The Baltic Sea’s ecology and prime location distinguish it from the planet’s other seas. One of the largest bodies of brackish water in the world, the Baltic is described by the Helsinki Commission (HELCOM – the body that ensures the Baltic Sea’s environmental protection) as “ecologically unique.” Its fragile ecosystem and limited oxygen levels restrict the number of marine and freshwater species that are able to thrive, and many are increasingly threatened by pollution and the effects of climate change. For this reason, Nord Stream was determined to keep the environmental impacts of its project on the sea and its inhabitants to an absolute minimum.

Feasibility studies carried out by North Transgas in the late 1990s had established that an offshore route would be preferable to an onshore route in terms of both cost and the environment. In 2006, the next phase of the project was to design the pipelines and establish a route offering the shortest and safest way across the Baltic’s variable seabed, and the best possible options from environmental, technical, and economic perspectives. This was achieved through a comprehensive programme of surveying and open dialogue with specialists around the Baltic Sea region, with environmental concerns remaining the key consideration throughout.

The Baltic Sea might be small, but it has some of the world’s busiest shipping lanes and is a vital fishing resource. Millions depend on this body of water for their livelihood and for recreation, so it was essential to keep potential impacts on shipping, shipping, and tourism to a minimum. “Environmental considerations were the overall driver throughout the planning. Obviously, a shorter route is also more environmentally friendly, as is a route across a more regular seabed,” explained Project Manager Simon Bonnell, who was responsible for overseeing engineering surveys, along with munitions clearance activities for Nord Stream. “Everything came together in the routing.”

From the start, Nord Stream cooperated with the five countries (Parties of Origin) through whose territorial waters or Exclusive Economic Zones (EEZs) the pipelines would pass – Germany, Finland, Denmark, Sweden, and Russia – as well as with Estonia, Latvia, Lithuania, and Poland, the other countries that might be affected. Apart from ensuring that the pipelines complied with the national legislation of all
Parties of Origin, and with the terms of the 1991 Espoo Convention, it was essential to ensure that the relevant non-governmental organisations (NGOs) and other bodies were in agreement with the measures taken to avoid adverse environmental and economic impacts. The consultation process involving all Baltic Sea countries began in 2006. Nord Stream was committed to being flexible throughout, offering alternative options to different governments and describing in detail what it planned to build, where, and with what materials. The development of the technical project was an iterative process – like a game of ping-pong – between surveying, engineering, and the authority consultation. With engineers focusing on the technical aspects and surveyors pointing out the environmental obstacles, it was essential for the two to find a way of seamlessly working together. “People coming from standard engineering and construction projects needed to understand the importance of the environmental restrictions,” said Bonnell. “They were asking, ‘Why do we have to report every barrel, why do we have to stay a certain number of metres away from a wreck?’” So we needed good communication between our environmental permitting team and the construction engineering team because of the sensitivity of the Baltic, and the commitments we made to authorities. Initially, that was hard for the results-oriented engineering and construction team to understand.”

**Establishing a working dialogue**

Constant dialogue between the two departments within the company and the authorities made this challenge manageable. “We’d say, ‘This is our proposal’, and in some cases the authorities came back and said, ‘We’d like you to investigate a route a little bit further east or a little bit further west, because there’s an area we’d like you to avoid’,” said Trond Gjedrem, Nord Stream Engineering Manager. His team and Italy-based Saipem Energy Services (formerly Snamprogetti S.p.A.) were responsible for the design of the pipelines. “So then we’d go in and investigate and say, ‘Yes, that’s feasible’. The process basically took three years, and all the technical planning went on parallel to the consultations with authorities and our environmental permitting team. We had something like 50 or 60 engineers working three years full time on this project.”

A good example was the discussion with the Danish authorities on how to get around the island of Bornholm. “Originally, we had the route on the south side, but there was a period in the planning phase when we were planning to go north,” said Gjedrem. “We went back south again because the authorities asked us to, and also, of course, because we came to regard that as the best route. There was a lot of this type of dialogue.” The only Baltic countries with existing offshore pipelines were Denmark and Germany, which meant that in other countries, the entire process needed to be painstakingly described from the start. “You had to explain what a pipeline is and how you can lay it, then go through the individual phases and processes of installation and the impact that could have – significant concerns I’d never heard of on previous pipelines,” said Bonnell.

“Looking at the Baltic Sea, you’d think there is so much space that it would be no problem to put a pipeline there that will take up less than one-thousandth of 1 percent of the Baltic Sea floor,” explained Gjedrem. “But when you go into the details, you see there are environmental areas such as Natura 2000 sites, along with shipping lanes, fishing areas, military exercise areas, cables, and wind parks that are planned.”

Determining the exact route required several years of surveys. An initial geophysical survey by PetraGaz in 2005 had established a 2-kilometre-wide research corridor. From 2006 onward, about 100 million euros were spent on detailed and transparent environmental studies. A detailed geophysical survey was carried out in 2016 across a 180-metre-wide corridor to allow the pipelines to be engineered in detail and to establish the position and condition of all items on the sea floor. Remotely operated vehicles (ROVs) inspected every object within 25 metres of the installation corridor was selected on the basis of these earlier surveys. Nord Stream then commenced a major programme of additional studies into how the route could be further optimised to minimise environmental impacts in the Exclusive Economic Zone (EEZ) of Estonia in the Gulf of Finland, further south of Gotland in the Swedish EEZ, and near the island of Bornholm, Denmark.

**The final extensive surveying campaign is launched.**

It is split into three stages and carried out by MBT to provide information on munitions and other potential obstacles.

**April 2007**

Following the first stage of consultation with the Baltic countries, Nord Stream commissions additional studies into how the route could be further optimised to minimise environmental impacts in the Exclusive Economic Zone (EEZ) of Estonia in the Gulf of Finland, further south of Gotland in the Swedish EEZ, and near the island of Bornholm, Denmark.

**July 2007**

The final extensive surveying campaign is launched. It is split into three stages and carried out by MBT to provide information on munitions and other potential obstacles.

**July 13, 2007**


**August 2007**

The pipelines are re-routed to run north, rather than south, of the Danish island of Bornholm.

**May 2008**

A soil and pore water sampling survey is carried out. This is done to screen for background levels of chemical munitions contaminants in the Bornholm area. Each sample is analysed by two independent laboratories.

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The remnants of a 300-year-old wreck found in the Bay of Greifswald, Germany, were salvaged by experts from the Mecklenburg-Western Pomerania Office for Culture and Care of Monuments (LaKD M-V). The wreck had to be salvaged in order to create the space required for constructing a 60-metre-wide corridor in which the Nord Stream Pipelines were laid.
surveys in 2007–2008 to provide even more detailed information. About 40,000 line kilometres were accurately surveyed to provide comprehensive information about munitions and any objects that might impact the construction and safe operation of the pipelines. The identified objects were as small as a paint can, or as large as a wreck. Along with munitions, numerous harmless objects were located and investigated, ranging from shopping trolleys, cars, bicycles, and washing machines to refrigerators, and much more.

Robots help create a map of the seabed

Split into three stages, the 2007–2008 surveys used state-of-the-art technology such as multi-beam echo sounders to map water depths, high-resolution side-scan sonars to determine the type of seabed sediment, and sub-bottom profilers to map the geological layers below the bottom. ROVs equipped with cable detectors, cameras, and highly accurate positioning systems were used to produce an incredibly detailed visual and acoustic profile of the sea floor. ROV-mounted gradiometers – metal detectors specially adapted for the project – provided the position of all metallic objects within the installation corridor, including those that might have been covered by the soft sediments on the seabed. The bulk of the seabed surveys were conducted by Swedish company Marin Mittnäckeln AB (MIMT) (See interviews on page 56), along with PeterOaz of Russia and DOF of Norway. During those surveys, every object found within a 25 metres distance on either side of the route was examined, along with the anchor corridor, which is about 1.5 kilometres from the pipeline route. “In excess of 10,000 objects were examined and documented,” Bonnell said.

Meanwhile, extensive field studies and environmental surveys were carried out by highly regarded institutions from across the Baltic region to establish potential environmental impacts from the construction and operation of the pipelines. Ramboll of Denmark, the Institut für Angewandte Ökologie (Institute for Applied Ecology) and Fugro OSEAME of Germany, and the Danish Hydraulic Institute carried out environmental impact studies and route surveys, for example. UK-based Environmental Resource Management compiled the Environmental Impact Assessment (EIA), a transboundary environmental impact assessment conducted under the terms of the Espoo Convention. Nord Stream also established an independent group of experts to investigate the impact the work on the pipelines could potentially have on marine life, bird habitats, water quality, and other environmental issues, and extensive field studies were carried out to analyse soil and water, as well as the behavioral patterns of wildlife.

As well as the environmental concerns, there were also significant cultural heritage sites, such as settlements, to consider in the route planning. In addition to the large number of shipwrecks in the Baltic: “There are fantastic shipwrecks, especially in Russia and the northern Baltic, the Gulf of Finland, because there are no boring worm [shipworms, which burrow into submerged wood in salty waters, have not yet infiltrated the Baltic] so the wood is beautifully preserved on the seabed,” explained Bonnell. “We found a number of new wrecks that weren’t known to the authorities – a significant number. Normally on engineering surveys, if there’s a wreck, the pipeline is routed away without detailed ROV inspections, but we did surveys of all the wrecks found to assess their cultural value, and it was fascinating.”

About 160 wrecks were identified, 64 of which were considered significantly by the relevant authorities. The route was designed to avoid these wrecks wherever possible, and when it was not practical, they were worked with national authorities to find an acceptable solution. “There are a lot of organisations and authorities with a lot of interest in the state and condition of the Baltic Sea, so there was a lot of expertise that we benefited from in our planning,” said Gjedrem. In March 2009, Nord Stream published its EIA, setting out the final 1,224-kilometre route from Vyborg, Russia, to Lüttin, Germany. Once the route was set, a total of 250,000 man hours were spent on the technical planning of the two pipelines. The plan was for the two pipelines to be constructed in three sections of varying thickness, welded together on the sea floor. The pipelines were designed with progressively thinner walls because the pressure would differ from one end of the pipeline to the other, starting at 220 bar in Russia, about 200 bar midway, and ending at 100 bar in Germany. Reducing the wall thickness also meant using less steel. “On a very large project such as this one, there are substantial savings to be made,” explained Gjedrem. “We saved more than 400 million euros with this design.” The team designed a safety system to ensure that pressure would never exceed the allowable level in any location or any situation over the lifetime of the pipelines. Building them in sections would also enable three pipeline vessels to work simultaneously. In addition to speeding up the process, this meant that if work had to be stopped somewhere for environmental reasons – such as the seal mating season – construction could still continue on the other sections and seabed intervention work, such as rock (gravel) placement or trenching could take place. “In Germany in the Bay of Greifswald, for example, we recovered a wreck and moved another one out of the way of the route of the trenching. In Russia, we filled some articles off wrecks to aid in the dating and documentation,” Bonnell explained.

Extensive work had to be carried out in the areas where it was not possible to avoid the high outcrops of rock, as the intention from the beginning was for a pipeline system that would prove completely safe and reliable for decades. “This meant physically placing gravel on the seabed in some areas so that the pipelines would not become over-stressed in the ‘free span’ areas. There were also concerns about soft soil in some areas, particularly in the northern part of the route. “I describe it as being like building on yoghurt,” said Gjedrem. “If you tried to place small stones on yoghurt, you could pile them up to a certain height but then suddenly it gives way. That’s the same challenge we had when we wanted to do gravel placement on soil that was very soft, and we really needed to put our heads together to solve these issues.”

Reducing risk from munitions

Before any construction or gravel placement could take place, a pressing problem had to be resolved – the clearance of munitions identified near the route. Mines had been laid in the Baltic since the mid-nineteenth century, and the area had been a dumping ground both for German weapons confiscated by the Allies at the end of First and Second World Wars and, later, for chemical weapons from the Eastern Bloc. The estimated number of mines in the Baltic Sea is between 100,000 and 150,000, about 50,000 of which are in the Gulf of Finland. A great deal of data about the location of munitions had already been gathered by NATO-member navies and fishing authorities. The surveys carried out for Nord Stream augmented their knowledge. The company organised several seminars with experts from national authorities, inviting them to evaluate the compiled data and to analyse the best means of clearance. (See mine clearance article on page 49.) “That was an excellent interaction between the Finnish and Swedish navies in particular, and also Germany, and without the specialist support we had from the Royal Danish Fleet regarding the chemical munitions, it would have been very difficult for us to proceed,” he said.

Gjedrem and the engineering team also conducted rigorous risk assessments with independent suppliers during the development phase. This was done to mitigate the potential impacts from planned activities, such as construction, and from unlikely unplanned events, such as accidental munitions detonations. “Risk management was essential at all stages of the project,” he said. There was also extensive dialogue with the maritime authorities, and assessments to ensure ship safety. “Any risks during construction and operation were analysed in detail and benchmarked against stringent and predefined acceptance criteria. It’s, of course, not possible to eliminate all risk in such a project, but there was a lot we could do to reduce it to an acceptable level,” Gjedrem said. The goal was for Nord Stream to be a benchmark, and Gjedrem feels this was achieved. “I’ve been involved in many offshore projects and I’ve never seen anything like this before – from the quality of the risk assessment, to the quality of the engineering. It’s a huge project in a very sensitive area, but we set a new standard.”

A marine archaeologist from the Viking Ship Museum in Roskilde searches the seabed. Both during the preliminary surveys and the construction of the pipelines, Nord Stream worked closely with the museum to ensure the protection of cultural heritage sites in the Baltic Sea.
October 2009
A munitions clearance permit is granted by the Finnish authorities, allowing for the disposal of unexploded ordnance in the security corridor of its pipeline route in Finnish waters.

March–April 2010
The seven munitions identified in Swedish waters are cleared by BACTEC International Ltd.

May–July 2010
The 30 munitions identified in German waters are cleared by SeaTerra GmbH, a German munitions clearance company.

February 2010
Re-routing in German waters is approved. Nord Stream re-routes the pipelines along a stretch approximately 12 kilometres long. The new route runs in a curve 2.3 kilometres north of the original route.

June 2009
Final Espoo meeting and closure of Espoo process.

July 2009
The first shipwreck remnants are pulled from the Bay of Greifswald. The salvage work is needed to create the 60-metre-wide corridor for the laying of the pipeline, after delays due to bad weather, strong currents, and poor underwater visibility.

October 2009
A munitions clearance permit is granted by the Finnish authorities, allowing for the disposal of unexploded ordnance in the security corridor of its pipeline route in Finnish waters.

November–December 2009
Munitions clearance work begins in Finnish waters.

The first part of the munitions identified in Finnish waters is cleared by BACTEC International Ltd., a munitions clearance company.

February 2010
Re-routing in German waters is approved. Nord Stream re-routes the pipelines along a stretch approximately 12 kilometres long. The new route runs in a curve 2.3 kilometres north of the original route.

March 2010
Twelve shipwrecks are discovered along the route. They are found in a corridor next to the pipeline route in the Swedish EEZ as a result of the seabed surveys carried out by MMT on behalf of Nord Stream.

March–April 2010
The seven munitions identified in Swedish waters are cleared by BACTEC International Ltd.

April–June 2010
Munitions clearance continues in Finnish waters.

The second part of the munitions identified in Finnish waters is cleared by BACTEC International Ltd. Over the course of the project, 48 munitions are cleared in Finnish waters.

May–July 2010
The 30 munitions identified in German waters are cleared by SeaTerra GmbH, a German munitions clearance company.
The Baltic Sea was of strategic importance and heavily mined during the First and Second World Wars. It also became a dumping ground for munitions up until the 1960s. Contrary to popular belief, munitions do not carpet the entire seabed. Instead, they are concentrated in relatively small areas. Project Manager Simon Bonnell who was responsible for overseeing engineering surveys, along with munitions clearance activities for Nord Stream, explains where these munitions were located and how they were managed along the pipeline route. “The more we learned during the process, the more complex it got, and the more we surveyed, the more we found – but the munitions issue was successfully managed,” said Bonnell of the challenging operation to find and clear munitions in the pipeline route.

It is estimated that there are up to 150,000 munitions in the Baltic Sea, some dating back as far as the Crimean War and many still active. In addition to all the mines laid over the years, many confiscated German munitions were dumped by the Allies after the Second World War. “So there are two issues,” said Bonnell. “There are the dump sites, which are principally in the Bornholm area and south of Gotland, and then there are the mines that were placed in both defensive and offensive barriers.”

Once the pipeline route had been decided, the 2007–2009 surveys provided detailed information about the location and state of the munitions. “It was a first for me,” said Bonnell. “My experience was in surveys and geo-hazard assessments for deep-water pipelines, and this was something new – to ensure that we had a survey technique that could locate munitions reliably, both for safe pipeline installation and operation.”

The route avoided munitions where practical, but this was not always feasible. “Where possible, we avoided munitions, but the pipeline is 48 inches in diameter and it’s very difficult to weave – there’s a restricted radius of curvature – so there were areas where we had to clear munitions for the safe installation of the pipeline,” said Bonnell. “There were other areas where we could move the pipelines a few metres and the munition would remain outside the security corridor, which is about +/-25 metres. These remaining munitions will be monitored through the operation of the pipelines.” The total number of munitions located during the project was 432. All those posing risk of interaction during the pipe-laying process were...
The umbilical attached to the ROV and provides protection to the ROV during its launch and recovery. Via the umbilical, the ROV transmits survey data to the support vessel. With its manipulator arms, it deploys the explosive charge to clear the munition and collects scrap.

cleared. Fifty-two munitions were found in Russian waters, of which all but two were cleared by the Russian Baltic Fleet. In Finland, 48 were cleared, and seven in Sweden. Thirty training munitions without explosives – including test model V1 and V2 rockets – were also found in German waters and cleared by SeaTerra. Just seven of the 432 munitions were confirmed as chemical and it was decided to install the pipeline without interacting with them. “We performed soil sampling and didn’t find any hotspots of contamination. Results were assessed by chemical munitions experts investigating the Bornholm area,” said Bonnell. “Anchors were laid around the munitions, so there was no interaction during the installation.”

In the Gulf of Finland, there was open communication between Nord Stream and the relevant authorities to establish the permit requirements for munitions clearance measures. Environmental assessments were prepared for each individual munition, plus agreements with the owners of nearby cables, and extensive mitigation measures for protecting marine mammals, fish, and birds, as well as monitoring cultural heritage sites.

Clearing munitions in the Baltic Sea is nothing new. The navies of the Baltic Sea nations have been clearing mines regularly from the sea floor for many years. According to the German navy, more than 1,000 mines were cleared between 1996 and 2019, the majority during the Baltic Sweep and Operation Open Spirit. The difference with the Nord Stream approach to mine clearance was that every effort was made to minimise potential environmental impacts. “When the military clears munitions, they don’t have specific environmental measures, so Nord Stream had to develop environmental measures together with the environmental authorities and NGOs,” explained Bonnell. Nord Stream, together with relevant authorities, developed a stringent environmental and safety management plan for the clearance of munitions.

While the majority of munitions was detonated in situ (in place) – especially if they were of a type sensitive to movement – those close to telephone cables had to be moved. “These munitions were air-drop bombs rather than mines. We’d lift the munition with an air bag and re-scale it to a safe area where it would be detonated. Projectiles – artillery shells – were lifted by a remotely operated vehicle (ROV) and placed to one side.”

Mines detonations in Finnish and Swedish waters were carried out by BACTEC International Ltd., a UK-based explosive ordnance disposal and mine action company, with Nord Stream instructing them on the necessary environmental measures. Operations were carried out in daylight and good weather with rigorous protection systems in place to make sure any marine mammals at possible risk could be detected by the marine mammal observers. Such measures included acoustic monitors to hear mammals in the water, acoustic “scrammer” deterrents to scare away seals, and separate charges to disperse fish.

Safety of shipping was ensured through close cooperation with the marine authorities, and a clearance zone of up to 2 kilometres was implemented around each munition. Prior to starting any clearance, a notice to mariners was released and advance warning was given via Navigational Telex (NAVTEX). The operation did occasionally become a tourist attraction, with cruise-ship passengers watching from outside the exclusion zone. They were likely to have been disappointed. “There wasn’t a big show of water,” said Bonnell. “All the work was performed with the vessels at a safe distance, which meant that the worst-case scenario in the event of an accidental detonation would be the loss of the ROV. Thanks to all of the mitigation measures set by the team, everything worked as planned. When you’re doing the surveys, it becomes a routine, but when you’re actually installing the pipelines, you’re totally reliant on having done a thorough job in your surveys,” said Bonnell. He is confident about the success of the surveys and clearance activities. “The survey team – office based and offshore on each vessel – safely delivered the success through their dedication.”

>When the military clears munitions, they don’t have specific measures, so Nord Stream had to develop environmental measures together with the environmental authorities and NGOs.

Simon Bonnell
Nord Stream Project Manager

A seal scrammer secured with buoys is carried on the deck of a survey vessel. The acoustic device will be placed in the water a few hundred metres away from the munition to be cleared. It emits very high intensity sounds that can be heard for many kilometres underwater. This noise makes the vicinity uncomfortable for marine mammals and causes them to vacate the area prior to any munitions clearance activities.
Surveying the seabed
The OMS Pollux research vessel carried out surveys of the sea floor. A remotely operated vehicle fitted with a gradiometer array was used to detect ferrous objects in the installation corridor. The gradiometer array was specially developed for Nord Stream.
Surveys Uncover Numerous Finds Along the Route

**German Sector**

The pipeline route passes through the Bay of Grentsholm, or Grenzholm Bodden, close to the German coast. Here, a schooner of 25 tons was sunk during the Great Nordic War (1700-1721). The wreck site is historically and archaeologically significant and represents a rich source of information on maritime technology of the period. The pipeline crosses through the area of a shipwreck, so the controlled removal of one of the smaller wrecks from the barrier was necessary, and remnants of a smaller cargo vessel were relocated. The work was managed by the Agency for Preservation of Monuments of the State of Mecklenburg-Western Pomerania and Landesamt für Kultur und Denkmalpflege Mecklenburg-Büsum, AS/M-0. The remnants of a shipwreck from the late Middle Ages or early modern era (circa 1545-1600) were found close to the end of the Bay. The find was classified as being of “supra-regional importance.” The cargo in question, which consisted of some 15 copper plates and several wood barrels, provides an important insight into the trade relationships in the Baltic region during that era. Altogether, 26 possible wrecks were identified in the German sector, 20 of which were of cultural value.

**Swedish Sector**

No wrecks were found within the pipeline corridor in the Swedish sector, but 12 wrecks were discovered in the anchor corridor next to the pipeline route. 10 of which were considered to be of cultural value by the Swedish National Heritage Board. Most of the wrecks were commercial ships, originating from the 18th and 19th centuries. However, the most ancient wreck may have been from the Middle Ages. During the Mesolithic Age (8,000-4,200 BC), parts of the Södra Midsjöbanken, located south of Öland and Gotland, were land areas. The pipeline route crosses between Norna and Södra Midsjöbanken, but no remnants of Stone Age settlements were found.

**Danish Sector**

Thirty-seven possible wrecks or objects related to wrecks were identified within the Danish sector. Eleven of these were confirmed to be wrecks of cultural value. An 8-metre-long rudder from the 17th or 18th century was identified along the route near the island of Bornholm. It was lifted and brought to the preservation facility of the Danish National Museum in Copenhagen in September 2000. specialists at the Viking Ship Museum in Roskilde examined the archaeological significance of the wreck sites and reviewed the survey data.

**Russian Sector**

The pipeline route is about 7.5 kilometres from the protected area around the wreck site of the passenger ferry Estonia, which sank in 1994. One of the wrecks was the remnant of the Russian battleship Rusalka, sunk in 1900. Both discovered were a scattering of brown objects that a palaeontologist believes to be a whale skeleton. The pipeline route in Russian waters is where the Battle of Vyborg took place in 1719. Twenty-seven wrecks were identified in Russian waters, nine of which were of cultural value, including two admiralty anchors from the 18th and 19th centuries. Some arches were lifted off the wrecks to aid in the dating and documentation process. The survey data was evaluated by the Institute of Material Culture History of the Russian Academy of Sciences, and the salvaged anchors were delivered to the Historical Architectural Museum of Kronstadt for study, preservation, and storage.

Even some highly degraded wrecks can yield valuable information. Due to the low-oxygen and salinity levels, and the absence of boring worms (worms that burrow into submerged wood in salty water) make it ideal for preserving organic materials such as shipwrecks. Nord Stream was very aware of the impacts that the pipeline project might have on the Baltic region’s cultural heritage. It therefore established a rigorous baseline of actual seabed conditions through surveys of the proposed route. Along with its own seabed surveys, Nord Stream also carried out a comprehensive investigation of previously published information databases, evaluating prior seabed surveys and consulting closely with relevant authorities and other organisations. This detailed information enabled Nord Stream to avoid cultural heritage sites wherever possible, or when this was not feasible, to work with national authorities to find an acceptable solution. A shipwreck does not have to be fully intact to be of archaeological interest. Even some highly degraded wrecks can yield valuable information. Using a range of sophisticated equipment, including side-scan sonar, magnetometers to detect ferrous materials, and remotely operated vehicle, Nord Stream was able to examine wrecks that were visible and those that were hidden under sediment, both in the pipeline corridor and further away. The information that Nord Stream gained was shared with national authorities.
Gathering a Sea of Knowledge: Experts Uncover the Secrets of the Baltic

Ola Oskarsson is the Founder and Managing Director of the Swedish marine survey company MMT (Marin Mätteknik AB), which carried out the engineering, munitions screening, and environmental surveys for Nord Stream. His initial involvement in the project dates back to 1998 when it was engaged to conduct surveys of landfill locations in Finland, Sweden, and Germany. Almost a decade later, MMT began its detailed seabed investigations for Nord Stream, and grew in the process.

Why do you believe Nord Stream chose MMT?

The Baltic Sea is quite special, because it’s brackish and layered, so there’s the tidal regime, the stratification of the water masses and the extremities of the sea floor. Companies can often have problems when they first start working in the Baltic region, so they come to MMT for our specialist knowledge and local experience.

What was it like to work with Nord Stream?

It was an interesting project because when we started the surveys in 2007, Nord Stream was just a small task force and we were an enthusiastic specialist company with only 20 employees. As the project went on, they grew and we grew. When we finished the work in 2011, we were 220 people, so we’d increased our staff fantastically. It was interesting work, and we had a very good working relationship – we developed some very unique working systems together that have proven to be very successful, especially in terms of unexploded ordnance (UXOs).

Which surveys did you carry out?

We did the engineering geophysical surveys, and later the surveys to locate munitions and environmental monitoring – all of the bathymetric [depth] surveys from the wide corridor down to the detailed safety corridor. For us, the project started in 2006 when we met with Nord Stream. We started the detailed seabed investigations in 2007.

Of all the factors involved in choosing the route, which one proved to be the main consideration?

Environmental, absolutely. When we started the project, it was very controversial, and in Finland, the majority of the public was against it. There were newspapers writing that it would be an environmental catastrophe and that the pipeline would destroy the whole Baltic, which is an interesting idea because if you look at all the proportions it would be like taking a drinking straw and putting it on a football field. That was really hard for people to understand. But due to that public concern, Nord Stream handled the project in a way that set a standard for future pipeline projects. They spent 100 million euros on environmental investigations and route planning and that has been made public to the science community. They have actually performed the largest ever ecological survey on any water body anywhere – definitely in the Baltic. It tells prove an invaluable benchmark.

The project now has a solid environmen-
tal reputation. Was it satisfying to see environmental organisations, the media and the public won over those initial concerns?

Nord Stream decided on a very good policy – to be open. They took the concerns seriously, rather than saying, “We don’t care, we just want to pump gas.” They won the public over slowly. The main problem in Finland and Sweden was not environmental, however. Due to historical experiences, the public is suspicious about Russian intervention, and will always suspect a military aspect. But by showing that it was a commercial consideration and using commercial companies, the public realised that this was just a huge infrastructure project. Of course, it was costly, but they managed to stay inside the time frame. They would never have been able to do that unless they took the environmental impact as seriously as they did.

You used state-of-the-art survey equip-
ment to make 3-D models of the seabed and detect buried metal objects. Were there any devices that proved especially valuable to the process?

The gradiometer arrays, which we actually developed for this project, as one of the larger tasks was to survey 1,224 kilometres multiplied by four [two per pipeline] without having to pinpoint all the scrap metal, small cans, and wires on the sea floor, but just pinpoint the large ferrous masses representa-
tive of mines. That required a sophisticated system that could make distinctions – and that had never been done before.

The gradiometer arrays were actually an idea by Simon Bonnell [Nord Stream Project Man-
aged], which we developed with the manufactur-
er. It’s important to remember that it’s not about the highest resolution – the whole idea was to have a resolution that would omit non-UXOs. If you had a much higher resolution, you’d have a few million targets to investigate, so it was a discriminating instrument.

How laborious was it to have remotely operated vehicles (ROVs) inspect every object within 25 metres of the pipeline?

It’s a fantastic expense to move the vessel and get the ROV down and very close in and thoroughly look at each munition. In some cases, we had to make a separate dive for each. The ROV we used probably swam the longest any underwater robot has ever swum – 10,000 kilometres in two years. Which is a pretty long way for a little robot!

As well as environmental concerns, you also had to consider cultural heritage sites, such as shipwrecks. Yes, the Baltic is unique because the shipwrecks don’t last apart.

Why is that?

No boring worms, little salt, and no oxygen to speak of, so everything was pretty much intact – some of the shipwrecks are amaz-
ingly intact in the Baltic. We measured them by multi-beam echo sounder, which yielded many millions of points and a 3-D model. The ROV then went to 20 well-recognisable features and filmed them for reference, and these points were revisited after the operation to ensure that the shipwrecks hadn’t been disturbed by the waves of the pipeline vessel on the explosion of the mines.

Moving on to the munitions, it was a vessel-and-ROV contract. Had MMT pre-
viously been involved in any similar mine clearance support operations?

We’ve done some work in Norwegian harbours but not a major operation such as this with mine disposal. But since Sweden had a conception system, most of the people who work offshore here have backgrounds as military divers, so it was not a task that was unfamiliar to them. But as a private company, it was pretty unique, and it was extremely successful – it was within the time frame and the environmental impact was about a tenth of what was estimated by the authorities, which we’ve very proud of.

Was it a daunting prospect? Did you know what to expect?

I’ve spent my life in the Baltic region so it was exactly what I expected. In the open sea – the salty water, the North Sea – a mine’s lifespan is typically 30 years. But in the Baltic Sea, we knew there were wooden mines from 1848 that were still active.

The whereabouts of some munitions would have been classified information. Did you have any problems getting ac-
cess to the information you needed from the countries involved?

By the end of the project, the trust was good between the people on the project and all the authorities, which made it much easier to get access to the information. There’s a little bit of bartering – you access information and you give information in return.

There was already data about the safety of the waters gathered by NATO-member navies and coast authorities. Therefore, Nord Stream organised seminars with key figures to discuss the situation – were you involved in these?

We took part in the Nord Stream seminars to explain the level of accuracy in the work to find the mines, and also to give them the mine database – there were meetings in Sweden, Finland, and Denmark and also some meet-
tings with the various archaeological bodies of the countries.

Were there ever any moments during your work with the mines when there was a genuine concern about the safety of your team?

No, because these are contact mines. I suppose if we had had a row of one of them in 40 metres of water – which was about the depth of the shallowest mine that we found – and it had gone off, there might have been some damage to the vessel. In an extreme case, there could be damage to the propeller shaft, which of course would have been a problem. But nothing that could sink a vessel – you would need to be very close to the mine for that to happen. In comparison with contact mines, modern mines are much more sinister.

Given that the Baltic Sea is such a fragile ecosystem, were there other issues that you had to take into account?

The Baltic requires that you do not dispose of waste and slag or have spillages in the water, but that’s a general regulation – it applies to all shipping in the Baltic. Techni-
cal tasks can be more demanding than in other seas because you have to do much more sampling of data to get the calibrations right, because of the differences in tempera-
ture and pressure. I’ve spent all my working life surveying the Baltic, so it’s my home turf, but I imagine that anyone who was used to working in the open Atlantic would find the Baltic more challenging.

All the information from the surveys was shared with NGOs, heritage organisa-
tions and HELCOM. Was transparency always an important consideration?

Yes, I don’t know how many divers I want to initially where people said, “You work for Nord Stream! That’s such a terrible project.” But it was very easy to defend because there was this misconception among the general public. Compared with other energy projects, it’s absolutely the one that had the highest environmental impact awareness.

Were there any valuable lessons learned – anything that you think could be relevant on a similar project in the future?

We learned so much from the project and developed so much during the project, so it’s really relevant to anything that a company has to do when considering whether or not to survey a large company. A huge process.

It says on the MMT website that your personal motto is, “to take arms against a sea of troubles, and by opposing, end them,” from Hamlet. Did you find this relevant to the project?

I think it’s relevant to whatever we do. There is a sea of trouble out there, but, by taking it on, you create a challenge and produce something good. And it’s a fantastic environment to work in – the oceans cover 70 percent of the globe and just 10 percent of them have been visited in any way by mankind, which means that more than half of the globe is still to be looked at. We’re in a situation such as this on the 30 years ago when the poles and the deserts hadn’t been inves-
tigated. Now you have to go to the oceans to do it, so if you’re an explorer, it’s a fantastic time to be alive.
The pipelines take up less than one thousandth of 1 percent of the Baltic Sea floor.

40,000 kilometres of Baltic Sea terrain were accurately surveyed prior to construction, equivalent to the circumference of the earth at the equator.

250,000 man hours were put into the technical planning of the two pipelines from 2006 onward.

€ 100 million were spent on detailed environmental studies of the Baltic Sea from 2006 up to construction.

150 monitoring locations were established to investigate the impact of the project on marine life, bird habitats, water quality, and other environmental issues.

59,000 The number of remotely operated vehicle visual inspections were carried out on over 30,000 targets.

200,000 side scan sonar targets were selected, 110,000 of which were in the Finnish sector alone.

600 barrels were among the many objects located and visually inspected in the Gulf of Finland.

Scale

- 0.001 %
- 40,000 kilometres
- 250,000 man hours
- 100 million
- 150
- 59,000
- 200,000
- 600 barrels

Defining the optimal route

The optimal route was selected on the basis of in-depth research, and alternatives were measured against three main criteria, with safety being a constant, overarching concern.

1) The first criterion was environmental and focused on avoiding areas designated as protected or sensitive, or areas with ecologically sensitive species of animal or plant life. Every effort was made to minimize work on the seabed that might disrupt its natural composition. The field studies included analysis of water and soil samples as well as observation of the behaviour of fish, marine mammals, and birds.

2) The second criterion looked at socio-economic factors to minimize any contact with shipping, fishing, dredging, the military, and tourism – and with sea installations, such as existing cables or wind turbines. Avoiding known areas with discarded conventional and chemical munitions was also a top priority in the route selection process.

3) The third criterion covered technical considerations, such as minimizing construction time, and therefore any disruptions, as well as reducing the technical complexity of the operation to keep the use of resources as low as possible. These criteria were applied to each of the main routing choices.

Telescope design

The twin pipelines have a constant internal diameter of 1,153 millimetres. However, Nord Stream designed the pipelines with three different design pressure sections (220, 200, and 177.5 bar) and pipe wall thicknesses (34.4, 30.9, and 26.8 mm respectively) corresponding to the gas pressure drop over the long journey from Russia to Germany. By designing each section according to the changing pressure, Nord Stream was able to save on the amount of steel used and thus the costs of the pipes.

Pressure sections

Pipe wall

34.4 mm
30.9 mm
26.8 mm
220 bar
200 bar
177.5 bar
1,153 mm

The challenge

A wide range of factors had to be taken into account in the process of finding the optimal route for the pipelines. Aside from shipwrecks and mines, it was also necessary to consider the location of protected sites, numerous fishing grounds, other energy infrastructure, shipping lanes, and military exercise areas.

1) Various environmental protection sites, such as Natura 2000, cover large parts of the Baltic Sea marine area. Natura 2000 designated areas have been identified as important wildlife habitats and, as such, should be managed in a way that ensures that biodiversity is maintained. According to the Helsinki Commission (HELCOM), these areas made up 12 percent of the Baltic Sea marine area in 2010.

2) Fishing is the livelihood of many Baltic Sea coastal communities. According to European Commission figures, more than 6,800 fishing vessels operate in the Baltic Sea each year.

3) Around a quarter of the route crosses or runs in proximity to various military exercise areas used by the navies of the Baltic Sea countries.

4) Each of the pipelines crosses 17 active cable routes, for which crossing solutions were developed. Other existing or planned infrastructure projects in the Baltic Sea had to be considered, such as windparks.

5) Ships crossing the Baltic Sea try to navigate the shortest and safest possible route, which is why the main shipping routes from the western to the eastern parts of the Baltic run almost parallel to the pipelines.

Munitions

432 The total number of munitions that were located during the project. Of these, 425 were conventional munitions.

Over 100 munitions were removed from the seabed to ensure a safe route.

52 munitions were found in Russian waters; 50 were cleared.

48 munitions were cleared in Finnish waters.

30 training munitions and test model V1 and V2 rockets were found in German waters.

7 chemical munitions were identified in Danish waters. And seven conventional munitions were cleared in Swedish waters.

Shipwrecks

12 wrecks were identified in Danish waters. Ten of these were of cultural value.

26 possible wrecks were identified in German waters; nine were of cultural value. At the entrance to the Bay of Greifswald, the pipelines traverse the historical shipwreck barrier of 20 sunken ships, one of which was recovered.

27 wrecks were identified in Russian waters; nine of which were of cultural value, including anchors from the 18th and 19th centuries.

37 possible wrecks were identified in Danish waters. Eleven were of cultural value, including a rudder from the 17th or 18th century.

56 wrecks were identified in Finnish waters; 25 were deemed to be of cultural value.

Photo below: a wreck identified in the Baltic Sea.
Munitions Clearance Procedures Explained

About 432 conventional munitions that were either left over from the two World Wars or other activities of the Second World War were found in the area of the North Stream Pipeline route, 135 of which needed to be cleared. In its clearance procedures, the company handled by BACTEC International Ltd., while the 30 munitions Clearance operations in Finnish and Swedish waters were handled by The Partnership for Peace, a programme between partner countries, which conduct mine clearing missions in cooperation with relevant authorities around the Baltic Sea in strict accordance with all applicable legislation.

The detailed effects of the detonation are minimal. In this endeavour, the company has ensured that the pipelines are safe and that the Munitions disposal takes place during approved environmental monitoring (PAM) is employed. Marine mammal observers oversee all activities and look out for marine life if any is sighted. Reporting System. Detonation is delayed for marine mammals and causes visual detection of mammals is effective. The radar beacon (yellow) makes it visible to ship traffic. The seal scrammer acoustic device emits very high intensity sounds underwater. This noise is the seal scrammer acoustic device. Fish, the sea mammals, and birds are kept away. The detailed effects of the detonation are minimal. The seal scrammer acoustic device emits very high intensity sounds from the support vessels.

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