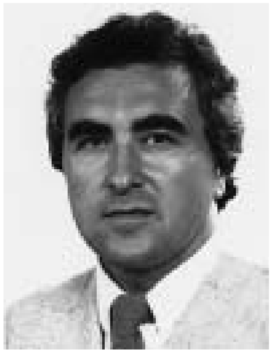
Noël Pille

NorFra Pipeline Installation Project: Pretrenching, Seabed Levelling, and Landfall Dredging and Civil Works

Abstract

During 1995, the Governments of Norway and France entered into an agreement to transport natural gas from Draupner to Dunkirk, France. As a result, Den Norske Stats Oljeselskap A.S. (Statoil), as operator for the NorFra Joint Venture, planned the NorFra transportation system. This 42" diameter, 835-km-long, high pressure natural gas pipeline designed for 156.8 bar was laid from the Draupner E platform in the Norwegian Continental Shelf to Dunkirk, at the northern coast of France.
Partners in the NorFra consortium were Statoil, Norsk Hydro, Saga Petroleum, Esso Norge, Mobil, Total, Elf Petroleum, Norsk Agip, Norske Shell, Neste Petroleum and Norske Conoco.

Mr Pille graduated as a Mechanical Engineer from the University of Ghent, Belgium in 1975. He then joined the dredging department of Jan De Nul N.V. Since 1992 he has been Manager of the offshore works department of their International Dredging Division. This department is involved with trenching and backfilling works for the installation of offshore pipelines, rock dumping and ballasting of offshore structures, shore approach dredging and landfalls, and other offshore industry works.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Introduction

The route of the NorFra pipeline starts from the Draupner E platform in North Sea block 16/11, and comes ashore at Dunkirk on the coast of northern France. Over a distance of 835 km, it crosses the Norwegian, Danish, German, Dutch, Belgian and French Continental Shelves (Figure 1).
During the 1997 season, the pipeline was laid by the laybarge *LB 200* from the Draupner E platform at KP 0 towards KP 546. Simultaneously, a second laybarge *DLB 1601* operated from KP 546 to the Dunkirk landfall.

Presweep activities for seabed levelling started at KP 591. From KP 591 to KP 726, the NorFra pipeline has been installed at between 50 to 100 m parallel to the Zeepipe gas transportation system which remained operational during all dredging and pipelay activities. At KP 726 the NorFra pipeline crossed the existing Zeepipe pipeline and diverged in the southwestern direction towards Dunkirk.

Further south at KP 758, the NorFra pipeline route crossed the Interconnector pipeline which goes from Bacton, UK to Zeebrugge, Belgium and was also installed in 1997, just prior to the installation of the NorFra pipeline.

The landfall section runs at Dunkirk from KP 825 to KP 835, before reaching the beach. In this section, several shallow sandbanks had to be crossed. A temporary cofferdam was installed on the beach in order to install the pipeline safely over the last 500 metres of the route.

On land, the pipeline crosses the Canal des Dunes through a tunnel and has been further installed up to the terminal building.

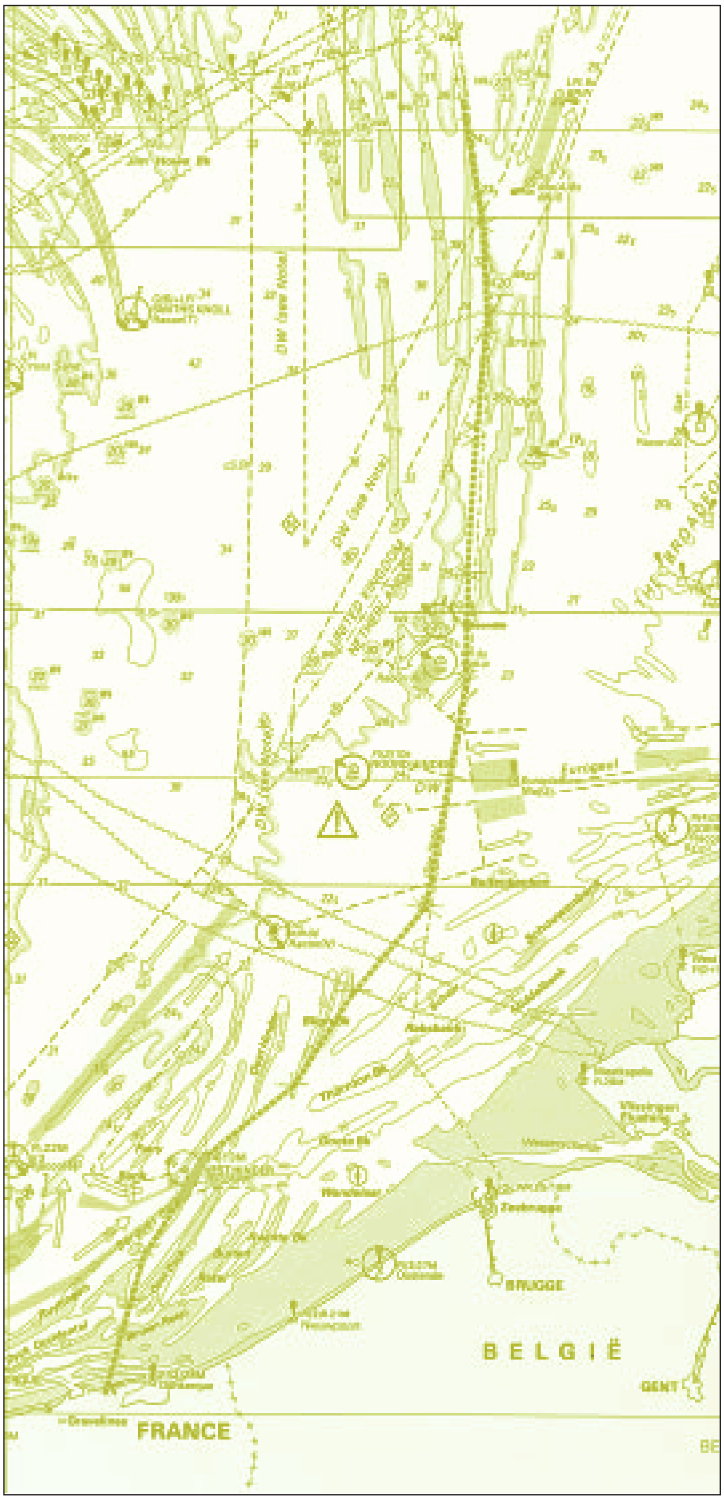

Figure 1. Nautical chart of the North Sea. The dotted line shows the route of the pipeline from the Draupner E Platform to landfall at Dunkirk in northern France.

Contract Form

Four dredging packages were tendered separately by Statoil, and in one combination, a contract of approx. US$ 80 million was awarded to Jan De Nul. The Contract Form was a target lump sum, with an agreement between the Company and Contractor to share on a 50/50 basis the underrun between this target sum and the actual installation costs.
This formula proved to provide the best incentive for both parties to arrive at the lowest project cost. Based on daily coordination between the Company and Contractor, and flexibility and understanding from both sides, savings have been achieved from all aspects of the project, resulting in a considerable underrun with respect to the original budget.

Scope of Work

The total dredging scope contracted to Jan De Nul involved the following sections:

- Offshore presweeping of sand dunes on the seabed over a distance of approximately 230 km on the Dutch, Belgian and French Continental Shelves. This enabled the pipeline to be installed within acceptable stress and strain and freespan criteria.
- Pretrenching in stiff clay at the location of the crossing of the Westhinder Shipping Lane on the Belgian Continental Shelf, and protection of the pipeline with at least 1 m of gravel above top of pipe.
- Dredging, backfilling and civil works related to the shore approach, beach crossing and pipepull at Dunkirk.

Presweeping of the Sandwave Areas

Before installation of the pipeline, presweeping of sand dunes was required from KP 591 to KP 825 in order to level the seabed. This enabled the pipeline to be installed within permissible limits with regard to span lengths, pipe stresses and off bottom clearances (Figure 2). A total quantity of approx. 1,200,000 cubic metres was dredged in order to provide a minimum 10 m wide pipelay corridor.

Depending on the progress of the pipelay vessel, one or more trailing suction hopper dredgers were used in order to remain an average of 30 km in front of the laybarge. This reduced the risk for maintenance dredging, but on the other hand provided a 10 day contingency in order not to slow down the pipelay vessel at any time.

The key vessel for the presweeping was the new very large trailing hopper dredger *Gerardus Mercator* (18,000 m^3). The introduction of new technologies

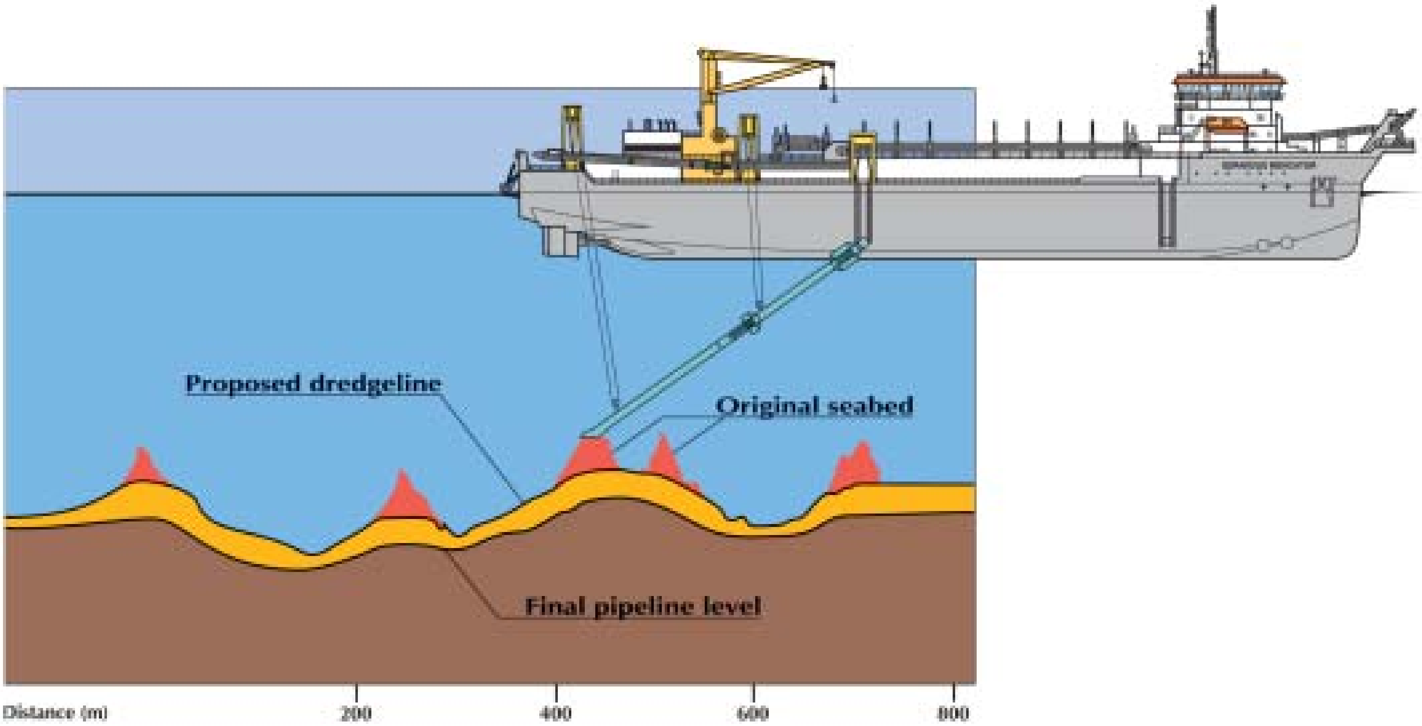

Figure 2. A typical presweep longitudinal profile.

such as dynamic tracking, a very wide presweep draghead and multibeam survey on this dredger resulted in increased presweep productions with better horizontal and vertical tolerances. This very large and heavy seagoing dredger also managed to work without any weather and technical delays in the period between May and July 1997.

Special safety procedures had been developed during presweeping between KP 591 and KP 726 as these works had to be executed approx. 50 m parallel to the Zeepipe gas transportation system under operation. During dredging, the position of the Zeepipe was visualised on the dredge computers by means of the multibeam survey system installed in the moonpool of the dredger (Figure 3). Also an emergency draghead hoisting system was installed just in case the position of the draghead were to come within the pre-defined minimum distance from the Zeepipe pipeline.

Trench Dredging and Backfilling in the Westhinder Shipping Channel

At the Westhinder Shipping Channel on the Belgian Continental Shelf, a trench had to be excavated to ensure that after installation the top of the gas pipeline would be at a depth of minimum 1.0 m below the original seabed over a length of 5,340 m (Figure 4). The soil consisted of very stiff clay with a shear strength of over 120 KPa which normally would have required excavation by means of a cutter suction dredger. However, in view of the water depth of more than 40 m, extensive modification to this type of dredger would have been needed. Therefore the new, very large trailing hopper dredger *Gerardus Mercator*, equipped with a heavy and wide draghead, was put to work and successfully completed the trench excavation. After pipeline installation, sea-dredged gravel was placed on top of the pipeline by the dredger *Cristoforo Colombo* in order to provide a minimum cover protection of 1.0 m above the pipeline. For accurate installation of the gravel, this dredger used one of its suction pipes as a fallpipe.

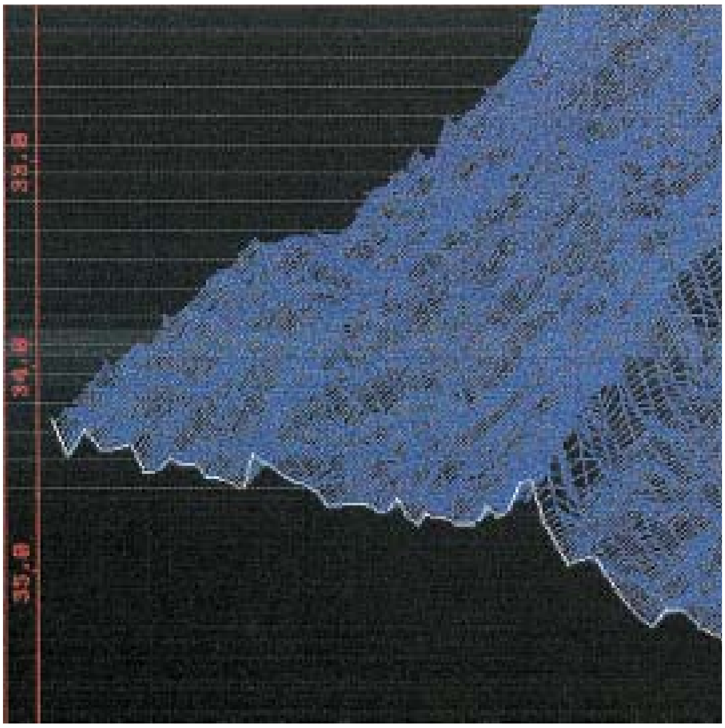

Figure 3. The on-line multibeam survey which was installed on the dredger Cristoforo Columbo *shows the position of the Zeepipe installation.*

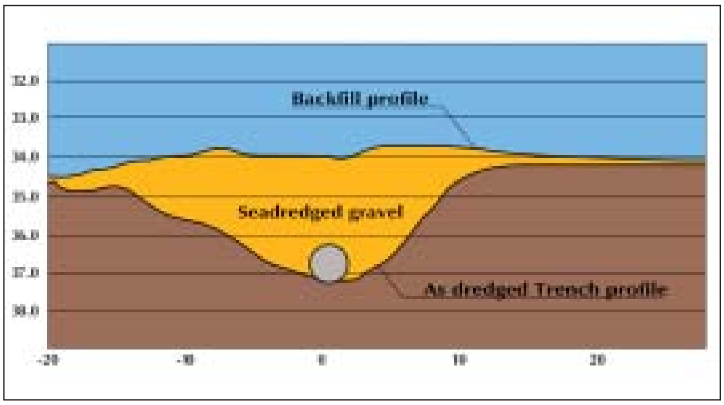

Figure 4. A trench profile in the Westhinder Shipping Channel before and after backfilling.

Trench Dredging and Backfilling of the Landfall Section

In the sandbank area at the shore approach at Dunkirk, access depth and width have to be provided for the shallow draught pipeline installation vessel *Castoro Due*. Access dredging was executed in the sandbanks Banc St-Pol, Banc Snouw, Banc Breedt and Banc In Ratel at a level of å6 m LAT by means of the shallow draught hopper dredgers *Galilei* and *Amerigo Vespucci,* and the very powerful sea-going cutter dredger *Marco Polo*.

In addition to the floatation channels, a trench to 1.5 m above final pipeline level with 10 metres minimum bottom width had to be dredged. During execution, it was decided to dredge the trench down to the final pipeline level in order to save on the costs and risks of post-trenching.

In particular in sections where clay and dense soils had to be dredged, the cutter suction dredger *Marco Polo* has been used successfully. The dredged materials were loaded into the hopper barges *Ni–a* and *Pinta* moored alongside this dredger in order to limit the obstruction to navigation in the shipping channel of Dunkirk.

The last 225 m in front of the cofferdam were dredged by the *Marco Polo* at high tide in order to avoid over-dredging as regards floatation requirements (Figures 5 and 6).

Figure 5. A view from the sea, looking landwards, the sea-going cutter dredger Marco Polo *dredging the shore approach in front of the cofferdam at Dunkirk.*

Dredge Programme for the Shore Approach

In view of environmental restrictions with respect to fishing grounds, dredging in the landfall section was not allowed to start before the 1st of May. Based on the programmed time for the dredging work, the resulting pipepull date had been scheduled for June 10th.

When the pipelay vessel became available earlier than scheduled, the Company asked the Contractor seek permission to enable the pipepull to take place 20 days earlier. For this purpose, cutting through the sandbanks was rescheduled by means of the highly productive *Marco Polo*, with the trailing hopper dredgers pretrenching the offshore part which was allowed to be completed later.

Through a combination of the very high production rates of the cutter dredger and a good weather window, the *Marco Polo* managed to reach the cofferdam on May 20th, just 4 hours before the arrival of the pipelay vessel *Castoro Due*.

Pipeline Cover with Gravel in the Shipping Channel

To protect the pipeline from damage from anchoring in the shipping channel, the pipeline was covered with sea-dredged gravel. The gravel was installed by the large trailing hopper dredger *Gerardus Mercator* using controlled discharging through her bottom doors over a very short period of only 5 days (Figure 7).

Without relaxing the engineering specifications as regards the required cover, considerable savings were made in working time and in costs as a result of using this very large dredger, compared with using rock dumping vessels for the installation of engineered backfill material.

Cofferdam Installation

In order to allow the safe and stable installation of the pipeline in the beach section at Dunkirk, a 520-m-long

Figure 6. A view from the shore, looking out to sea, of the installation of the cofferdam and winch foundations at Dunkirk.

and 6-m-wide cofferdam was designed (Figure 8). The cofferdam was situated from the –3.0 LAT contour level to the high-water level on the beach. As a result, the cofferdam had to be constructed partly from the beach and partly from offshore with the aid of a jack-up platform. This method was introduced on the Zeebrugge landfall for the Interconnector pipeline, and was also successfully applied on the Norfra pipeline. For the seaward section, a jack-up platform was used from which the sheetpiles are driven. This allowed the work to be done without interruption, undisturbed by either tides or sea-state conditions.

After installation of struts and wallings in between the sheet-piled walls, trench excavation took place by means of a clamshell and underwater pump equipment. The landward section was installed using tracked land-based equipment working during low-water periods.

Figure 7. The very large trailing hopper dredger Gerardus Mercator *installing a gravel cover on the pipeline in the shipping channel at Dunkirk.*

Figure 8. To ensure the safe and stable installation of the pipeline, a 520-m-long and 6-m-wide cofferdam was constructed, partly from the beach outwards and partly from offshore with the aid of a jack-up platform.

Figure 9. The NorFra pipeline being post-lowered by 2 metres after the pull-in.

Pipeline Post Lowering

During execution, the Company requested the section of the pipeline at the end of the cofferdam to be installed 2 m deeper than originally planned in order to provide additional safety and protection. To avoid the additional cost of longer sheetpiles, Jan De Nul proposed to delete the cofferdam over this last section, and to post-lower the pipeline after installation during periods of low tide. This method had been introduced successfully on the Zeebrugge landfall of the Interconnector pipeline, and was now also applied with success on the NorFra pipeline (Figure 9).

Beach Civil Works

Prior to excavation of the winch area, the existing road was diverted to form a by-pass road section around the winch area. The dunes at the proposed area for the winches were excavated to the bottom foundation level.
Concrete form work was set and the foundations for the winches and ancillary equipment poured. Double sheet-piled walls combined with tie rods were installed as an anchor wall for the 800 ton winch set up.

Safety

It was a declared objective at the contract signing to improve safety by training and by increasing people's awareness of a healthy and safe working environment. Safety on board the dredgers was improved by paying close attention to the working conditions, to wearing proper safety clothing and to keeping all safety devices and signs in good condition.

A special project safety video film was made in order to introduce the crew, staff and visitors to all safety aspects of the project. Also, a safety training course was required for all personnel staying more than 3 days on board the vessel. Visitors for less than 3 days were given a short, but detailed, safety introduction.
All these measures contributed to the success of meeting the challenging target of no lost time accidents.

Postscript: Post-trenching

A contract was awarded to HAM, dredging and marine contractors with its partner EMC to trench the pipeline down from the as-laid level to the final pipeline level, which is 0.70 to 2.00 m. below the seabed. The total length to be trenched was from the Doggersbank at KP 269 to Dunkirk at KP 825.
Owing to the very short time between laying of the pipeline and the unworkable winter period in the North

Figure 10. The trencher HAM 950, a remote-controlled underwater vehicle designed to bury pipelines to a maximum depth of 500 m.

Sea, four trenching tools were used for this project. Each piece of equipment has specific capabilities to cope with the different soil conditions of the southern North Sea.

The Doggersbank with cohesive soils and trench depths of 0.70 m was trenched with the *PL2* (plough) and support vessel *Bar Protector*. Additional tugboats, totalling 30,000 hp installed, are required to pull this plough. The southern section with the sandwaves and variable trenching depths was trenched with the trencher *HAM 950, Geopotes 14* with jetty device, and the *Castoro 10*.

The trencher *HAM 950* is a remote-controlled underwater vehicle that is designed to bury pipelines working to a maximum water depth of 500 m. Energy and controls are supplied from a support vessel (*HAM 602*) through an umbilical to the trencher. The trencher is of neutral buoyance but has an above-water weight of 100 tonne. This very complex robot moves along the pipeline whilst jetting away the sand under the pipeline and lowering the pipeline to the required depth.

The trailing suction hopper dredger *Geopotes 14* was equipped with a Mass Flow Excavation (MFE) jetframe. By means of this jetframe, very powerful waterjets penetrate the bottom and bring the soil in suspension. The water flow removes the suspended sand and a trench is made into which the pipeline sinks. The water for the MFE is supplied from the jet and dredge pumps.

Figure 11. The trailing suction hopper dredger Geopotes 14, equipped with a Mass Flow Excavation jetframe, which penetrates the bottom with powerful waterjets.

On the *Castoro 10* the work was supplied by high pressure pumps on deck and transported through hoses to the underwater nozzles of the jetsled. Moored at anchors, the *Castoro 10* pulls the jetsled along the pipeline. The *Geopotes 14* completed the trenching work in December 1997.

Conclusions

Based on daily coordination between the Company and Contractor, savings have been achieved from all aspects of the project, resulting in a considerable underrun with respect to the original budget. Savings (20 percent below the targeted lump sum) were achieved from:

- optimalisation of working methods during construction;
- introduction of new technologies and high capacity dredgers;
- flexible availability of dredgers in view of pipelay production, resulting in reduced maintenance; and
- no weather delays.

The underrun between the target lump sum stipulated in the contract and the actual installed costs were shared between the Company and Contractor on a 50/50 basis. In addition, besides saving on costs, the common objectives of having no accidents or incidents and keeping to the time schedule were also achieved.