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***THE STOREBÆLT FIXED LINK :  
THE FIXING OF MULTIPLICITY***

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**Groupe Bagnolet**

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## **THE STOREBÆLT FIXED LINK: THE FIXING OF MULTIPLICITY**

RESUME .....	3
INTRODUCTION .....	5
CHRONOLOGY OF THE STOREBÆLT FIXED LINK.....	5
SETTING UP A CLIENT .....	8
FIRST PROJECT MANAGEMENT MOVES OF A/S STOREBÆLTSFORBINDELSEN....	10
PROCUREMENT STRATEGIES AND THE FORMATION OF CONSORTIA .....	11
THE "BUY-DANISH-CLAUSE" .....	12
THE LOCALISATION OF CONTRACTS AND INVESTMENTS .....	13
FINANCING, BUDGET AND PLANNING DEVELOPMENTS .....	14
MANAGING AN INTERNATIONAL CONSORTIUM .....	15
CONCLUDING REMARKS .....	17

# THE STOREBÆLT FIXED LINK : THE FIXING OF MULTIPLICITY

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## RESUME

Cette contribution décrit la réalisation d'un projet d'infrastructure nord-européen notoire: le lien fixe de 16 km du Storebaelt, reliant l'Est et l'Ouest du Danemark. La construction de ce lien, achevée en juin 1998, pour un montant total de 22 milliards de couronnes danoises (prix 1988), a réuni une série de consortiums multinationaux. Notre recherche a porté sur l'analyse de la politique publique, des stratégies d'entreprises et du management technologique, dans la perspective de la constitution d'un marché européen de la construction et de l'ouverture à la concurrence internationale. Il retrace l'historique du processus de décision publique, en s'appuyant sur l'examen des plans et des spécifications du projet. Il développe une approche constructiviste en montrant comment la multitude d'intérêts en présence a conduit à un agrément sur la conception d'un lien fixe combinant la route et le rail.

Pour la première fois dans la politique de transport au Danemark, le régime de la concession est appliqué à un projet d'infrastructure. La société publique concessionnaire ne mise, en retour de ses investissements, que sur les péages pour les automobilistes et sur les taxes versées par la compagnie publique de chemins de fer. En effet, les infrastructures de transport au Danemark ont toujours été, jusqu'ici, financées sur le budget annuel de l'Etat et gérées par des agences publiques dépendant du Ministère des Transports.

Après une présentation des grandes étapes de la chronologie du lien fixe et de son organisation, l'analyse porte sur les montages contractuels. Trois d'entre eux concernent des grandes entreprises associées en joint ventures internationales tandis que le quatrième - le contrat de travaux pour le pont de l'East bridge - a été attribué à une entreprise générale italienne. Cette diversité traduit les différentes stratégies du concessionnaire qui, dans ce dernier cas, a retenu l'entreprise italienne sur la base de sa conception de la superstructure.

La différence de cultures managériales et d'organisation, issues de divers systèmes nationaux, a marqué aussi bien les rapports au sein et entre les entreprises que leurs relations au client. D'après l'expérience des équipes multinationales, il semble bien qu'une année soit nécessaire pour obtenir entre elles une coopération efficace.

Une attention spéciale est portée à la construction du tunnel ferroviaire. Le choix technologique du creusement de tunnel répondait à l'origine à des considérations environnementales justifiées par la présence de couches glaciaires en mélanges complexes sous le Storebaelt. L'inondation du tunnel et des machines a constitué un événement marquant entraînant des conséquences pour les entreprises du groupement international, en particulier le changement de direction du projet, qui est passé de l'entreprise danoise au groupe français. Bien que le projet dans son ensemble ait rencontré de graves difficultés sur le plan technologique, et d'importants dérapages en termes de budget et de planning, la livraison du tunnel démontre néanmoins une étonnante capacité à gérer avec succès une technologie innovante et à répondre véritablement au défi technique. Sans doute l'apprentissage organisationnel au sein du consortium a-t-il permis de compenser l'importance des risques encourus.

En conclusion, le cas du Storebaelt est riche d'enseignements pour les différents acteurs de la construction, notamment en ce qui concerne le management technologique et l'apprentissage

organisationnel. Les retombées de ce transfert technologique pourraient être exploitées pour les futurs développements en joint venture en Scandinavie et sur le reste du continent européen.

## INTRODUCTION

The aim of this paper is to provide overview of and insight into a major construction project of our time, the fixed link across Storebælt in Denmark. Five research themes central to the characterisation of such large international projects will be addressed in accordance with the methodology articulated by the Groupe Bagnolet. The overall objective of combining these perspectives is to identify essential *points of friction* around which the main actors of construction mediate their co-operation and develop their competencies.

As the single elements of this conceptual framework have been further elaborated in a series of *theme papers*, it has not been within the scope of this paper to evaluate its relevance as a global structuring tool for understanding large international construction projects. This methodological perspective is of course also central to future efforts in the Groupe Bagnolet. In this connection, however, the thematic structure serves the purpose of bringing order to a first generation analysis of large amounts of empirical data.

At the time of completion of this paper, the road part of the Storebælt link was just being completed and put into operation. This means that only limited parts of the project could be analysed retrospectively as closed events. On the other hand the possibility of being able to monitor real time sequences and their impacts in organisations often reveal more accurately the successively developing interdependent relations between actors and structures in such organisations. It should, however, be stated that these conditions together with other practical circumstances had an influence on the access to information, leading to a quite heterogeneous and non-systematic pile of empirical data of restricted analytical validity. Consequently this study is rather narrative in its substance.

The main sources of information referred to are firstly a number of interviews with client and consortia representatives, executed during two periods in the summer of 1994 and in the early 1996. Secondly the client organisation published a fairly comprehensive flow of PR material throughout the entire project period. And thirdly more research oriented studies, although few in number, have been drawn upon whenever possible. It is hoped that this paper despite, or perhaps because of, its methodological broadness and sporadically composed empirical basis, will advance the understanding of the multiplicity of driving forces within the entirety of large construction projects and thus inspire further research into the nature and intervening mechanisms of these forces.

## CHRONOLOGY OF THE STOREBÆLT FIXED LINK

Bridges have a way of coming in shoals (Axél 1992). This saying has proved its validity in twentieth century Denmark. During a short inter-war period in the thirties two very large bridges were constructed, linking up major regions of the Danish insular topography. One of these, *Storstrømsbroen*, with its 3.5 km full length is among Europe's largest. Whereas it can be assumed that the profound economic depression of the thirties released decisive political support for these projects, this activity generating perspective cannot alone explain the second major shoal of bridges towards the end of this century, the Storebælt and the Øresund fixed links, which are now under construction, (and with vast probability encompassing also a Femern Belt link).

In most exceptional fixed link projects, for instance the Channel tunnel (see Working Paper 11), the conceptualisation of the first proposals can historically be traced back to the boundless visions of industrialisation in its childhood. The idea of a fixed link across Storebælt was first presented to the Danish parliament mid-19th century by war minister Tscherning, obviously emphasising the military strategic gains inherent in the project!

Throughout Danish history the notion of *east and west Denmark* was indeed constituted by the Storebælt, some 20 km wide, between the eastern island Zealand with the capital Copenhagen and the western island Funen, which is linked to the main land Jutland. With Zealand's

geographical and cultural proximity to Scandinavia and Jutland being part of the European mainland, the Storebælt has politically been associated with a wall of water impeding steady and homogenous development of national unity. However, the significance of this conception should be seen primarily as ideological wrapping to much more tangible arguments in the fixed link decision debate. (Nevertheless at a certain point in the decision process, when the demand for an Øresund link was strongly put forward by in particular Swedish multinational industrial interests, the anxiety about national unity was accepted as a definite reason for a political agreement stating that the Storebælt link should be constructed first of the two.)

Not surprisingly the steady development of car-based transport technology and its significant growth rates from the post-war years and onwards have represented the dominant themes in this debate. The first government board, specifically appointed to work on a fixed link solution to traffic problems on the Storebælt, was set up in consequence of the ice-winter in 1947, which hindered all traffic between east and west Denmark for weeks. Already at that time the board's working premises were changing rapidly: more than a doubling of car crossings in three years from 110.000 in 1948 to 300.000 in 1951 (Axél 1992 p. 15).

Already at that time the debate among professionals concerning the technical design of a fixed link identified a variety of construction methods, which were all considered technologically practicable but of course more or less economically realistic. A bored tunnel as well as a suspended bridge and the idea of using the island Sprogø as a technology split point were put on the agenda in the discussion. It may be claimed that - although a rather traditional lattice bridge was finally proposed by the board in 1959 - the concept of a composite fixed link matured from that time as a result of public and industrial interests gradually focusing their preferences on the features of the different types of technology. On the basis of the board's recommendations the first law on Storebælt passed the Parliament in 1961, initiating technical investigations and design proposals and determining the link to be completed by 1975!

During the 60s a variety of technical solutions was again explored in an international design contest, and the idea of transporting car traffic in a railway tunnel proposed was for the first time put on the agenda in the Storebælt decision process. This was the so-called "tunnel/ferry construction" which later on the Channel Tunnel project developed into the shuttle concept, however, still did not receive much interest.

Gradually as the parliamentary committee evaluated the 144 contest entries on the background of the professional and political attitudes in the 60s the lattice bridge design was abandoned in favour of a cable-stayed or a suspension bridge. The technical discussion around this shift primarily focused on the need for free span across *Østerrenden*, the heavily trafficked sea lane between Sprogø and Zealand. Hereby, however, was introduced a decision process deadlock : the greater the span needed to reduce collision risk, the more difficult it became to design a combined car-railway bridge (due to the load stress associated with train traffic). Inherent in this relation of interdependence was the solution achieved many years later; meanwhile it was of course exploited strategically by actors trying to optimise their specific interests in the process. Furthermore, in 1970, a new technical committee, (the Jespersen-Committee) had been appointed and commissioned to provide an economic basis for a parliamentary resolution. The committee's cost-benefit calculations, however, gave no clear preference to any of the technical alternatives, basically they were all considered profitable.

Contrary to the seemingly endless discussions about the design of this eastern part of the link, (in which the controversial idea of constructing a separate tunnel for railway traffic became more and more persistent), the proposals for the crossing of the western water *Vesterrenden* between Sprogø and Fünen quite early concentrated on a combined railway and car traffic low-level bridge.

Then finally, in 1973, the Danish Parliament adopted a resolution, empowering the Minister of Public Works "to build a bridge across Storebælt". As could be expected the open-ended issue of the technical design of the entire link was not specifically reflected in this resolution, which

simply stated that the link should consist of an eastern high level and a western low-level bridge, both intended for railway and car traffic. The inherent technical problems, which obviously could not be solved without further substantial political and financial considerations, were hereby brought to an interim *political* agreement, clarifying primarily that the fixed link *should* be completed.

Nevertheless the resolution did embrace more radical elements, concerning specifications for the organisational and financial set-up of the construction project. Thus two innovations in the context of public works in Denmark were introduced: the establishing of a state-owned company *Statsbroen Storebælt* which as client was to build and run the bridge, and secondly a financial model based on state guaranteed loans and toll earnings. Hitherto in Denmark, the ministry's *Road Directorate* had acted exclusively as client and administrative authority on infrastructure traffic projects; likewise their funding and operation costs would always be covered by public tax revenues. The new *concession-like* approach to these two issues in fact passed almost unmodified into the actual realisation of the link more than 10 years later (Axél 1992, p.19).

But the intention of the 1973 resolution, namely that the bridge should be completed by 1986, began deteriorating already during that year's autumn when the first oil crisis struck the traffic forecasts of the Jespersen Committee. Thus one of the first assignments of the newly established concessionaire - *Statsbroen Storebælt* - was to recalculate traffic development and to evaluate energy consumption on the various fixed link solutions in relation to a continued ferry service. In this period the energy issue in fact raised public concerns about environmental matters more broadly, and as the grass-root movements quickly converted into momentous lobby organisations this meant also a unification and focusing of the scattered groups of fixed link opponents.

In 1975, however, the *Statsbroen Storebælt* report concluded that a fixed link would still be economically lucrative. Furthermore a combination of the reduced traffic level and the emergence of new shuttle technologies seemed to tilt the balance in favour of a plain railway link service across the belt. This statement of course revived the public discussion about the project, whilst at the same time a rapidly growing number of actors appeared at the scene of debate. However, in 1976 the Parliament confirmed its previous decision by which the concessionaire could commence pre-design and further technical investigations for a combined link.

In a report on national investments, issued by the Ministry of Finance in 1977, problems in the national economy - in particular concerning trade balance deficit - were exposed. The ministry was anxious about the inflationary effects of two planned huge investments in infrastructure - the fixed link and the national natural gas network - which *accidentally* now seemed to take off simultaneously. An order of priority was consequently recommended. This issue became crucial after parliamentary elections in 1978 as it was put on the agenda in the government negotiations between the Liberals and the Social Democrats. As an element in a complex political deal, a five year postponement of the fixed link was agreed in favour of the natural gas network before these two odd partners could join a coalition government!

In the following years the Danish political environment was generally very confused, and the fixed link planning process once again became an arena of political manifestations, which at times seemed to set the whole project back to square one. The largest political party, the Social Democrats (SD), was decisively deposed when the first non-socialist government for thirty years was formed in 1982. The SDs, however, could then abandon previous positions on design solutions in order to regain voters' support for the party, and old SD issues like public transport at the expense of private cars were reintroduced - matching conveniently the rapidly increasing public awareness of environmental matters, to which otherwise the Socialist Peoples' Party further to the left in parliament were anxiously trying to address themselves. Thus, as late as in 1984, a parliamentary resolution on renewed technical investigations for the fixed link was in fact being impeded by the SDs, whose votes were needed by the minority government. Restraining the planning process further was the split among the non-socialist parties, of which

in particular the Liberals in the coalition government were conducting a rather sceptical policy towards the fixed link.

Nevertheless the incremental build-up of technological knowledge during this period was gradually pointing towards new solutions to the design controversy. The bored tunnel technology which had finally gained acceptance due to the Channel Tunnel project now became an important shield against the numerous water environmentally based arguments in the debate, representing the ultimate *zero-impact solution*.

Then in 1985, obviously triggering the decisive developments towards renewed political agreement, the Minister of Traffic, who represented a small ultra pro- car party, made what could be characterised a tactical move when he presented to parliament a proposal for huge investments in an urgent renovation of the existing car and railway ferryboat systems on the *Storebælt*. The old political majority behind the fixed link apparently experienced a crisis, to which the only answer was a speeding up of the fixed link project. The final legitimising steps included an investigation of the environmental impacts of the link and then, in June 1986, the four parties in the non-socialist government on one side and the Social Democrats from the opposition on the other side, joined in a compromise of remarkable content - *the time-lagged combined fixed link*. This agreement was confirmed in a Public Works Act of June 1987.

The pragmatism of this act concerned the variety of design solutions as well as their scheduled time of completion. Obviously for the *Vesterrenden* a combined car and railway low-level bridge was fixed, whereas the link across *Østerrenden* was to comprise a railroad tunnel and for car traffic either an elevated bridge or an immersed tunnel. By scheduling the railway link to be completed three years ahead of the road link - in 1993 compared to 1996 - it was furthermore anticipated to improve the competitiveness of public transport and its operator, The Danish State Railways. This Social Democratic strategy later suffered severe defeats due to technical problems.

In January 1987 the state owned client *A/S Storebæltforbindelsen* was established as a BOOT-company and the final design considerations concerning primarily environmental questions were completed. Thus from 1988 the following main link elements were being prepared for tender by the client's design organisation:

- the railway tunnel, *The East Tunnel*, total length 8 km, under the *Østerrenden* between Zealand and Sprogø to be constructed either as a bored tunnel or as an immersed concrete or steel tunnel.
- the combined road and rail bridge, *The West Bridge*, total length 6.6 km, across *Vesterrenden* between Funen and Sprogø as an all-concrete bridge.
- a elevated motorway bridge, *The East Bridge*, across *Østerrenden*, total length 6.7 km.

## SETTING UP A CLIENT

As specified in the Parliament agreement of June 1987 the client company *A/S Storebæltforbindelsen* (The Great Belt Link Ltd.) was established as a state owned principal to the project. The company's purpose was to design, construct and operate the fixed link. As mentioned earlier, bridge and road infrastructure projects in Denmark had never before been organised in a BOOT-setup, and, indeed, the specific model chosen in some respects differs rather much from being a "real concessionaire" (Martinand 1993).

The idea of having a limited company in charge of the project instead of the Road Directorate or State Railways under the Ministry of Traffic eventually materialised during *the social construction* of the decision on the fixed link (Bonke 1996), in fact together with the 3-year time-lag issue as the main "piece of candies" or bait for the hesitating actors.

Seen in this social constructivist perspective it was an obvious act of *closure* to encircle the project in a quasi-private organisation, out of reach of unpredictable political interests which could block the annual State Budget negotiations. Furthermore as indicated, the concessionaire model was in fine accordance with the ideology of privatisation which from the early 80s has



been dominating the public debate about the inefficiencies of institutions in the post-war social-democratic state. This argument, however, had no bearing in recent performance of the Road Directorate whose previous fixed link project, the *Farø Bridges*, in the mid 1980s had been completed on time within a 2% budget excess.

The official background for the replacement of the Road Directorate as acting principal on the project is mainly to be found in the financial aspects of the agreement in the Public Works Act. A limited company could independently raise loans and subsequently run the project economy sheltered from general political and public interference. In contrast, the Road Directorate, being a state institution, which was obliged to operate within the annually agreed limits of the State Budget and was furthermore subject to a law on freedom of information.

When the state principal in "real" concession contract situations delegates its power to a private limited company it is evidently ascribing priority more to the outcome of a project than to the process through which the specific outcome is being produced (Bourgeat *et al.* 1997, p.22). This renunciation of managerial influence is in principle compensated by the selection of a qualified concessionaire as well as in the specific terms of the concession contract. From a legal point of view, however, these means of control oblige the principal to possess an advanced preconceptual understanding of the project and to be very explicit and detailed in its statements. Such foresight in itself has basic limitations in construction. But the weaknesses of the concession model become obvious if, furthermore, the principal prefers to maintain some influence as technology manager throughout the project phases.

According to act of parliament, the preparation of A/S Storebælt as the concessionaire/ client in particular should allow for the conflict between the political, economical and technological interests of the state principal:

*The intention of the act concerning this new type of client is to combine the knowledge, qualities and possibilities inherent in the traditional organisation of public works under ministries with the financial independence of a limited liability company and the culture of private contractors. The client is in charge of construction under the provisions of the public Act and to existing Danish tender and design practices. And the Act specifies particular obligations on the client: it shall manage the public funds on a business basis, i.e. balancing expenses, incomes and interests, it shall act as a main political actor in transports, and it shall deploy an environmental policy.*

As a means of mediating the interaction between A/S Storebæltssforbindelsen and society two governing bodies were then established - a board of directors and a *political monitoring committee*. This twofold "belt and braces" organisation aimed to provide a watertight guarantee against unruly conduct by the principal.

Obviously the state, being the sole shareholder, could all by itself nominate the members for the board of directors. In doing so the Minister of Traffic sought a composition of the board which on a basis of confidence could ease the relationship between the state and A/S Storebæltssforbindelsen. The membership was as follows:

- the managing director of a large Danish multinational company (Chairman)
- the president of the Danish Metal Workers' Union (Deputy Chairman)
- the managing director of the Danish Industrial Employers' Association
- a former Minister of Finance, now managing director of Copenhagen Airport
- a managing director from Denmark's National Bank
- the general manager of the Danish State Railways
- an assistant secretary from The Agency of Environmental Protection
- a permanent under-secretary from The Road Directorate

It seems rather clear that the projected role of board of directors was not to add specific project management expertise to the company organisation - indeed, none of the members were 'fixed-link professionals'. More likely the nomination guarded against areas of potential political unrest

- a function, however, which the board only partly managed to fulfil successfully during the project.

In fact the introduction of the above mentioned political monitoring committee could indicate that the autonomy of the board of directors became overshadowed - within A/S Storebæltsforbindelsen the committee has consequently been referred to as "the upper board". And it had actually been laid down in the Public Act (as a provision for the parliament compromise itself) that the political insight should *not* be diminished as a result of the new concession-like set-up!

The establishment of this stratified client organisation obviously added new complexities to the communication lines of the project. Not surprisingly the opinions on its efficiency now differ considerably. But the rationale was quite precisely expressed by the chairman of the board: that if the monitoring task was not treated on a consensus basis within the political committee «...then instead we would have these perpetual discussions in the parliament ...».

According to Andreassen and Bundgaard Nielsen one piece of evidence of the well-functioning interplay between the «two boards» is represented by the substantial environmental improvements which were added to the project after the Act first passed in Parliament. However, more critical public voices have stated that the political committee possessed no real influence in such matters but merely served to «... legitimise the decisions which already were taken by the board on the basis of its detail knowledge».

From a technology and project management point of view, however, the Board's exploitation of the new organisational lines of action seems quite logical : their understanding of the new client set-up was exactly focused on the shift of politicians' influence from detailed to general control level. Thus in daily practise the board could, whenever appropriate, insist on already taken (political) decisions or pursue convenient changes on more operational foundations.

### **FIRST PROJECT MANAGEMENT MOVES OF A/S STOREBÆLTSTFORBINDELSEN**

If as indicated the state's considerations concerning the control of its client representative were in some respects contradictory the same can not be said about the Storebælt company's operations once it was established. Its first employee, Managing Director Construction H.-H. Godfredsen, took up his position in April 1987 - a month before the Parliament adopted the Act on the fixed link! As an experienced project manager in bridge building and having the previously failed fixed link run-ups in fresh mind his immediate strategy was to have the project materialise quickly as possible in order to prevent new political setbacks. It was considered crucial to pass the point of no return or - as it was phrased in the words of the classic goal oriented construction manager - «... we had to have concrete *on the table* in a hurry ... «!

From his previous job as head of the Road Directorate's bridge department Godfredsen took with him a technocratic approach to project management which, however, due to the fact that the construction organisation did not exist, could only partly be applied. As virtually no facilities were installed, whether physical or routines of work, the launch of the project was not comparable with that of an «ordinary construction project» Consequently at the same time Godfredsen had to cast the roles for the staff, implement a *modus vivendi* for his organisation, and to produce the design and planning outputs necessary to his strategy.

Obviously, this situation lead to a strong dependence on the large Danish engineering consulting firms - firstly as suppliers of personnel to his staff, secondly because a substantial conceptual design work straight away from the start had to be contracted with these firms. Not surprisingly Munch's (1997) interviews with the consulting firms expose a *generic* relationship between the two parties which soon brought along a new mutual sharing of their professional perspectives (i.e. the client's more political and the engineer's more technical perspective). COWIconsult, the predominant consulting firm of the project, is experiencing a conspicuous problem trying to define the characteristics of the job. On one side «a good consulting engineer» cannot interfere with the political basis of a project («politics is not a rational

process»). On the other side « the Scandinavian art of engineering» highlights the capability of adaptation, i.e. integrating the «soft aspects» of the projects in the design. And indeed, COWIconsult's first commission in 1987, given by Storebælt's Managing Director Construction Gottfredsen, was to re-examine the politically institutionalised key elements of the project (and not least the degrees of freedom) which could be deduced from the political agreement and the Act of Parliament.

## **PROCUREMENT STRATEGIES AND THE FORMATION OF CONSORTIA**

Thus in May 87 when COWIconsult commenced developing a strategy for the conceptual design work and the subsequent procurement phase it was considered appropriate to freeze the subdivision of the entire fixed-link project as structured by the Act. Consequently separate conceptual designs were prepared for the three main sub-projects: the Railway Tunnel, the West Bridge and the East Bridge.

From a technology management point of view it seems evident that strategies laid down at that time concerning the technical and organisational properties of the sub-projects and their interfaces would have a determining impact on other parties' performance throughout the project. Of particular importance in lengthy and complex projects are the conditions for, and readiness to, absorb successive alternatives to already taken decisions. It is remarkable that these comprehensive considerations were taken under great time pressure and sanctioned by a not yet operational client organisation - in the light of 20 years run-up to the political resolution some would even say absurd)!

Besides the above mentioned *point of no return* strategy of Gottfredsen, the position of COWIconsult appears to have been decisive. For more than 20 years COWI had acquired useful experience from bridge design and consultancy jobs all over the world - most recently on the *Pont de Normandie*. Obviously, the company had been able to maintain continuity and to develop routines within several modern bridge technologies (COWI, 1994). Even more important for COWI's capacity for the "fast track" approach was probably the company's extensive involvement in production and evaluation of design proposals for earlier versions of the fixed link. Literally speaking, COWI had on the shelves comprehensive files containing all sorts of information from preliminary surveys to ready-for-use designs.

It therefore certainly makes sense to characterise this principal - agent relationship by massive asymmetric knowledge in favour of the agent, a situation which inevitably gave rise to the self-esteem of the client's main consultant:

*COWI's staff ... is probably the most superb in this field in the Kingdom of Denmark. The job we defined was to establish a broad view of what the Storebælt organisation should get going with...*

In this perspective the principal's *agent costs* could be considered high - to some extent locking up the implementation of general and contractor oriented technology strategies to the culturally and commercially defined premises of the consulting engineer. It might on the other hand be argued that the client in this period achieved what he thought necessary and felt comfortable with: a quick move towards materialising a vast number of open ended project variables - a *fixing of multiplicity*. Ostenfeld from COWI describes this as a rather iterative and apparently unruly process:

*The work methodology alternates between broad view considerations and technical details; we took several rounds and aimed at including as many project dimensions as possible. ... One predominant issue in the discussions was the procurement strategy: it is important to have an idea of who is going to build which part of the project and to urge an interest among tendering firms.*

Thus integrated in this initial work of technical and organisational planning was also a focus on the tendering procedures and contractual conditions. Throughout the project's long past of

political existence the issue of national industrial and labour market benefits had developed into an imperative, and almost become personified by the client company's board of directors. However, the Danish State being sole share holder in the company, such interests could not be pursued in the direct sense that contracts and work could be awarded to specific (Danish) contracting enterprises.

According to article 7 of the Treaty of Rome construction works such as the fixed link are subject to a prohibition regarding the differential treatment of tenderers within the EEC, (all companies with more than 50% government involvement are subject to this stipulation). The EEC rules, however, did provide an opportunity for A/S Storebætsforbindelsen to employ a procedure of pre-qualification which obviously complied well with the company's need for establishing commercial contacts with a restricted number of qualified and financially solid contractors.

As the Danish companies in international terms are relatively small they were encouraged by the A/S Storebætsforbindelsen to acquire international co-operation partners in connection with the pre-qualification. In the first round of pre-qualification, for the Railway Tunnel, which was announced in June 1987, this strategy proved practicable, and in November 87 the Board of Directors pre-qualified "four strong international consortia, all with Danish participation" (*Storebætt Annual Report 1988*, p.27). During the same autumn also the second round of pre-qualification, this time for the Western Bridge, came out with internationally broad-based consortia, all with participation of Danish contractors. As some consortia were identical in these two, technologically unlike prequalification rounds it could be argued that the client's (as well as the participating contractors') criteria for evaluating the efficiency of a given consortium are more based in financial requirements and commercial strategies than oriented towards questions of technological and managerial competencies and capacities. Several incidents during project execution confirm this general hypothesis.

#### **THE "BUY-DANISH-CLAUSE"**

Having applied the procedure of prequalification and hereby demonstrated an almost unbounded openness towards foreign contractors A/S Storebætsforbindelsen obviously felt confident in relation to EEC rules. This tranquillity turned out to be transitory! In autumn 1988 the five prequalified West Bridge consortia submitted their tenders for the three alternative solutions contained in Storebætt's tender documents. Negotiations about app. 40 alternatives and variations, proposed by the consortia, in early 1989 resulted in nomination of a favourite, *The Western Bridge Joint Venture* which had Bouygues (F) and Trafalgar House Construction (UK) as main foreign partners together with a minor, later bankrupt Danish contractor, Jespersen & Søn A/S. They had proposed a composite steel and concrete solution at a price of DKK 2.97 bn. However, 2 month later the favourite was rejected with the following argument:

*The contractor is presupposing the employment of 3-5 Danish and one or more foreign steel firms and subcontractors. This is worrying from a technical-quality perspective... The risk of delay due to the many actors is found to be critical.*

Therefore number two in the tender, European Storebætt Group, offering a plain concrete solution at DKK 3.15 bill. was awarded the contract. To this consortium was subsequently added the largest Danish contractor, Højgaard & Schultz A/S as well as the medium-sized C.G. Jensen A/S, owned by Skanska of Sweden. Both were members of another losing consortium.

The underlying motives for this sudden shift in Storebætt's attitude are unclear, but it certainly caused exasperation within the Western Bridge Joint Venture. Headed by Bouygues, it then initiated an energetic campaign against the client's decision - a step which can be characterised as most unusual - at least in the cultural context of contracting in construction! Bouygues argued referring to EEC rules that Storebætt A/S intended to give preference to domestic industrial interests. Even the tender documents were prescribing that tenderers as far as

possible should employ Danish materials and consumables, equipment and labour force. However, during tendering period nobody protested against this so-called "buy-Danish clause"!

Bouygues' complaint was obviously accepted by the EEC-commission, which then requested the Danish Minister of Foreign Affairs to put off the signing of contracts until legal matters had been investigated. After intense political discussions the Danish government decided to ignore the request and to contract as above mentioned - however, now without the clause! Otherwise, according to Danish contracting rules, the submitted tenders would be repealed and the future of the entire project again become insecure.

As could be expected the government's decision aggravated the crisis in relation to the Commission, and in July 1989, legal action was taken against Denmark, stating that Denmark had disregarded the obligations resting on her according to Community law and would therefore be brought before the European Court. The crucial issues were almost identical with the content of Bouygues' complaint, and the Commission requested the Court, as a provisional measure, to request Denmark to suspend the construction works under the contract between A/S Storebæltssforbindelsen and the European Storebælt Group until the Court's could pronounce judgement in the main case. "This can be expected in around two years"! The Commission furthermore requested a new invitation to tender.

During the following high-level political and legal negotiations the Commission yielded - construction could commence - and Denmark agreed to compensate those tenderers which were able to document losses due to the "buy Danish clause". Such compensation totalled approximately. DKK 20 ml. In June 1993, the European Court finally ruled that A/S Storebæltssforbindelsen and Denmark had violated both the Treaty of Rome and the EEC tender regulations in connection with the construction of the West bridge: Denmark could not invoke the provisions of the Danish tender rules against procedures laid down by the EEC. The ruling was not followed by sanctions.

## THE LOCALISATION OF CONTRACTS AND INVESTMENTS

Historically seen construction is a rather local physical activity. This general fact might imply a reduced need for all the above described political worries, legal expert considerations and procurement exercises aiming at protecting domestic industrial interests and ultimately pulling the client into the supranational EEC turbulence.

A survey of the Storebælt construction contracts in fact confirms that the predominant cost-efficient solution for contractors is to use local materials and local manpower, thus avoiding, for instance, transports costs. The consortia involved include companies representing seven other nations, primarily Italy, Germany and France. By country the construction contracts are distributed as shown in table 1.

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<b>country</b>	<b>percentage share of works</b>
Italy	21
Denmark	21
Germany	17
France	14
Holland	10
Great Britain	7
USA	6
Switzerland	4

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*Table 1 : Share of Storebælt Works by Country*

Despite the relative small proportion of contracts awarded to Danish companies a quite large share of the project budget has been spent on domestic resources. In the 1996 survey the localisation shown in table 2 could be stipulated.

So far as materials are concerned, principal suppliers include 370,000 tonnes of cement, all supplied by Aalborg Portland A/S (DK), and 270,000 tonnes of steel, 30% of which was supplied by The Danish Steelworks A/S, the remaining volume being delivered primarily by Italian, German and British suppliers.

manpower	man-years	percentage share
total employment generated in Denmark and abroad (direct and indirect employment)	66,000	
- of which domestic manpower	50,000	75
directly employed at construction sites	24,000	
- of which domestic manpower	21,600	90
indirectly employed by suppliers	42,000	
- of which domestic manpower	27.300	65

*Table 2 The Share of Danish Employment in Total Employment on Storebælt*

## FINANCING, BUDGET AND PLANNING DEVELOPMENTS

As earlier described major Danish transport construction works have always been financed via the State Budget. The Storebælt fixed link represents a totally new concept in this field as its budget is procured by raising of loans in Denmark and abroad and subsequently repaid by road and railway users. In 1987 the Danish state contributed as share capital DKK 355 m to A/S Storebæltstøtseforbindelsen, thus contributing a little over 1% of the anticipated total financing requirement. In relation to the original Construction Bill adopted in May 1987, which estimated the total construction costs at DKK12.9 bn, Storebælt's 1988-updating totalled DKK 17.4 bn. (1988-prices) plus financing costs. These were estimated at that time to at approximately DKK 12 bn. For a planned project completion in 1996.

In 1992 A/S Storebæltstøtseforbindelsen had to increase the construction budget to DKK 21.6 billion (1988-prices), mainly due to problems with the tunnel project. Despite several other substantial project budget excesses, the client has managed to maintain this construction cost level up till now (DKK 29 billion in 1998 prices). At the end of 1997 A/S Storebæltstøtseforbindelsen's debt totalled DKK 37.7 billion, including financing costs. This excess is mainly caused by increases in interest cost due to prolongation of loan periods corresponding to the project completion time overruns. Generally, however, the A/S Storebæltstøtseforbindelsen has been favoured by extremely attractive borrowing conditions and interest rate levels.

When the fixed link is in full operation from June 1998, the yearly turnover for the operator is expected to amount DKK 2 billion, with DKK 1.45 billion contributed by the road link and DKK 525 million by the Danish State Railways. Assuming that the traffic forecasts are accurate, the operator will be out of debt by year 2038.

sub-project	contract sum bn DKK (1988/ 1990 prices)	scheduled completion	final budget bn DKK (1988-prices)	completed
West Bridge	3.1	January 1994	3.9	January 1994
East Tunnel	3.1	October 1992	4.9	August 1996
East Bridge (substructure)	2.5*	October 1995	-	October 1995
East Bridge (superstructure)	2.9*	December 1997	-	June 1998

Source: *Jyllands Posten*, 20/03/97. Final budgets for East Bridge projects not available due to disputes.

Table 3 : Main Project Budgets Plans And Outcomes

### MANAGING AN INTERNATIONAL CONSORTIUM

It appears from Appendix B that substantial parts of the fixed link have been built by international consortia. The East Bridge superstructure represents an exception to this general rule which as indicated was strongly encouraged by the client's early procurement policy. In this section aspects of project management in an international organisation will be reviewed. Politically as well as strategically the East Tunnel project played an important role in the fixed link because it was a central element in planned *time-lagged link* - a completion by stages in order to give an initial three years advantage for train traffic (see above). Technologically the tunnel project required a considerable innovativeness as tunnelling through soft and heterogeneous ocean subsurface layers was practically untested at that time. Tenders for the East Tunnel were submitted to A/S Storebæltforbindelsen in June 1988 and based either on a bored or immersed tunnel. MT Group was awarded the contract on its proposal for a bored solution. The client referred to economic as well as environmental criteria leading to his choice. In early negotiations about the contract it was laid down by the client that tunnelling should take place simultaneously in two tubes from both Zealand and Sprogø. Consequently four tunnel boring machines (TBM) were to be procured. Scottish firm Howden was chosen as supplier of the TBMs, based on Japanese technology, because only this company offered a very short period of delivery. MT Group is a true international joint venture, with the distribution of the partners' capital investment as shown in table 5. Thus from the beginning Monberg & Thorsen was appointed sponsor of the consortium. Although established on M&T's initiative during the tender preparation phase the role as sponsor obviously became a sensitive issue as the project evolved and technology problems started accumulating.

member	nationality	share %
Monberg & Thorsen	Denmark	24
Campeon Bernhard	France	19
SOGEA	France	19
Dyckerhoff & Widmann	Germany	19
Kiewit Construction Company	USA	19

Table 5 : MT Group

It could be argued that the JV-formation process at this early stage had been determined by pragmatic considerations and perhaps even by the casualties of a busy period in which the main concern of all major Danish contractors and their international companions was to get in a favourable position for submitting tenders rather than focusing on the specific planning and management properties inherent in the single projects tendered for.

However, at a formal level nothing seems to indicate that the different firms in MT Group were not technically qualified for the JV-partnership - M&T had at earlier occasions performed successfully with all members and not least the French and German firms possessed recently updated knowledge of tunnel boring. Nevertheless - as mentioned - the management functions of the newly established JV organisation were not resistant to the internal and external pressures which inevitably will accompany unforeseen incidents during execution.

An important task for a sponsor in a JV is to ensure progress in the first critical period of a project, i.e. during the organisational running-in phase. However, even the critical delivery conditions for the TBMs mentioned above caused substantial delays. Functional defects on the machines subsequently increased delays in the production plans - in October 1990 estimated to be 9 months behind schedule - and disputes between MT Group and A/S Storebætsforbindelsen were a fact. This early project situation is best characterised by inconsiderate client requirements, insufficient specifications from MT Group, and lack of quality control within Howden's production. Only one year and minor progress later, however, the project was struck by the first of several really spectacular disasters: a water burst from the seabed found its way through the TBM-head which had been left open due to modification works. Both 300 m long drives at the Sprogøsite were instantly flooded and the two TBMs seriously damaged.

On the political level this incident resulted in a questioning of the integrity of the bored tunnel project, and requests for a reconsideration of alternative solutions were put forward by the political monitoring group. But renegotiations on the fulfilment of the contract between the client and MT Group eventually led to a resumption of operations. The two parties agreed on a splitting model for the expenses incurred but also on an expanded project economy as well as revised scheduling and organisational provisions.

As an element of this restart and in order to upgrade its supervisory capability A/S Storebætsforbindelsen recruited tunnelling expertise from the Channel Tunnel project. The client accordingly assessed MT Group's organisational performance as being poor in particular concerning the building-up of an efficient site team. As from the start the competence of the organisation in relation to the specific technology management issues had appeared to be low also «the learning curves» developed much too slowly. The manning, for instance, of the four TBMs was characterised by a turbulence which was impeding the development of routines and efficient co-operation in the individual teams.

Characterising the reorganisation of MT Group, imposed by this project turn, was consequently an attempt to comply with such assessments. The project management function (held by the French firm Campenon Bernard) was reinforced by a project director from the same firm. This additional level represented a strong liaison with the board of the joint venture which (incidentally!) at the same time was undergoing a sponsor change due to a merging of Campenon Bernard and SOGEA in France. The Danish firm M&T, from that time, was left in a secondary role and received the deputy manager function.

Although from a formal perspective this reorganisation is appearing to be quite radical it is obviously not perceived as such by its actors - or rather, it is precisely of a formal nature, reflecting external claims and pressures from client and parent firms. On the informal level, however, it seems likely that MT Group already at that time had worked up a *modus vivendi* as an independent organisation, having passed through a year-long team building process. Some circumstances even indicate that the technological and contractual problems experienced by the MT Group throughout the initial project stages had rather hardened the temporary JV organisation and led to a strengthening of the actors' perception of project completion as a joint concern.

Thus two main precautions obviously proved valuable for the «new» MT Group's relatively successful performance during the remaining project stages:

- MT Group developed a hitherto quite unforeseen «public relations» profile as part of its technology management concept. The effect of openness was evidently rehabilitating the



image of MT Group and making the handling of the spectacular technical problems an almost nation-wide, common concern! Breaking the client's monopoly in relation to the press furthermore changed and balanced the «interpretation» of project complexities, eventually leading to better collaboration with the technical experts in A/S Storebælt.

- The reorganisation of the MT Group brought decision processes in better accordance with *social constitution* of the JV, i.e. the variety of local social constitutions anchored in different national contracting systems was reduced during this process. Several changes in the manning of the organisation contributed to this rationalisation, most important the merging of the two French participants in the JV. One of these was characterised as a traditional, mainly domestic oriented firm adherent to centralised planning and limited delegation of responsibility, whereas the other French partner is an experienced international contractor with a more «diluted», global managerial concept. During the JV reorganisation staff from the former was replaced with staff from the latter, apparently giving room for the implementation of a more consensus-oriented, «hybrid» project management style, thus facilitating problem solving and co-operation within MT Group.

Seen in the light of the immense technical challenges experienced on the tunnel project it is now broadly recognised that the MT Group produced remarkable innovative and operational results during completion of the project. However, the overall project economy and time overruns remain disastrous. Within MT Group as within the other observed international consortia at Storebælt the organisational ability throughout the first critical existence of the JVs is striking. While the JV organisations almost occur to become operational by chance their parent firms do not appear to have management and organisation *implementation* strategies ready when they enter into international collaborative constellations. As demonstrated in this case, these deficiencies could, for instance, be rectified through application of a distinctive technology management programme concept within the joint ventures - a capability which should be integrated within the client's contractual provisions.

## CONCLUDING REMARKS

The paper has examined the public decision process for the Storebælt fixed link in a historical perspective, pointing to the peculiar project plans and product specifications for the varying technology elements of the link. This was indeed a story of *social constructivism*. It exposed the lengthy momentum of socio-political procedures originating from classical Danish social-democratic divide and rule traditions which, however, from the late 70s have been increasingly influenced by supranational regulative measures as well as by the internationalisation of construction business and technology in general.

Thus the paper outlines the multitude of interests which led to an agreement about the design of a *combined, time-lagged fixed link*, encompassing heterogeneous specifications for the road and railway parts of the link. Couched in techno-economic rationality this decision endeavoured to comply with seriously conflicting criteria. As shown, however, the possibilities of achieving overall project success in this environment of multiplicity were condemned to be dim.

As one crucial area of dispute and hence contractual success the paper has identified the interpretation of and dialogue about the client's technical specifications. But also the encounter between culturally determined managerial and organisational preferences embedded in different national regulative systems was immense - within the various joint venture organisations as well as in relation to the client. Such issues repeatedly caused delays and budget overruns and were subject to litigation.

The Storebælt fixed link project is a long history of technological incompatibility, experienced by social actors on all levels in client, design and production organisations. As shown much of this inconsistency originated in external (i.e. political) spheres and thus beyond the immediate reach of the most exposed, productive parties. Seen in this light, however, the production of the fixed link also becomes a case of successful performance, demonstrated - 'against poor odds' - at the micro level by managers, technicians and operators. Technological disasters, budget overruns

and planning hurdles were eventually tackled with great innovativeness and collaborative ingenuity in the multicultural environment of professionals and nationalities. And the link was actually completed and is now in full operation.

But a crucial issue of technology management remain unresolved after this huge project as well as in construction in general: how to exploit the good and bad learning produced in temporary, loosely coupled organisations for the benefit of future projects. The client A/S Storebælt in fact does deploy a knowledge transfer strategy for the current Øresund fixed link project. Whether this initiative will actually come through as organisational learning and improved project performance is still to be demonstrated.