to be executed and the construction work is now going on.

5. Södra Länken (the Southern Link)

Construction work has begun on Södra Länken (the Southern Link), an urban motorway housed principally in rock tunnels. The main tunnels consist of two parallel tubes, one for each direction of traffic.

Södra Länken (the Southern Link) is slightly more than five kilometres long and will connect the Essingeleden (the Essinge Link) in the west with Värmdöleden (the Värmdö Link) in the east. With through-traffic directed underground, a better environment can hereby be created for those living and working in the southern suburbs of Stockholm.

It has been estimated that Södra Länken will cost approximately SEK 6,500 million (USD 810 million). The intention is to open the main tunnels to traffic in 2003, and the remaining components the following year.

Great attention has been given to the design of the tunnels. Stringent requirements have been placed on the road geometry and aesthetics. The basic objective is that road users will perceive the tunnel environment as a natural part of the urban setting. The tunnels have therefore been designed with an inner ceiling and carriageways that are light in tone. This, in combination with the artistic ornamentation, good illumination and spacious dimensions will make travelling in the tunnel a safe, harmonious experience for road users.

High demands have been placed on road traffic safety. The ultimate goal as far as the safety concept is concerned is that it shall be safer to travel in tunnels than on a normal motorway. To this end, great emphasis has been placed on road user comfort. Lighting, geometric design, aesthetics, ventilation, orientation, traffic monitoring and management are some of the factors that have been considered important. Various designs have been analysed in simulation models. Special attention will be paid to the transport of dangerous goods. From a safety point of view, it would probably be most suitable that these be permitted in the tunnels. However, this question must be dealt with thoroughly, with carefully thought-out routines for supervision, escorts and restrictions - depending on the nature of the transports.

6. Concluding Remarks

Tunnels and tunnel systems are primarily of interest in areas with heavy traffic and where land is at a premium. In Sweden, this applies to metropolitan areas. Södra Länken is the first such project in Stockholm. An exact date for a further extension of the road system around the central part of Stockholm through the construction of Norra Länken has not as yet been determined. The Swedish National Road Administration has been commissioned by the Government to continue the work with the planning process. Once this has been completed, the necessary prerequisites will exist for making a decision on the continued construction of a road tunnel network in Stockholm.

Tunnel structures are often regrettably looked upon as harmful to the environment. It appears that in the eyes of the public, as well as in the political debate, longterm benefits to society and environment are often overshadowed by shortterm inconveniences during the period of planning and construction. Different activities have to be undertaken in order to find solutions that take into account the longterm needs of future transport systems and the demands of a sustainable development of society. Planners, technicians, politicians as well as media must all take responsibility for achieving this.

IABSE Colloquium "Tunnel Structures 1998"

The name of IABSE suggest that bridges and structural engineering are the main topics of interest. This is quite true when you consider the theme of the events organized worldwide by IABSE . In the same way the ITA is concerned with international exchange of knowledge about Tunnels.

Nevertheless tunnels just as bridges overcome obstacles for traffic of any nature. Tunnels are increasingly important for public transport in cities and underneath waterways. They are being constructed in areas where traditional bored tunneling is not possible or not the optimum solution.

This means that not only traditional knowledge of rock and softground tunneling is required for design and construction of tunnels. Immersed tunnels, Cut and cover tunnels and a wide variety of new and alternative methods of tunneling require an up to date knowledge of structural engineering, risk analysis, impact of construction methods, environmental considerations and aspects of maintenance and repair. All of this should sound familiar to the structural engineer of the turn of the century. These themes are frequently the subject of IABSE events.

It is a beneficial fact that the Swedish Group of IABSE took the opportunity to link an ITA conference in Stockholm with this IABSE colloquium.

For tunnels Scandinavia is an interesting place to visit now. Great works from which people and engineers have been dreaming for centuries, like the Great Belt tunnel, linking Denmark with a fixed connection and the Öresundtunnel, connecting Denmark with Sweden, are being realized here around. Many others as the sessions on current and planned projects of this colloquium will follow.

The response on the call for papers for this colloquium, issued in autumn 1996 has been great. The scientific committee has tried to make an interesting selection for the participants. We hope that the participants of the colloquium, in the end, will agree that this is true.

Prof. Ir Charles .J. Vos

Chairman of the scientific committee