

External Quality Assurance of the Fehmarn Belt Fixed Link Business Case—Too Little, Too Late, and Too Unreliable

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Abstract

The external quality assurance (EQA) of the Fehmarn Belt fixed link business case commissioned by the Danish Ministry of Transport is critically analyzed regarding the *New Construction Budgeting* requirements as well as common practical criteria. A time line of analyses, decisions and external quality assurance activities as well as external criticism is established as a basis for analyzing the completeness, timeliness and trustworthiness of the quality assurance. Information obtained per the Public Records Act is included. It is found that the external quality assurance was grossly incomplete with limited scopes and exclusion of major elements of the project. The overall financial performance and financial uncertainty analyses were not subject to external quality assurance at all. The bulk of external quality assurance was carried out only after the decision-to-build was made, preparatory construction activities initiated or major economic commitments made, thus jeopardizing the timeliness. The trustworthiness of the external quality assurance is limited for different reasons: bad timing of activities, lack of independence of consultancies, and controversial findings of opposing analyses. The external quality assurance is found to be too little, too late, and too unreliable. The status of the project as a high-risk business case is not improved by the external quality assurance.

Keywords

External Quality Assurance, Fehmarn Belt, New Construction Budgeting, High-Risk, Business Case

1. Introduction

The Fehmarn Belt fixed link project, currently put on hold due to lacking German approval, has a long and turbulent history, of which a short account is giv-

en (in the **Appendix**, a detailed timeline is presented). Way back in 1991 in connection with the Danish-Swedish agreement to build the Øresund fixed link the project was put on the official political agenda of the Danish Parliament. Denmark announced that the possibility of a fixed link crossing the Fehmarn Belt should be further investigated as an important element in the direct connection between Stockholm and Paris. Some of the early investigations may be found in [FTC \(1999\)](#), [TRM \(1999\)](#) and [Femern A/S \(2003\)](#). In 2000, the Ministries of Transport of Germany and Denmark launched an inquiry of commercial interest (ECI) to investigate the private sector's interest in implementing a fixed link for road and railway traffic across the Fehmarn Belt, [State Memorandum \(2000\)](#), and the results were published, [FDJV \(2002\)](#). The forecasted income from the project was considered too low and uncertain to support a private sector investment, in part due to the competition from other links, such as ferry services and the Great Belt fixed link. The conclusion from the ECI is that the project can only be realized with substantial public support either in the form of guarantees or direct government support. The Ministers of Transport agreed on 13 June 2002 to review some of the most important questions regarding the commercial risks involved in the project, including the traffic forecasts and the revenues from both the road and railway traffic, [TRM \(2003\)](#).

Another memorandum confirming German and Danish cooperation was agreed upon, [State Memorandum \(2004\)](#). The Danish Ministry of Transport published quite a lot of positive information about the project, [COWI \(2004\)](#), [TRM \(2006b\)](#), however, in vain. On 19 June 2007, the state-owned shipping business Scandlines, jointly owned by Denmark and Germany, was sold off to a consortium of German and British private investors, [Berlingske Business \(2007\)](#). Only ten days later, yet another memorandum was agreed upon, [State Memorandum \(2007\)](#). However, the German government had already decided to pull out, except for building and financing the German hinterland constructions, [State Treaty \(2008\)](#). The treaty followed a binding political agreement between a majority of Danish political parties, [Danish Parliament \(2008\)](#). Still, the environmental approval of the project part on German soil must be given by the local state government of Schleswig-Holstein, or more precisely by the organization: Landesbetrieb Strassenbau und Verkehr Schleswig-Holstein. The agreement, [Danish Parliament \(2008\)](#), only two pages long, was unconditional. It merely stated the political intention to build, finance and operate such a fixed link without mentioning any economic or other conditions to be fulfilled. At the time, some initial financial analyses had been done, [Femern A/S \(2003\)](#), [TRM \(2004\)](#), based on a recent traffic forecast, [FTC \(2003\)](#). Also, external criticism was exercised prior to the political agreement, [Jespersen \(2007\)](#) and [Vieregg-Rössler GmbH \(2008\)](#). A new financial analysis was carried out, [Femern A/S \(2008\)](#), however still using the traffic forecast from 2003.

As from 2008 the Danish political parties behind the project have continued the struggle to implement the project despite the lack of commercial and German political support (except for the hinterland constructions) and severe public

criticism from sceptics. Following another binding political agreement on a green transport policy, now also including the Danish People's Party in the Fehmarn Belt agreement, [Danish Parliament \(2009a\)](#), a planning act was passed that allowed for the planning process to continue with increased intensity, [Danish Parliament \(2009b\)](#). At the same time the [State Treaty \(2008\)](#) was ratified. The rivalry between a cable stayed bridge, originally preferred, and a submersed tunnel was ended with a victory for the immersed tunnel, [Femern A/S \(2010a, 2010b, 2010c\)](#), decided by the politicians behind the fixed link on 1 February 2011, [Femern A/S \(2011a\)](#), and calculated by [Femern A/S \(2011d\)](#). A proposal to locate the tunnel element factory in Rødbyhavn, [Femern A/S \(2011c\)](#) was also agreed on, [TRM \(2011b\)](#). Construction activities were advanced by the approval of the Ministry of Finance, [Danish Parliament \(2011\)](#), and consolidated construction costs of the immersed tunnel were put together, [Femern A/S \(2011d\)](#). To advance the bidding process for the tunnel construction works the Ministry of Finance had to approve of yet another act, [Danish Parliament \(2013\)](#).

At the time, there was a lot of optimism concerning the implementation time schedule of the project, [Femern A/S \(2012\)](#). It was planned that the application for German approval would be submitted by April 2013 and the approval obtained by January 2015. Resolving of potential court cases was not considered. As of today, the approval is expected by 2020 at the earliest, including the resolution of court cases. The building process was expected to take 6.5 years, today 8.5 years are expected. Initially, the fixed link was expected to be inaugurated by 2018, [State Treaty \(2008\)](#), now the expectation is 2028, at the earliest, [Femern A/S \(2016a\)](#).

In Section 2 an outline is given of the concept of *New Construction Budgeting* initiated by the Danish Ministry of Transport in 2006, and how and to what extent external quality assurance should be applied to the Fehmarn fixed link project. In the following sections the paper deals with quality assurance of elements of the Fehmarn Belt fixed link project. Section 3 covers road traffic forecast quality assurance, which is of critical importance for link economy. Special attention is devoted to the question of assumed road traffic transfer from the Great Belt and discontinuation of the existing privately owned ferry service crossing Fehmarn Belt. Section 4 focuses on quality assurance of the construction costs of hinterland constructions, tunnel construction and allocated reserves and the delayed German approval process, including the contractual consequences. In Section 5 the consolidated financial analysis is considered including financial uncertainties. Finally, the conclusion and references follow.

This paper was completed by 18 March 2017. It is a revised version of [Schjær-Jacobsen \(2017b\)](#). Quite a substantial part of the information and documents used in the paper has been obtained while the author and others were granted access to public records in accordance with the Public Records Act. A few access applications are still pending.

2. New Construction Budgeting, Quality Assurance and Reserves

After a couple of years with many serious cost overruns on projects run by the

Ministry of Transport, an analysis done by the Ministry of Finance revealed usage of inadequate budgeting methods and uncertainty analyses. Consequently, in 2006 the Ministry of Transport launched a new approach by the name *New Construction Budgeting* and informed the Ministry of Finance about it, TRM (2006a). Two new instruments are introduced in the decision process:

- 1) External quality assurance carried out by an external and independent consultancy.
- 2) Experience-based correction supplements which are percentage reserves added on the cost side.

The aim is to improve cost control and prioritizing of projects. The principles should be used in all larger infrastructure projects within the domain of the Ministry of Transport and apply to the appraisals at the two points in the decision process labeled Level 1 and Level 2. At Level 1 it is decided which projects are taken forward and at Level 2 the decision-to-build is made. The standard for experience-based correction supplement is 30% of the base budget, TRM (2010a).

In the main memorandum, TRM (2010a), the principles for implementation are laid out. Terms of reference for the external quality assurance at Level 1 is found in TRM (2010b) and Level 2 in TRM (2010b). We will focus on Level 2 external quality assurance that should be carried out as a basis for the political decision-to-build to be taken by Parliament, usually by passing a construction act.

The financing of the fixed link across the Fehmarn Belt is based on a state guarantee model. This model entails financing of the project via loans guaranteed by the Danish Government, and which are to be repaid via revenue from the users of the fixed link. These and further details of the Fehmarn Belt immersed tunnel project are available from the subsidiary project company, *Femern A/S* (2017b), fully owned by a state company, *Sund & Bælt Holding* (2017a), which in turn is fully owned by the Danish state.

New Construction Budgeting is applicable to the Danish land works but, surprisingly enough, not to the immersed tunnel construction or to the entire fixed link project. It is argued by the Ministry of Transport, TRM (2015b), that this is the case because the construction of the land works is done by Banedanmark and the Danish Road Directory, respectively, while the immersed tunnel construction is the responsibility of Femern A/S. Apparently, state-owned companies are exempted from *New Construction Budgeting*. This does not make much sense when it comes to the consolidated finances of the total project where income from the users plays a major role. In fact, no external quality assurance of income and consolidated project finances, including uncertainties, was ever carried out.

Despite the fact that *New Construction Budgeting* is not applicable to the tunnel construction and the entire project, it was the guiding principle for some of the external quality assurance carried out. It is therefore interesting to study the timing in relation to the decision process, see **Table 1**. Following the guideline

Table 1. Timeline of decision process and external quality assurance. Extracted from the **Appendix**.

Date	Decision	External Quality Assurance (EQA)	Reference
19 June 2007	Scandlines sold off		Berlingske Business (2007)
29 June 2007	Memorandum of understanding between Denmark and Germany		State Memorandum (2007)
2 September 2008	Binding political agreement to build fixed link		Danish Parliament (2008)
3 September 2008	Agreement between Denmark and Germany		State Treaty (2008)
29 January 2009	Binding political agreement: Green transport policy		Danish Parliament (2009a)
15 April 2009	Parliament passes Planning Act No. 285		Danish Parliament (2009b)
23 June 2011	Construction activities advanced, Act No. 149		Danish Parliament (2011)
26 April 2012		EQA of railroad constructions published	KPMG (2012)
8 June 2012		EQA of E47 South Motorway published	Deloitte (2012)
20 March 2013	Authorization of call for tenders, Act No. 97		Danish Parliament (2013)
20 April - 21 May 2015		Work program for EQA of Fehmarn traffic developed	COWI (2015a)
28 April 2015	Parliament passes Construction Act L141 conditionally		Danish Parliament (2015)
1 June 2015		EQA of competition by ferry services started	KPMG (2016)
1 October 2015		“Due diligence” of reserves and risk distribution	TRM (2015a)
21 October 2015		Commissioning of EQA of tunnel construction reserves and risks	Ernst & Young (2016)
10 November 2015		EQA of road traffic forecasts published	COWI (2015b)
12 November 2015		EQA of road traffic transfer from the Great Belt requested	TRM (2015d)
24 January 2016		EQA of competition by ferry services published	KPMG (2016)
28 January 2016		EQA of tunnel construction costs, reserves and German approval process published	Ernst & Young (2016)
4 March 2016	Binding political agreement about future development		Danish Parliament (2016)
4 March 2016	Upgrading of existing rail track begins		Ingeniøren (2016a)
30 May 2016	Conditional tunnel construction contracts signed		Femern A/S (2016d)
17 March 2017	Contracts signed with engineering consultants		Femern A/S (2017d)
17 March 2017		EQA of road traffic transfer from Great Belt not yet completed	S&B (2017b)

of *New Construction Budgeting*, external quality assurance at Level 2 should be carried out before the decision-to-build is taken in Parliament, usually represented by the passing of the construction act. Obviously, in the Fehmarn Belt case the decision process is creeping. It is a mix of unconditional and conditional decisions taken over time, constantly increasing the cost incurred and approved while confirming the commitment to build. The decision-to-build was in fact taken already on 2 September 2008 by the binding political agreement because it was unconditional: No matter how costs and other consequences develop the agreeing political parties wanted to build. This decision was reconfirmed several times during the following years. The phenomenon is characteristic of a particular culture in the Danish Parliament: Once a binding political agreement has been reached it will be practically unbreakable independent of changing circumstances. Furthermore, there are no obligations to take down minutes of meetings between members of Parliament or to make them available to the public.

Obviously, it is seen from **Table 1** that none of the external quality assurance activities was timed in accordance with the guidance of *New Construction Budgeting*. The earliest attempts were made in 2012 and concerned the land works, [KPMG \(2012\)](#) and [Deloitte \(2012\)](#), but at that time construction works had already begun, [Danish Parliament \(2011\)](#), and construction costs already incurred. The rest of external quality assurance activities were all begun after the construction act had been passed, [Danish Parliament \(2015\)](#), some are even not completed yet, [TRM \(2015d\)](#). Additional spending was authorized by another binding political agreement, [Danish Parliament \(2016\)](#). In March 2016 costs totaling DKK 13.2 billion had been spent or allocated while still awaiting German approval, [Ingeniøren \(2016a, 2016c\)](#). “In practice, Danish politicians have made the project too big to fail”, Bent Flyvbjerg said in [Ingeniøren \(2016c\)](#), (translated by the author). Since then, major contracts representing a value of approximately DKK 30 billion were conditionally signed with the tunnel contractors, [Femern A/S \(2016d\)](#). Consequently, it is fair to conclude that the timing of external quality assurance has been inadequate in relation to the practical decision process and the accelerating economic commitment. Some initial investigations by the author on the external quality assurance were presented, [Schjær-Jacobsen \(2016d\)](#). A status of the Fehmarn Belt fixed link may be found in [TRM \(2017a\)](#).

3. Road Traffic Forecasts

The consulting company COWI was chosen to perform external quality assurance of the road traffic forecasts. Since COWI has a major interest in the realization of the Fehmarn Belt fixed link and is a consulting partner of the consortium Fehmarn Link Contractors that won the Tunnel North Contract, the Tunnel South Contract and the Tunnel Portals and Ramps Contract (only the Tunnel Dredging and Reclamation Contract was won by another consortium), [Ingeniøren \(2016b\)](#) and [Femern A/S \(2016d\)](#), it is obvious that COWI is disqualified as an independent, external quality assurance consultancy as required by *New*

Construction Budgeting and by common sense as well.

During April and May 2015, the work program, COWI (2015a), for an external quality assurance of the road traffic forecasts was negotiated between The Ministry of Transport and COWI simultaneously with the preparatory work of the construction act. The method adopted for the quality assurance was *New Construction Budgeting*, TRM (2006a, 2010a, 2010b, 2011a). When the report came out, COWI (2015b), the initiative had not been announced publicly, and the timing was peculiar considering that the subject of traffic forecasts was not considered to be critical in relation to the passing of the construction act, Danish Parliament (2015). The early traffic forecasts, FTC (1999, 2003), had been criticized by Jespersen (2007) and Vieregg-Rössler GmbH (2008) and Andersen (2014) and the updated forecasts, Intraplan/BVU (2014a, 2014b, 2015a) and Femern A/S (2014a), by Andersen (2015) and DIW Econ GmbH (2015a, 2015b, 2015c). The criticism was answered, Femern A/S (2015a), but the matter was not closed. Consequently, at the time of Parliament passing the construction act there was plenty of evidence that the traffic forecasts were under heavy external criticism for being way too optimistic. Nevertheless, the construction act was passed without mentioning any doubts concerning the validity of the traffic forecasts. Apparently, the Ministry of Transport had second thoughts, as it decided to commission the external quality assurance, COWI (2015a, 2015b).

During the years 1999-2015 the estimated construction costs of the fixed link had escalated considerably, thereby jeopardizing the entire project (see Section 4). It is interesting to observe that the road traffic forecast during the same period underwent a substantial growth in volume, FTC (1999), FTC (2003), Intraplan/BVU (2014a, 2014b, 2015a) and Femern A/S (2014a).

The external assurance report, COWI (2015b: p. 9) has a main conclusion in two parts (translated by the author):

“The main conclusion is that COWI assesses that the traffic forecast of the main scenario is a realistic estimate of the traffic volume on a Fehmarn Belt fixed link provided the ferry operation Rødby-Puttgarden is discontinued. The forecasted growth over time corresponds to the historical growth in later years. The assumptions are considered reasonable and the forecast models are consistent with the professional practice of traffic forecasts. However, we think that there are elements in the forecast that appear to be difficult to substantiate. Particularly, the expected transfer of passenger car traffic from the Great Belt is difficult to substantiate due to a lack of data concerning the actual traffic pattern crossing the Great Belt fixed link. The forecast is conservative in estimating the creation of new traffic due to the lack of tools for forecasting the potential dynamic effects of the fixed link”.

In the report COWI does not address several fundamental questions of great importance for the trustworthiness of the traffic forecasts, such as the inability of the forecasting method, FTC (2003) and Intraplan/BVU (2014a, 2014b), applied to handle the complexity created by two different segments of passenger cars (Europe travelers and border shoppers) and two competing transport modes

(tunnel and ferry). Likewise, the lack of evaluating the degree of uncertainty in data for the traffic forecasts is ignored. However, the estimated transfer of passenger car traffic from the Great Belt is explicitly addressed. This is particularly important because the estimated volume amounts to approximately 800,000 one-way cars per year, corresponding to approximately 25% of the expected tunnel traffic.

Despite the reservation in the main conclusion and the weaknesses mentioned above the Minister of Transport is quoted as saying on 12 November 2015 (translated by the author): “COWI has found that the traffic forecast is thorough and presents a realistic estimate of the tunnel traffic. This is an important conclusion and then we politicians can concentrate on the remainder of the project”, TRM (2015c). The minister’s omission was pointed out, Bredsdorff (2015b) and Schjær-Jacobsen (2015b), but even more interestingly: On the very same day, namely 12 November 2015, as the Minister of Transport approved the traffic forecast quality assurance, it turned out that the Ministry of Transport requested an analysis, TRM (2015d) and Sund & Bælt Holding (2016), of the traffic transfer from the Great Belt which has not yet been delivered although announced to be finished by 1 February 2017, at the latest. 16 months after being requested, the analysis has not yet been completed and results have not even been exchanged between Sund & Bælt Holding, Femern A/S and the Ministry of Transport, Sund & Bælt Holding (2017b). Being the exclusive owner of the project company Femern A/S and the future operator of the Fehmarn Belt fixed link on behalf of the Danish state, Sund & Bælt Holding does certainly not qualify as an independent external consultancy for quality assurance.

The transfer of passenger car traffic from the Great Belt fixed link to the Fehmarn Belt fixed link had already caused some controversy, COWI (2011), Femern A/S (2011b), Andersen (2015), Femern A/S (2015d), Sund & Bælt Holding (2015), and Intraplan/BVU (2015b), but no trustworthy forecast has been produced so far.

Although the growth of traffic crossing the Fehmarn Belt during the period 2011-2019 is markedly lower than presumed in the traffic forecasts, the long-term growth assumption is maintained by the Ministry of Transport, Ingeniøren (2016e).

Commissioned by the Ministry of Transport and unknown to the public, a consulting company had already started a business analysis of the Scandlines ferry business by 1 June 2015, and the confidential report was finished by 14 January 2016, KPMG (2016). Prompted by a leakage of the report to a German journalist, the report was made public by the Ministry of Transport by 14 March 2016. As to be expected, Scandlines was furious about having been kept ignorant of the work and the content of the report as well, TRM (2016b), and commissioned a response report, Deloitte (2016). The two reports arrive at completely opposite conclusions. The former concludes (translated by the author): “After opening of the fixed link in 2026 Scandlines will be a loss-generating business”. The latter concludes: “In our opinion, there are significant uncertainties related to conclusion in the KPMG report that the Rødby-Puttgarden ferry service be

loss-making from 2026. We consider it more likely that the Rødby-Puttgarden ferry service will continue to be profitable in 2026". To the author's knowledge the only attempts to base this discussion on a genuine competitive theory were [DIW Econ GmbH \(2015c\)](#) and [Aigner \(2016\)](#). Particularly the latter suggests that the ferry is a much stronger competitor to the fixed link than assumed and that one should not take it for granted that the ferry will exit the market. In fact, it seems more likely that the ferry will make positive profits in equilibrium and stay in the market. This is quite a challenge for the fixed link because the results also suggest that if the ferry competes, the tunnel will not be a profitable business, [Aigner \(2016\)](#).

4. Reserves and Risk Distribution of Tunnel Constructions

Already in 2012, the external quality assurance of the Danish land works was carried out according to the procedures laid out in *New Construction Budgeting, TRM (2006a)*, for the railroad constructions, [KPMG \(2012\)](#), and the E47 South Motorway, [Deloitte \(2012\)](#). No serious problems were uncovered and these sub-projects of the Fehmarn belt fixed link are non-controversial, partly because they are standard technology. The estimates of the land works construction costs have been stable over time and reserves have been allocated in accordance with *New Construction Budgeting*, see [Table 2](#).

Otherwise, see [Table 2](#) for the coast-to-coast tunnel construction costs. Even though *New Construction Budgeting* did not apply, two alternative calculations were made in 2014, one with reserves of only 14% and one with 30%, [Femern A/S \(2014b\)](#). The former was based on estimates from the tunnel construction consortia, the latter on requirements from *New Construction Budgeting*. Only a few months later the construction costs exclusive of reserves had risen from DKK 40.5 to 49.4 billion due to new incoming bids from the tunnel construction consortia, [Femern A/S \(2015b\)](#), increasing the payback period to 39 years. This was essentially the financial calculation behind the presentation of the construction act L141 to Parliament, [Danish Parliament \(2015\)](#). However, tunnel construction costs were increased by DKK 2 billion and reserves reduced by DKK 1.8 billion, see [Table 2](#). A brief status report was issued at the same time, [Femern A/S \(2015c\)](#). The construction act was passed conditionally, meaning that construction work startup had to await a negotiated reduction of construction costs, a clarification of the amount of EU subsidies that could be obtained, and an acceptable time schedule for the German environmental project approval. It turned out that negotiations with the tunnel construction consortia resulted in lower bids, a prolonged construction period, and a redistribution of risks between the master builder and the construction consortia, [Femern A/S \(2016b\)](#). The question about EU subsidies was clarified by 29 June 2015, resulting in much lower subsidy than expected, [Børsen \(2015\)](#). A time schedule for the German approval process has not yet been presented by the Germans, [Femern A/S \(2016f\)](#).

On 1 October 2015, the Danish Ministry of Transport decided to have a "due

Table 2. Base Case construction costs of the Fehmarn Belt fixed link. Based on Schjær-Jacobsen (2016c).

Base Case construction costs (DKK billion)	Femern A/S (2014b) Main Scenario	Femern A/S (2014b) Table 20	Femern A/S (2015b)	Danish Parliament (2015)	Femern A/S (2016a)
Price level	2014	2014	2014	2015	2015
Danish land works					
Construction costs excl. reserves	7.3	7.3	7.3	7.3	7.3
Correction allowance (10%)	0.7	0.7	0.7	0.7	0.7
Reserves (20%)	1.5	1.5	1.5	1.5	1.5
Sum reserves	2.2	2.2	2.2	2.2	2.2
Sum reserves (%)	30%	30%	30%	30%	30%
Sum construct. costs incl. reserves	9.5	9.5	9.5	9.5	9.5
Coast-to-coast construction					
Construction costs excl. reserves	40.5	40.5	49.4	45.8	38.9
Project preparation, organisation etc.				5.6	6.4
Total construction costs excl. reserves	40.5	40.5	49.4	51.4	45.3
Reserve for contractor risk	1.8	1.8	1.8		
<i>Other reserves:</i>					
Client reserve	3.7	3.7	3.7		
Extra reserves (16.4%)		6.7			
<i>Total other reserves</i>	3.7	10.5	3.7		
Sum reserves	5.5	12.3	5.5	3.7	7.3
Sum reserves (%)	14%	30%	11%	7%	16%
Sum construction costs incl. reserves	46.0	52.7	54.9	55.1	52.6
Total project					
Total construction costs excl. reserves	47.8	47.8	56.7	58.7	52.6
Total reserves	7.7	14.5	7.7	5.9	9.5
Total reserves (%)	16%	30%	14%	11%	18%
Total construction costs incl. reserves	55.5	62.2	64.4	64.6	62.1
Base Case Payback Period (Years)	32	37	39	39	36
Partial sensitivity analysis (Years)	[28; 41]	NA	NA	NA	[31; 48]

diligence” made, TRM (2015a) and on 21 October 2015, the agreeing political parties, Danish Parliament (2009a), decided to commission an external assessment and quality assurance of the Fehmarn Belt fixed link reserves and risk distribution between the master builder and the main contractors of the tunnel construction works, including a perspective of the delay of the German approval process, Ernst & Young (2016). This initiative was taken after the construction act was conditionally passed by the Danish Parliament, Danish Parliament (2015). The task was to answer four questions (translated and edited by the author):

- 1) How are today’s risks distributed between the master builder and the con-

struction consortia and how were they distributed earlier? 112 risks were identified, 9 of which changed the risk allocation and 12 caused a change of Fehmarn A/S's risk exposure. Only 10% - 15% of the reported cost reduction is caused by change of risk distribution while 85% - 90% is caused by a reduction of tasks and an increase of the building period.

2) Does the risk distribution correspond with the common praxis of construction contracts for large projects? The actual distribution is comparable with international standards of other large international projects. The risk distribution should be supported by an improved risk management process.

3) What are the risks connected with the German approval plan? Are there sufficient reserves to cover additional costs of the German approval plan and special approval conditions, that may cause additional costs, delays etc. in the construction phase? It is highly likely that the construction work can be started during the period medio 2018 - medio 2020. Approximately 25% of the actual reserves are related to the German approval process. There are still several unknown circumstances connected to the German approval process.

4) How many reserves should be included in the construction budget based on the binding bids? Since 75% - 80% of the total construction costs are covered by the bids, a reserve of minimum 15% - 20% at a P80 level gives a greater confidence that the reserves are sufficient. Benchmarking with other projects indicates reserves of 10% - 20%. The necessary reserves are calculated to be DKK 7.3 billion at a P80 level, [Femern A/S \(2016a\)](#).

In [Ernst & Young \(2016\)](#) it is further observed that the risk categories applied by [Femern A/S \(2014b, 2016a\)](#) are not in compliance with the recommendations in *New Construction Budgeting*, [TRM \(2010a\)](#). This could lead to a problem in relation to the Ministry of Transport reporting process. It is further observed that uncertainty of revenue is ignored and missing in the analyses, [Femern A/S \(2014b, 2016a\)](#).

The statistical approach applied by [Ernst & Young \(2016\)](#) to arrive at a forecast of the date of the German approval is criticized, [Ingeniøren \(2016d\)](#). Actually, the approval has already been delayed by another 6 months since the forecast was published, [TRM \(2016c\)](#). Consequently, it is highly likely that construction work *cannot* be started before medio 2020. The delay of the German environmental approval has got the political attention of the Danish Minister of Transport. Bypassing the political parties behind the project as well as the state government of Schleswig - Holstein he addresses the federal government in Berlin directly to find ways of speeding up the approval process, [TRM \(2017b\)](#).

5. Financial Analysis and Uncertainty

The financing of the fixed link across the Fehmarn Belt is based on a state-guaranteed model. The model entails financing of the project via loans guaranteed by the Danish Government which are to be repaid via revenue from the users of the fixed link. These and further details of the Fehmarn Belt immersed tunnel project are available from the project company, [Femern A/S](#)

(2017b), fully owned by the state company, Sund & Bælt Holding A/S, S&B (2017).

The political criteria for the go/no-go of the project were expressed at the first readings of the construction act L141 on 18 March 2015, Danish Parliament (2015), by the spokesman of the Liberal Party of Denmark using the metaphor of traffic lights, Lorentzen (2015): “With the actual economic assumptions, the expected payback period is 39 years. This means that we are still in the green zone. The Liberal Party does not want to go into the yellow or red zone, thereby taking the risk that the taxpayers must pay part of the project”. When asked about what lengths of the payback period he associated with the colored zones mentioned, he responded: “We have the rule of thumb in the Liberal Party - and I think this is also the case elsewhere - that as long as we are under 40 years we are in the green zone, then we are on safe ground regarding the taxpayers avoiding to pay. When we are between 40 and 50 years we are in the yellow zone, then it begins to be on shaking ground. When we are over 50 years we are in the red zone and we must stay completely out of that one, that is what I mean”, quoted from Schjær-Jacobsen (2016b, 2017a).

Based on alternative calculations, Bredsdorff (2015a), Schjær-Jacobsen (2015a), Rasmussen (2015), the finances of the Fehmarn Belt business case were criticized prior to the passing of the construction act on 28 April 2015.

Although of immense importance for the financial feasibility of the fixed link project, the external quality assurance efforts carried out as described in this paper did not address such vital items as:

- Inability of the traffic forecasts methods to handle a business case subject to competition.
- Transfer of road traffic from the Great Belt to the tunnel (quality assurance requested 16 months ago).
- Uncertainty analysis of road traffic volume.
- Tariffs for tunnel road traffic.
- Uncertainty analysis of road traffic income.
- Amount of EU subsidies.
- Economic consequences of needed renegotiations of main tunnel construction contracts.
- Maintenance and administration costs of the fixed link.
- Consolidated financial analysis of the business case.
- Financial risk and uncertainty analysis of the business case.

Genuine uncertainty analyses beyond simple partial sensitivity analyses applied by Femern A/S can be found in Table 3. By comparison with Table 2 it turns out that the financial uncertainties are much larger than the impression left by the official financial reports conveyed to Parliament and the public. Clearly, the likelihood that the Payback Period will be in the green zone is practically equal to zero.

Consequently, the external quality assurance was rather incomplete leaving large areas of continued doubt concerning the financial performance of the fixed link.

Table 3. Payback periods and uncertainty analyses. Extracted from Schjær-Jacobsen (2016b, 2017a).

Payback Periods and uncertainties	Base Case 1	Base Case 2
Road traffic income/volume	Femern A/S (2014b)	DIW Econ GmbH (2015b)
Tunnel construction costs excl. reserves (DKK billion)	40.5	49.4
EU subsidies (DKK billion)	10.3	4.4
Base Case Payback Period (Years)	37	>60
Likelihood of Payback Period in green zone	7.5%	0.0%
Likelihood of Payback Period in yellow zone	55.9%	12.3%
Likelihood of Payback Period in red zone	36.6%	87.7%
Worst and Best Case (Years)	[37; >60]	[48; >60]

Since the most recent financial analysis, Femern A/S (2016a), exhibiting a Base Case Payback Period of 36 years and a partial sensitivity range of [31; 48] years (see Table 2) and the external quality assurance of reserves and risk distribution, Ernst & Young (2016), was published, a lot of things happened, for example:

- Tunnel contractors have been appointed, Femern A/S (2016c), and conditional tunnel construction contracts have been signed, Femern A/S (2016d). Thus, extra costs will be incurred due to stand-by fees until construction start-up and additional costs for keeping Femern A/S operating over an extended period, estimated in total to DKK 0.5 billion per year.
- A renewed application for German approval has been completed and submitted, Femern A/S (2016e), replacing the previous one, Femern A/S (2013). This has incurred extra costs.
- The German approval process has been delayed by another 6 months, TRM (2016c). Consequently, the tunnel construction contracts must be renegotiated because the German approval will probably not be obtained before the contracts expire. The amount of extra costs is unknown.
- Answers to 12,600 German objections to the fixed link projects have been completed and submitted, Femern A/S (2017a). This has been a cumbersome and costly affair, costs being unknown.
- Scandlines announces long term competition with the Fehmarn Belt fixed link by upgrading the Gedser-Rostock ferry connection, Børsen (2017a). This initiative may cut away a substantial part of the forecasted traffic transfer from Gedser-Rostock to the Fehmarn tunnel.
- Scandlines announces a possible court case concerning obstruction of ferry operations during the tunnel construction period, Børsen (2017b).
- Femern A/S signs contracts with two consortia of engineering consultants, Femern A/S (2017d).

On 27 February 2017, Femern A/S (2017c), it is claimed that the financial analysis from 3 February 2016, Femern A/S (2016a), is still valid. No new financial analyses are presented, only one-year old key figures are repeated. Appar-

ently, all the above-mentioned potential costs are expected to be accommodated in the budget without depleting the reserves and jeopardizing the economy of the project. Particularly notable is the absence of any kind of risk or uncertainty analysis, not even partial sensitivity analyses are included. In the author's opinion, the Fehmarn Belt fixed link business case is still a financial high-risk project, as pointed out by Schjær-Jacobsen (2016a, 2017a), despite the efforts of the project owners to rationalize the decisions and the economic commitments made by performing external quality assurance.

6. Conclusion

In summary, the external quality assurance dealt with in this paper includes the following official reports (in chronological order) as well and the contexts in which they were created, published, and received:

- KPMG (2012). EQA of railroad constructions.
- Deloitte (2012). EQA of E47 South Motorway.
- COWI (2015b). EQA of road traffic forecasts.
- KPMG (2016). EQA of competition by ferry services.
- Ernst & Young (2016). EQA of tunnel construction reserves, risk distributions and German approval process.
- Sund & Bælt Holding A/S, EQA of road traffic transfer from the Great Belt to Fehmarn Belt (in process since 12 November 2015).

The paper finds that the quality assurance concerning the Danish land works is carried out in compliance with the principles laid out in *New Construction Budgeting* concerning completeness, timeliness and trustworthiness.

This is not the case concerning the tunnel construction work and the entire business case including Danish land works. Paradoxically, *New Construction Budgeting* is claimed not to apply but nevertheless it is invoked, however in general not complied with. The quality assurance commissioned and carried out is not complete, since large and important issues are not dealt with and left out of the analyses. The quality assurance is not timely since it is carried out at times when decisions and large economic commitments have already been made. Largely, the quality assurance is limited in trustworthiness, partly due to bad timing, partly due to lack of independence of consultancies, and partly due to findings of opposing analyses. In other words, the external quality assurance of the Fehmarn Belt fixed link business case is too little, too late, and too unreliable. Thus, the Fehmarn Belt fixed link project is still a high-risk business case, which contrasts with the impression created by official communications. The political majority of the Danish Parliament has decided to continuously promote the Fehmarn Belt fixed link project despite the large likelihood of a financial project failure. Generally, the external quality assurance efforts have not contributed to verification of the financial viability of the project.

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Appendix: Timeline

Fehmarn Belt fixed link analyses, decisions, external quality assurance (EQA), and external criticism. Extracted from References.

Date	Analysis	Decision	External Quality Assurance (EQA)	External criticism	Reference
January 1999	Traffic demand study				FTC (1999)
August 1999	Economic investigations				TRM (1999)
6 December 2000		Further development of fixed link			State Memorandum (2000)
June 2002	Finances and organization				FDJV (2002)
March 2003	Summary report				TRM (2003)
March 2003	Financial analysis				Femern A/S (2003)
1 April 2003	Traffic forecast				FTC (2003)
29 March 2004	Economic analysis				COWI (2004)
23 June 2004		Cooperation, Germany-Denmark			State Memorandum (2004)
June 2004	Financial analysis				TRM (2004)
19 December 2006	Overview of project				TRM (2006b)
19 June 2007		Scandlines sold off			Berlingske Business (2007)
29 June 2007		Memorandum of understanding			State Memorandum (2007)
August 2007				Road freight transport	Jespersen (2007)
January 2008				Traffic forecasts and cost calculations	Vieregg-Rössler GmbH (2008)
2 September 2008		Binding political agreement to build			Danish Parliament (2008)
3 September 2008		Agreement Denmark- Germany			State Treaty (2008)
September 2008	Financial analysis				Femern A/S (2008)
29 January 2009		Binding political agreement			Danish Parliament (2009a)
15 April 2009		Parliament passes Planning Act No. 285			Danish Parliament (2009b)
1 November 2010	Construction costs of a cable sustained bridge				Femern A/S (2010a)
1 November 2010	Construction costs of an immersed tunnel				Femern A/S (2010b)
1 November 2010	Construction costs of bridge and tunnel				Femern A/S (2010c)
1 February 2011		Backing of immersed tunnel			Femern A/S (2011a)
16 February 2011	Customer survey of Fehmarn Belt				COWI (2011)
21 April 2011	Great Belt traffic Zealand-Germany				Femern A/S (2011b)

Continued

25 May 2011		Proposal of production site		Femern A/S (2011c)
1 June 2011		Decision on production site		TRM (2011b)
23 June 2011		Construction activities advanced, Act No. 149		Danish Parliament (2011)
24 August 2011	Construction costs of immersed tunnel			Femern A/S (2011d)
17 April 2012	Time schedule for tunnel construction			Femern A/S (2012)
26 April 2012			EQA of railroad published	KPMG (2012)
8 June 2012			EQA of E47 South Motorway published	Deloitte (2012)
20 March 2013		Call for tenders, Act No. 97		Danish Parliament (2013)
1 October 2013		Application for German approval		Femern A/S (2013)
June 2014			Critical analysis of 2003 traffic forecasts	Andersen (2014)
November 2014	Update of traffic forecasts from 2002			Intraplan/BVU (2014a, 2014b)
November 2014	Traffic forecast			Femern A/S (2014a)
November 2014	Financial analysis			Femern A/S (2014b)
January 2015			Critical analysis of 2014 traffic forecasts	Andersen (2015)
16 January 2015			Analyses based on misinterpretation	Femern A/S (2015a)
20 January 2015			Comments to new traffic forecasts	DIW Econ GmbH (2015a)
17 February 2015	Status of construction budget			Femern A/S (2015b)
19 February 2015			Investigation of cost-benefit analysis	DIW Econ GmbH (2015b)
2015			Robustness of financial analysis	DIW Econ GmbH (2015c)
February 2015	Addendum to update of traffic forecasts			Intraplan/BVU (2015a)
2015	Transfer of Great Belt road traffic			Intraplan/BVU (2015b)
26 February 2015	Status of work in Femern A/S			Femern A/S (2015c)
2 March 2015			Under estimation of financial uncertainty	Schjær-Jacobsen (2015a)
9 March 2015			Worst investment in Danish history	Rasmussen (2015)
20 April - 21 May 2015			Work program for traffic EQA	COWI (2015a)
21 April 2015	Road users on the Great Belt			Femern A/S (2015d)
28 April 2015		Construction Act L141 passed conditionally		Danish Parliament (2015)

Continued

5 May 2015	Foreign passages of the Great Belt		S&B (2015)
1 June 2015		EQA of ferry services started	KPMG (2016)
29 June 2015	EU appropriates reduced subsidy		Børsen (2015)
1 October 2015		“Due diligence” of reserves etc.	TRM (2015a)
2 October 2015		Financial uncertainty analysis	Bredsdorff (2015a)
21 October 2015		EQA of tunnel commissioned	Ernst & Young (2016)
10 November 2015		EQA of road traffic forecasts published	COWI (2015b)
11 November 2015	Appl. of <i>New Construction Budgeting</i>		TRM (2015b)
12 November 2015	Traffic forecast approved by Minister		TRM (2015c)
12 November 2015		EQA of road traffic transfer requested	TRM (2015d)
20 November 2015		Traffic transfer from the Great Belt	Bredsdorff (2015b)
26 November 2015		Minister ignores criticism from EQA	Schjær-Jacobsen (2015b)
13 January 2016		Financial high risk project	Schjær-Jacobsen (2016a)
20 January 2016		Proposal of Great Belt traffic analysis	S&B (2016)
24 January 2016		EQA of competition by ferry services published	KPMG (2016)
28 January 2016		EQA of tunnel published	Ernst & Young (2016)
January 2016		Competition between ferry and tunnel	Aigner (2016)
3 February 2016	Financial analysis		Femern A/S (2016a)
10 February 2016	Memo: Financial analyses		Femern A/S (2016b)
22 February 2016		High risk business case	Schjær-Jacobsen (2016b)
4 March 2016	Binding political agreement		Danish Parliament (2016)
4 March 2016	Upgrading of existing rail track begins		TRM (2016a)
4 March 2016	Upgrading of existing rail track begins		Ingeniøren (2016a)
4 March 2016		COWI is the big winner	Ingeniøren (2016b)
10 - 18 March 2016		Correspondence Scandlines-Ministry	TRM (2016b)

Continued

11 March 2016		Project is “too big to fail”	Ingeniøren (2016c)
21 March 2016		Criticism of EQA of German approval	Ingeniøren (2016d)
31 March 2016		Five questions answered by TRM	Ingeniøren (2016e)
3 April 2016		Preferred tunnel contractors appointed	Femern A/S (2016c)
30 May 2016		Tunnel construction contracts signed	Femern A/S (2016d)
13 June 2016		Renewed application for German approval	Femern A/S (2016e)
24 June 2016		Review of KPMG quality assurance	Deloitte (2016)
22 August 2016		Revisiting financial uncertainty	Schjær-Jacobsen (2016c)
8 September 2016		Financial uncertainty	Schjær-Jacobsen (2016d)
14 November 2016	Memo: German approval status		Femern A/S (2016f)
12 December 2016	German approval delayed by 6 months		TRM (2016c)
2017	Status of Fehmarn Belt construction project		TRM (2017a)
14 February 2017		High risk business case	Schjær-Jacobsen (2017a)
15 February 2017	12,600 German objections answered		Femern A/S (2017a)
16 February 2017		Letter to Federal Minister of Transport	TRM (2017b)
27 February 2017	Confirmation of financial analysis		Femern A/S (2017c)
14 March 2017		Scandlines announces possible court case	Børsen (2017b)
17 March 2017		Engineering consultants signed up	Femern A/S (2017d)
17 March 2017		EQA of traffic transfer from GB uncompleted	S&B (2017b)

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