Danish infrastructure projects complement Eurasian Land-Bridge

by Poul Rasmussen

In the months following the fall of the Berlin Wall, on Nov. 9, 1989, the smaller countries of Europe had two options in adjusting to the completely new strategic and economic situation that appeared with the emergence of a unified Germany, and the open access to the countries of eastern Europe. Either they embraced the perspective put forward in the proposal for physically integrating all the European nations through a series of massive intrastructure projects, the "Productive Triangle: Paris-Berlin-Vienna" program presented by American economist and statesman Lyndon LaRouche, only weeks after the Wall tumbled, or, they joined Margaret Thatcher and the British government, in defining a reunified Germany as an outright adversary, a "Fourth Reich," as British Minister of Trade Nicholas Ridley so viciously labelled the country, in the summer of 1990.

In Denmark, the debate about which of the two options to follow, was rather short-lived. Despite a flourish of anti-German articles in the liberal press in the winter and spring of 1990, the conservative coalition government led by Poul Schlüter chose to approach the reunification of Germany as a unique and positive economic and strategic opportunity. The Schlüter government actively intervened into the debate about the attitude toward unified Germany, with a clear emphasis on the positive historical roots of Denmark's close political and cultural relations with its neighbor to the south. Of course, the historical nadirs of the relationship, were the two German-Danish wars of 1848 and 1864, and the Nazi occupation of 1940-45, but, in the view of the Schlüter government, they represented exceptions to an overall peaceful and positive relationship.

The reunification of Germany became the source of a surge of cultural optimism in Denmark. It was generally expected that the new Germany would become the economic engine in a comprehensive rebuilding of the former Warsaw Pact countries, and that this process in turn would lead to a massive economic upswing in all of Europe. In this perspective, the primary question for Denmark then became, "How do we hook up to this Central European economic process?" The answer was a series of impressive infrastructure projects.

Bridges and tunnels

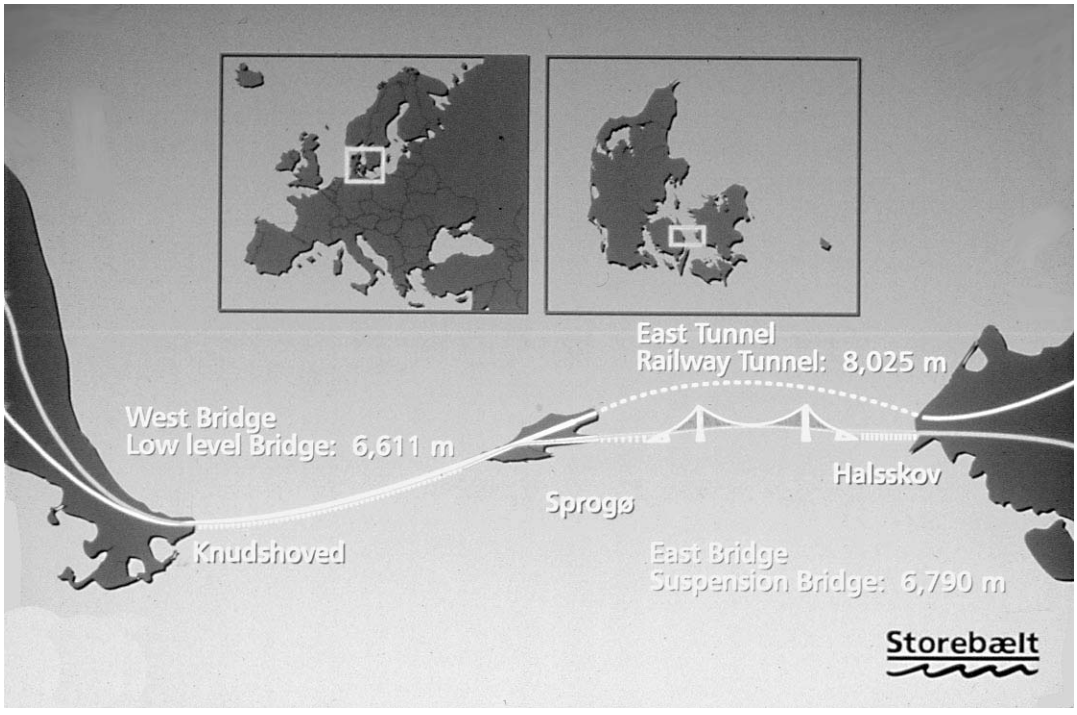
For most of this century, three major infrastructure projects have been high on the economic wish-list of Denmark. First of all, linking the eastern and western parts of the country, by means of bridges and tunnels. The peculiar geography of Denmark, a nation of just one major peninsula, and several hundred islands of varying size, makes water more dominant than land. This was an obvious advantage in the days when sea and water transport were quicker and more efficient than transport by land, but in today's modern industrial society, it is a disadvantage. Second, the creation of a connection to the rest of Scandinavia, through a bridge or tunnel to Sweden; and third, the creation of a direct link across the Baltic Sea from the eastern parts of the country, to Germany and the European continent. The reunification of Germany, and the prospect of a Central European economic boom, transformed these three projects from wishful thinking, into an economic necessity.

The initial preparations for building a bridge across the Great Belt, the "missing link" in the connection between the islands in the east and the western part of the country, were already made in the 1970s, but the two oil crises of 1974 and 1979 sent Denmark to the brink of national bankruptcy, and the Liberal and Social Democratic coalition government was forced to postpone the entire project. Then, in 1987, the Danish parliament approved a new Great Belt project, and on June 23, 1988, construction of the Fixed Link began. But, there was still a lot of political foot-dragging, and, despite the ongoing physical construction, political circles around Radikale Venstre, the small liberal party, still hoped to stall the entire project once again. The prospects for the second and third projects, the bridge to Sweden and the tunnel to Germany, were not looking good at all. Then came the fall of the Berlin Wall, and the political tide changed dramatically, in favor of the infrastructure program.

On March 6, 1991, the Danish parliament approved the Sound Project, the building of a fixed link across the Øresund to Sweden, and at the same time, the initial political declaration of intent for the construction of a tunnel across the Fehmarn Belt of the Baltic Sea was issued. Thus, two of the three major infrastructure projects were well on their way, and the third in the preparatory stage.

The physical excavations for the land projects of the sound link were commenced immediately around Copenhagen International Airport, and the ongoing construction of the Great Belt Link was accelerated. Nobody said so, but this was done deliberately in order to quickly reach a point of no return—

FIGURE 1
The Great Belt Fixed Link project



The West Bridge and the East Tunnel are now completed, and the entire project will be finished in June 1998. Travel times have been reduced from an hour or more, to seven minutes.

just in case the political tide turned against the projects once again.

The Great Belt Fixed Link

The first part of the Great Belt project has recently been completed. On June 1, the East Tunnel, the rail tunnel from the main island of Zealand, to the tiny island Sprogø, in the middle of the Great Belt, was officially opened by Queen Margrethe II (**Figure 1**). The West Bridge, the 6.6 kilometer rail and road bridge between Sprogø and the island of Fünen, has been ready for two years, but so far only used for transport of materials for the construction of the East Tunnel and the East Bridge. Since a rail and road bridge across the Small Belt, between the Jutland peninsula and Fünen, was already built in 1935, the opening of the rail tunnel across the Great Belt meant that Jutland, and the two largest Danish islands, Zealand and Fünen, were physically connected—for the first time since the Ice Age, 12,000 years ago.

Anyone who has visited Denmark, has experienced how travel times are disproportionately long for such a small country. No matter where you would go in an east or west direction, traveling by car or train, it would take at least one ferry, or sometimes two. Many tourists marvelled at the Danish train-ferry system, where entire trains were put on a ferry. But it still took extra time. First, the train was divided up into sections, and then taken onboard the ferry. Crossing the Great Belt took one hour, if the weather was good. Under bad weather conditions, it could easily take an hour and a half, or more. Today, with the East Tunnel and the West Bridge, crossing the Great Belt takes a mere seven minutes. In June 1998, the Great Belt Fixed Link will be completed, when the East Bridge opens for road traffic. It will be the world's longest offshore suspension bridge, with a span of 1,624 meters, 220 meters more than the Humber Bridge in England. The total length of the bridge will be 6.8 km, and the bridge towers, the pylons, will reach 254 meters into the sky, becoming the highest points in the entire Kingdom of Denmark—and they are man-made.

Challenges and innovations

An often-overlooked aspect of large-scale infrastructure projects, is the development of new technologies. Most often, the concept of new technologies is associated with computer science, space programs, or other exotic adventures, while the building of rail links across the Eurasian continent only involves old-fashioned features, such as bridges, tunnels, and rail lines. These are things we already know everything about, right? Wrong!

The Great Belt Fixed Link is by no means a small project. The West Bridge is the longest combined road and rail bridge in Europe; the East Tunnel is the second-longest underwater tunnel in Europe; and the East Bridge is the longest offshore suspension bridge in the world. But, a giant infrastructure project like LaRouche's proposal for a Eurasian Land-Bridge will involve many projects of the size of the Great Belt Fixed Link, and this will tax our innovative skills to their limits. The Central Asian geography is no small challenge, even for the best engineers in the world.

When compared with the remote and desolate mountain areas of Central Asia, the geography and geology of the Great

Men working on the suspension bridge section of the Great Belt Fixed Link project. Three projects, linking the Danish islands of Fünen and Zealand, Denmank to Sweden, and Denmark to Germany across the Fehmarn Belt, are a necessity for Denmark to fully participate in the Eurasian Land-Bridge.

Belt area in Denmark ought to be as well known as anybody's backyard. People have lived and worked here for thousands of years, and for most of a century, a virtual army of engineers has done all kinds of studies, measurements, and preparations for the prospect of building either a tunnel or a bridge here. And for the final project, detailed computer simulations were carried out. Nevertheless, when the construction finally commenced, there were some nasty surprises waiting out there in the real world.

The complex ground structure underneath the Great Belt, where moraine clay mixes with Paleocene marl, made the boring of the East Tunnel a much more delicate task than the construction of the Channel Tunnel, where the boring was done almost entirely in compact and uniform limestone. Nevertheless, as much experience as possible from the French-English Channel project, was transferred to the Great Belt, and a few of the best work-teams were even employed for special tasks on the East Tunnel. Thus, the 31 cross-passages between the two tunnel pipes were dug out by hand by a Scottish work-team from the Channel Tunnel project.

The Moses Project

A very thorough geological survey was made of the Great Belt, in order to construct a precise picture of the soil composition. Because of this, the tunnel curves to the north, to gain maximum benefit from the local geological conditions, making the East Tunnel 8.1 km long, while the East Bridge, spanning the same water, is only 6.8 km long.

The two pipes of the tunnel were cut out by four huge Tunnel Boring Machines (TBMs), two of which started from Sprogø, and the other two from Halsskov on Zealand. After four years of work, the four machines met in pairs, 40 meters below the seabed, where they were laid to rest in a concrete sarcophagus. Despite all the tests and computer calculations, the real world turned out to be considerably different than expected. Physical ground tests had been performed for every single meter in the path of the tunnel. Nevertheless, on Oct. 14, 1991, one of the TMBs ran into an unexpected fissure in the morain clay, with direct access to the sea above. All the workers had to be evacuted, and within a few hours, seawater flooded both tunnel pipes on the Sprogø side. This delayed the tunnel construction by several months.

The bottom of the entrance pits on both Zealand and Sprogø, are 26 meters below sea level, and way down in the groundwater layer of the soil. Therefore, a number of pump wells have been established to keep the groundwater table below the excavations. On the Zealand side, these pumps remove 1,100 cubic meters of water every hour; on Sprogø, 220 cubic meters per hour. This will have to continue as long as the East Tunnel exists. If the pumps were to stop, the tunnel would be flooded within 24 hours—by sweet groundwater, not seawater. One of the major problems in boring the tunnel, was the unexpectedly high water pressure in both the Paleocene marl and the moraine clay. This water pressure was not due to seawater, but to the great amount of groundwater. But, when the tunnel entrance pit was constructed on Sprogø, the engineers noticed that the lowering of the groundwater table for the excavations had an effect far out into the Great Belt. Later, this phenomenon became the basis for an ingenious operation.

The high water pressure was a problem for the TBM machines. They were constructed to operate in much drier soils,

and the water-logged mud constantly destroyed the hydraulic systems, causing major delays. Also, the cutter head itself had difficulty operating in the water-logged soil. The solution was to lower the groundwater table in the seabed underneath the sea. Nothing like that had ever been done before. Forty-five pumping wells were established across the Great Belt, and for the remainder of the construction period, they removed up to 1.5 million cubic meters of groundwater every month. This operation was appropriately named "The Moses Project."

Another ingenious invention solved another serious problem. The appearance of unexpected fissures, like the one that flooded the tunnel in October 1991, made it necessary to proceed with caution. Therefore, whenever unstable moraine layers were approached, either in the main tunnel pipes, or in the cross-passages, the soil would be frozen by liquid nitrogen, thereby transforming the water to solid ice, making it much easier for the cutter head to cut through the soil, and at the same time preventing any flooding.

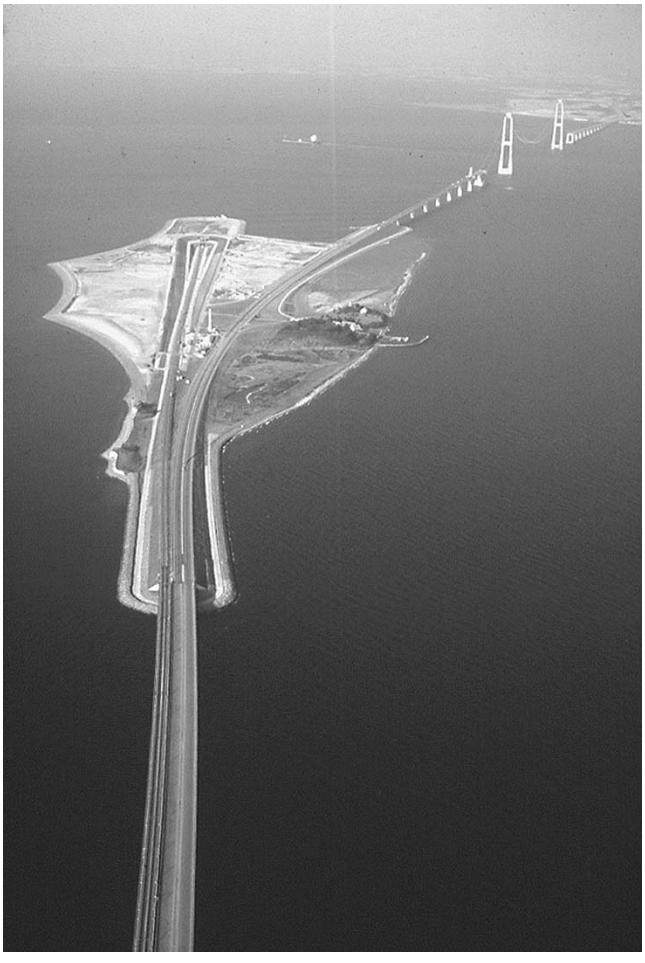
The East Bridge

The construction of the Great Belt Fixed Link is a truly international enterprise. The West Bridge was constructed by the European Storebaelt Group, a consortium of Danish, Dutch, British, and Swiss companies. The East Tunnel was constructed by MT Group, a consortium of Danish, German, and French companies, and the East Bridge is being constructed by a German-Dutch-Danish consortium, Great Belt Contractors, that is building the concrete substructure, while the steel superstructure is handled by the Italian company Coinfra S.p.A., in cooperation with Steinman, Boynton, Gronquist, and Birdsall from the United States. In addition, specialists from Japan are attached to the project. The substructure of the East Bridge consists of the 19 bridge piers of the approach spans, the two giant towers, and the anchor blocks for the cables in the main span. All of this adds up to 259,000 cubic meters of concrete, and 44,000 tons of reinforced steel.

The superstructure is mainly steel. Each of the two cables for the main span consists of 18,700 steel strands, 5 millimeters thick. They form a cable 85 centimeters in diameter and 3 km in length. If all the steel strands of the two cables were placed end to end, they would reach 2.7 times around the Earth at the Equator.

The prefabrication of the bridge girders constitutes an impressive international assembly line, thousands of kilometers in length. The basic girder elements, the reinforced panels, were welded, in Liverno, Italy. Then the panels were shipped to Sines in Portugal, where they were assembled into sections. Then, these sections were shipped 2,500 km to Ålborg in northern Jutland, where they were welded into complete bridge spans. The spans were then stored in Ålborg until shipment for assembly in the bridge alignment.

The approach sections of the East Bridge are ready, and the two cables are in place on the towers. The attachment of the bridge girders in the main span has begun, and the work is presently seven weeks ahead of schedule. The East Bridge will open for traffic in June 1998, thereby completing the Great Belt Fixed Link.



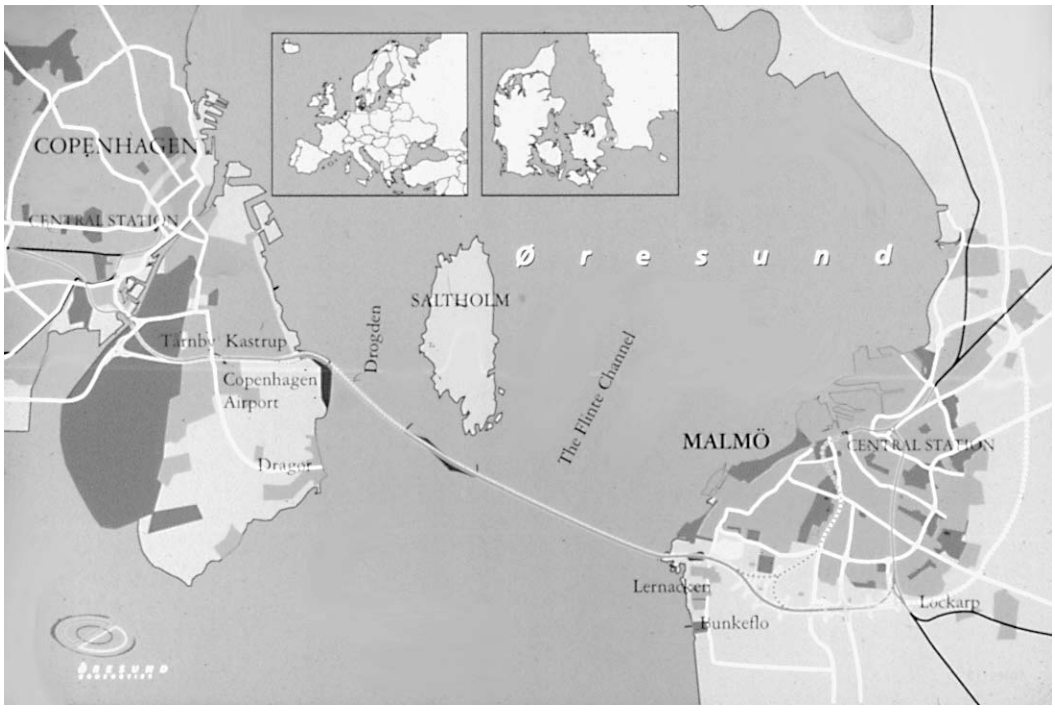
An aerial view of Sprogø Island, in the Great Belt Fixed Link project. In the foreground is the West Bridge, and in the upper right, the towers of the East Bridge are visible.

At the peak of its activity in 1992, the Great Belt Link involved a total of 11,720 workers and engineers. Of these, only 4,144 were directly employed in on-site construction, while 7,576 were employed by secondary suppliers. Both the Great Belt Link and the Øresund Link have been financed by loans on the international markets and by the European Investment Bank, and will be paid off by bridge tolls.

The Øresund fixed link

The second large Danish infrastructure project, the fixed link across Øresund, is as impresive as the Great Belt project (see **Figure 2**). Connecting the Danish capital of Copenhagen, to the southern Swedish city of Malmö, the Øresund Fixed Link will be 16.2 km in length, consisting of a 7.5 km elevated bridge, a 2.2 km low bridge, a 4.5 km man-made island, and a 2 km tunnel. It is planned to be completed in the year 2000.

FIGURE 2
The Øresund Fixed Link project



Connecting the Danish capital of Copenhagen, to the southern Swedish city of Malmö, the Øresund Fixed Link project will create the largest integrated urban center in Scandinavia, with 3.2 million people. It is planned to be completed in the year 2000.

While the Øresund Fixed Link itself does not break as many records as the Great Belt, the accompanying landworks will make the entire project much more comprehensive. Both in Copenhagen and in Malmö, major road and rail construction is well under way. Copenhagen will get a new additional subway system.

These days, travellers arriving at the Copenhagen International Airport in Kastrup, jump right into the largest construction site in Europe. The Øresund Fixed Link connects to the shore only a few hundred meters from the main terminal of the airport. Here, a four-lane highway, a two-track railroad, and an underwater tunnel are now under construction. In addition, a submerged train station directly connected to the airport terminal, plus a brand new terminal finger, are also being built. All of this makes a breathtaking sight. When in operation in the year 2000, Copenhagen Airport will not only be the largest airport in Scandinavia, but also the second-most-trafficked train station in the region.

The tunnel at the airport will carry two rail tracks and four lanes of road 2 km into the sound, to the man-made island located just south of Saltholm, a small island in the middle of the sound. In order to protect the 40,000 birds and 12 seals that inhabit Saltholm, environmentalists demanded that an artificial island be added to the project, costing several hundred million dollars. Appropriately, the new island has been named Pepperholm.

From Pepperholm, a low bridge will take both rail and road traffic to a 7.5 km bridge, that will be able to handle the heavy shipping traffic through the sound, one of the most trafficked waters in the world.

Population density

The Øresund Fixed Link will make Copenhagen and Malmö the largest integrated urban center in Scandinavia, with a total population of 3.2 million. Already in the 1960s, when the first studies of a fixed link across the sound were made, the greater population density potential of Copenhagen and Malmö was the major argument for placing the fixed link here, and not between Helsingör and Helsingborg, where the sound is only 4.8 km wide. In 1965, a report on the sound project was published by the municipality of Copenhagen. The authors of the report, Prof. Kristian Antonsen of Copenhagen University and engineer Anders Nyvig, argued in favor of a Copenhagen-Malmö connection over a Helsingör-Helsingborg connection, based on their study of the potential population density of the two urban centers. By using a model developed by the American astronomer and sociologist John O. Stewart, a modified version of the LaGrange equations for the energy potential in a gravitational field, Antonsen and Nyvig concluded that the Copenhagen-Malmö connection would give the highest potential population density.

Antonsen and Nyvig also had a second argument. Writing in 1965, before the onslaught of the post-industrial insanity which has since gripped the brains of many politicians in the West, and before the World Bank and the International Monetary Fund succeeded in writing off the so-called Third World from any industrial development, they wrote:

"In the decades to come, a growing portion of the industrial exports from Western Europe will go to the Third World. These countries will first and foremost demand various means of production, i.e., machines and machine tools. Since the

A view of construction on the West Bridge section of the Great Belt Fixed Link project. Most often, the concept of new technologies is associated with computer science, space programs, or other exotic technologies. But an often-overlooked aspect of large-scale infrastructure projects, is the development of new technologies.

industries in the greater Copenhagen area are expected to concentrate on the various iron and metal industries, and especially those sectors requiring a highly skilled labor force and technical research, one can expect a rise in the overseas export, especially from Copenhagen. The situation in the Malmö area is in many ways similar to the one on this side of the sound, since the lack of local industrial raw materials has caused an industrial composition similar to Denmark's. . . . Such a specialization around the southern part of the sound could lead to a local expansion of exports to the Third World, which could have an important impact on the development of the cities, especially the use of the port facilities."

Unfortunately, both Copenhagen and Malmö have been hit by the kind of massive deindustrialization over the past 30 years, that Antonsen and Nyvig never would have dreamed of. Today, the most active proponents of the Øresund Fixed Link, are found in Malmö. The city has been reduced from one of Sweden's most active industrial centers, to a desolate area of high unemployment and economic depression. With the other Swedish urban and industrial centers of Stockholm and Gothenburg far away, the Øresund Link is the only way for Malmö to break its geographic and economic isolation.

Undoubtedly, the Øresund Fixed Link will have a major impact on the entire Malmö region. But, if this kind of infrastructure project can have such an importance for an area like southern Sweden, which is by no means isolated when compared to the cities in the vast hinterlands of Central Asia, what then will be the impact of an infrastructure program like the one that LaRouche proposes in his Eurasian Land-Bridge concept? The idea of the Land-Bridge is not merely to connect China and Europe with a few railroad tracks. The Land-Bridge will also bring roads, rails, energy, communications, and other kinds of infrastructure to cities and areas with millions of people, who today are living in a state of isolation which is orders of magnitude greater than Malmö and southern Sweden. If the Øresund can bring economic development back to southern Sweden, the Eurasian Land-Bridge can create an economic miracle for an entire continent.

The Fehmarn Belt Link

The third leg in the Danish infrastructure program, a rail and road link across the Fehmarn Belt, was included in the list of central projects in the European Union Commission's work on Trans-European Networks, a part of the Delors White Paper, which was presented at the Essen Summit in December 1994. The Fehmarn Link is also seen as an important part of the establishment of a European-wide high-speed rail network. The Fehmarn Belt Link project proposal consists of a 23 km-long combined rail and road tunnel. The costs are estimated to be around $4 billion.

Unfortunately, the Fehmarn Belt Link project has entered the same state of hybernation as the rest of the projects of the Delors White Paper. Studies and reports are still being made, but nothing decisive is happening. Perhaps, the new winds from the debate at the Amsterdam Summit in June, about solving the unemployment crisis, the French government's revival of the Delors Plan, and the growing interest in implementing the Eurasian Land-Bridge concept, can bring this ambitious plan back onto the drawing boards, to become an important addition to the Eurasian Land-Bridge of the future.