Background Story: Pipeline Construction

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Introduction

The EU’s domestic gas production is in rapid decline. To meet demand, the EU needs reliable, affordable and sustainable new gas supplies. The Nord Stream 2 Pipeline will provide this by transporting gas from the world’s largest reserves in Russia to the EU internal market, increasing security of supply and contributing to the objectives of the European energy policy.

With its state-of-the-art technology, the pipeline will offer reliable, economic and environmentally sound natural gas supplies over the coming decades, building on the proven experience of the existing Nord Stream Pipeline system and the mutually beneficial long-term energy relationship between the EU and Russia.

The twin pipeline stretches over 1,230 kilometres through the Baltic Sea from the Russian to German coast and runs largely parallel to the existing Nord Stream Pipeline system. On each end, landfall facilities will be constructed to connect the system with the Russian and European networks, with the pipeline laid along the seabed in between.

Nord Stream 2 works with some of the world’s leading suppliers and applies rigorous health, safety, environmental and social standards to protect the sensitive Baltic Sea at every step of preparation and construction. All works are carried out in compliance with national permit conditions and monitored for potential impacts on the environment and marine life.
Before construction began, Nord Stream 2 conducted thorough survey operations, which are the cornerstone of massive international infrastructure projects like the offshore pipeline. The data gathered plays a pivotal role in enabling the project to move forward safely, providing critical information for engineering, route optimisation, Environmental Impact Assessments (EIA) and permitting, environmental management and monitoring, financing and insurance, quality control and operations.

The entire Baltic Sea route from Russia to Germany was surveyed from the sea shore to depths of more than 200 metres for around 55,000 line kilometres. To ensure a clear and safe route every detail of the seabed shape had to be identified. This included steep slopes, sediment types and rock outcrops, environmentally sensitive areas, water depth and any items that could affect pipeline installation and operation, from existing infrastructure to shipwrecks and unexploded ordnance (UXO).

Using the latest technology to collect some of the most resolute 3-D data sets being produced today, a fleet of 41 high-performance vessels has mapped a route that will minimise environmental impact and ensure the safe operation of the new natural gas pipeline.
Due to the physical conditions in the Baltic Sea the preservation of cultural heritage – objects that represent evidence of past and present human activity – is exceptional, and the value and scientific potential are great.

Physical disturbance of the seabed has the potential to damage cultural heritage sites or render these inaccessible for future research. The pipeline route was therefore optimised to avoid negative impact on valuable cultural heritage sites wherever possible.

In the five countries whose waters the pipeline traverses, cultural heritage is protected by legislation. From the beginning of the planning process for the pipeline, we paid attention to the effect that Nord Stream 2 might have on cultural heritage and cooperated closely with the relevant cultural heritage authorities and experts in each of these countries. In doing so, we follow the best practice example set by the existing Nord Stream Pipeline.

There are a large number of shipwrecks on the seabed of the Baltic Sea that reflect a diverse group of vessels. Some shipwrecks are of no archaeological interest, whereas others are unique due to their construction method, the degree of their preservation or special historical factors. Objects which are more than 100 years old are protected by legislation in the Baltic Sea Littoral States. The relevant authorities in each country may additionally decide that more recent wrecks (i.e. aircraft or ships from WWI or WWII) are also to be protected.

Comprehensive surveys have been conducted to identify and map features or areas of cultural heritage to be avoided or safeguarded. The mitigation measures to deal with cultural heritage finds includes several aspects: avoidance, caution and salvaging finds.

To avoid interference with cultural heritage objects, a minimum buffer distance of at least 50 metres between the pipeline corridor and these objects is recommended by the experts in many countries such as Finland and Sweden. Placing pipelines at a sufficient distance from cultural heritage objects, e.g. by surveys of the pipelay corridor prior to installation, will reduce impacts. If intervention works such as the installation of rock berms are necessary, these are conducted with caution, and they will also account for the minimum distances recommended. If artefacts must be moved, Nord Stream 2 decides together with experts how to proceed: Salvaging finds and handing them over to the authorities or moving them to a safe distance from construction activities.
Russia
The preferred route for the pipeline’s Russian section, the Narva Bay route, runs through the area that was important for the sea trade between Russia and the West Baltic in the past. Archival evidence about numerous merchant and military ships sunken in Narva Bay confirm this.

A geophysical reconnaissance survey was carried out for the pipeline in 2015-2016 to gather information about anthropogenic objects on the seabed. In the corridor with a width of 1.5 kilometres, around 10 of the identified objects have been classified as potential objects of cultural heritage, i.e. wrecks or wreck parts. Following this general description of the objects, further detailed marine archaeological surveys in the corridor of the planned pipeline took place in summer 2017. The purpose of the research campaign was to determine if the objects could indeed be classified as cultural heritage. Five of them were recognized as movable archeological objects related to marine fishing and shipping. Three of them were recovered and transported to the Kingisepp Museum of History and Local Lore after field conservation. These included two horned anchors shaped by press forging and a hook, both of which were conceivably from the 19th to early 20th centuries. Another object was a water breaker with a capacity of 12 to 40 litres, which was used as reservoir storage most likely in 18th to early 20th century. Two other objects were moved out from the pipeline corridor: and admiral anchor from as early as 1862 and a wooden capstan for a vessel from the 18th to 19th century.

Finland
In Finland, two targets of cultural historical interest were identified: an 18th century merchantman and a late 18th-early 19th century cannon barge. Two inspected Word War II targets, a cargo supply ship and the anti-submarine net installation have also been included in the list as being of historical interest and significance, even though they do not meet the over 100-year criteria as such.

Together with these sites, a total of 32 potential targets of cultural interest or World War II potential historical sites are located in an area which extends to up to 1,000 metres away from the pipeline route. In the Finnish route section, a dynamically positioned vessel will therefore be used to ensure that pipelay activities have no impact on these targets. Due to the distance of the targets to the pipeline, these targets will not be further surveyed and assessed.

Sweden
No cultural heritage objects have identified in the immediate vicinity of the pipeline route in Swedish Exclusive Economic Zone (EEZ). Six potential archeological shipwrecks have, however, been identified within 50 to 250 meters from the pipeline route. Detailed inspections by remotely operated vehicles (ROVs) will therefore be performed before and after construction to make sure they are not impacted negatively.

Experts have assessed that with the mitigation measures planned, the overall impact from the construction and operation of the pipeline on cultural heritage objects in Sweden is of no or negligible significance.

The probability of encountering submerged settlements along the route within the Swedish EEZ is very low, as these areas most likely have undergone erosion since submergence or
are located at deeper water depths, where it is highly unlikely to find remains. The relevant cultural heritage authority, the Swedish National Maritime Museums (SMM), therefore recommended not to investigate the matter further.

**Denmark**

Seven potential wrecks have been identified along the base case route in Danish territorial waters. These are located at distances ranging between 100 and 1,200 metres. Two of these wrecks were found during surveys for the existing Nord Stream Pipeline and are already registered in the national register of shipwrecks.

Along the alternative route, stretching north-west of Bornholm, eight potential wrecks have been identified. These are located at distances ranging between 200 and 2,600 metres.

All objects were visually inspected and assessed by marine archeologists in consultation with the Danish Energy Agency for Culture and Palaces. Safety zones were established around confirmed cultural heritage objects and the route was developed to ensure that the pipeline avoids any areas of cultural value.

The impact of the construction and operation of the pipeline on cultural heritage objects in Danish waters is therefore expected to be negligible and insignificant. No dedicated monitoring of cultural heritage objects or further mitigation measures have been recommended by the Danish authorities.

**Germany**

In German territorial waters, at the threshold of the Bay of Greifswald, several remains of shipwrecks of archaeological value are located. In 1715, the Swedish marines ballasted some 20 ships in a line to hinder enemy fleets from entering the bay.

For the construction of the existing Nord Stream Pipeline, remains of a ship in the historic barrier of wrecks were removed by experts and conserved for scientific and historical purposes. It is currently being assessed as to whether one or two more remains of wrecks have to be salvaged before laying the new pipeline. The exact cultural heritage preservation measures will be agreed in close cooperation with the relevant authority, the State Office for Culture and Care and Preservation of Ancient Monuments and Artefacts of Mecklenburg-Western Pomerania.
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Logistics

The aim of Nord Stream 2's logistics concept is to supply the materials needed in an efficient, timely and cost-effective manner, minimising impacts on the sensitive ecosystem of the Baltic Sea. Low-emissions transportation such as ships and trains are used with the shortest possible routes. Local workforce, services and service providers around the Baltic Sea are used as much as possible.

Production of the approximately 200,000 pipes requires steps from plate production, pipe milling, welding, stretching, treatment of pipe ends (chamfering and bevelling) all the way to quality control. After quality control, all pipes receive an internal anti-friction coating and an external anti-corrosion coating. The pipes for both pipelines have been produced by the German company EUROPIPE GmbH (41 percent) and the Russian companies United Metallurgical Company JSC/OMK (31 percent) and Chelyabinsk Pipe-Rolling Plant JSC/ChelPipe (28 percent).

Nord Stream 2 contracted Wasco Coatings, part of the Malaysian-based energy group Wasco Energy, to provide concrete coating, storing and logistics services for the more than 2,400 kilometres of pipes needed for the project.

To ensure that the pipeline will be laid as efficiently as possible, four ports were chosen to serve as the project's logistics hubs. Kotka on the Finnish coast and Mukran on the island of Rügen, Germany, were selected as locations for the concrete weight coating and interim storage yards. Koverhar Harbour in Hanko, Finland, and the Port of Karlshamn in Sweden were selected as additional interim storage yards to ensure short transport distances to the pipeline route.

The steel pipes were transported from the pipe mills by rail to the concrete weight coating plants on the Baltic Sea coast: Kotka in Finland and Mukran in Germany by the Russian Railways, Finnish VR Transport and DB Cargo Deutschland AG respectively. A small number of pipes were coated in ChelPipe’s subcontractor’s plant in Volzhsky, Russia, and railed directly to storage yard in Koverhar in Hanko, Finland.

At the coating plants, the pipes will receive a concrete weight coating, doubling their weight from approximately 12 tonnes to 24 tonnes each. The extra weight is necessary to add the pipeline’s stability on the seabed and adding mechanical protection during handling, transport and pipelay operations, as well as protecting it in the seabed from external damage.
Wasco will concrete weight coat approximately 100,000 pipes in its coating plant in Kotka, approximately 83,500 in Mukran. From these coating plants, pipes are then transported to interim storage yards in Koverhar and Karlshamn. A total of 52,600 pipes will be stored in Karlshamn, 61,300 in Koverhar before being transported to the pipelay vessel at the time of construction.

The handling and transport of the pipes to storage yards in Koverhar and Karlshamn as well as storage activities are provided by Wasco’s Danish pipe transport sub-contractor, Blue Water Shipping A/S. At the end of the logistics chain, three pipelay contractors undertake offshore pipelaying of the two lines. Nord Stream 2 has signed contracts covering the offshore pipelay capacities with Allseas Group S.A., Saipem and MRTS JSC.

Special pipe carrier vessels will transport the pipe segments to the pipelay vessels. On board the pipelay vessels, they will be welded onto the pipeline and then lowered to their designated place on the seabed.
Construction Activities

Preparatory Activities

Munitions Clearance

After the World Wars, mine lines were abandoned and numerous conventional and chemical munitions were dumped in the Baltic Sea. Nord Stream 2 has carried out extensive and detailed surveys to verify that the seabed is safe for the construction and operation of the pipeline. By April 2018, more than 55,000 line kilometres had been inspected, adding to the comprehensive data already collected prior to the existing Nord Stream Pipeline’s construction.

Nord Stream 2 has optimised the pipeline route to avoid munitions objects wherever feasible. Conventional munitions that cannot be avoided through localised rerouting have been cleared on location, if these measures could be consistent with safe practice and in agreement with the relevant authorities. The data and experience gained from the previous project were utilised for planning the clearance methods, mitigation measures and monitoring of the environmental impacts according to the highest standards.

Nord Stream 2 contracted international munitions clearance experts to perform the operations. Extensive mitigation measures were used to reduce potential impacts to environment. The basic principles of the munitions clearance method involved placing a small charge next to the identified object on the seabed using a remotely operated vehicle (ROV) or divers. These charges were then detonated from a surface support ship located at a safe distance from the target. In the Finnish Exclusive Economic Zone (EEZ), munitions were cleared using ROVs, thus limiting the risk for the personnel onboard the vessels involved in the munitions clearance. In shallower waters in Germany, divers were also used.

In Finland, N-Sea/Bodac and MMT/Ramora performed the clearance activities. A detailed munition-by-munition clearance plan was developed for each individual object. The companies used four vessels, with two vessels working simultaneously on one munition: a main disposal vessel and a bubble curtain vessel that mitigated the noise impact of underwater
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explosions on marine life. Marine mammal observers on board the main vessel conducted visual observations searching for marine mammals and other sea life. Passive acoustic monitoring and fish scanning monitoring to detect marine mammals and/or fish were carried out. Operations would have been postponed should a mammal be seen within a 2 kilometre zone, however no mammals were observed. Acoustic deterrent devices, i.e. seal scrammers, were deployed for removals to scare any marine mammals and fish away from the clearance area within the 1 to 2 kilometre mitigation zone.

In Germany, some 79 UXO items were identified and cleared with assistance from the local authorities. Denmark’s preferred route section has been planned to avoid any conventional or chemical munitions. In the Swedish EEZ, the route has been locally re-routed to avoid the finds, whereas in the Finnish EEZ, a total of 74 munitions were cleared. In Russian waters, the Baltic Fleet carried out the required clearance.

The monitoring results from the existing Nord Stream Pipeline have shown that the impacts of munitions clearance were smaller than expected. The first monitoring results of munitions clearance in Finland were submitted to authorities at the end of September.

Trenching

Although the route has been optimised, some seabed preparation works are still necessary to safely install the pipelines. Preparation works are required at different locations before and after pipelines are laid to guarantee stability, provide support and protection at crossings and ensure a stable foundation. During normal operation, the pipeline can move on the seabed. Potential changes in topography are detected by maintenance surveys, and seabed intervention works will be performed if needed.

The offshore installation of the pipelines along some sections of the route, especially in shallow waters, requires additional stabilisation and/or protection against hydrodynamic loading (e.g. waves, currents), which can be achieved by trenching the pipeline into the seabed where rock placement is deemed impractical.

Pipeline installation in a pre-lay excavated trench by means of dredging is the
preferred trenching method in these shallow-water areas. In deeper waters, the most commonly used trenching method is post-lay ploughing, where trenching is performed after pipelay. Post-lay ploughs are towed by a powerful surface support vessel and create a trough of pre-determined length, depth and width. Partial, natural backfilling occurs over time as a result of currents close to the seabed.

At the landfalls in Russia and Germany, the pipelines will be entirely buried in the seabed to ensure their stability. The excavated material will be removed, temporarily stored and then can be used for backfilling.

**Rock Placement**

Due to the uneven nature of the seabed in the Baltic Sea, rock placement will be required along certain sections of the route to ensure that pipeline integrity is maintained for the 50-year design lifetime of the pipeline system.

The seabed along the entire route was carefully surveyed ahead of pipelay. Rocks serve as basement structures and protection at pipeline crossing areas as well as providing stability wherever required. The types of rock placement works include installation of rock berm supports (before and after pipelay) and rock cover (after pipelay) in precise locations. The rock material is granite with an average size of 60 millimetres. To minimise the environmental impact, only clean, freshly crushed rocks are used. They may not contain contaminants, such as heavy metals that could be dissolved in the water, or clay, silt, lime or vegetation.

Due to the uneven seabed in some locations, the pipeline may have to cross a ravine or valley, effectively forming a “bridge” with a free space beneath it, called a freespan. Rock placement conducted before pipelay is the main method to mitigate freespans.

Boskalis-Van Oord, the joint venture in charge of all rock placement along the pipeline routes, commenced rock placement operations at the end of April 2018 in the Finnish EEZ. They use dynamically positioned fallpipe vessels.

Rock material is transported by the FPV to each of the positions where rock placement is required. The fallpipe traverses the water column to accurately install the rock at the pre-determined berm locations on the seabed. The lower end of the fallpipe is fitted with a state-of-the-art remotely operated vehicle (ROV) which guides the FPV during the operation to ensure that the rock is installed per design.

Most of the rock placement will take place in the Gulf of Finland due to its uneven seabed. Just over half of the total amount of the estimated rock material for the project will be used in Finnish waters, a third in Russian, and around 10 percent in Swedish waters. Rock placement requirements in German and Danish waters are negligible.
Cable Crossings

The route crosses power and telecommunications cables, the two existing Nord Stream Pipelines and infrastructure that is being planned in the Baltic Sea. At crossing locations, concrete mattresses will be placed over the cables for their protection. When a pipeline crosses another pipeline, the placement of rock berms is often also required in addition to mattresses.

Concrete mattresses keep a pipeline separated from a cable (the black line).
Landfall Russia

Landfall Facilities
The Russian section of the pipeline is divided into a 3.7 kilometre-long onshore segment and a 114 kilometre-long offshore segment.

The starting point of the pipeline is located on the coast of Narva Bay in the Kingisepp district of the Leningrad region. Gas that flows into the Nord Stream 2 Pipeline will come from the Northern Corridor of Russia’s Unified Gas Supply System (UGSS) to the Slavyanskaya compressor station, some 5 kilometres from the landfall facilities. Here, the gas will be pressurised to secure transportation without intermediate compressor stations along the route.

The compressor station and the pipeline are connected by four underground pipelines that are operated by Gazprom. The landfall is 3.8 kilometres away from the shore at the landfall facilities. It is equipped with all systems necessary to monitor the parameters of the incoming gas and ensure safe operations, including the Pipeline Inspection Gauge (PIG) trap area and shut-down valves, as well as systems to monitor gas flow.

The Russian onshore section of the pipeline passes through the Kurgalsky nature reserve. To ensure the smallest possible environmental footprint, this section will be built using an innovative open-cut construction method. Trench boxes will be deployed to reduce the width of the construction corridor and related impacts by some 50 percent.

The technique also helps to preserve local hydrology, since no draining of the trench is required for pipeline installation. Upon completion of construction, the entire area will be reinstated. A 30 metre-wide corridor directly above the pipeline will be kept free of trees, as required by Russian safety standards. Vegetation will be allowed to return to this area naturally.

Onshore Pipelaying
The starting point of the pipeline system is in Russia’s Narva Bay in the Kingisepp district of the Leningrad region. At this location, the pipeline route crosses a protected area, the Kurgalsky peninsula, over a distance of approximately 6.2 kilometres, of which approximately 3.7 kilometres are onshore and 2.5 kilometres offshore.
Nord Stream 2 has appointed a world-leading contractor to employ a design that adheres to the requirements for minimising the corridor and any other environmental impacts associated with the construction.

Following an in-depth study, the contractor came up with a method that will have a substantially smaller environmental impact than the conventional approach, the trench box construction method. The method relies on trench boxes to maintain vertical trench walls and reduce the width of the trench, allowing the pipelines to be laid within a 30-metre corridor, or right of way, through the most sensitive habitat.

In addition to reducing the footprint, this method will also reduce the amount of excavated material by approximately 70 percent when compared to a conventional unsupported trench. Installation in a flooded trench limits the dewatering required during construction. This ensures that groundwater levels during and after construction will not be altered, keeping surface hydrology in its natural condition and safeguarding the habitats which rely on a high water table for their survival.

The trench box method requires pipe fabrication to take place at two locations rather than alongside the trench: on the lay barge and at the gas inlet terminal. The pipeline strings are pulled from the pipe-lay barge anchored nearshore and are welded at a temporary welding station established adjacent to the gas inlet facility. The two parts will be welded together on the eastern margin of the dune. This installation method requires almost no heavy equipment on site during pipeline installation and limits the number of vehicles on used, significantly lowering the width required for the corridor as well as noise emissions and associated disturbances during the pipeline installation phase. After installation of the pipelines, the trench boxes will be extracted, the trench will be backfilled and a vegetation cover will be reinstated.

Lateral thinking and the application of advanced construction techniques has enabled us to find a safe, reliable and environmentally acceptable design solution that will minimise habitat loss, reduce the severance effect on continuous habitats and preserve the hydrological regime of the area.

**Offshore Pipelaying**

The seabed must be prepared before pipelaying can begin. In the nearshore approach to the Russian landfall, this includes dredging and backfilling. The pipelines will be buried in the seabed to ensure that water and sand movements do not affect their stability, which requires the excavation of a trench using dredgers. The excavated materials will be removed, stored temporarily, and then used for backfilling where possible. Nearshore and offshore construction activities will be performed using two state-of-the-art pipelaying vessels, with these two sections of the pipeline later joined by above-water tie-in.

Throughout construction, comprehensive environmental monitoring will be carried out for the onshore and offshore sections to ensure that actual environmental impacts do not exceed thresholds outlined in the environmental impact assessment report. Responsible authorities will conduct external oversight.
Offshore – Pipelaying

Pipelaying Process

Constructing an underwater pipeline is a major undertaking. Over 200,000 pipes will be needed to create both strings of Nord Stream 2. Pipelay began in the beginning of September 2018 in the Gulf of Finland by pipelay vessel Solitaire, in a carefully planned and tightly managed process. During the construction phase, up to five individual pipelay vessels will build the pipeline at a rate of up to 3 kilometres per day. Several measures will be taken to minimise disturbance to the sensitive Baltic Sea environment, which has dense shipping traffic and historic sea mines.

Safety and environmental protection are the foremost considerations throughout construction. The individual 12-metre, 12-tonne steel pipes produced at plants in Germany and Russia have a constant internal diameter of 1,153 mm and a wall thickness of up to 41 mm. The pipes have been coated internally to reduce friction, and externally to reduce corrosion. Finally, a concrete coating on top increases protection and doubles their weight, making the pipeline more stable on the seabed.

Nord Stream 2 has contracted some of the world’s leading contractors to install the pipeline through the Baltic Sea: Allseas, Saipem and MRTS JSC. The pipelay vessels operated by Allseas, i.e. Solitaire, Audacia and Pioneering Spirit, will be responsible for installing 96 percent of the two pipeline strings. Saipem’s Castoro Dieci will pull ashore the final section of the pipeline and connect it to the landfall in Germany. It will also connect the pipeline sections above the water in German waters. Russia-based MRTS JSC is installing the starting section of the twin pipeline in the shallow waters off the Russian coast with pipelay vessel Fortuna, including the two above-water tie-ins close to the Russian landfall.

Each pipelay vessel is a floating factory where the pipes are received from carrier vessels, welded together and then installed on the seabed in sections. In the first step, the pipes are delivered to the lay vessels by pipe carrier vessels regularly. To prepare the pipes for welding, the ends are bevelled to make them exactly the right shape to be fitted together. The inside of the pipe is then cleaned using compressed air before it is conveyed to the double-joint welding station. Here, the 12-metre pipe joints are aligned and welded together to create a double-joint segment measuring 24 metres.

The double-joint is moved to a non-destructive testing station where every millimetre of the weld undergoes automatic ultrasonic testing (AUT) to detect any unacceptable flaws. Any
defects will be removed and the weld will be rescanned to ensure it meets international standards. Following AUT, the double-joint is moved in a pipe elevator to the central assembly line. There, the insides are checked for debris and the double joint is aligned with the main pipe string in preparation for welding. The double-joint is then joined to the end of the pipeline using a semi-automatic welding process. Qualified welding inspectors oversee each of the steps and authority approved welding procedures.

Following welding, the weld between the double-joint and the main pipeline undergoes AUT before a corrosion resistant, heat-shrink sleeve is applied over the circumferential girth weld. Any unacceptable flaws are removed and the weld is re-scanned to ensure it meets international standards. Once the weld is confirmed acceptable, a corrosion resistant heat-shrink sleeve is applied over the circumferential girth weld and polyurethane foam is poured into a former surrounding the weld area. This foam hardens, providing further protection.

The completed pipeline will undergo rigorous testing and assessment by an independent certification body. Once the safety of the pipeline is assured, gas will be able to flow directly from the world’s largest natural gas reserves into the EU’s internal energy market.
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Pipelay Vessels

Solitaire
- Dynamically positioned pipelay vessel, Operator: Allseas Group S.A.
- Performs the majority of the offshore pipelaying
- 2 double-joint factories (each with 3 welding stations and 1 Non-Destructive Testing (NDT) station), 5 welding stations for double joints, 1 NDT station and 4 coating stations
- Solitaire can lay pipes in depths between 18 and 2,775 metres
- Lay rate of approximately 3 km/day
- Accommodation capacity: 420 people
- Size: 300 metres by 41 metres

Pioneering Spirit
- Largest pipelay vessel in the world, dynamically positioned, Operator: Allseas Group S.A.
- Used for offshore construction
- Double-joint factory, 5 line-up stations, 2 stations for combined external/internal welding
- Firing line with 6 (double joint) welding stations, 1 NDT station and 6 coating stations
- Pipelaying can be conducted at a depth of up to 4,000 metres
- Lay rate of approximately 3 km/day
- Accommodation capacity: 571 people
- Size: 382 metres by 124 metres

Audacia
- Dynamically positioned pipelay vessel, Operator: Allseas Group S.A., built 2005
- Used as an anchored vessel (10 anchors) for offshore pipelay in German waters
- Firing line with 7 (single joint) welding stations, 1 NDT station and 3 coating stations
- Pipelaying from a depth of 18 metres down to 2,775 metres
- Lay rate approximately 1.2 km/day
- Accommodation capacity: 270 people
- Size: 225 metres by 32 metres

Castoro Dieci (C10)
- Anchor positioned offshore lay-barge with low draught and no means of self-propulsion, Operator: Saipem
- Used for preparatory works in Germany and landfall installation
- Up to 6 pipe lifting davits may be mounted on the main deck to facilitate the tie-in of pipelines above water
- Accommodation capacity: 168 people
- Size: 164.62 metres (with stinger) by 36.57 metres

Fortuna
- Multipurpose flat-bottomed pipelay barge, 12-point anchor barge, Operator: MRTS
- Used for pipelay works in the Russian section, pipelay at a depth up to 200 metres
- 6 welding stations, 1 repair station, 2 coating stations, an anode installation station and an NDT station and a 47-metre long stinger
- Equipped with 6 davit cranes to perform above-water tie-ins
- Accommodation capacity: 310 people
- Size: 169 metres by 46 metres
Landfall Germany

Landfall Facilities

PIG Receiving Station
The pipeline inspection gauge (PIG) receiving station is the Nord Stream 2 part of the German Landfall in Lubmin. It is the logistical link between the pipeline and the European pipeline network. The onshore facilities of the receiving station include service buildings, the PIG receivers and the important safety shut-down valves. In the event of malfunctions, these valves reliably separate the offshore section of the pipeline from the station's land area.

When the pipeline is commissioned, gas transport through the pipeline system will be monitored and controlled 24 hours a day from the dispatching centre in Zug, Switzerland, where the project company is based. The data from the various sensors for monitoring pressure, temperature, gas quality and gas flow, among other things, are forwarded to the control centre. In addition, control consoles will be installed in Lubmin to enable on-site operation of the pipeline components.

Gas Receiving Station
From the PIG receiving station, the natural gas will flow to the adjacent gas receiving station of Gascade, and from there into the NEL (North European Gas Pipeline) and EUGAL (European Gas Link) onshore connecting pipelines.

Two connected safety shut-down valves separate the landfall area from the downstream measuring and control area of the station. In this section of the facilities, the quality of the incoming and outgoing gas flows is examined, the gas is measured and its pressure and volumes adapted for transfer to the downstream pipelines. Safety valves protect the two pipelines from exceeding the maximum permissible pressure.

Microtunneling
In the Bay of Greifswald, the twin pipelines are laid approximately 1.5 metres below the seabed. Approximately 350 metres before Lubmin beach, the pipelines enter the two microtunnels which run all the way to the PIG receiving station. The microtunnels pass under the coastal area and the infrastructure north of the PIG receiving station: the shallow water area, the beach, the dune, the coastal forest, supply lines, a road and a railway track. This construction option greatly minimises the environmental impact of the pipelines’ construction works.
The two microtunnels are built by pipe jacking, a trenchless construction method. Each tunnel is about 700 metres long and consists of over 200 concrete pipes with an external diameter of 2.5 metres, a wall thickness of 225 millimetres and a length of three metres. The concrete pipe sections are prefabricated in a dedicated factory and transported to the construction site.

From a specially prepared launch pit, a tunnel boring machine (TBM) excavates the microtunnels at a depth of up to 10 metres below the waterline and the pipe sections are driven toward their target location, the offshore exit point of the pipelines. As the excavation progresses, the concrete pipes are lowered into the launch pit one after the other. Soil loosened by the TBM (drill cuttings) is separated from the drilling fluid, removed and appropriately disposed of. The cleaned drilling fluid is then reused in the drilling process.

After the TBMs have reached the target location, all the equipment and fixtures required to drive the microtunnels are dismantled and removed. The TBMs are then recovered at the offshore exit point using an appropriately equipped vessel. Following that, the tunnels are prepared for the installation of the pipelines. When they are installed, the annular gap between the inner walls of the tunnels and the gas pipeline is insulated and filled with a special mortar.
Environmental Monitoring

Independent contractors will monitor the actual impacts on the environment and marine life before, during and after construction along the pipeline route across nine categories to ensure that construction impacts remain within the limits laid out in approved permitting documents.

Environmental monitoring will take place in a wide range of different categories: water quality, underwater noise, birds, marine mammals, flora and fauna, fish and fisheries, cultural heritage, munitions, and onshore environment. National monitoring programmes approved in the countries whose waters the pipeline passes through verify compliance with the project’s permit provisions. The results will be provided to the national authorities and summary reports disclosed on the Nord Stream 2 website.

Water quality is measured according to turbidity, or cloudiness caused by suspended seabed sediment, to ensure that relevant threshold values are not exceeded. Turbidity plumes are tracked to measure levels of suspended sediment in the areas where seabed intervention works are performed. Chemical analysis of water samples shows whether changes in water quality have occurred.

Activities that cause underwater noise, such as munitions clearance and rock placement, will be monitored with hydrophones. Noise from munitions clearance was reduced where necessary with the use of bubble curtains that absorb sound.

Seabirds are monitored from land, sea and air in the coastal and marine areas near the Russian and German landfalls. These areas are particularly important for migration, nesting, and foraging. The resulting data are used to determine any construction impacts.

A variety of monitoring methods determine whether construction activities have an impact on marine mammal populations. Hydrophones are used to assess if underwater noise could have any effect on the resident populations, while visual observations and tracking are conducted to evaluate potential behavioural changes.

Benthic (aquatic) flora and fauna are monitored to document changes during construction, and their subsequent recovery. Epifauna is expected to colonise the finished twin pipeline in areas with favourable conditions, and growth will be recorded as part of post-construction recovery studies. Infauna is monitored where dredging or trenching will disturb the seabed to follow its recovery as well.
Potential changes to fishery patterns, fish catches or fishing behaviour are evaluated during and after the pipeline installation. Bottom trawling patterns will need to be adapted in certain areas due to the presence of the pipelines, but these could potentially become a new habitat for fish.

Objects of cultural heritage value along the route are monitored with video surveys before and after construction. Consultations with the national cultural heritage authorities are also ongoing to ensure that these artefacts are assessed and safeguarded.

The pipeline route was adjusted to avoid mines and munitions wherever possible, though a number of conventional munitions had to be cleared. The impact of clearance was reduced with the use of various mitigation measures. Additionally, monitoring of chemical warfare agents in seabed sediments ensures that contaminants are not spread during construction.

Extensive onshore monitoring of biological and physico-chemical parameters takes place at the landfalls in Russia and Germany. Emissions and noise levels are measured near residential areas to ensure minimal disturbance and compliance with regulatory thresholds. Baseline monitoring of flora and fauna also documents the state and variety of local populations. In the sensitive areas at the Russian landfall, monitoring of plants and animal life is performed throughout construction and operation of the pipeline.