

International Marine and Dredging Consultants (IMDC) is an engineering and consultancy company specialised in a vast range of water related projects. Our highly qualified staff

offers advice based on recent research results of leading universities and research institutes and hands-on experience acquired throughout the years.

One of IMDC's core activities is presented in this booklet: Subsea Power Cables.

More information can be found on our website: www.imdc.be

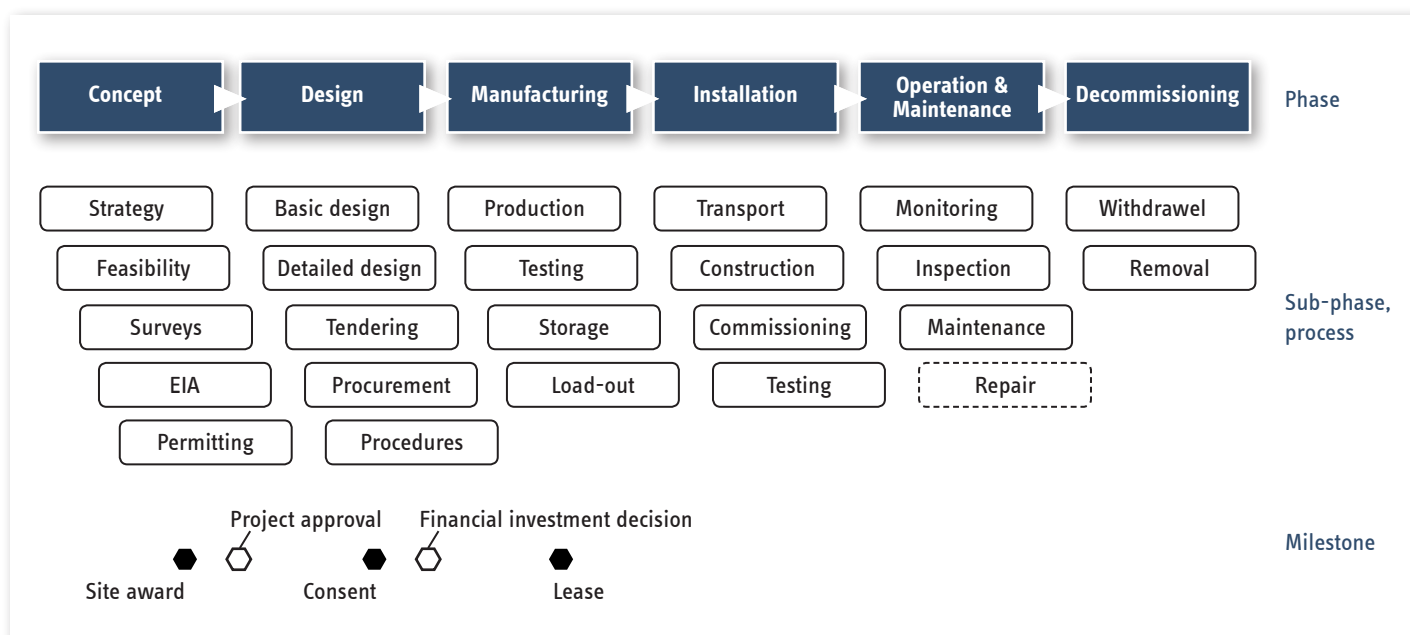
Subsea Power Cables and Pipelines



Since the start of the offshore wind farm (OWF) development in Belgium in 2001 and the installation of interconnection cables for transporting electricity wto land, IMDC has assisted developers and contractors through the different phases of their projects, starting with permit applications, contracting, engineering execution, operation and maintenance requirements. The lifecycle of subsea power cables projects may be characterized by a number of specific phases and processes that are illustrated in below figure. These processes can run in

sequence of each other or simultaneously and can be active over a different number of phases. IMDC can tackle all processes of the project and is able to bring each phase toward a project milestone according to industry offshore standards (e.g. DNV-GL, ICPC) and guidelines due to the strength of our highly qualified staff, years of experience in the industry and in project interface management.

Additional services along the project phases related to subsea power cables and pipelines are discussed further in this brochure.



IMDC SERVICES

MARINE CONSULTING

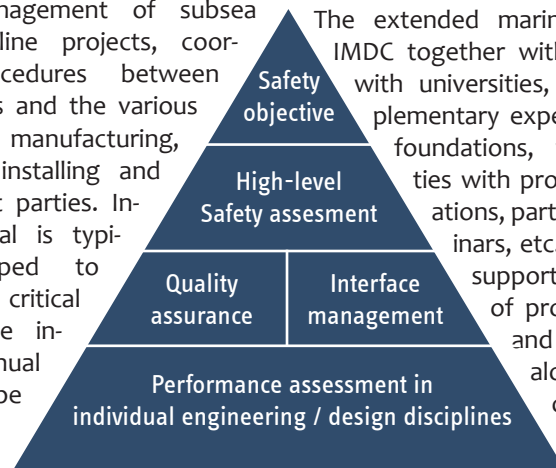
Procurement Stage and Management

IMDC manages and ensures the success of the project with the safety philosophy implemented in the different parts of the management system. The safety objective is quantified by key figures as safety, environmental and project / economical risk. The overall safety can be obtained by complying with the prescriptive requirements in this standard combined with a risk assessment (HAZID-based) that assures that all additional risks not covered by the prescriptive requirements are identified and mitigated

Years of experience in the sector guarantees that IMDC can cover the interface management of subsea cable / pipeline projects, coordinating procedures between data providers and the various designing, manufacturing, transporting, installing and other relevant parties. Interface manual is typically developed to manage the critical interfaces, the interface manual will describe responsibilities,

data requirements, data format and data schedule.

The extended marine expertise of IMDC together with collaborations with universities, Tractebel complementary expertise (electrical, foundations, wind turbines), ties with professional associations, participation to seminars, etc. guarantees the support and guidance of project developers and contractors along all phases of a subsea cable project.



Concept Phase

During the conceptual phase of the project, IMDC provides a high level of feasibility desktop studies with aim to define the cost-effective cable routes and eventual restrictions for the project (e.g. proximity works, crossings of existing infrastructures). The conceptual design of a landfalls and offshore platform landing are also analysed. The desktop study is based on existing data collected from the site (geophysical / geotechnical investigation, position of existing

subsea infrastructures / substation / wrecks, regulatory frameworks). These data is managed on GIS software package that is used to share geographic information for the entire duration of the project in an information database. The feasibility study focuses on the analysis of natural hazards (geology and geotechnical conditions, seismicity, metocean conditions, coastal conditions, topography and seabed morphodynamics) and anthropogenic hazards (regulatory factors, presence of other cables,

pipelines or other subsea structures, commercial operations, navigation routes, restricted areas, sea defence systems, subsea obstructions as wrecks, boulders).

In parallel, the environmental team with the support of the engineering team initiates the Environmental and Social Impact Assessment (ESIA) study that will be the basis for permit applications and to feed the regulatory frameworks (see the Marine Environment and EIA product sheet).



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Site Characterization and route selection

The feasibility desktop study is the basis to define a fit-for-purpose scope of works of future geophysical surveys (topography, bathymetry, seismic, side scan, magnetometer), geotechnical investigations (CPT, SPT, boreholes, laboratory testing) and metocean measurements (current, waves, tides, water quality and sampling). IMDC has years of experience in managing these surveys campaigns, from writing technical specifications, managing the procurement stage, the supervision, the review of procedure and the review of collected data, without forgetting an extended experience in the execution of metocean measurement.

Based on the collected data, IMDC can develop engineering studies which will feed the design phase of the project as interpretation of geophysical and geotechnical reports (including 3D ground model), waves, wind and current numerical modelling, seabed morphology and morphodynamic studies.

Based on the geotechnical and geophysical analysis, a route selection is assessed taking into account selection natural and anthropogenic (e.g. criteria (minimize route length, avoid boulders or hard sections with respect to dredging and trenching, avoid obstacles / obstructions / constructions) and challenges (geotechnical unstable areas, local slide risks or steep slopes, crossings, route deviations bends etc.). All data collected from different sources (incl. geophysical and geotechnical) and the cables / pipelines routes are integrated into a centralized in a GIS database. The use of GIS software package results in better precision capability in optimizing the route as well as saving time and engineering costs. GIS software package can be used to share geographic information in a database during the entire duration of the project.

Design / engineering phase

IMDC can support both project developers as contractors across the design phase of the project, producing detailed engineering studies. A non-exhaustive list of these studies is given:

- The management of the **design and procurement interface**;
- Detailed engineering calculations / modelling for installation of subsea cables and pipelines including **pull-in forces, cables / pipeline lay management tables**, touch-down monitoring (Dynamic Catenaries), cable over-boarding analysis, free-span cable / pipeline analysis, Pipeline Stress Analysis. These analyses are performed using specific software such as OrcaFlex and Ansys packages;
- **Stability design** calculations for pipelines under the influence of hydrodynamic forces, risk of soil liquefaction, design of mitigation measures (e.g. concrete weight coating, anchor / screw blocks, rock berms), etc.
- Conceptual and detailed design of **third party cable / pipeline crossings**;
- The **cable / pipeline landfall** design: conceptual design, layout and logistics drawings, pull-in forces calculation are created;
- **Cable pull-in design** at offshore (fix or floating) structure;
- Conceptual and detailed design of **scour protection** at offshore foundation including the interface with subsea cable and pipelines;
- **Weather** workability assessment task specific and **estimated WDT**;
- **Cable Burial Risk Assessment (CBRA)** study;
- **Burial Tool Assessment (BTA)** and “**best reasonable endeavour**” analysis;

Manufacturing and Installation

IMDC supports project developers and contractors during the manufacturing and installation phase. Strong of years of supervision and experience in marine works (from seabed surveys to installation works), IMDC is able to provide a high quality of:

- **Selection of transport and installation spread**;
- Conceptual **procedures for subsea cable / pipeline installation** (laying, pull-in, burial, crossing, anchoring) and **landfall construction works** (HDD, open-cut trench).
- **Review of installation procedures** and detailed engineering analysis;
- Analysis of weather workability and **weather downtime assessment** for specific offshore activities;
- Draft of installation specific risk assessment and **HAZOP** reports;
- **Offshore supervision** 24/24 and 7/7;
- Review of **as-built information**, punch list and acceptance criteria;
- Development of **hand-over manual to O&M team**

Operational and Maintenance

Based on involvement in all phases of the project, IMDC can deliver a high quality **Operational and Maintenance Plan** for subsea cables and any interface construction with other marine structures (foundations, turbines, crossings). Based on the Risk Based Inspection and Maintenance concept (DNVGL-ST-0145).

During the last years, IMDC has also been involved in management and supervision of O&M monitoring and maintenance works for subsea cables as cable replacement and periodical interpretation of geophysical surveys.

REFERENCE PROJECTS

Since 2004, IMDC is acting as Owner's Engineer for the marine aspects of the C-Power Thornton OWF in Belgium. After being responsible for the EIA, the interface management, the cable routing, the cable crossings, the cable installation, the pull-in and the landfall studies during the design and the installation phase of the inter-array and export cables, IMDC is now assisting the project owner in the management and supervision of most of the O&M activities, from periodical measurement surveys (bathymetry, side scan) to remedial maintenance activities (repair burial, cable replacement).

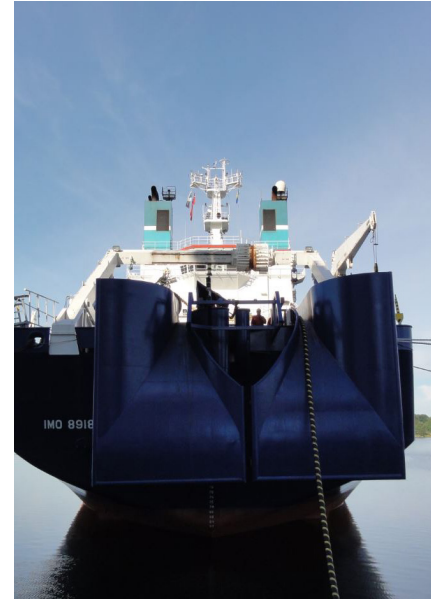


In June 2012 IMDC was selected as Marine Consultant for Elia Asset NV and requested to assist Elia Asset NV (the Belgian national grid owner) in the development of their Belgian Offshore Grid (BOG). The main tasks were related to export cable routing, cable burial assessment and seabed survey specifications and follow-up as well as ESIA and consenting phase. For the same project in June 2013 IMDC was selected as Owner's Engineer for the development of an Artificial Island in the North Sea, including interface services for cable installation and OHVS installation. During 2016, IMDC was selected as marine consulting for the Modular Offshore Grid (MOG) project (that is a continuation of the BOG project) for similar studies.

In January 2013, the Réseau de Transport d'Électricité (RTE, the French national grid owner) selected IMDC to perform the necessary services as Owner's Engineer for the project AMO EOS1 Fécamp and Calvados. Our services for the connection of the export cable between OHVSs of the offshore wind farms and landfall included the set-up of offshore geophysical and geotechnical survey specifications and cable routing, cable burial risk assessment and burial analysis.



Recently IMDC has performed engineering services as Marine consultant for the project in Dominica for the connection of two interconnection cables between Dominica, Martinique and Guadeloupe.



As from July 2016, IMDC is performing engineering services for the "Nord Stream 2" Project to connect the Russian and German Baltic Sea coasts with two new pipelines, parallel to the existing Nord Stream 1 pipelines (approx. 1220 km long). As part of this project, IMDC has provided dredging consultancy for interpretation of geophysical and geotechnical survey data, calculation of underwater slope stabilities, evaluation of soil liquefaction risk and pipeline buoyancy, production of dredging equipment, losses during dredging, dumping and backfilling, evaluation of productions from tenderers.

