

## Appendix 6 – Technical risks

### 1. Background

Establishing a project such as the Fehmarnbelt Fixed Link involves a large number of risks and the management of these is the basis for success in terms of finance and time – or the opposite. The company’s professional assessment is that a cable-stayed bridge with two passage spans of 724 m each would pose a greater technical challenge than an immersed tunnel.

An analysis of the Øresund fixed link’s eight most important risk elements, which combined cover 75 per cent of the identified risks in the efforts to open on time, (which involved financial risks for the developer), resulted in the following picture, including distribution of risk elements:

Rank	Greatest risk to punctual opening	Percentage	Developer percentage	Contractor percentage	Other percentage
1	Interface management	18.0	18.0		
2	Element production	17.0		17.0	
3	Developer organisation	14.0	14.0		
4	Contractor organisation	12.0		12.0	
5	Accidents	6.5			6.5
6	Planning	3.0	1.0	2.0	
7	Labour	2,5		2.5	
8	Weather conditions	2.0	1.0	1.0	
<b>Total</b>	<b>The eight biggest risks</b>	<b>75.0</b>	<b>34</b>	<b>34.5</b>	<b>6.5</b>

From the above, it can be seen that the developer’s management of interfaces, and that the developer’s organisation is competently manned (to make both judicious and timely decisions) constitutes only one-third of the developer’s potential risks.

### 2. The developer’s risks

The developer’s organisation and the developer’s risk management thus, in itself, constitute a large risk element in the execution of the project, and in line with the contractor’s risk.

The developer is responsible for decisions on the following matters:

- Choice of technical solution

- Authority approval
- Pre-qualification, procurement planning, tender and bid assessment
- Contract commencement and administration, technical supervision of construction
- Operation and maintenance

Elements in the decisions the developer must make are illustrated briefly below.

## 2.1 Choice of technical solution

This phase, which is now close to being concluded, involves putting forward a recommendation for the technical solution which can subsequently gain authority approval without appreciable changes or delays and which simultaneously entails the least time and financial risks for the developer.

## 2.2 Authority approval

This phase has not yet commenced, but the preparations for application for authority approval in Denmark and Germany have been underway for several years. The success criterion is that the authorities change the proposal submitted by Femern A/S as little as possible and that the risk of appeals about the project that are found in favour, is kept to a minimum.

Through Femern A/S' strategy we will attempt to fulfil these goals by investigating all conceivable issues in detail so the application for authority approval appears as complete as possible within a reasonable financial framework .

## 2.3 Pre-qualification, procurement planning, tender and bid assessment

The tender process will be governed by EU directives, which the developer must comply with in order to avoid appeals.

### *Contract type*

So far, Femern A/S has been working with the same type of contract as for the Øresund link, i.e. "Design & Build", but with a more detailed tender basis in order to reduce the bidders' costs relating to the technical and time-demanding design work in the tendering phase.

### *Pre-qualification*

Pre-qualification will take place in a market in which it is estimated that approx. 25 possible candidates exist to form joint ventures in the competition for three main contracts worth approximately EUR 1,1-1,3 bill. each.

The results of the pre-qualification will ensure that there is subsequently sufficient competition for the tendered contracts.

### *Contract division, interface control*

This means that the company determines an appropriate contract division so that the interfaces between the individual contractors and between contractors and developer, etc. can be subsequently optimally managed.

### *Tender*

Since a tender process (including assessment) lasts approximately 21 months, to keep to the time schedule it is necessary for tendering to take place concurrently for all main contracts. This is a complication since all bidders in the tender process must be treated equally.

### *Division of risks*

The number of bidders will depend on the bidder's assessment of the risks the developer has allocated to the bidder in the tender documents as well as the number of pre-qualified competitors. A single bid on a single contract is assessed to cost the bidder approx. EUR 10 million depending on the scope of necessary planning in this phase.

The results of the division of risks will ensure that there is subsequently sufficient competition for the tendered contracts.

A proposal has been incorporated into the current timetable to utilise the potential for "competitive dialogue" in order to achieve synergy, harmonisation and coordination between the three main contracts, including optimal placement of production sites and minimising of investment in material as well as construction time. Despite the added work and a longer process in terms of time, this is expected to improve the contractors' appetite to bid.

## 2.4 Contract commencement and administration, technical supervision of the construction

### *Administration and supervision*

Even though the construction contract is the most important element in the relationship between the developer and the contractor, often the administration of the contract, including exercising the supervision obligation, is the crucial element for success or the opposite.

In the administration of the contracts, the developer has very significant influence on the risk picture, and an organisation characterised by great continuity would be an advantage when any requirements are to be dealt with.

### *Incentives*

It must be decided whether incentives should be a part of the strategy for execution.

In the tendering phase – in light of the limited number of potential bidders, see the section on pre-qualification – this could include limited remuneration to the bidders. This would encourage more contractors to bid for the contract. A certain degree of payment will furthermore ensure that in the further optimisation work, Femern A/S could have useful elements in the bidders' bids at its disposal and contribute to constructive progress of the negotiations in the “competitive dialogue” phase.

In the construction phase, incentives could be used to meet functional requirements regarding restrictions on sediment spill during dredging and depositing work as was the case for Øresund, or for the execution of a punctual (early) delivery:

The latter could be linked together with punctual (early) delivery leading to Femern A/S being able to obtain operating income faster from the fixed link.

### 2.5 Operation and maintenance

The developer's decisions regarding appropriate requirements for design solutions, materials and the quality of the construction work influence the subsequent, actual costs of operation and maintenance over the life of the chosen solution. Should significant traffic inconvenience to users of the link occur as a result of repeated restrictions due to repair and maintenance work, this could harm the traffic facility's reputation throughout its entire lifetime.

Appropriate coordination regarding emergency preparedness cooperation with the authorities in Denmark and Germany is therefore also of significant importance.

## **3. The contractor's risk picture**

The contractor's risk picture is, however, more transparent and straightforward.

However, it must be noted that all the contractor's decisions have an influence on and implications for the contractor's risk picture.

### 3.1 The contractor's organisation

The contractor's organisation and decision-making competence is an equally big risk for the developer as for the contractor. If the contractor fails in any way, this will have consequences for the developer.

A great risk lies in a joint venture between various contractors of various nationalities being manned by employees who do not work as a team. The developer can minimise his risk by ensuring a contractual right to be able to influence the contractor's manning if this is found to be necessary and/or appropriate, but this right must be administrated with due care.

### 3.2 The contractor's production

The contractor's decisions during the tendering phase are the basis for production in the construction phase. This is often perceived as the phase with the greatest risks, but this is entirely dependent on the preliminary work. The contractor's decisions in this phase are however, to a significant degree, dependent on whether he considers the contractual sum as sufficient or too low. In the latter case, decisions on investments in sufficient production equipment (new/old, buy-lease) and/or production capacity may prove to have significant influence on not just the contractor's risk picture, but also the developer's.

The developer can minimise this risk by making appropriate requirements regarding the contractor's underlying planning and choice of methodology in the tender documentation, including any unsuitable choice of methodology, which in the developer's opinion carries an overly high risk of spill-over onto the developer.

### 3.3 Cable-stayed bridge

The cable-stayed bridge's span of two spans of 724 m each would be the largest spans ever built for a cable-stayed bridge for both road and rail traffic and they would both be more than 200 m longer than the span on the Øresund Bridge. Equally, construction would take place in a channel where the weather conditions are often harsh and where the vessel intensity is high. Not insignificant risks for the contractor are estimated for the construction phase, in terms of both delays and occupational injuries.

The risks of the detailed planning are especially focused around the cable-stayed bridge where the combination of the cantilever method and the long cables will require the utmost precision in coordinating the work and in the level of design detail. The long cables in combination with the free-standing pylons require buffering of vibrations, which must be based on extra buffing in view of e.g. experiences from the Øresund Bridge. The planning of the cable-stayed bridge is therefore characterised as being development work with the related challenges.

Even though the girders of the approach bridges are basically identical, the substructures differ in shape, size and height, due to the curve of the bridge at the vertical level.

The construction work is also characterised by many heavy and precise lifts and the placement of bridge elements. Bridge girders weighing up to 9,000 tons will have to be raised up to a height of 80 metres to the upper side of the bridge girder and be placed with

centimetre precision. Bridge foundations weighing up to almost 5,000 tons must be placed in 30-40 metre deep water, with centimetre precision as well.

The choice of method, including the sturdiness of the lifting equipment to be used, is a critical factor for timely execution. However, while there is no existing material available, new lifting units would be built to handle the project. In this regard, the developer's challenge is to assess, time permitting, whether the contractor, after signing a contract, is to select equipment himself or whether any reservation should be made by the developer beforehand for certain types of equipment.

The basic premise as regards pricing is that the steel constructions are to be produced wherever it is cheapest, which is currently assessed as being in the Far East, e.g. China. In regard to production in this part of the world, there will be a challenge for the developer to ensure that the contractor and his sub-contractors meet the developer's contractual requirements for corporate social responsibility and occupational health & safety.

The sea transport of the elements from the production site to the bridge line is likewise subject to significant risks from the weather and from the surrounding vessel traffic. Additionally, the cable-stayed bridge is characterised by simultaneous construction of three large pylons approximately 270 metres high, which can be a critical element in the time schedule. The northern approach bridge (the longest) will presumably be the most critical activity for the time schedule.

### 3.4 Immersed tunnel

An immersed tunnel will also pose a significant technical challenge but it does not entail similar technical "breakthrough" activities since it fundamentally involves executing the same operation as with the construction of the Øresund link's immersed tunnel (the Drogden tunnel), just many more times and in somewhat deeper water (up to depths of 30 m–40 m). Thus, the increased length of the total tunnel will not mean an increase of risks to the same degree as is the case with an increase of the bridge span in the cable-stayed bridge's passage span.

The planning work is characterised by a large number of identical tunnel elements, which will be identically produced so, if necessary, they will be able to replace each other. This means that the planning work can focus on optimising the tunnel element itself. The challenge lies in planning the 10 special elements, which are on two levels so that the installation is optimised.

The construction part is characterised by approximately 80 transits of 75,000 ton heavy 200 m long tunnel elements from the production site, followed by a similar number of

submersions of the large tunnel elements. These sea activities will be subject to significant risks from the weather and the surrounding intense vessel traffic.

The dredging works in great depths of water, and thus containment of sediment spillage (and compliance with the developer's requirements in the contract) will also present a major challenge for the contractor.

### 3.5 Accidents, weather conditions

The consequences of accidents and weather conditions are equally divided between the developer and the contractor, but are fortunately not the biggest contributors to the risk picture for either the developer or the contractor.

The developer can minimise his (and the contractor's) risk by applying sufficient requirements for the contractor's planning and safety management in the tender documentation so that only the effects of very extreme weather conditions will have an influence. This aspect must be dealt with by the developer in the tender conditions, so that all contractors compete on equal terms to achieve robust planning.