

Øresund. A Cross-Border Best Practice Above and Below Water

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1 Introduction

If one looks at the development of cross-border connections in Europe as a whole, substantial differences emerge both in the approach taken and in infrastructure provision. These differences arise from different local contexts which may be more or less favourable to the development of interactions between neighbouring areas. Among the most important aspects are the history of the countries, economic exchanges, culture and language differences.

Long-distance connections are probably more developed than short-distance connections for local commuting. In rare cases, however, these two dimensions overlap and in such cases there is room for particularly advanced cross-border mobility solutions. Of these, the Øresund connection between Denmark and Sweden is certainly a case with exceptional aspects. In this chapter, the main features of this link, which has been connecting two countries across the sea border for 20 years, are presented.

2 History

Ideas for building a bridge or tunnel between Sweden and Denmark already existed during the second half of the 19th century and reappeared several times during 20th century. Finally in the 1990s the planning and discussions between Denmark and Sweden came to a decision and implementation.

During discussions lasting more than a century there has always been a debate concerning the alternatives routes Helsingborg-Helsingør or Malmö-Köbenhavn, the first implying a much shorter tunnel under the sea.

The final decision by the Swedish and Danish Governments in 1995 saw a great advantage in prioritising the connection between the larger conurbations of Copenhagen and Malmö. First, this southern area has roughly 2,600,000 inhabitants, compared to 300,000 of the Helsingborg-Helsingør alternative. Second, a tunnel on the Helsingborg-Helsingør connection would also present difficulties with the through traffic in the municipalities on the Danish side. Furthermore, despite the relatively short sea crossing between the two cities (less than 5 km), the tunnel still would have been long, because of the existing buildings and of the depth of the water (41 m maximum, compared to 10-15 m in the area of the current connection further south). These reasons prompted the decision for the southern connection, although the Helsingborg-Helsingør route and other connections are still on the agenda, and a report about possible alternatives has been submitted to the Danish and Swedish Governments in January 2021.

Until 2000 there were several ferry connections between Denmark and Sweden. The most frequent was Helsingør-Helsingborg, the narrowest part of Öresund, with a ferry running every 20 minutes or more often. The ferry services between southern Sweden and northern Germany such as Trelleborg-Travemünde were also important, and still are to some extent. The Helsingør-Helsingborg service still remains with a ferry every 20 or 30 minutes, still used by some cross-border commuters.

The construction of the Öresund connection started 1995 and it opened on July 1st 2000, on budget and three months ahead of schedule. The connection cost EUR 2 billion, and the road and rail links in Denmark and Sweden EUR 1 billion; the EU contributed EUR 140 million. The rest was financed through loans guaranteed by the Swedish and Danish governments.

Although the connection was supported locally by politicians, businesses and society in general there were protests, in particular from environmentalists who claimed that the connection would induce more car traffic. Today after 20 years of service there is hardly any opposition.

3 Geography

A description of the entire connection should take into account the infrastructure investments and improvements in Denmark and Sweden [fig. 1]. It should be mentioned that these improvements benefit also traffic in the two countries, and not just cross-border. The main parts of the connection are:

- 12 km** Motorway and railway connections in Denmark. Two new stations for regional, including Øresund, trains. One new station at Københavns Lufthavn (CPH airport) and a double track freight line bypassing the airport. A new depot for Danish trains terminating at CPH airport.
- 4 km** Drogden tunnel with 2+2 lanes and two tracks [fig. 2].
- 4 km** Peberholm, an artificial island where the tunnel changes to the bridge. Peberholm is not accessible to the public.
- 8 km** The actual bridge with 2+2 roads and two railway tracks. The national border between Denmark and Sweden is situated on the bridge.
- 10 km** Motorway and railway connections in Sweden. Three new stations (Svågertorp, Hyllie, Triangeln) for regional trains including Øresund services. A substantial reconstruction of Malmö Central station.

The actual Øresund connection *coast-to-coast* is thus $4+4+8 = 16$ km.



Figure 1 Railway network in Skåne and eastern Sjaelland (Denmark) showing single and double track (----- single track ===== double track)

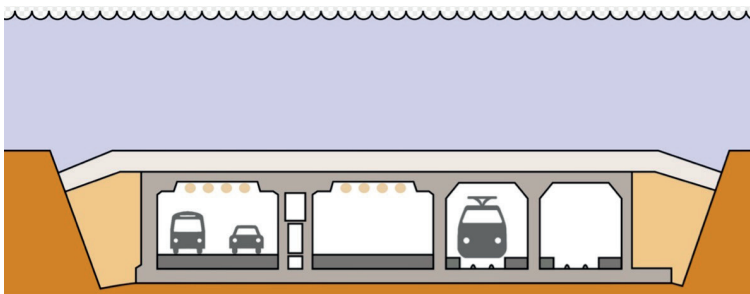


Figure 2 Drogden tunnel cross-section

4 Technical and Interoperability Issues

International train operations are complicated and there are often century old technologies, rules and traditions which have to be considered. Swedish railways use 15 kV 16.7 Hz electrification. This was chosen around 1910, at that time this 'German' system was the best option for electrification of main lines. In the 1970s Denmark chose 25kV 50Hz for their main lines. That was the best option at that time when connections to Sweden or Germany were not on the agenda. In today's operations changeover between the Swedish and Danish traction system is done automatically at speed at Lernacken, on the Swedish side just east of the bridge.

Denmark and Sweden have different systems for Automatic Train Protection (ATP). The ATP system, as well as national safety regimes and traffic control, are changed automatically at Peberholm. A contract has been signed to install ERTMS (STM). There were initial ATP problems, train brakes were wrongly applied causing delays and service disruptions.

Passenger trains must also be equipped with emergency brake override. At present (January 2021) only X31K/ET and X2K multiple units (EMU) have this feature but no loco-hauled passenger carriages. When the luxury Orient Express visited Sweden the vintage carriages had to be hauled empty across the Øresund connection and passengers crossed by bus.

The environment in the Drogden tunnel is so humid that it affected the track circuits which are the basis for most train safety systems. A section of the track (block) could be wrongly indicated as occupied (but not the other way around). Track circuits were therefore replaced by axle counters, a widely used solution on the continent but unusual in Scandinavia.

Since this is a highly innovative and particularly complex infrastructure, it is inevitable that problems have also occurred. Several infrastructure problems and shortcomings - mainly concerning the railway - have occurred, mainly due to lack of investments in the railway and to an increased demand for rail transport for both goods and passengers. Neglected maintenance in combination with a heavily trafficked infrastructure leads to more and more extensive wear and tear and also failures, with traffic disruptions affecting customers and goods. This affects all of Denmark and Sweden, not just the Øresund area. At the same time, the intensive use makes it difficult to handle the disruptions, since there are limited margins to remedy delays. In spite of this, traffic has grown and punctuality has improved in later years. Substantial infrastructure investments are under way especially in the Lund-Malmö corridor. Nevertheless, Skånetrafiken intends to develop traffic in priority corridors such as the rail service Helsingborg-Lund-Malmö-København as well as city express buses in major towns and cities.

There are capacity problems in Denmark as well, especially in the vicinity of CPH Airport, Københavns Lufthavn, the station has only two platform tracks. These tracks and platforms are used not only by Øresund trains, but also by domestic Danish services from all over Denmark which terminate here. There are as well two freight tracks bypassing the passenger station, these may in the future be rebuilt and used as passenger tracks. However, the space available between the airport terminal, the motorway and nearby housing is very limited.

When a train carrying dangerous goods is running in the Drogden tunnel, no other trains are permitted.

A further interoperability problem is the different currency used in Sweden and Denmark, which will be discussed in the section on ticketing.

Finally, the Danish and Swedish languages are similar and can be mutually understood after some training. However, there are special language rules for communication between trains and traffic control, especially concerning numbers where Swedish and Danish differ significantly.

5 Organisation of Rail and Public Transport

Both Denmark and Sweden have fully implemented the EU rail and Public Transport (PT) packages. Rail infrastructure in Denmark is managed by Banedanmark and in Sweden by Trafikverket (for road and rail) The regions (21 in Sweden, six in Denmark) are responsible for local and regional PT by all modes through their Transport Authorities (PTAs). The PTAs are almost exclusively funded by regional taxation, the role of the state is to provide infrastructure for rail and road.

Rail rolling stock (X31K), in total 111 3-car sets, is owned by the PTAs and put at the winning bidders disposal to operate the services. Some train sets are owned by Danish State Railways, DSB. The relevant PTAs are MOVIA in Denmark and Skånetrafiken in Sweden. Operations are now tendered out in competition.

Public Transport in general in Sweden has a cost recovery level of about 50%, the Øresund rail service has a higher rate of cost recovery. The subsidies are paid by PTA Skånetrafiken which is an organisation belonging to Region Skåne. Neighbouring regions contribute to the Øresund traffic to a lesser extent – related to the level of operations in the respective region.

The actual infrastructure of the Øresund connection is managed by a separate organisation, *Øresundsbrokonsortiet*, separate from Banedanmark and Trafikverket, but a more detailed description is outside the scope of this paper. There is no special train traffic control organisation for the connection, this is carried out by Banedanmark and Trafikverket, responsibilities change at Peberholm.

Over time, competitive tendering of non-commercial rail services has successively become the norm in Sweden and Denmark. Skånetrafiken is the contracting or procuring organisation in Sweden but in Denmark the Ministry of Transport is responsible, not the PTA MOVIA.

This is the timeline of the Øresund train services:

- 2000** Traffic København-Malmö started 1 July. At that time Swedish State Railways, now SJ, had declared that they could not operate the service on commercial terms. The Swedish Central Government assigned Skånetrafiken as the responsible Swedish partner. Trains were then operated by SJ and DSB for eight years.
- 2009** After tendering the service was taken over by DSBFirst, a joint venture between Danish State Railway operator DSB and British transport operator FirstGroup.
- 2011** Serious financial problems were discovered in DSBFirst who requested more money to operate the service. More money was temporarily provided by Skånetrafiken but DSBFirst's operations were terminated earlier than the contract stated. Veolia was directly awarded a contract, after a second tender Transdev was awarded a contract for the Swedish part of the service until 2020.
- 2020** After tendering SJ was awarded an 8+2 years contract and SJ took over operations in December 2020. This procuring organisations for this 'intermediary' contract are Skånetrafiken and the Danish Ministry of Transport.
- 2022** From December 2022 trains from Sweden will terminate at Østerport in northern København instead of continuing to Helsingør. There will be no Danish contracting organisation, only Skånetrafiken, although cross-border ticketing schemes will continue to exist. Skånetrafiken has the right to unilaterally extend the contract by two years without tendering.

6 Öresundståg Service Pattern and Ticketing

The Öresundståg (Öresund trains) operations Helsingør/København/Malmö/Lund/Göteborg/Kalmar/Karlskrona should be regarded as regional/inter-regional services. The Malmö-Kalmar route is 312 km. On the other hand Helsingør-København (40 km) is rather a local/regional service with more frequent stops and shorter journey times. This has led to criticism concerning the trains adopted (X31K). They are considered to be not comfortable enough for 3 hour journeys such as Malmö-Kalmar but on the other hand they don't have enough room for commuters in Denmark with 20 min journey times. A 20 min interval train service between Malmö and København was started in 2000. Services have since then expanded. In 2019 trains run

every 20 minutes from Helsingør to København-Malmö-Lund. The service then splits up and trains continue to Göteborg, Kalmar and Karlskrona on an hourly basis. During peak hours, trains run every 10 min København-Malmö-Lund (2019).

In 2019 there was an average of 15,000 passengers per day in each direction between Malmö and København. There are also services by Swedish operator SJ on a fully commercial basis; 6-8 trains per day run København-Malmö-Stockholm. Furthermore, there are 12-15 freight trains per day in each direction.

There are also extensive regional train services in Denmark and Sweden that do not cross the Øresund connection. These are operated by various categories of EMUs running on Swedish or Danish traction current, therefore they cannot operate across the border. However, there are a few cross-border regional bus services.



Figure 3 The Øresundståg network

For the Øresund connection special fares with special zones apply [fig. 4]. It is possible to buy tickets from, for instance Zone E in København to Kristianstad in Zone I, single tickets as well as 30 day season tickets. These tickets are valid on all PT, rail (except high-speed services), metros, bus and the ferries Helsingør-Helsingborg. In 2021 a so-called 10/30 ticket has been introduced, this is valid for 10 journeys for 30 days, a fare that is especially aimed at non-daily commuters.

For journeys with the Skånetrafiken company in Sweden there is an app-based regional ticketing system. For travel with MOVIA in Denmark there is a zone-based system.

The ticket prices have to take into account currency fluctuations as Denmark and Sweden are not Euro countries. Sweden is not a member of the Euro-zone, while the Danish Krona (DKK) is linked to the Euro ($\pm 2.5\%$).

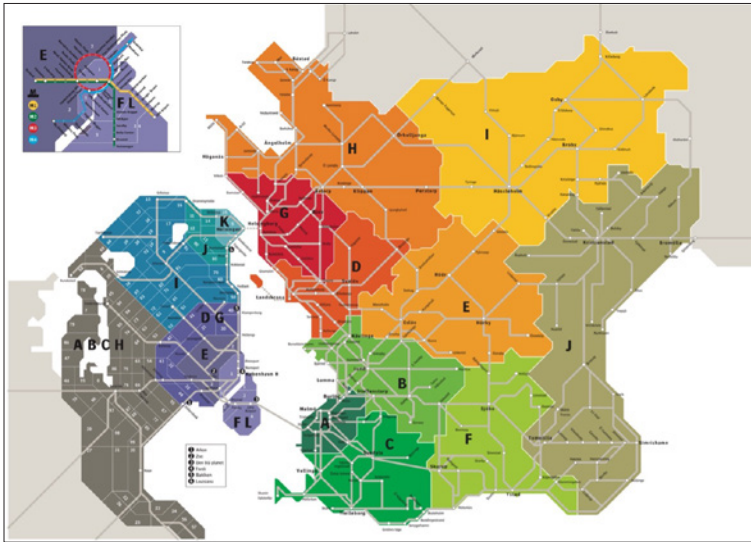


Figure 4 Øresund fare zones

Passenger figures and traffic development in general has been affected by many exterior factors outside the control of the PTAs or the operator influence. Over time, several events have occurred that changed the travel patterns between the two countries. Some of these are worth mentioning. In 2012 shopping hours were deregulated in Denmark. With the exception of a few holidays Danish shops can stay open as they like. Such deregulation was implemented in Sweden already in 1990, so the Danish deregulation led to fewer Sunday shoppers from Denmark to Sweden. In 2015, the migration crisis, also known as the refugee crisis, brought large numbers of refugees from the North African and Balkan routes to Europe. Before 2015 travel between Denmark and Sweden, as Schengen members, was in fact without any barriers. Due to this crisis, Sweden reintroduced border controls from Denmark and the situation changed radically. Passengers had to change trains at Copenhagen airport and commuting times increased by 20-40 minutes as an effect of border con-

trols in Denmark and Sweden. Then, the COVID-19 pandemic led to reduced travel generally, commuting is reduced, and this may be a trend that will affect public transport in general, also after the end of the pandemic, if teleworking were to remain widespread. In fact, a relevant issue is how public transport will develop after COVID-19.

7 Conclusions

The Øresund train service, with 15,000 passenger per day in each direction, must be judged as a success. There is not enough space in this chapter to go into all aspects of this particular cross-border mobility project. However, from such experience, some general recommendations for cross-border mobility should be highlighted:

- Do not focus on just the shortest stretch or the route between some major cities, consider real commuting and travel needs which may not be self-evident.
- MultiModal information and ticketing has been the norm in Denmark and Sweden for many years, that is not the case in all European countries
- The Mobility as a Service (MaaS) must be introduced across borders as well.
- Be prepared for unexpected events. The migration crisis 2015 was impossible for the transport sector to foresee
- Listen to customers, present and potential, through surveys, focus groups etc.
- Get media on your side and admit mistakes, do not cover up doubtful procedures
- Customers are prepared to pay for quality and punctuality but not for overcrowding and delays

These points may seem self-evident but they are worth reiterating. During the author's extensive work in projects and studies concerning rail and public transport it has been quite evident that the rail and PT sectors are not always acting with them in mind. However, the Øresund traffic development shows that further progress is still possible.

Acknowledgements

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