

DEP SPECIFICATION

METOCEAN DATA ACQUISITION – DEFINITION, IMPLEMENTATION AND ANALYSIS

DEP 37.00.10.11-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies the requirements and gives recommendations for the acquisition of various types of metocean/ice data needed to:

- derive metocean/ice design criteria;
- derive metocean/ice operational and or downtime statistics;
- derive tow route criteria.

This DEP specifically addresses the requirements for the DCAF deliverable; Metocean (and Ice) Data Acquisition and Analysis, DCAF ID 127 (refer to DCAF). The Metocean requirements have been developed in detail in this DEP; the Ice requirements are only presented in summary form as they are still under development.

The purpose of this DEP is to primarily provide requirements and specifications for those aspects of metocean and ice data acquisition that are mandated by Shell as part of the project deliverables. This DEP includes onshore, coastal and offshore applications in upstream and downstream projects. However, metocean and ice data are often required for other activities within the oil and gas lifecycle outside of the DCAF process, such as acquisition of acreage and exploration drilling, and the same principles and recommendations can apply.

Metocean and ice data required to be displayed in real-time for the support of operations for both onshore and offshore projects (previously covered by this DEP 37.00.10.11-Gen.) is now covered in DEP 37.00.10.12-Gen. Note that DEP 37.00.10.12-Gen. is a DEM1 and the real-time monitoring systems are considered a safety critical requirement.

This DEP Specification provides an overview of metocean data acquisition, highlighting the key issues and requirements. The associated DEP Informative also contains further information including rationale for certain requirements and recommendations in the DEP Specification and references to some best practice scopes of work, standards and procedures.

The main purpose of DCAF deliverable Metocean (and Ice) Data Acquisition and Analysis DCAF ID 127 and hence this DEP, is to ensure that data collection programs are correctly designed so that the data available is adequate to be used to derive metocean and ice design, operational and tow criteria to within the required uncertainty and, hence, provide both safe and cost effective design and operational criteria.

If metocean data acquisition for a new project/installation is not completed early enough in the schedule or thoroughly enough, then the environment may not be understood sufficiently resulting in the installation being either:

- Under-designed and leading to an unsafe installation or inappropriate operational model. This would result in expensive remedial actions and interruptions to operations.
- Over-designed and leading to an over costly design and higher CAPEX.

Additionally, if real-time data is not available in support of operations, then this can lead to poor planning, unnecessary downtime, delays and incidents.

To ensure that design criteria, tow criteria and operational/downtime statistics are accurate and aligned to a new project, appropriate, accurate and sufficient data must be available for their derivation.

Where safety is particularly important, reference is made to this. In addition, national legislation may also determine local requirements for metocean and ice measurements. Specific recommendations on these are not provided here.

This is a revision of the DEP of the same number dated January 2010; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorisation to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in project development and operations of various facilities both offshore and onshore, including oil refineries, chemical plants, gas plants, loading terminal, exploration and production facilities and supply/distribution installations. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Continental Shelf	Continental shelf or the area at the edges of a continent from the shoreline to a depth of 200 m, where the continental slope begins. The shelf is commonly a wide, flat area with a slight seaward slope.
Design Criteria	Metoccean extreme storm event values with return periods ranging from 1 year to 10,000 years.
Dry Bulb Air Temperature	The dry bulb air temperature, commonly referred to as air temperature, is basically the ambient air temperature indicated by a thermometer not affected by the moisture of the air.
Forecasting	Technique using numerical models to predict the state of the atmosphere and the oceans for a future time and given location(s).
Gust	A sudden, brief increase in the wind speed over a specified duration of time, e.g., 3-s gust which is the wind speed averaged over a 3-s duration. Different sensor types may record different gust speed values depending upon the individual sensor response characteristics.

Term	Definition
Hindcasting	Technique using numerical models to compute the state of the atmosphere and the oceans for times in the past at given locations.
Ice	Ice used in this DEP refers to any cold climate/ice related parameters, including those directly related to sea ice and icebergs but also could include frost penetration and icing where relevant.
Infragravity Waves	Infragravity waves are low frequency waves (nominally 0.003 to 0.05 Hz), generated through: 1. nonlinear wave-wave interactions within incident sea waves and swell waves; 2. wave refraction and breaking on a sloping beach, as well as wave reflection at the shoreline; 3. oscillations in the longshore current. Infragravity waves are important to harbour oscillations, sediment transport, and other nearshore hydrodynamic processes and therefore have a high impact on the response of moored large vessels in coastal waters.
Internal Waves (solitons)	Internal waves are gravity waves which oscillate within the body of a fluid, typically propagating on the interface between two fluids of different density. Hence in the ocean they typically propagate along the thermocline. Nonlinear solitary internal waves are called soliton.
Metocean	Abbreviation of the words meteorological and oceanographic . (Metocean used in this DEP refers to meteorological and oceanographic when applied to offshore and to just meteorological when applied to onshore.)
Metocean Peer Review Process	The 'Metocean Peer Review Process is the Shell's internal process for metocean document review
Nonlinear Wave-Wave Interaction	Nonlinear wave-wave interactions often occur when waves are steep enough so that wave components (e.g., with different wave frequencies) affect each other. This process can result in both low and high frequency waves beyond the incident wave frequency range.
Nowcasting	The forecasting of the weather in the next 6 hours, aimed at identifying smaller features such as thunderstorms or showers.
Operating Conditions	The metocean conditions experienced during normal operations.
Project	The Project is typically the wider engineering project, but may also refer to the metocean (and ice) specific project.
Relative Humidity	Humidity is the quantity of water vapour present in air. Relative humidity can be expressed as the ratio of the vapour partial pressure of the air to the saturation vapour partial pressure of the air at the actual dry bulb temperature. Relative humidity can also be expressed as the ratio of the vapour density of the air to the saturation vapour density at the actual dry bulb temperature.
Return Period	This is an estimate of the likelihood of extreme events (storms, wave heights, wind speeds, etc.) of a certain intensity or size. Also known as recurrence interval.
Sea State	A description of the properties of sea surface waves at a given time and place. In engineering applications, this is usually expressed in terms of the significant wave height and wave period.

Term	Definition
Sea Waves and Swell Waves	Sea waves are waves that are generated locally by wind, whereas swell waves are produced by distant storms and progress to the considered location. Swell waves have longer periods than sea waves and are not correlated to local wind conditions in terms of wave direction and wave height.
Seiches	Seiches usually appear in the form of standing waves or sloshing/oscillations of the free surface of a body of water in a closed or semi-closed basin. These oscillations are of relatively long period, extending from minutes in harbours and bays to over 10 h in large lakes. Any external perturbation to the lake or embayment can induce an oscillation.
Significant Wave Height	This is 4 times the standard deviation of the sea surface and is approximately equal to the average of the 1/3 highest waves.
Storm Surges	Storm surges represent the water surface response to wind-induced surface shear stress and pressure fields. Storm-induced surges can produce short-term water surface rise to an elevation considerably above mean water levels.
Storms	Storms are the result of atmospheric disturbances and result in strong winds, heavy rainfall, and in high waves offshore.
Tsunamis	Tsunamis are very long waves, occurring as responses in the sea surface to underwater earthquakes, mass movements above or below water, volcanic eruptions and other underwater explosions, landslides, large meteoroid or asteroid impacts, etc. They are rare and unpredictable and become of concern for design periods of about 100 years or longer.
Visibility	The horizontal distance at which the light intensity from a standard source drops to 5 %. This is calculated by measuring the amount of infra-red scatter in a small volume of air at the sensor location and assuming this sample has similar properties to the surrounding air mass. Contaminants in the air will lower the inferred visibility.
Wave Diffraction	Wave diffraction is the bending, spreading and interference of waves when they pass by an obstruction or through a gap.
Wave Reflection	Wave reflection occurs when waves reach an obstacle, e.g., a sea wall or a breakwater; waves also reflect off beaches and at locations with sharp depth changes.
Wave Refraction	Refraction is the bending of the wave propagation direction due to variations in the water depth under the waves. The part of a wave in shallow water moves slower than the part of a wave in deeper water. So when the depth under a wave crest varies along the crest, the wave bends.
Wave Shoaling	Shoaling occurs as waves enter shallower water. The wave speed and wave length decrease in shallow water, therefore the energy per unit area of the wave has to increase, resulting in an increase in the wave height. The wave period remains the same in shoaling.

1.3.3 Abbreviations

Term	Definition
ADCP	Acoustic Doppler Current Profiler
AMO	Atlantic Multi-decadal Oscillation
AO	Arctic Oscillation

Term	Definition
AUV	Autonomous Underwater Vehicle
AWWS	Adverse Working Weather Standard
BoD/BfD	Basis of Design/Basis for Design
BDP	Basic Design Package
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
CTR	Cost, Time, Resource
DCAF	Discipline Controls and Assurance Framework
DAP	Data Acquisition Plan
DEP	Design and Engineering Practice
DP	Dynamically Positioned
EMS	Engineering Management System
ENSO	El Niño-Southern Oscillation
EP	Exploration and Production
EPBM	EP Business Model
FEED	Front End Engineering and Design
FPSO	Floating Production, Storage and Offloading vessel
G&P	Gas and Power
Hs	Significant wave height
HSSE	Health, Safety, Security and Environment
IER	Ice Environment Report
IOD	Indian Ocean Dipole
IPS	Ice Profiling Sonar
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LNG	Liquefied Natural Gas
MRD	Metoccean Reference Document
MSL	Mean Sea Level
NAO	North Atlantic Oscillation
OGP	Oil and Gas Producers
OPMG	Opportunity and Project Management Guide
ORP	Opportunity Realisation Process
PDO	Pacific Decadal Oscillation
PSU	Practical salinity units
SAI	Shell Aircraft International
SP	Social Performance
SWAN	' <u>Simulating WAVes Nearshore</u> ' numerical model
Tp	Peak period of the spectrum
TQAF	Technical and Quality Assurance Framework

Term	Definition
VAR	Value Assurance Review
WMO	World Meteorological Organization

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets (). Standards and other documents referenced by this DEP are listed in (7) and (8).

1.5 SUMMARY OF MAIN CHANGES

This is a revision of the DEP of the same number dated January 2010. The changes have been made to: 1) update this DEP into the new format with a DEP Specification and DEP Informative, 2) bring this DEP in line with the requirements of the DCAF deliverable Metocean (and Ice) Data Acquisition and Analysis, DCAF ID 127, and 3) add additional information on the required environmental considerations, the process flow requirements and the risks and mitigations. Where information has been removed from the DEP Specification document, it has been included in the DEP Informative document.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. GENERAL

2.1 OBJECTIVES

This DEP specifically addresses the requirements for the DCAF deliverable; Metocean (and Ice) Data Acquisition and Analysis DCAF ID 127. Full implementation of this DEP is mandatory for provision of this DCAF deliverable. The Metocean requirements have been developed in detail in this DEP, but the Ice requirements are only presented in summary form as they are still under development. Metocean and ice data is often required for other activities within the Oil and Gas lifecycle and the same principles and recommendations apply. The overall objectives of this DEP are to:

- a) guide Metocean and Project Engineers in determining the need for metocean and ice data acquisition and analysis for developing and operating assets. It is emphasised that the project-specific needs for metocean and ice data are dependent on the environment, the project concept and the operating philosophy and all aspects should be taken into account when determining this need.
- b) guide Metocean and Project Engineers in the options for collection of metocean and ice data and how to determine the best way to collect this data to satisfy the project needs. The following criteria shall be considered when reviewing the options:
 - a. Data accuracy
 - b. Data representativeness of the environment
 - c. Data relevance
 - d. Cost effectiveness
 - e. Timeliness with reference to the project schedules
- c) guide Metocean and Project Engineers in specific parameter requirements and the applicability of different sensors to meet these requirements depending upon the project type, concepts being considered or selected, operating philosophy, environment type and the remoteness of the location.
- d) provide specifications for the requirements of the metocean data collection in terms of: equipment and sensors, systems, installation, inspection, maintenance, data processing, data quality control and data formats.
- e) provide Metocean Engineers with guidance on the data analysis requirements which could impact the data collection in addition to those specified in DEP 37.00.10.10-Gen., which is a DEM1.

2.2 INTRODUCTION

To address the requirements for accurate, representative and relevant metocean and ice data to meet the design and operational needs of a project within the cost and timescale targets, work shall be planned in three phases: 1) definition, 2) implementation and 3) assimilation and analysis. The steps for each phase shall include the following:

- 1) Definition of the metocean data acquisition, including:
 - a. Identify and assess the project needs for metocean related deliverables and their required delivery schedule. These deliverables include metocean design criteria, operational statistics, tow criteria, real-time data and forecasts (see also DEP 37.00.10.12-Gen.). Different deliverables will be required for different project types and at different project stages.
 - b. Understand the metocean conditions of the project area such that potential hazards, unknowns and possible risks associated with these conditions are identified. The type of conditions in the area of interest will impact the metocean data acquisition strategy and the project needs.
 - c. Define the metocean deliverables for each stage of a project. For all projects a metocean reference document containing design and operational criteria is

required to support the BoD and BDP. However the content of this document will vary dependent on the type of project and location. For some projects a separate tow criteria reference document will be required.

- d. Define the metocean data needed in order to generate the required metocean deliverables for the project, including determining data already available, the time necessary to collect or model appropriate metocean data, and the time to carry out necessary analyses, studies and reviews.
 - e. Determine how best to obtain the required metocean data from the various sources (e.g., in-situ measurements, remote satellite and model hindcast data) as there can be considerable benefit from integration of data. Consider the risks associated with the data acquisition plan including aspects which could impact; accuracy, representativeness, relevance, cost and timelines of the data and whether iterations of criteria will be required as different data becomes available.
- 2) Implementation of the metocean data acquisition, including:
- a. The methods available and system types for collecting and obtaining metocean data.
 - b. The specifications and scopes of work for measurement types and metocean systems
 - c. The performance specifications for metocean measurement systems
 - d. The requirements for system/instrument calibration, installation and servicing/maintenance
- 3) Assimilation and analysis of the data to provide the deliverables including:
- a. The specifications for data processing to derive metocean parameters
 - b. The requirements for data quality control
 - c. The performance specifications for data handling, formatting and delivery
 - d. Defining how data from various sources will be integrated and analysed.
 - e. Specifications of how the data will be compiled
 - f. Specifications of which techniques will be used to analyse the data, for example joint criteria or response based techniques. Any differences or deviation to DEP 37.00.10.10-Gen. shall be highlighted in case derogation is required.

The overall process is shown schematically in Figure 2.1 below and described in detail in (3), (4) and (5).

2.3 DATA ACQUISITION FLOW DIAGRAM

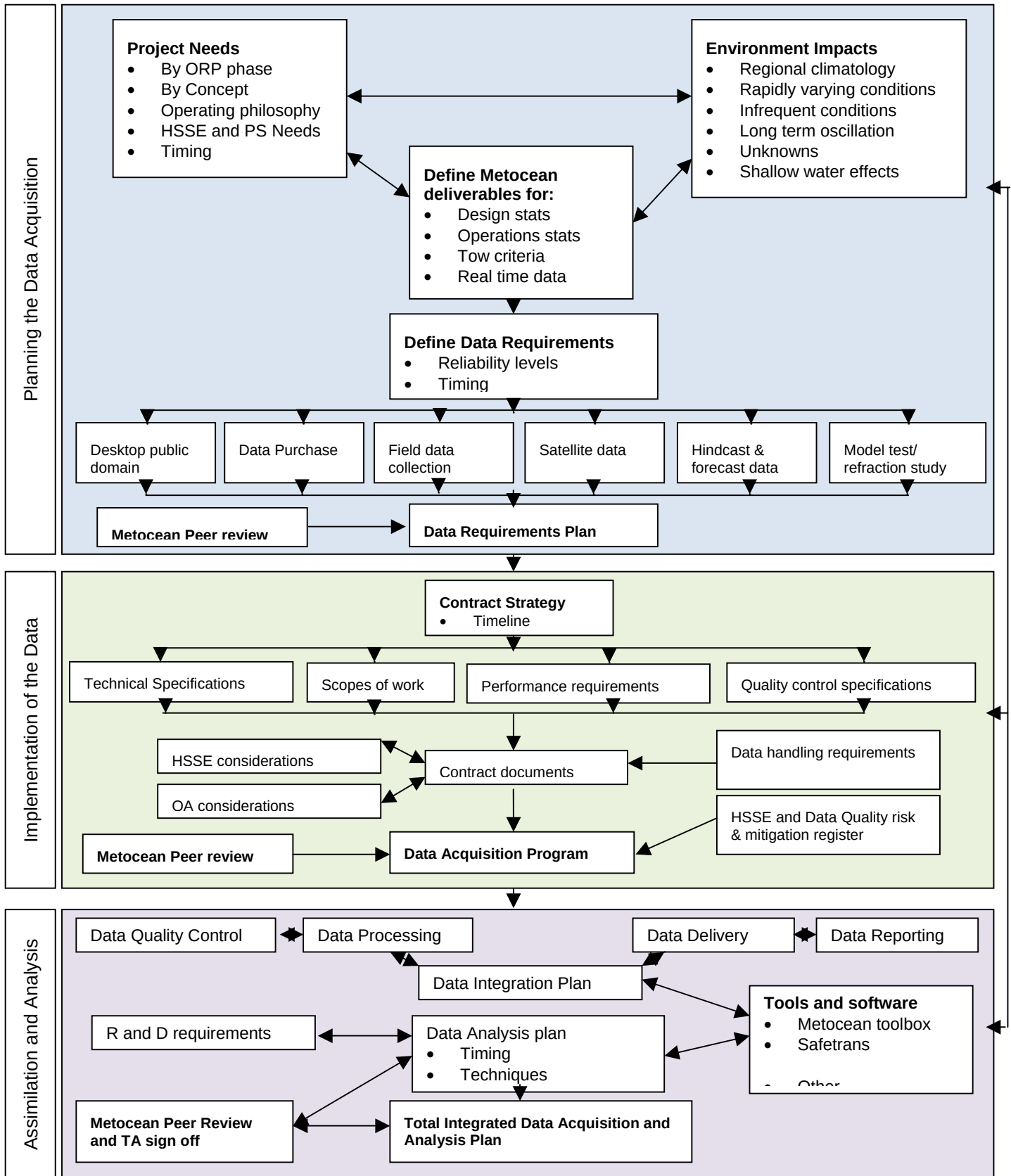


Figure 2.1 - Data acquisition and analysis flow chart

2.4 RESPONSIBILITY FOR THIS DEP

It is the responsibility of the appropriate Civil, Structural and Offshore TA1 (which may be metocean TA1 but could also be outside the metocean discipline) to assign a competent metocean TA2 to the project to implement the Metocean (and Ice) Data Acquisition and Analysis DCAF ID 127. This person should be appointed as Metocean and/or Ice TA2 for the project and meet the minimum competence associated with the Metocean Dsn and Exe JG4 Competence profile and be approved as covering metocean in the DCAF Discipline Authority Manual.

2.5 TECHNICAL AUTHORITY REVIEW

While the different data acquisition activities of planning, implementation, assimilation and analysis may be carried out by either the Principal's staff or Contractors, the same specifications and requirements apply in all cases. When using Contractors for any of these activities, this DEP document shall be provided as part of the contract documentation and attention shall be drawn to the sections relevant to the type of service contracted. The Metocean Technical Authority (TA2 or above) designated for the project shall authorise the Metocean (and Ice) Data Acquisition and Analysis Plan (DAP) and establish that the functional performance specifications will meet specific project needs and is appropriate for the local metocean and ice conditions.

Though metocean data collection systems and methods have common features, (instrumentation, data processing, etc.), a data collection plan shall be put together in a bespoke manner in order to meet the regional climate and specific project needs.

2.6 HSSE CONSIDERATIONS

2.6.1 HSSE for data collection operations

Health, Safety, Security and Environment (HSSE) shall be considered at each stage of the metocean and ice data acquisition process. The following shall be included as part of the risk management process:

- A risk register identifying the key risks involved at each stage in the data acquisition process.
- An HSSE plan including detailed deployment and retrieval procedures, Job Hazard Analysis (JHA) and emergency response plan that will be followed to mitigate the risks.

OGP Report 447 (2011) shall apply. Requirements and recommendations on the health aspects of working in extreme climates are contained though in OGP Report 398 (2008).

2.6.2 HSSE competence

One of the primary HSSE issues relating to metocean and ice data acquisition activities is Contractor competence assurance. Within Shell, tools are available to carry out Contractor competence assessment. In Shell, these shall be followed in line with Group HSSE Policy. Additionally, there are rules that apply to contract holders of medium (and higher) risk contracts such as remote metocean and ice data acquisition contracts. These are defined in the Shell HSSE and SP Control Framework, Contractor HSE Management. The Principal's staff, engaged in Contractor management activities, shall demonstrate appropriate HSSE competence in addition to their technical competence.

For metocean and ice data collection systems mounted on platforms, in plants and in refineries, it may be necessary for some sensors to be located in hazardous areas. In these situations, sensors shall be specified that satisfy the various HSSE requirements and standards. This is discussed in more detail in DEP 37.00.10.12-Gen. and (4.4).

NOTE: This requirement is a DEM1 requirement in DEP 37.00.10.12-Gen.

2.7 QUALITY ASSURANCE CONSIDERATION

2.7.1 Quality assurance for data collection operations

Quality Assurance shall be considered at each stage of the metocean and ice data acquisition process and review process. The following shall be included as part of the risk management process:

- A risk register identifying the key risks that could impact the data quality at each stage in the data acquisition process;
- A quality plan including:
 - o detailed information on the steps taken to ensure the quality of data collected is not compromised including
 - o a quality check list to ensure that all the items identified in the quality risk register have been addressed (these may also need to be included in the deployment and recovery procedures),
 - o a spares strategy and
 - o a data quality control procedure.

2.7.2 Peer review process

The Management System of the Principal shall define the overall processes that shall be followed for ensuring quality of deliverables across the project, however the Metocean (and Ice) Data Acquisition and Analysis Plan shall comply with the Metocean Peer Review System.

2.8 RELIABILITY OF METOCEAN CRITERIA AND STATISTICS

When metocean advice, design criteria and statistics are provided to project customers, due account shall be taken of uncertainties and potential inaccuracies in the data obtained and provided.

Typically, the accuracy of the metocean data required increases as the project progresses through each of the development phases. Five reliability levels for metocean criteria and statistics are distinguished in this DEP and are listed in Table 2.1.

The metocean deliverables shall be scheduled to match the project phases and requirements, and classified as to their use and applicability by the Principal's Metocean specialist. The most accurate and complete set of metocean and ice criteria and statistics available should be used for each of the project phases. The level of accuracy shall be clearly stated on any metocean document provided to customers.

Table 2.1 Metocean criteria and statistics reliability levels

Level	Definition	Description – typical
1	For information only	Preliminary estimates of metocean criteria are based upon limited information. The degree of uncertainty associated with the derived values will usually be relatively broad, with a tendency to be on the conservative side.
2	Issued for initial use	Existing metocean information and data are used to produce preliminary metocean criteria and operational statistics.

Level	Definition	Description – typical
3	Issued for preliminary design purposes – to be verified	Metocean criteria and statistics are often based on limited site-specific measurements. These preliminary criteria and statistics have yet to be verified. The measurements are also used to calibrate and validate hindcast models, as part of the process of generating a long-term hindcast database of the key metocean parameters.
4	Issued for detailed design purposes – to be relied upon	The measured and hindcast data are used to derive refined metocean criteria and operational statistics for detailed design purposes. As the information is also needed for making operational decisions, more detailed operational statistics are usually included.
5	Operational support	Further refinements are made to the metocean design criteria and statistics in support of production operations and for structural integrity purposes. Use may be made of response-based joint probability analysis techniques.

Expected relative accuracies for the five levels are also shown schematically in Figure 2.2.

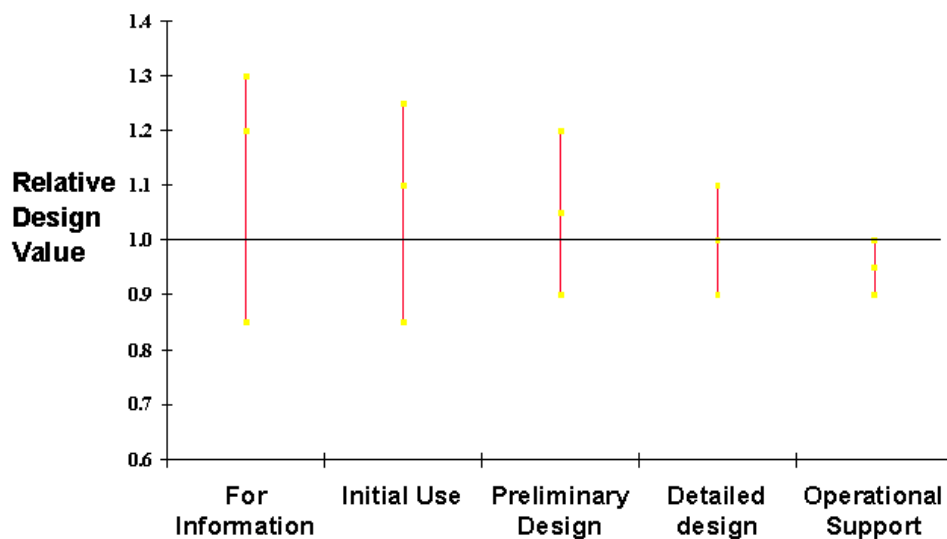


Figure 2.2 Metocean criteria and statistics reliability levels

NOTE: The absolute values should not be taken literally; the diagram is intended only to display the relative significance of the different reliability levels. For each level, there is shown an error bar with a centre point and a confidence interval range. This highlights that at Level 1, there is greater uncertainty associated with the values compared with the higher Levels. While there is an expected bias towards conservatism at Level 1, the diagram illustrates that this may not always turn out to be the case. This is something always to be borne in mind.

3. METOCEAN AND ICE DATA ACQUISITION AND ANALYSIS – DEFINITIONS

3.1 GENERAL

As discussed in the Introduction, this DEP specifically addresses the requirements for the DCAF deliverable; Metocean (and Ice) Data Acquisition and Analysis DCAF ID 127. This deliverable includes the three phases of 1) definition, 2) implementation and 3) assimilation and analysis.

Definition of the metocean and ice data acquisition and analysis work is discussed in detail in (3) and covers the five steps specified in (2.2) under item No. 1, with the implementation of the metocean and ice data acquisition in (4) and the assimilation and analysis of the data to provide the project deliverables in (5).

3.2 IDENTIFY A PROJECT'S NEEDS FOR METOCEAN AND ICE INFORMATION

The first step is to clearly identify the project's needs for metocean and ice information, in the context of the overall project strategy including metocean design criteria, operational statistics, tow criteria, real-time data and forecasts; this helps to generate the lowest cost practicable solution without jeopardising safety. The activity shall be carried out jointly with the Principal's project team and respective discipline engineers. The following key questions shall be addressed across each stage of the project:

- a) What are the metocean conditions in the planned development area that impact both design and operations and cause hazards and risks?
- b) What elements of the project (exploration, design, logistics, operations etc) involve metocean and ice?
- c) In what ways can metocean input potentially help to make the project safer, operations more efficient and costs lower overall?
- d) What deliverables does the project need? At what stage and when?
- e) What are the metocean 'value-added' critical activities? Are there benefits in close interaction between the metocean and development engineers to fine-tune the deliverables?
- f) What are the main risks and uncertainties, both environment and project?

Indicative project requirements are shown in Table 3.1 with some example indicative aspects inserted into each box of the table. The deliverables indicated in the table are needed close to the start of each phase, as the information is required to enable the phase to proceed. Each project team shall draw up its own list, tailored to its individual needs and in greater detail than shown in the table. The table can be used as a check box, to tick off that all relevant aspects of expected deliverables and timing have been considered.

Time schedule constraints on projects will often limit the time available to undertake the metocean work considered necessary, for example to collect field data over a number of years and/or to undertake numerical hindcast modelling studies. As a consequence, the optimum or required level of accuracy and reliability of the metocean and ice criteria and statistics may not always be achievable in time for specific project phases. Where this occurs, it may be necessary to incorporate some conservatism and apply appropriate safeguards should significant changes be necessary at a later stage. The plan shall cover all the deliverables for each stage even if this is reached in a stepwise process as more data becomes available.

The data required at each stage of the project development will in part relate to the concepts being considered and the final concept selected for the project(s). Uncertainties in the concept need to be considered in the data acquisition plan and if necessary data collection options provided dependent upon the concepts being considered.

Further follow-up work shall be defined for the future project phases, and the levels of accuracy shall be classified according to the reliability levels defined in (2.7). This shall be done in consultation with the Principal's metocean specialist, while the project team shall be

made fully aware of the situation upfront. Possible mitigating measures shall also be documented as part of the Principal's review and approval process. Based on the assessment above, a preliminary list of the required metocean deliverables and schedule of delivery dates shall be drawn up. This list shall be at the level of detail needed for a well-defined scope of work and CTR. The scope of work may now need further refinement and iteration to establish how best to meet the project's needs for metocean. See (3.3) and (3.5) and Table 3.1 below.

Table 3.1 Indicative project needs for metocean and ice information

Project Phase	What Metocean information does the Project need?	Metocean Related HSSE Safety Impact?	Potential Cost Impact?	Level of detail required?	How accurate? Level of acceptable uncertainty/ confidence in information	When required? Timing	Benefits of iteration/ close interaction project/ Metocean
IDENTIFY Exploration, Assess, Scouting	Statistics for seismic and drilling. Criteria for rig selection. Weather forecasts	Personnel safety; Rig and equipment integrity	Weather downtime; incorrect concept or feasibility assessment	Monthly statistics; Criteria values; Site-specific forecasts	Level 1 initially, then Level 2. Rig selection may need Level 3.	Prior to vessel and rig selection process, initial concept selection	Everyone made aware of key potential Metocean and ice risks and uncertainties
ASSESS Feasibility	Overview of criteria and statistics. Real-time data to support drilling operations	Essential to identify Metocean and ice related HSSE risks even at this early stage	High, if later refinements in Metocean and ice criteria and statistics have significant impact on project.	Design criteria; Operational statistics; Identification of risks and uncertainties	Level 2/3	At early planning stage	All relevant Metocean aspects and uncertainties in Level 2/3 information are considered
SELECT Concept	Criteria and statistics matched to concepts - BoD	Relate Metocean HSSE risks to concepts	High, if later refinements in ice and Metocean criteria and statistics significant necessitate design changes	Design criteria; Operational statistics; Identification of risks and uncertainties	Level 3/4	Prior to starting on concept design	Metocean and ice criteria and statistics tailored to concept applications – potential savings

Project Phase	What Metocean information does the Project need?	Metocean Related HSSE Safety Impact?	Potential Cost Impact?	Level of detail required?	How accurate? Level of acceptable uncertainty/ confidence in information	When required? Timing	Benefits of iteration/ close interaction project/ Metocean
DEFINE Detailed Definition	Criteria and statistics for the design, construction, tow and installation – MRD, IER	Quantify and mitigate	High if Metocean and ice criteria and statistics are modified; mitigation may be possible during construction	Detailed Design criteria; Operational statistics within a full MRD	Level 4	Is there enough time to derive Level 4 criteria and statistics?	Potential savings
EXECUTE Construct, Tow and Installation	Statistics for construction, tow and installation – MRD, IER Weather forecasts and AWWP	Quantify and mitigate	High if damage or delays to tow and installation	Detailed Design criteria; Operational statistics; Site-specific weather forecasts	Level 4 Level 5	For detailed design; in support of operations	Potential savings, safety issues
OPERATE Operate facilities and logistic	Real-time data; Weather forecasts; Criteria and statistics for structural reviews – MRD, IER AWWP, oil spill contingency	Crew transfers; Structural integrity	High if HSSE incidents, damage or delays	Metocean stations; Site-specific forecasts; Detailed design criteria; Operational statistics;	Level 5	In support of daily operations	Potential savings, safety issues

Project Phase	What Metocean information does the Project need?	Metocean Related HSSE Safety Impact?	Potential Cost Impact?	Level of detail required?	How accurate? Level of acceptable uncertainty/ confidence in information	When required? Timing	Benefits of iteration/ close interaction project/ Metocean
ABANDON Abandonment	Criteria and statistics for planning and executing abandonment; Weather forecasts	Personnel safety; Minimise environmental impact	High if delays	As for detailed design	Level 5	At early planning stage	Tailor to need; Potential savings, safety issues

3.3 UNDERSTANDING THE METOCEAN AND ICE CHARACTERISTICS OF THE AREA

The “environment risk” identification process defines the characteristics of the metocean and ice conditions that may impact the project. General conditions should be understood before data collection commences. This ensures data collection and analysis will be designed in a way to ensure it is sufficiently representative of the conditions and condition variation.

Prior to finalising the data collection plan, the following shall be reviewed:

- The regional climatology - to identify aspects and hazards that require specific consideration;
- The timescales of the relevant metocean processes - to ensure variations on different timescales such as seconds/minutes, daily, seasonally, annually and inter-annually are considered;
- Data availability and data collection proposed - to consider the data accuracy, representativeness and relevance to the location and local environment.

The following items list environmental aspects that shall be considered for the design of the data acquisition plan.

3.3.1 Rapidly varying conditions

Risk: If conditions in an area are able to vary very rapidly, the data collection regime shall take this into account. For example, individual maxima and continuous ‘high time-resolution’ data shall be measured and recorded in addition to averaged values, to enable extreme conditions to be derived. Examples of this include:

- Winds: squalls, microbursts, downdrafts, tornadoes, tropical storms, harmattan winds, katabatic winds
- Waves: tropical storms
- Currents: solitons, density or turbidity events, eddy events, restricted flows
- Ice: ice pressure build up in high ice concentrations
- Atmospheric pressure: rapid pressure change such as during topical storms or depressions and polar lows

If rapidly varying conditions could exist in an area, data collection shall be undertaken such that the rate of build-up/fall and individual maxima/minima can be measured. In this case, data shall be collected continuously at a high time resolution i.e., 1-second to 1-minute depending on the parameter. This may have implications for battery life and memory capacity.

3.3.2 Infrequent conditions

Risk: In many areas, the type of metocean conditions or environment that will cause an extreme event (10 to 100-year or higher return period) may occur very infrequently. As a result, short- to medium-length data sets may miss the key extreme phenomena and result in severe under-estimation of extreme conditions.

- Typhoon, hurricanes and tropical cyclones (Especially when they occur outside of their normal range and when they do, will dominate the metocean design criteria. For example, a tropical storm event between 10°N and 10°S).
- Tornadoes
- Tsunamis
- Icebergs – related to seabed scour and ice free water depth

If infrequent but severe conditions could exist in an area, data collection shall be supplemented by other long term data sources which cover both time and space (in the region of interest) such as satellite, hindcast or public domain data (if available).

3.3.3 Long-term oscillations and inter-annual variability

Risk: There are several long term oscillations which occur naturally in different areas of the globe and impact different regions. Most installations will have to survive the full cycle of these oscillations but as these oscillation periods are typically 5 to 30-years, data acquisition often will not cover the full oscillation cycle. The phases of relevant oscillation and their impact on the data collected shall always be considered as they can lead to more calm/rough, hot/cold or dry/wet periods than the regional norm. These oscillations include but are not limited to:

- The **North Atlantic Oscillation (NAO)**: This is the fluctuation in the difference of atmospheric sea level pressure between the Icelandic flow and the Azores high and controls the strength and direction of westerly winds and storm tracks across the North Atlantic.
- The **Arctic Oscillation (AO)**: This is the dominant pattern of non-seasonal atmospheric sea level pressure variations north of 20°N latitude. The AO is believed by climatologists to be related to weather patterns in locations many thousands of miles away.
- The **Pacific Decadal Oscillation (PDO)**: This is a pattern of Pacific climate variability that shifts phases on an inter-decadal time scale (20 to 30 years) and is detected as warm or cool surface waters in the Pacific Ocean.
- The **El Niño/La Niña-Southern Oscillation (ENSO)**: This is a climate pattern that occurs across the tropical Pacific Ocean roughly every five years and is characterized by a weakening of the trade wind and associated variations in the temperature of the surface of the tropical eastern Pacific Ocean. The warm oceanic phase, El Niño, accompanies high atmospheric sea level pressure in the western Pacific, while the cold phase, La Niña, has low atmospheric sea level pressure.
- The **Indian Ocean Dipole (IOD)**: This is an irregular oscillation of sea-surface temperatures in which the western Indian Ocean becomes alternately warmer and then colder and can impact typhoon severity.
- The **Atlantic Multi-decadal Oscillation (AMO)**: This is a climate pattern in the North Atlantic characterized by decadal-scale oscillations of slightly higher versus slightly lower average temperature and impacts hurricane severity.

The literature shall be studied to assess if any long term trends impact the area of interest, the extent of this impact, the phase of this trend during any data acquisition period and the expected impact of this on the data shall be considered in design. Other long-term data sources which cover a sufficient period such as satellite, hindcast or public domain data (if available) shall be obtained.

3.3.4 Climate change (trend and variability)

Risk: Climate change is resulting in both higher variability and trends in conditions in many areas. These need to be considered when making measurements and preparing design criteria. Short data collection may not capture trends, variability or fully representative conditions.

3.3.5 Unknown area

Risk: Where little is known about an area and no data has been previously collected, an incorrect assessment of the region could be made. For a frontier data collection campaign, data collection shall start as early as possible in the project timeline to ensure that there is sufficient time to understand and validate the metocean and ice conditions. Data collection shall be extended where logistics allow so that the longer term trends can be assessed. The types of non-routine phenomena to watch out for include strong bottom currents, solitons, strong local winds, flash floods, etc.