BMT

Offshore oil and gas

Metocean
services and solutions

Contents

> “Our metocean operability assessment services provide insight into the risks associated with marine operations.”

Metocean services and solutions

With over 35 years of experience and a rich heritage of marine research, we apply our understanding of the marine environment to reduce risk, whilst minimising costs in challenging engineering projects.

We offer advanced analysis of the metocean conditions that can be customised according to our clients requirements. This can range from a simple statistical assessment of the sea state to support an offshore pipe-lay operation to complex studies supporting feasibility, detailed engineering and vessel manoeuvrability assessment during site selection and development of an LNG terminal.

Our metocean services are used throughout the life-cycle of marine infrastructure developments in offshore and coastal regions worldwide.

To provide these services, we maintain over 35 years of extensively validated in-house global archives of modelled and observed metocean data.

This allows us to provide customers with a rapid turnaround of metocean data to gain a better understanding of the marine environment at their site of interest throughout the world.

BMT metocean information provides solutions to:

- Assess the marine environment and metocean risks during initial exploration
- Increase asset availability by eliminating unnecessary weather downtime
- Assess the operability and safety of floating and fixed structures during design
- Support subsea pipeline feasibility and engineering studies, including scour assessments
- Support effective transport and installation of offshore assets
- Study vessel manoeuvrability in terminal design and tanker offloading operations
- Support infrastructure developments nearshore.

1

Metocean statistics and data

Our extensive metocean databases are based on over 35 years of hindcast modelling - calibrated with satellite altimeter observations, coupled with in-house knowledge and experience and in-situ measurements of working in the marine environment. These are used to derive site-specific metocean statistics and identify operational risks.

Safe operational working limits for weather and sea state, and the number of working hours required for the completion of each phase of a project may be provided in a short turnaround from existing data sets, thus providing valuable information to operators and installation contractors' during the construction and operation of marine structures.

Percentage Exceedence Level

	Min.	90%	70%	50%	30%	10%	5%	1%	0.5%	0.1%	Max
Jan	0.49	0.89	1.11	1.35	1.59	2.01	2.3	2.78	3.25	3.35	3.35
Feb	0.45	0.82	0.93	1.25	1.69	1.87	2.3	2.45	2.80	2.99	2.99
Mar	0.35	0.52	0.74	0.96	1.23	1.64	2.3	2.13	2.15	2.20	2.20
Apr	0.45	0.91	1.50	1.76	1.89	2.11	2.3	2.31	2.37	2.43	2.43
May	0.21	0.35	0.69	0.89	1.15	1.25	2.3	1.85	2.05	2.15	2.15
Jun	0.19	0.34	0.55	0.82	0.93	1.16	2.3	1.47	1.59	1.89	1.89
Jul	0.35	0.41	0.96	1.21	1.35	1.69	2.3	2.11	2.35	2.54	2.54
Aug	0.17	0.27	0.59	0.67	107	1.29	2.3	2.09	2.40	2.54	2.54
Sep	0.38	0.55	0.78	1.24	1.35	1.63	2.3	1.96	2.25	2.59	2.59
Oct	0.45	0.92	1.18	1.29	1.38	1.89	2.3	2.78	3.01	2.59	2.59
Nov	012	0.38	0.75	0.89	1.37	1.68	2.3	2.05	2.58	2.59	2.59
Dec	0.18	0.34	0.82	1.15	1.68	1.79	2.3	2.69	2.97	3.15	3.15

Significant Wave Height for Given Percentage Exceedence

Metocean data is vital in the reduction of weather downtime

By customising metocean services to the requirements of a customer, we can provide detailed information about the local climatology, determine the probability of occurrence of suitable weather windows, assess the likelihood of extreme events occurring in the area and provide an assessment of an assets performance in the marine environment throughout its lifetime.

Where insufficient existing data are available to meet a design or operational need, we can support design and execution of a metocean measurement campaign to obtain additional site specific data.

Our metocean statistics and data support:

- Regional metocean climatology assessment
- Weather windows and persistence analysis to assess risk of marine operations
- Rig selection and site specific operability assessment
- Feasibility studies for early assessment of project finance and concept design
- Workability assessment and planning of marine infrastructure installation
- Heavy lift operations and pipe-lay assessment of FPSO performance and offloading operations
- Vessel manoeuvring simulation studies to study terminal operability
- Marine forensic incident investigation

Case study: Marine terminal, Caribbean

We carried out a study of the feasibility of placing an unsheltered LNG Marine Terminal in the Caribbean. This involved conducting an evaluation of arrival and departure manoeuvres as well as the behaviour of the ship at berth.

In-house developed simulation software (REMBRANDT) was used to determine the ideal location, alignment, layout and mooring facilities. Using our metocean data, a 25-year simulation of operations was conducted which identified the operational downtime, cargo transfer and cargo storage requirements during this period.

The study also confirmed that, given an adequate configuration of the terminal, no breakwater needed to be built to achieve acceptable longevity and operational conditions.

Case study: Offshore site, Brazil

An offshore contractor needed to assess the operability at a site offshore Brazil for a series of heavy lift operations. We were able to assist by providing a hindcast of full 2-D wave spectra. The data provided enabled the customer to analyse various different scenarios in-house, enabling assessment of the response of the vessel to local wave climate and the risks involved with the operation.

Case study: Makassar Straits, Indonesia

Pearl Oil's development of a new oil and gas field in the Makassar Straits required the design of a 350km pipeline to deliver the products to land facilities safely and with minimum risk and detailed criteria study. We completed a metocean measurement campaign to gather the data needed to support the pipeline design.

Case study: NW Shelf, Western Australia

BMT provided Chevron Australia Pty Ltd (CAPL) with the successful deployment, maintenance (downloading/servicing) and retrieval of noise monitoring equipment associated with the Jansz-Io Subsea Compression project in late 2018.

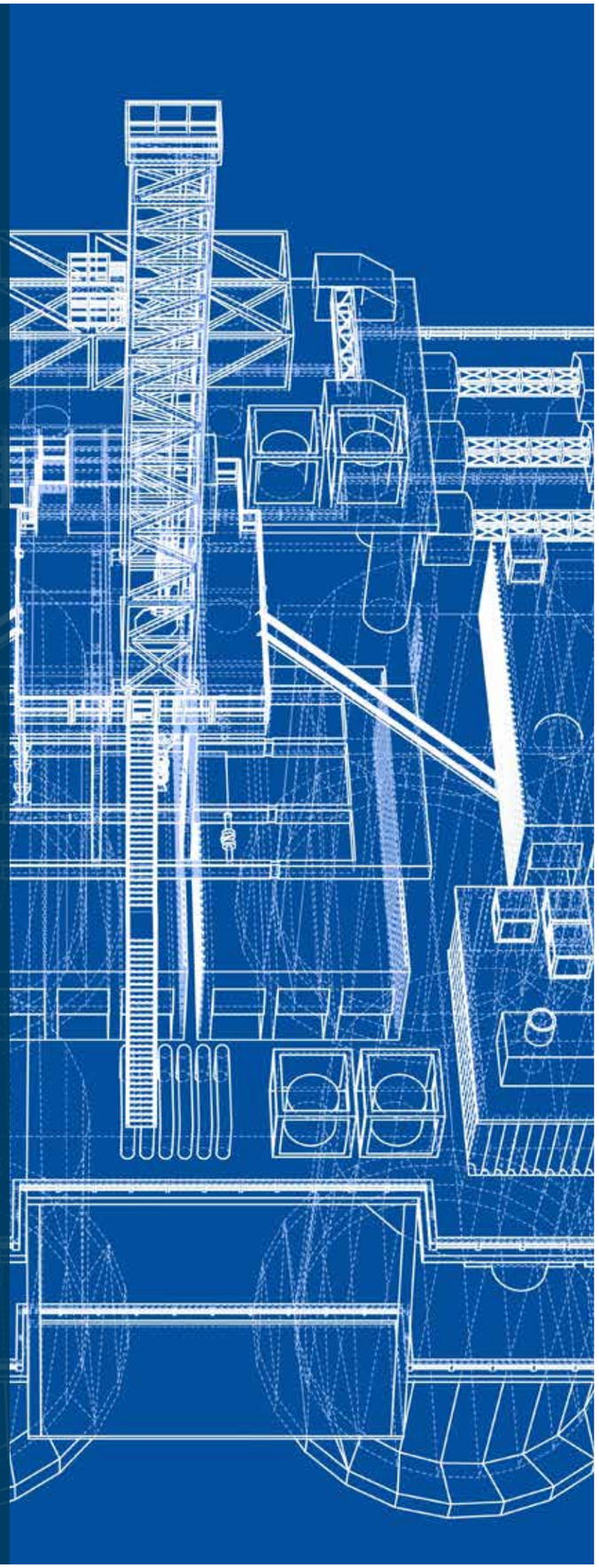
BMT deployed noise loggers within the Jansz-Io Subsea Compression area (~140 km northwest of Barrow Island in ~1,360 m water depth) for the purpose of better understanding noise in the receiving environment.

BMT provided all project management, logistics and planning, lead HAZID, procurement, field survey, party chief, on-going monitoring and response and reporting.

2

Design criteria

Metocean information is essential for the safe and economical design of a marine facility, from the initial concept feasibility assessment through to the final detailed design. Using historical metocean databases, tailored numerical modelling and data analysis expertise, our metocean advisors are able to assist in enabling the optimal design of vessels, subsea infrastructure, offshore structures and coastal facilities all over the world.



Our understanding of the metocean processes and conditions that influence the design and operation of marine infrastructure is based on extensive experience in the industry. We maintain a suite of proprietary software for the quality control, statistical analysis, extreme value extrapolation and presentation of in-situ, modelled and satellite observed metocean data to ISO engineering standards.

The requirements of a customer can range from general advice for location selection during the prefeasibility phase of a development through to the detailed metocean criteria required for Front End Engineering Design (FEED). The strategy for the metocean basis for design varies according to location, type of structure and available data sets.

Metocean design criteria services support:

- Feasibility and site selection assessment
- Preliminary design criteria
- Front End Engineering Design (FEED) criteria studies
- Terminal access channel and manoeuvring Studies
- Breakwater and terminal layout design
- Mooring layout design studies
- Scour protection design
- Pipeline lay out, landfall and burial design
- Pipeline free span analysis

Case study:
Gas Field Development (Norwegian Sea)

The scope of this work was to evaluate both extreme design and typical (ambient) operational criteria for a site in the northern North Sea (Norwegian sector). The gas field was situated in approximately 115m water depth.

This study involved a detailed comparison of multiple hindcasts generated from a selection of in-house and commercially available modelling tools, in-situ measured (Wave buoys) and satellite data (Altimeter and Scatterometer).

The final product was a comprehensive metocean study involving basic extreme criteria, environmental contours, wave spreading and fatigue analyses, plus a full suite of operational criteria presented in tabular and graphical engineering formats, e.g. wind roses, scatter plots.

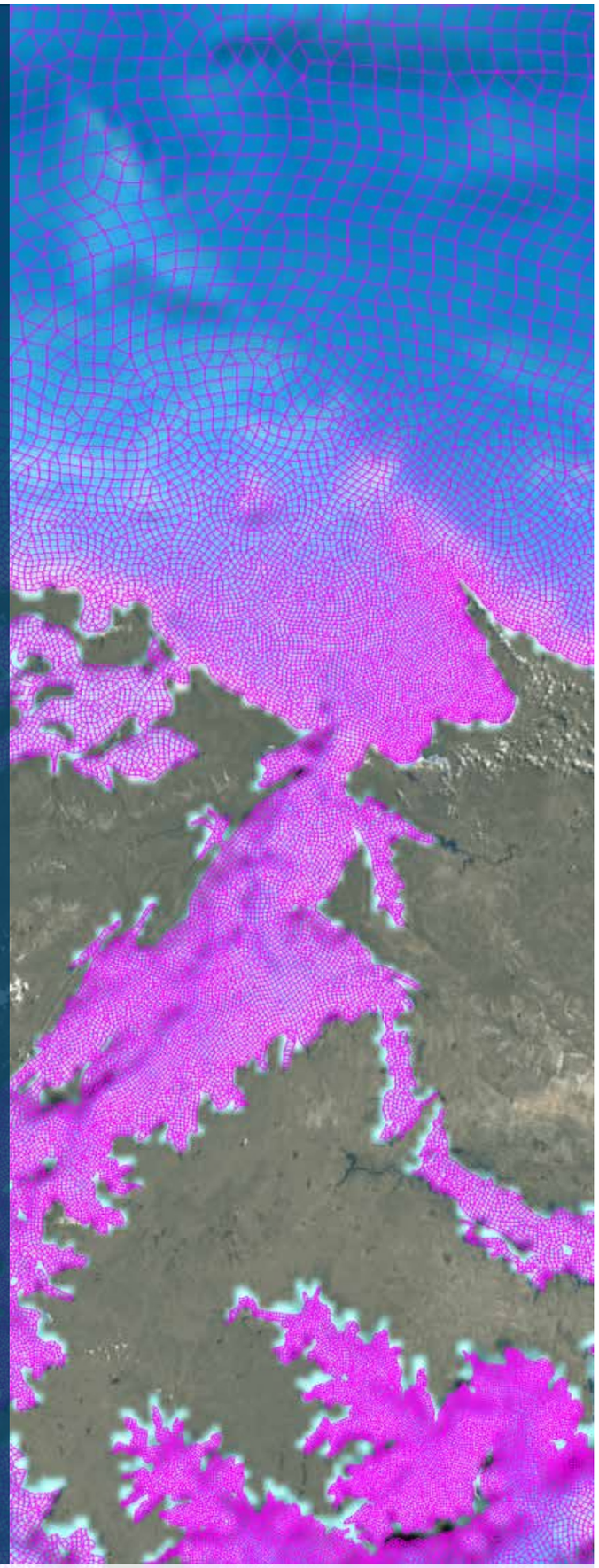
The pre–project and Basic Engineering (“FEED”) is now completed and the customer is entering the detailed engineering phase. Extension of this work provided additional criteria to cover the entire development of the field.

Our metocean advisors are able to support operators and engineers with a metocean strategy for any development, offering straightforward customer focused cost-effective desk studies to support the early stages of a development, through to complex modelling and derivation of the metocean extreme criteria tailored to customer requirements.

3

Hydrodynamic and wave modelling services

Our capabilities extend beyond the collection, verification and interpretation of global metocean data sources, using these data sets as input boundary conditions to produce fine-scale site specific numerical models to study local conditions and topographic influences for feasibility and design assessments.



Complex problems require clever solutions. We author and sell globally the TUFLOW suite of numerical models which are used in both 2D and 3D formats for coastal processes, riverine flooding and water quality applications. With many offshore clients also interested in feasibility studies regarding onshore facilities, our customised cost-effective models can be efficiently created using TUFLOW to support these coastal and nearshore feasibility assessments, using global data sets such as HYCOM, WAVEWATCH III and CFSR as the boundary condition inputs.

Hydrodynamic and wave modelling services provided in the offshore and nearshore environments include:

- Deep water studies of currents and waves
- Tropical revolving storm modelling
- Hydrodynamic (HD), Advection Dispersion (AD) and morphological modelling in 2D and 3D
- Nearshore coastal processes studies
- Dredging impact and siltation assessments
- Model scenarios and outputs suitable for ship simulators
- Tsunami modelling
- Specialist dredging advice
- Coastal structure design and construction supervision
- Expert services including peer review

Case study: Falkland Islands, South America

A study in the Falklands Islands off Argentina required the development and execution of a hydrodynamic model system from which to derive water levels and currents to support a wide range of higher level applications, including engineering and operational design, and as an input to spill simulations, iceberg trajectory assessment and other environmental modelling.

The model system comprised a regional ‘oceanic’ model and a nested fine resolution coastal model, covering nearshore areas of complex bathymetry and topography. The project delivered a 3-dimensional hydrodynamic dataset at hourly time intervals covering the period January 1992 to December 2012, optimised and validated against all available in-situ measured datasets.

Case study: West Kalimantan, Indonesia

We were engaged to carry out a pre-feasibility metocean study to assess preliminary wave and current conditions for the proposed port in West Kalimantan, Indonesia.

This included an assessment of the requirement for a breakwater to protect ships at berth and potential scour and sedimentation around the facility.

Project outcomes included the development of two-dimensional wave and hydrodynamic models of the region using boundary data derived from global metocean datasets. The models were then used in the assessment of extreme wave and current fields suitable for pre-feasibility design as well as the detailed assessment of sedimentation and scour around the proposed port facility.

4

Metocean Monitoring

BMT performance monitoring helps reduce risk in the offshore environment by keeping operators informed about the state of the environment and the platform or floating facility in real time for the life of a field. Operational risk reduction and operating cost savings are the key benefits for commissioning a long-term metocean monitoring system which can be integrated with multiple sub-systems.

Metocean data generated from our monitoring systems provides indispensable information for validating the integrity and behavior of offshore assets. Our highly qualified and experienced data analysts and ocean engineers provide consulting to the offshore and marine industries and government agencies on all aspects of interpretation and understanding of marine systems.

Our capabilities also take a more holistic approach to monitoring the environment. Our integrated systems provide a complete understanding of an asset's long-term integrity when introducing parallel integrity systems (e.g. helideck, mooring, position, structural). Integrity monitoring and management is essential for determining whether assets are operating as designed, reducing potential downtime and minimising risk.

For those areas of the world experiencing seasonal weather extremes, our maintenance team can individually inspect and maintain monitoring systems in preparation, ensuring readiness. If necessary, repairs are made, damaged units are replaced and outdated equipment is upgraded. Operators have found that such preparations for hurricane, typhoon or cyclone season pay off when the environment and vessel response data acquired during hurricane evacuation feeds into and informs of the fixed or floating asset and mooring inspections that are required before restarting production.

Our metocean monitoring services:

- Measure the metocean (wave, current profile, meteorological) conditions in-situ at the asset location
- Acquire synchronised sensor data in time stamped files
- Identify and alarm malfunctioning sensors and other components
- Display data in a form and time frame for operational requirements with threshold limits set for user defined operational limits
- Provide 'user-friendly' displays of operationally important information
- Archive of metocean conditions over the life of the asset for input into fatigue and life extension assessments
- Data access from multiple platform locations as well as shore-based computers via networks or other data links
- Interfaces to available platform control systems
- Hurricane preparation and post structural assessment
- Monitor local metocean data across a fleet of regional or global offshore assets
- Our systems are found on and capable of monitoring a wide range of offshore facilities (e.g. FPSOs, semi-submersibles, TLPs, spars and platform).

Case study: Malikai Oil Field, Malaysia

The Malikai TLP is a fully manned platform located at the Malikai Oil Field in Malaysian waters in Block G around 110km offshore Sabah in a 500m water depth.

The Technip MMHE JV contracted us to provide the Marine Instrumentation System and Marine Advisory System (MIS/MAS) for the Shell Malikai TLP. The MIS/MAS is a Windows PC-based comprehensive monitoring system for acquiring, displaying and recording real time marine, environmental and tendon tension information to assess the facility's integrity over time.

The MIS/MAS provided by us is an integrated system using state-of-the-art sensors to make vessel, marine and environmental data readily available to the marine systems operators in an easy to understand format.

Our integrity monitoring systems allow offshore operations personnel greater access to information to enable them to work safely by making informed decisions.

Case study: Glen Lyon FPSO, BP UK

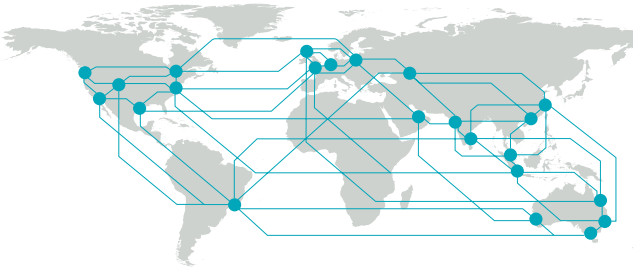
In the extremely harsh waters west of Shetland, our real-time information monitoring system on the Glen Lyon FPSO helps to ensure the safety of operations and personnel.

The integrated system collects, processes, displays and stores meteorological and oceanographic (metocean) and environmental data.

The data provided is summarised in four distinct groups::

- Metocean data related to the environment and all relevant surrounding natural conditions
- Vessel attitude and motions that describe the motions and environmental forces on the FPSO moorings and risers
- Structural load data concerning the FPSO's loading condition
- Marine Vessel Interface data that provides the position and operating status of vessels within a 500m zone

We continue to carry out preventive maintenance including the calibration of instrumentation on an annual basis and onshore management of the suite of data.



BMT applies engineering, science and technology to help customers design, manage, maintain and improve their assets. Founded on a century's heritage in the marine environment and with a worldwide network of offices, BMT is an independent organisation held in trust for its employees.

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