

Construction vessel guideline for the offshore renewables industry



CONSTRUCTION VESSEL GUIDELINE FOR THE OFFSHORE RENEWABLES INDUSTRY

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FOREWORD

The Crown Estate and the Energy Institute (EI) have collaborated on the development of good practice in the offshore renewables industry, to support the safe and successful delivery of renewable energy projects for the UK. This has led to the publication of *Construction vessel guideline for the offshore renewables industry*.

This guideline is designed to follow on from *Vessel safety guide – Guidance for offshore renewable energy developers (Vessel safety guide)* published by RenewableUK in January 2012 and is intended to assist by providing guidance to developers and the supply chain for the construction of an UK offshore wind farm project.

Offshore wind is expected to become a major UK industry, bringing significant inward investment, thriving businesses and jobs. As landlord of the seabed, The Crown Estate has taken a proactive approach to supporting the offshore wind industry in order to help realise its full potential. Since 2000, there have been a number of leasing rounds for the development of offshore wind projects, with each leasing round generally increasing in scale and technical complexity as the industry has developed. The wave and tidal industry has experienced a number of leasing rounds for wave and tidal projects and current developments are at a very early stage of initial commercialisation. Therefore, this guideline mainly focuses on assisting offshore wind development projects, but many sections of information can also be used to assist wave and tidal projects.

Due to the increased size and complexity of projects, their being further offshore and the anticipated increased need for further vessel development and capabilities, this guideline aims to assist development teams in the planning and resourcing of renewable sector related projects located within the UK waters.

This guideline is intended to provide industry-specific guidance. Whilst the EI and the contributors have applied reasonable care in developing this publication, no representations or warranties, express or implied, are made by the EI or any of the contributors concerning the applicability, suitability, accuracy or completeness of the information contained herein and the EI and the contributors accept no responsibility whatsoever for the use of this information. Neither the EI nor any of the contributors shall be liable in any way for any liability, loss, cost or damage incurred as a result of the receipt or use of the information contained herein.

This guideline will be reviewed in line with the publication development and content of technical publications issued by the Energy Institute.

Suggested revisions are invited and should be submitted through the Technical Department, Energy Institute, 61 New Cavendish Street, London, W1G 7AR. e: technical@energyinst.org

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1 PURPOSE

This guideline has been produced to assist developers in planning offshore renewable industry operations with particular focus on offshore wind farms in the UK. The guideline also aims to assist in reducing the construction risk and provides a solid foundation for safe and efficient offshore operations. This guideline is designed to follow on from the *Vessel safety guide* and is intended to assist by providing guidance to developers and the supply chain for the construction of an offshore wind farm.

A comprehensive understanding of construction hazards and the challenges of the offshore environment is vital to the successful delivery of a project. It is essential therefore to embed the analysis of risk into a project from the earliest design stage and to capture the lessons learnt from previous projects. In addition, specific offshore experience and guidance where available also provide a key role in development project planning.

The *Vessel safety guide* supports the process of assessing vessel safety; it also provides information to developers in order to better evaluate the issues related to offshore operations with regard to the selection of vessels and associated equipment for the construction phase of a project. Some of that information, particularly the supporting information contained in Annexes A, B and C, is again presented in this guideline in order to better understand the capabilities of the vessels and associated operating criteria; however, for detailed information the vessel owners should be contacted.

The most important element is that the health and safety strategy is fully integrated into the offshore construction project from the outset and as an on-going process throughout the life cycle. This will not only deliver a safer project but, from experience and lessons learned in other offshore industries, will deliver a technically and commercially successful project as well.

Merchant Shipping Regulations are complex but give valuable and legal information and guidance to vessel owners and operators. It is essential to plan for compliance from the outset to ensure that vessels do not face delays or operating restrictions. Merchant Shipping and Health and Safety Regulations cover operational or occupational hazards over which the Owner and Master of the vessel have direct personal control, and can manage those risks by providing appropriate work equipment, properly qualified staff and ensuring safe working practices. However, there are many risks that operators cannot easily quantify, where the cost of mitigation is high and it is important that all operators face a level playing field of costs, or where the consequences are so serious and widespread that Government and/or the international community has decided what protection has to be provided. These matters are covered in Merchant Shipping Regulations for the design and construction of vessels, and the qualifications and training of the persons on them.

In summary, the aim of this guideline is to:

- Offer information and insight on key health and safety and related elements in the selection of vessels and project equipment for offshore operations, to mitigate risks, provide a solid foundation for the decision making of developers and also assist the expectations of the supply chain.
 - Enable developers to raise the necessary questions of contractors and sub-contractors.
 - Provide developers with key information to enable them to instruct third parties to ensure an appropriate selection.
 - Provide developers with information to inform the audit of all vessels and equipment prior to contracting together with the vital assessment of the supplier's capability, training record and experience of key personnel.
 - Provide a comprehensive reference to the applicable regulations and other applicable guidance.
-

2 SCOPE

The scope of this guideline covers six main areas; these areas are listed below along with a brief summary of their content.

Regulatory framework:

- A summary overview of the regulations that may need to be followed by the project developer or the contractor.

Health and safety management:

- An insight into the fundamentals of good health and safety practice.
- Guidance to ensure that health and safety is fully integrated into the offshore construction project from the outset and remains an on-going and embedded process throughout the life cycle.

Vessel selection, matrix and flowchart:

- The information provided here is to assist developers to make informed decisions that take health and safety into account. Vessel types are introduced along with their various operating ranges. By understanding and taking account of the operating envelope, project managers can have more confidence in the project having lower risks. The construction vessels utilised within the offshore renewables industry vary widely and there are several types within each category. The matrix within the Annexes has been developed to provide guidance together with images. The full matrix is shown in Annex C. There is awareness that there will be a new generation of offshore wind farm vessels in construction and this guideline deliberately only addresses those currently in operation. The vessel matrix and flow chart of decision making demonstrates how the whole project design, vessel selection and operations are closely interconnected and therefore that health and safety needs to be considered from the very start through a 'Safe by Design' approach. Safe by Design is about incorporating safe design principles in the design, construction and maintenance of workplaces. A number of countries include safe by design requirements in their health and safety legislation. This is to ensure that hazards and risks that may exist in the design of a workplace are eliminated or controlled at the design stage as far as reasonably practicable.

Vessel assurance audit:

- Provides initial information on the benefits and scope of appropriate vessel audits.

Major construction equipment audit:

- Provides guidance on the major equipment items and the audit processes that should be followed.

Training and competencies:

- This section provides an overview of the training and competencies that key personnel and their staff should have whilst working on an offshore construction job. These areas are set out to follow the flowchart process illustrated in Annex A in terms of project design, vessel selection and operations stages.

The target audience for this guideline is considered primarily to be duty holders such as:

- developers;
- project managers;

- package managers;
- health and safety teams, and
- supply chain equipment manufacturers.

This guideline can be used to inform the supply chain as a useful reference to provide an overview of the expectations of developers. As a consequence, the supply chain can benefit from a more integrated approach in many aspects of project planning, including the training of personnel and expectations for audit and performance.

3 REGULATORY FRAMEWORK OVERVIEW

Regulatory requirements address a number of aspects including:

- Flag state and classification requirements.
- Minimum numbers of marine personnel on board.
- Training and competencies.

There are specific regulations that apply to vessels and given vessel types (see section 11 for a list of the regulations and references). There is a wide range of design, operations and propulsion methods now in the industry and an overview of the regulatory regime is provided in Table 1. The table refers to using jack-up vessels as an example for explanatory purposes only. This table is not exhaustive and additional reference may be made to documents in section 11. Detailed professional guidance should be sought in order to confirm applicable regulations for a particular project.

Table 1 Regulatory regime (example)

Principal regulatory regime for safe construction	Critical factors (Manned/unmanned refers to condition in-transit and self-propelled)	
SOLAS ¹ /load line (international conventions), or MODU code (alternative)	Manned and with up to 12 non-crew carried, including jack-ups	
Classification society rules		
Load line (convention or national rules)	Unmanned, including jack-ups	
SCV Code (MGN280)/Brown Code or equivalent flag state rules	Manned, including jack-ups, up to 12 non-crew carried and <24 m load line length	
MARPOL (marine pollution)	Prevention of pollution	
MLC 2006 (Maritime Labour Convention)	Standards of existing international maritime labour and conventions	
SOLAS or EU – for a passenger ship/load line, or special purpose ships (SPS) code	Ship-shaped ² vessels (including WTIVS)	Manned with more than 12 non-crew carried
Classification society rules		
MODU Code ³	Jack-ups and semi-subs	
Classification society rules		
¹ For construction requirements, SOLAS applies to non-passenger ships ≥ 500 gross tonnage, but flag/coastal state requirements may apply. ² Non-self-propelled-jack-ups and non-semi-submersibles. ³ For new ships built for offshore renewables, this may be the SPS Code with additions from the MODU Code.		

The responsibility for the Maritime and Health and Safety Regulation of the offshore renewables industry within the United Kingdom Renewable Energy Zone (UK REZ) lies predominantly with the Maritime and Coastguard Agency (MCA) and the Health and Safety Executive (HSE). As basic guidance, vessels when afloat are regulated typically by the MCA and when fixed, for example jacked-up, by the HSE. A Memorandum of Understanding (MOU) has been established between the MCA and the HSE to ensure coordination between organisations. Table 2 summarises the responsibilities of the respective organisations.

Table 2 Organisational responsibilities

MCA	Responsible for enforcing all Merchant Shipping Regulations in respect of occupational health and safety, the safety of vessels, safe navigation and operation (including manning levels and crew competency). Merchant Shipping Health and Safety Regulations extend to all those working on the ship, and all shipboard activities carried out by the crew under the control of the ship's Master. The MCA is responsible for enforcing IMO, MLC (2006) and ILO requirements.
HSE	Statutory body whose main function is to make arrangements to secure the health, safety and welfare of people at work and to protect the public from dangers arising from work activities. The HSE's statutory powers and responsibilities are derived from the Health and Safety at Work etc. Act 1974 (HSWA) and associated relevant statutory provisions including the Docks Regulations 1988 and other related legislation. Its powers under the HSWA are extended to activities offshore under the Application Outside Great Britain Order where these activities involve preparing for and being involved in construction of offshore energy installations.
IMO	The primary purpose of the International Maritime Organization (IMO) is to develop and maintain a comprehensive regulatory framework for shipping which includes safety, environmental issues, and legal concerns, as well as encouraging technical cooperation, maritime security and the efficiency of shipping.
	Examples include but are not limited to: <ul style="list-style-type: none"> – International Convention for the Safety of Life at Sea (SOLAS) – International Regulations for Preventing Collisions at Sea (COLREG) – International Convention for the Prevention of Pollution from Ships (MARPOL) – MLC (Maritime Labour Convention), 2006

The selection of a suitable vessel that is safe and appropriate for the range of intended activities needs to be a well-established process that takes into account the regulations that govern vessel build, maintenance and operation.

4 HEALTH AND SAFETY MANAGEMENT

Within the UK and its territorial waters there are statutory legal requirements on vessel owners and other organisations in control of work to both ensure the health and safety of persons at work and the safety of the vessel. UK Merchant Shipping Act-based legislation (not when dealing with the prevention of pollution from ships – i.e. MARPOL) is generally limited in its application to UK ships anywhere and other ships within UK territorial waters. Beyond territorial waters, the enforcement authority for a ship's maritime safety standards falls on the flag State. This can include forms of LOLER and PUWER if the flag is EU.

Project developers should therefore take all reasonably practicable steps to ensure that there are adequate management arrangements (vessel and shore based) to ensure the safety of the vessel and the health and safety of the crew, passengers and project workers on the vessel. Therefore, prior to vessel selection there should be a suitability audit or audits of those arrangements to determine if they are adequate.

For the safety of the vessel and crew the responsible organisation will be the vessel owner, with statutory roles and responsibilities for the vessel Master. The operational safety management system for the vessel should comply with:

- International Safety Management (ISM) Code requirements of the IMO, if 500 gt or over.
- Managed in accordance with MCA requirements.
- A documented procedure for jack-ups that includes all key requirements of the ISM Code if not ISM compliant.

Furthermore the vessel operator should be able to demonstrate that all vessel work equipment including lifting equipment is maintained to ensure safety and inspected by a competent and suitably qualified person. Suitable certificates and/or records of maintenance should be made available for audit.

The organisation responsible for the health and safety of project works should be clearly identified as part of the client's and/or principal contractor's duties under the Construction (Design and Management) Regulations 2007¹ (CDM). The responsible organisation should be able to demonstrate, prior to the commencement of work, that it has adequate arrangements to successfully manage health, safety and environment.

There are a number of different management systems available but all should have the following principles:

- Adequate arrangements for the effective **planning** of good health and safety, including a systematic approach to the completion of a risk assessment that identifies the most appropriate measures to control risk.
- **Organisation** for health and safety including arrangements which involve employees when determining health and safety control measures, provision of effective means of communication and consultation, securing competence by the provision of adequate information, instruction and training, its evaluation and where necessary certification.
- Establishing the means to **control** risk including clear and concise health and safety responsibilities for all persons involved in the work, the setting of suitable performance standards and sufficient supervision.

¹ Under review at time of publication.

- Proactive and reactive arrangements to **monitor** performance including work place inspections, incident investigations, with appropriate recording and reporting procedures.
- **Reviewing** the health and safety performance and the effectiveness of the health and safety arrangements detailed here.

Once a suitable vessel has been selected then attention should be given to the deck layout, with particular attention to safe access and egress, safe lifting operations and work at height. Where the work activities are not the responsibility of the vessel owner then there should be a bridging or interface document to ensure there is compatibility between the two operating management systems.

Prior to the commencement of work the project developers should check that there are adequate arrangements for cooperation, coordination and communication between all organisations and individuals on the vessel and relevant shore-based personnel. This could include daily briefings, toolbox talks, HAZID, risk assessments and information alerts.

4.1 MARINE CONTROL

With the increasingly large number of vessels operating on site, a robust marine control centre, providing marine coordination and a strong protocol for communications, is essential to ensure safe and efficient operations. This may include a marine coordination base at the onshore operations base as well as a control centre offshore.

4.2 CLIENT REPRESENTATIVE

Where appointed, a client representative (client rep) plays a key role in ensuring effective coordination and communication of relevant contractual, operational and health and safety matters particular to the project/vessel. In carrying out this role the client rep should have sufficient training, knowledge and experience to enable them to undertake the defined responsibilities they are required to carry out; this would include, but not be limited to:

- Understanding of the contract and contractual requirements.
- Adequate experience and familiarity of vessels (general and specific).
- Adequate knowledge and understanding of the planned tasks and activities to be performed.
- Adequate health and safety knowledge.
- Adequate marine knowledge.

4.3 SIMULTANEOUS OPERATIONS (SIMOPS)

The role of the marine coordinator both onshore and onsite is a vital element to safely manage the complex simultaneous operations that are an intrinsic part of the construction phase of an offshore wind farm.

A marine coordinator should be appointed to manage all vessel traffic and to coordinate emergency response activities in the event of an incident, this being a requirement of an

emergency response cooperation plan (ERCoP). IMCA M 203 *Guidance on simultaneous operations (SIMOPS)* gives further information on SIMOPS.

SIMOPS occur when two or more potentially conflicting activities or process operations are being coordinated in the same location at the same time, which is very typical on an offshore wind farm.

5 VESSEL SELECTION, MATRIX AND FLOWCHART

As the industry has evolved, a range of vessels has been developed, adapted and utilised and with offshore wind farms moving into deeper waters, a new generation of vessels is coming into operation. The overall concept and holistic view in the selection of vessels, including how vessels work alongside one another, how they operate and dependencies and interdependencies within an emergency situation, is essential.

In addition, other purpose built vessels are entering the market, some already utilised within the oil and gas industry and others built specifically for the installation of offshore wind farms. There are also new installation methods that are evolving, often previously used in the oil and gas sector such as 'float-over' installation for substations. With larger turbines and a range of foundation designs being used, this will encourage other types and new vessels to enter the industry. For example, installation vessels may increasingly remain on site and the components will be transported to site by transportation barges.

Furthermore, with the Round 3 REZs being typically further offshore, it will require significantly longer export cables that may necessitate larger purpose-built cable lay vessels capable of carrying a full length of cable and the range of lay equipment required. Alongside the vessels themselves is the wide range of project equipment that is required. This should be assessed onboard in its fully operational condition and subject to an audit as described in section 9.

Towed jack-ups were initially used as a stable platform from which to make the sensitive lifts required for turbine installation. However, as the need arose to carry larger deck loads and accommodate the significant increase in size of the components, in particular the blades, the building of much larger, self-propelled units with Dynamic Positioning (DP) has evolved. The Nautical Institute states that the definition of DP is:

'a vessel capability provided via an integration of a variety of individual systems and functions. A computer control system automatically maintains a vessel's position and heading by using its own propellers and thrusters. Position reference sensors, combined with wind sensors, motion sensors and gyrocompasses, provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position'.

This has enabled units to complete the installation works much more efficiently and quickly move to the next location.

The nature of the industry now requires 24/7 operations and this requires an in-depth assessment of the training and competencies of all offshore personnel. The process flowchart provided in Annex A gives an overview of the complete selection process, with further details to be considered covered in Annex B.

The vessel matrix in Annex C illustrates the different types of vessels now being utilised in the industry. It also provides generic guidance on these types of vessels with their typical activities and operating criteria, although for full specifications it is recommended that the owner of the vessel be contacted.

The types and/or characteristics of vessels currently being utilised in the industry include the following:

- anchored barges;
- transportation barges (TBs);
- wind farm installation vessels (WIVs);

- jack-up barges (JUBs);
- heavy lift vessels (HLVs);
- dynamic positioned diving support vessels (DPDSVs);
- air range diving support vessels (ARDSVs);
- offshore support vessels (OSVs);
- cable lay vessels (CLVs);
- rock dump vessels (RDVs), and
- flotels.

There are other associated vessel types that would be holistically considered; these could include crew transfer vessels (CTVs), guard vessels, supply vessels, anchor handling tugs (AHTs) and stand-by vessels, and many other types, and these have also not been included in Annex C.

5.1 VESSEL FAILURE MODES/LIMITATIONS (FAILURE MODES EFFECTS ANALYSIS (FMEA))

IMCA published a document² to highlight best practice in the use of Failure Modes and Effects Analysis (FMEA) techniques when applied to the technical systems associated with offshore vessels. FMEA is a technique that assists in the identification and countering of potential weak points in the early design phase of products and processes.

It is important to specify the standard to which the FMEA is to be carried out. The use of a clearly defined methodology for carrying out the FMEA will allow the required in-depth study to be attained without the uncertainty and indiscipline that a less structured approach would bring. Consequently, whoever requires the analysis to be undertaken will know that it has been performed in a structured manner. They will have increased confidence that all operators understand the capabilities and any limitations, allowing achievement of best performance.

Standards that are usually referred to when carrying out an FMEA include:

- US Department of Defence MIL-STD-1629A.
- IEC 60812: *Analysis techniques for system reliability*.
- Procedure for FMEA.
- BS 5760-5 *Reliability of systems, equipment and components. Guide to failure modes, effects and criticality analysis (FMEA and FMECA)*.
- IMO MSC Resolution 36(63) Annex 4 – *Procedures for failure mode and effects analysis* (whilst this is primarily for high speed craft under the HSC Code, it gives good guidance on FMEA procedures).

There are other standards, such as that included in the Japanese Industrial Standard, which use similar techniques, but the ones listed here are sufficient for reference purposes.

Where DP vessels are concerned, the FMEA should also make use of all current DP related guidelines that can assist in improving the redundancy and operability of a DP vessel. These include IMO MSC Circular 645 *Guidelines for vessels with dynamic positioning systems* and IMCA M 103 *Guidelines for the design and operation of dynamically positioned vessels*.

² IMCA M 166 *Guidance on failure modes and effects analysis (FMEAs)*

These guidelines provide a good guide as to which shipboard systems relating to DP require to be covered.

Specifying a standard will not guarantee an acceptable FMEA but it will guarantee an acceptable procedure and format for carrying out an FMEA. It will not dictate what areas should be analysed in a particular system or to what level of detail they should be analysed. Only an expert analyst fully conversant in the standard selected, the system architecture, the characteristics and performances of the different components of the system can achieve this.

Also, specifying an FMEA standard will not limit design innovation, as has been stated in some circles. The FMEA does not carry out the design itself but analyses a particular design, be it innovative or traditional design, for weaknesses with respect to failure modes.

6 CONSTRUCTION VESSELS

The following vessels are a selection of the major types currently in use for the construction phase of an offshore wind farm. Whilst the list is intended to be thorough it focuses on the major types only and does not seek to reflect all the vessels available.

6.1 VESSEL STATION KEEPING SYSTEMS

The use of dynamic positioning (DP) systems for station keeping has become standard for newly built vessels, and an upgrade on older commercial vessels. Station keeping capability is required to maintain the vessel's position during offshore support operations. Station keeping performance is essential not only for safety (collision, diving operation, etc.) but also for operability; therefore, the DP system is considered as one of the most critical systems on board the vessel.

6.1.1 Dynamic positioned (DP)

The Nautical Institute states that the definition of DP is:

'a vessel capability provided via an integration of a variety of individual systems and functions. A computer control system automatically maintains a vessel's position and heading by using its own propellers and thrusters. Position reference sensors, combined with wind sensors, motion sensors and gyrocompasses, provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position'.

The computer program contains a mathematical model of the vessel and information pertaining to the wind and current drag of the vessel and the location of the thrusters. This knowledge, combined with the sensor information, allows the computer to calculate the required steering angle and thruster output for each thruster. This allows operations at sea where mooring or anchoring is not feasible due to deep water, congestion on the sea bottom (pipelines, templates) or other problems.

DP may either be absolute in that the position is locked to a fixed point over the bottom, or relative to a moving object like another vessel or an underwater vehicle. The vessel can also be positioned at a favourable angle towards wind, waves and current, called weathervaning.

Based on IMO MSC Circular 645 *Guidelines for vessels with dynamic positioning systems* these are stated as follows:

Equipment Class 1 has no redundancy (DP-1):

- Loss of position may occur in the event of a single fault.

Equipment Class 2 (DP-2):

- Has redundancy so that no single fault in an active system will cause the system to fail. Loss of position should not occur from a single fault of an active component or system such as from generators, a thruster, switchboards, or remote controlled valves. It may occur after failure of a static component such as a cable, pipeline or manual valve.

Equipment Class 3 (DP-3):

- Which also has to withstand fire or flood in any one compartment without the system failing. Loss of position should not occur from any single failure including a completely burnt fire sub-division or flooded watertight compartment.

Whilst DP vessels can be used in shallower water their efficiency becomes more significant in water depths in excess of 30 m, and with the Round 3 REZs being in the area of 35 m to 45 m or deeper, it is likely that DP vessels will be used much more extensively.

6.1.2 Non-dynamic positioned (NDP)

There are some advantages to having NDP vessels, as vessels operating DP will have disadvantages including: complex systems with thrusters, extra generators and controllers, high initial costs of installation, high fuel costs, a chance of running off position by system failures or blackouts, underwater hazards from thrusters for divers and remote operated vehicles combined with higher maintenance of the mechanical systems.

6.2 VESSEL TYPES

6.2.1 Barge



Barges are utilised extensively in the offshore renewables industry for a range of activities, including:

- accommodation units;
- transportation of components, and
- inter array cable lay.

These barges range in size and facilities from a truly 'dumb' barge to more sophisticated barges that can be ballasted and moored and are able to carry a range of deadweight cargo or equipment; a selection of these barges is described within the vessel matrix (Annex C).

6.2.2 Jack-up barge



Jack-up barges have been the main 'workhorse' of the industry over the last decade as, when jacked-up, they provide a fully stabilised platform for the various sensitive lifts required in the installation of a turbine.

With several of the Round 2 projects and all Round 3 REZs being further offshore and in deeper water, several purpose built units have been developed that are able to carry a larger number of turbine components and operate in deeper water conditions. In order to offer increased efficiency, they are self-propelled and several have the capability to operate on DP for final positioning and relocation.

During the development of the initial Round 1 offshore wind farms, smaller jack-ups were utilised that ranged in size and had accommodation units added as required. The need for 24/7 operations has brought much larger vessels into the industry and delivered significant improvements in efficiency.

The barges utilised in Round 1 offshore wind farms and in the beginning of Round 2 projects were typically 30 m by 20 m, a deck load of 400 t and able to operate safely in water depths up to 25 m. They were typically equipped with a crane of 180 t capacity and a dedicated pile gate to hold a monopile of up to 3 m in diameter during driving operations.

Larger jack-up barges were built or converted with six or eight legs for increased stability and an ability to work in water depths up to 40 m. These would be typically 60 m by 32 m and able to carry both a higher deck load and a larger number of personnel of up to 50 persons to accommodate the more complex project requirements.

Whilst the term 'jack-ups' is still in use and relevant, it has in part been superseded by the purpose built wind farm installation vessel (WIV) that again will typically 'jack-up'. This newer type of vessel is able to work in significantly deeper water depths and offers a wider range of capabilities.

6.2.3 Wind farm installation vessel (WIV)



These are new generation purpose built vessels specifically designed for the requirements of offshore wind farm projects. They will typically be self-propelled and able to operate on DP whilst moving to location and when relocating between work sites. They will then 'jack up' to provide the required stable work platform.

With the significantly increased water depths and wind farm projects becoming further offshore, larger deck loads are required and these vessels are now able to meet this requirement whilst operating in the more hostile environments.

WIV types are in the order of up to 160 m in length with a significant beam of up to 50 m and a draught of 10 m. This provides a capacity to carry and install up to 12 units of the 3,6 MW wind turbine generators (WTG). They can operate in water depths of up to 60 m and 'jack-up' 15 m above the ocean surface to provide a stable platform minimally affected by the wind and waves.

In addition, main crane capacity is now typically in the order of 1 200 t and the vessel will have accommodation for over 100 persons with a helideck for crew change and essential supplies.

6.2.4 Heavy lift vessel (HLV)



The term 'heavy lift' has different parameters in the offshore renewables industry compared to the oil and gas industry; however, several of the same types of vessels are in use.

As described in 6.2.2 and 6.2.3 jack-ups and WIVs are used for many of the sensitive lifts in the installation of a turbine, in particular the nacelle and blades. The heavy lift vessels are more typically used for the installation of foundations and substation structures.

With the REZs moving into water depths of 35 m to 65 m it is probable that there will be an increasing number of tripod foundations and other variations that will require HLVs for installation.

These vessels are substantially larger and are both mono-hulls of typically 180 m in length and 36 m in beam. There currently is the capacity to have significant deck space of up to 2 500 sqm and a load capacity of 5 000 t.

There is likely to be accommodation for more than 120 persons and a fully equipped helideck. There are also semi-submersible heavy lift vessels that provide even more deck capacity and crane capacity. These vessels are up to 200 m in length and can have two main cranes that can operate independently or carry out a tandem lift; each crane will typically have the capacity of up to 7 000 t.

6.2.5 Dynamic positioning diving support vessel (DPDSV)



These are very specialised vessels that offer a wide range of capabilities including a built-in diving system that offers both air, surface supplied diving operations, through to bell deployed fully integrated saturation systems. Working alongside are typically remote operated vehicles (ROV) and work remote operated vehicles (WROV). Both the diving bells and ROV are often deployed through a central moon pool.

DPDSVs are large, typically around 100 m in length with a beam of 20 m, with a project crane capacity of approximately 120 t. They are normally fitted with an integrated 18 man saturation diving system, together with an air diving capability and possibly both ROVs and WROVs.

These vessels are relatively hi-cost but can offer a versatile stand-alone option for construction projects with sufficient deck space to accommodate cable laying, stabilisation and heavy lifting capabilities to carry out a variety of tasks in addition to subsea requirements.

6.2.6 Air range diving support vessel (ARDSV)



These are smaller anchored vessels that have been in common use in shallower waters associated with Rounds 1 and 2. They are capable of carrying out surface supplied air diving operations to a depth of 50 m.

Typically 30 – 50 m in length with a beam of 6 – 12 m. Diver deployment is usually over the side or stern of the vessel. They generally have limited lifting capability with a crane capacity of up to approximately 30 t.

Before considering these vessels for diving in deep water, informed assessment of all aspects of the proposed activities is essential; particular consideration should be given to the following:

- Environmental conditions: these vessels, due to size and anchored moorings, are less tolerant to adverse weather and tidal conditions than larger DP vessels.
- Safety: surface orientated air diving in deep water carries an increased risk of decompression related incidents; major diving contractors now limit air diving to 30 m to minimise this risk.
- Productivity: air diving is restricted to the amount of time a diver can stay at his maximum working depth.

6.2.7 Offshore support vessel (OSV)



OSVs will be similar to a DSV but less specialised and not necessarily requiring the same level of DP redundancy. They will often provide a different range of services, including supply vessel function and may have fire fighting and medical support facilities.

There is a wide range of support services these vessels can provide, which could include:

- safety standby vessels;

- supply vessels/crew change;
- construction support, or
- anchor handling tugs (AHT).

6.2.8 Cable lay vessel



The early offshore wind farms were close to shore and in a more sheltered 'near shore' environment and consequently simple barges were utilised with carousels and cable lay equipment installed as required.

As the wind farms have moved further offshore and the cable routes for the export cables have become more exposed, more sophisticated vessels are required. The export cable lengths from some of the Round 3 REZs are in excess of 100 KM and more larger purpose built cable lay vessels are required with integrated carousels to be able to carry these much longer lengths of cable safely.

The new generation of cable lay vessels is multi-purpose; they are able to lay, trench and survey the cable from an integrated system; with a dead weight of up to 8 500 t, a vessel length of 120 m, with a beam of 28 m and a DP-2 system, these vessels are able to lay heavy and long export cables.

6.2.9 Rock dump vessel



Rock dump vessels are increasingly used within the offshore renewables industry for a range of activities, including cable protection, crossings protection and scour; with the accuracy that a rock dump can now be deployed, this is an efficient option.

The latest generation of rock dump vessels is up to 175 m in length with a beam of 26 m and a dead weight of more than 25 000 t; operating typically on DP-2 they are able to accurately dump up to 3 000 tons/hour through a flexible fall pipe system.

6.2.10 Flotel



The use of 'fotels', offshore accommodation units, has increased with projects further offshore and with larger workforces. Ranges of different units are in operation from small anchored cruise liners, jack-up accommodation units and offshore support vessels that may also provide support in stores and workshop facilities.

These units provide an offshore facility for 24/7 operations without the need for the time consuming and sometimes arduous travel to site from a port, they can be moored alongside a facility with a hydraulic gangway to provide access.

7 VESSEL RELATED ASSURANCE AUDITS

The process of assessing a vessel and the associated project equipment is complex and it is recommended that an appropriately qualified and experienced organisation and specific, experienced and qualified individuals be appointed to carry out the evaluation.

Detailed knowledge of the project and the range of activities to be executed should comprehensively inform the evaluation. It is also important that information relating to the soil conditions, weather and tidal conditions is made available to the contractors and the evaluation team.

The major consultancies offer marine warranty surveyors (MWSs) who have well-established checklists that ensure a thorough and professional audit process is undertaken. The audit is often alongside a review of installation method statements and may include an evaluation of sea-fastenings design and calculations.

A generic scope of work for a MWS is included in section 8 and this can be tailored accordingly since this scope of works should be developed to reflect the specific needs of each project. In addition, each MWS will typically have a generic suitability survey format that should be reviewed and customised so as to fully inform the selection process and reflect all appropriate risks (see 7.4).

7.1 SITE DATA

The location where the primary project activities are to be carried out should be clearly identified and well documented. Validated vessel operations data should also be provided to assess the vessel(s)' capability to perform the tasks and the foreseeable risks for the site. The assembled data should be provided to both the contractor and also the audit and survey teams to ensure they are fully informed and able to assess the vessel(s) in context.

The selection of a construction vessel is often made ideally based on past experience of the vessel (and its management, both office and crew), but as a minimum from vessel specification datasheets. It is essential that mandatory inspections be completed using a competent surveyor (specialised where necessary e.g. crane/jacking systems) to ensure that vessel (and crew) not only performs, but performs reliably to charterer's expected performance. Multiple surveys using specialist surveyors may be required to produce findings to allow the (competent) developer/project manager to make an informed decision to take a vessel on-hire.

7.2 ACTIVITIES AND DURATIONS

A clear understanding of the activities that are to be carried out, the nature of operations and overall duration of the project are all important in selecting a suitable vessel. The actual schedule of activities and frequency of operation should also be considered.

7.3 VESSEL FACILITIES

The vessel facilities required should be documented to reflect the type of operation to be undertaken, including the number of both marine and project team and associated manning levels. These facilities will need to be assessed to ensure the safety and needs of the persons on board are fully met in both normal operating conditions and in an emergency situation.

7.4 VESSEL RELATED MANAGEMENT

A suitability survey will typically address the following factors:

- vessel general particulars;
- certification and documentation;
- management;
- hull structure and condition;
- machinery;
- lifesaving appliances;
- fire fighting equipment;
- health, safety, security and environmental inspection;
- on-hire/off-hire survey(s);
- critical systems, or
- vessel quay side interface parameters.

In addition there will be sections that reflect the type of vessel and these may include:

- tug supplement;
- barge (deck, submersible, launch) supplement;
- heavy lift vessel supplement;
- DP vessel supplement;
- anchor assisted mooring supplement;
- dive support vessel supplement;
- cable laying supplement;
- jack-up vessel supplement;
- rock dumping vessel supplement;
- transportation barge supplement;
- helicopter supplement, or
- accommodation supplement.

8 MARINE WARRANTY SURVEYOR (MWS) SCOPE OF WORK – GENERIC

The following scope of work is provided solely for guidance as to the generic duties that may be required of an MWS or other third party. Depending on the developer's resources an MWS may be engaged throughout a project (possibly in a part-time role) to review design and/or amend documentation. It will be important for the MWS to have a firm understanding of all planned offshore activities in order to make fully informed assessments and to fulfil the intended role of the MWS in supplying independent 3rd party review to provide the appointed insurance companies with adequate professional assurance.

8.1 GENERAL REQUIREMENTS

The services provided by the MWS will in principle cover the following:

- meeting attendance;
- document reviews;
- vessel(s) and equipment survey(s), and
- on-site surveillance.

The MWS organisation will provide a multi-disciplined team of suitably qualified and experienced personnel, who will be available to provide the range of services at an agreed time frame and will have full responsibility and authority for the efficient and timely execution of the services.

8.2 SCOPE

The MWS should participate in kick-off meetings and should review all relevant documents and issue certificates of approval, recommendations, protocols and reports for the following:

- Conditional, suitability survey of installation vessels, barges and equipment and survey of mobilised installation set-up on the vessels and barges.
- Planning of the installation of sub-stations, accommodation platforms, foundations and wind turbines.
- Planning of the installation of the export cables and inter array cables.
- Manufacturing and supply of inter array cables and export cables.
- On-site surveillance and approval.
- Vessel selection criteria should be assessed against site conditions.

9 MAJOR CONSTRUCTION EQUIPMENT AUDIT

The inspection and audit of the major construction equipment is equally as important as the vessel inspection and audit. It should also be fully informed by the same site and project information; in addition, each element of construction equipment should fully comply with both relevant regulations and design criteria and be appropriate for the tasks it is required to perform.

Certain types of construction equipment will be an integral part of the vessel, for example the crane, whilst others will be mobilised for the specific project and quite often reflect the design requirements for installation works.

Types of major construction equipment and their compatibility could include:

- crane(s);
- hydraulic hammers;
- ROVs and WROVs;
- monopile upending frame;
- pile guidance tool(s);
- drilling equipment, and
- dive systems.

In addition, there will be specifically designed rigging for lifting and handling that should be fully certified, stored and handled correctly. It is also recommended that a level of spares be agreed for all major construction equipment.

The inspection and audit of the construction equipment should be carried out by a person or company experienced with the particular equipment and the operation. Furthermore, it is essential that the equipment be inspected after installation on the vessel and in a fully operational status so that both the functions and health and safety factors can be fully assessed.

10 TRAINING AND COMPETENCIES

The selection of a vessel suitable for work to operate in a UK Renewable Energy Zone (REZ) has to take account of a wide range of factors. A vital and significant element is the training, competencies and manning levels of both marine personnel and project team.

In order to deliver safe management and professional operation the training, qualifications and experience of all marine crew is vital together with appropriate manning levels.

10.1 MARINE PERSONNEL

The Master and crew of a self-propelled jack-up are required under the provision of the International Convention on Standards of Training, Certification and Watch Keeping for Seafarers (STCW), to be available as required by the vessel's Safe Manning Certificate; this includes Global Maritime Distress and Safety System (GMDSS) operator's certificates. Competences may be demonstrated through Certificates of Competence (CoC) issued under the provisions of STCW.

The areas of competencies that should be assessed include:

- Vessel and safety management systems.
- Health and safety management, including first aid.
- Marine operations, equipment and communications.
- GMDSS system and operation of radio equipment.
- Understanding of meteorology in the marine environment.
- Management of vessel stability, floating and jacked-up.
- Hazards of operating in an offshore wind farm (soil conditions, cables, unexploded ordinance (UXO)).
- DP operator's certificate (DPO).

Dependent on the type of vessel and other factors, 24/7 operations, including distance offshore and from a safe haven that requires extended operations, the marine crew should meet the requirements of:

- STCW;
- MGN 280 *Small vessels in commercial use for sport*³, and
- Equivalent Certificates of Competence (CoC) provided, or approved, by the MCA.

Marine crew should already hold a medical certification appropriate to the type of vessel to meet MCA or STCW requirements such as:

- ENG1 *Seafarer Medical Certificate*.
- ML5 *Medical Report Certificate*.
- Seafarer Medical Certificates accepted by MCA MSN 1815 (M) *Countries whose Seafarer Medical Certificates are accepted as equivalent to the UK Seafarer Medical Certificate (ENG1) from 1 July 2007*.

³ Under review at time of publication.

IMO Resolution A.1079 (28) adopted 4 December 2013 provides recommendations for the training of all personnel on mobile offshore units operating in the offshore environment. This resolution provides an international standard for training that is complementary to that required by the STCW code.

The International Jack-up Barge Association (IJUBOA) has worked extensively with barge owner/operators and industry to develop a series of national occupational standards that relates specifically to jack-up operations; IJUBOA has an official logbook recognised by industry.

It is important that managers and key personnel recognise that there will probably be persons from different cultures who speak various languages. The need for fluent communications throughout both the marine crew and project team is vital to ensure good health and safety practice and avoid miscommunication.

10.2 PROJECT TEAM

The project team training should be primarily based on risk assessment for the various activities to be carried out and specific project requirements; these could include:

- RenewableUK *Marine Safety Training* (MST).
- STCW *Personal Survival Techniques* (PST).
- *Basic Offshore Safety Induction and Emergency Training* (BOSIET).
- Safety Induction Training on joining a vessel covering the requirements of MCA MGN 390(M) or MGN 120(M).
- DP Operators (DPO) certificate.
- Helicopter Underwater Escape Training (HUET) (if helicopter transfers are to be used).

The project team should have medical certificates to confirm their fitness to work offshore by having medicals carried out in accordance with either:

- RenewableUK *Medical fitness to work – Wind turbines – Guidelines for near offshore and land based renewable energy projects*.
- Oil and Gas UK (OGUK) *Offshore medical certificate*.

The other significant area of training, experience and competence is with regard to all persons involved with lifting activities. There needs to be a 'Responsible Person (RP)' with overall responsibility for the coordination and control of work activities involving lifting operations.

The RP is typically but not limited to the project manager, installation manager, project engineer or vessel master and they will normally appoint a 'Competent Person' (CP) to plan all safety-critical operations. The CP is defined as a person who has the required level of competence and experience to plan and supervise the required safety-critical activities, including when there is a transfer of responsibility between individuals, and this should be recorded within the project documentation.

11 REFERENCES AND FURTHER READING

The following list of documents provides an overview of the relevant health and safety regulations, guidelines and codes of practice:

**Energy Institute (EI)/G9 Offshore Wind Health & Safety Association (G9)
(www.energyinst.org and www.g9offshorewind.com)**

The management of service vessels used in the offshore wind industry⁴

International Labour Organization (ILO) (<http://www.ilo.org>)

Maritime labour convention, 2006

International Marine Contractors Association (IMCA) (<http://www.imca-int.com>)

IMCA 012 *Medical guidelines for non-marine crew working in the offshore environment*

IMCA C002 *Guidance document and competence tables: Marine division*

IMCA D014 *IMCA international code of practice for offshore diving*

IMCA D035 *The selection of vessels of opportunity for diving operations*

IMCA D035 *Guidance on the selection of vessels of opportunity for diving operation*

IMCA M103 *Guidelines for the design and operation of dynamically positioned vessels*

IMCA 113 *IMO Guidelines for vessels with dynamic positioning systems (MSC Circular 645)*

IMCA M149 *Common marine inspection*

IMCA M166 *Guidance on failure modes and effects analysis (FMEA)*

IMCA M171 *Crane specification document*

IMCA M187 *Guidelines for lifting operations*

IMCA M189 *Marine inspection for small workboats*

IMCA M202 *Guidance on the transfer of personnel to and from offshore vessel and structures*

IMCA M203 *Guidance on simultaneous operations (SIMOPS)*

IMCA M205 *Guidance on operational communications*

IMCA M223 *Guidance for the positioning of dynamically positioned (DP) jack-up vessels on and off the seabed*

IMCA R018 *Guidelines for installing ROV systems on vessels or platforms*

IMCA SEL 003 *The initial and refresher familiarization of vessel crews*

IMCA SEL 007 *Basic safety training and vessel induction for non-marine personnel working offshore*

IMCA SEL 025 *Guidance on the transfer of personnel to and from offshore vessels*

International Maritime Organization (<http://www.imo.org>)

Guide to maritime security and the ISPS Code

IAMSAR manual:

- *Volume I – Organization and management*
- *Volume II – Mission coordination*
- *Volume III – Mobile facilities*

International convention for the prevention of pollution from ships, 1973 (MARPOL 1973/78)

⁴ Guideline currently under development, due to be published later in 2014.

International convention on load lines, 1966
International convention on search and rescue, 1979 (SAR 1979)
International convention on standards of training, certification and watchkeeping for seafarers, 1978 (STCW 1978) and supporting STCW Code
International maritime dangerous goods code (IMDG Code)
International safety management (ISM) code
 MSC Circ. 645 *Guidelines for vessels with dynamic positioning systems*
 MSC Circ. 738 *Guidelines for dynamic positioning system (DP) operator training*
Resolution A.1079(28) Recommendations for the training and certification of personnel on mobile offshore units (MOUs)
Safety of life at sea convention (SOLAS), 1974
Ships' routing (a consolidation of requirements and guidance on routing and reporting systems under SOLAS chapter V)
Standards of training, certification and watch keeping for seafarers (STCW)
STCW Personal survival training (PST)
The convention on the international regulations for preventing collisions at sea (COLREG), 1972

SOLAS-related codes and guidelines that may be applicable:
Code for the construction and equipment of mobile offshore drilling units (MODU) Code – Resolution A.1023(26)
Guidelines for the design and construction of offshore supply vessels (OSV Guidelines) – Resolution MSC.235(82)
The special purpose ships (SPS) code – Resolution MSC.266(84)

Note: The above list is not exhaustive. The scope of application of international standards is subject to their implementation in UK Regulations that may also be EU-related. Detailed technical regulations are normally contained in annexes to international conventions. SOLAS and SOLAS-related documents may be subject to amendments, and earlier versions or amendments may be applicable, depending upon a vessel's date of construction.

UK Merchant Shipping Legislation

These are referred to in MCA published guidance, much of which is referred to under Maritime and Coastguard Agency.

Maritime and Coastguard Agency

(<https://www.gov.uk/government/organisations/maritime-and-coastguard-agency>)

MGN 20 (M+F), *Implementation of EC directive 89/391, Merchant shipping and fishing vessels (health and safety at work) regulations*

MGN 280 (M), *Small vessels in commercial use for sport or pleasure, workboats and pilot boats, alternative construction standards⁵*

MGN 323(M+F), *Explosives picked up at sea*

MGN 325(M), *Helicopter assistance at sea*

MGN 332 (M+F), *The merchant shipping and fishing vessels (lifting operations and lifting equipment) regulations 2006*

⁵ Plans are to replace this document late 2014 with a new, version 2 of the safety of small workboats and pilot boats – a code of practice.

MGN 352 (M+F), *The merchant shipping and fishing vessels (control of noise at work) regulations 2007*

MGN 353 (M+F), *The merchant shipping and fishing vessels (control of vibration at work) regulations 2007*

MGN 371 (M+F), *Offshore renewable energy installations guidance on UK navigational practice, safety and emergency response issues*

MGN 372 (M+F), *Offshore renewable energy installations (OREIs): Guidance to mariners operating in the vicinity of UK OREIs*

MGN 390 (M), *Construction standards for offshore support vessels and other special ship types [planned to be replaced mid-2014]*

MGN 432(M), *Safety during transfers of persons to and from ships*

MGN 436 (M+F), *Whole-body vibration: Guidance on mitigating against the effects of shocks and impacts on small vessels*

MIN 444(M+F), *MARPOL – Forthcoming amendments to MARPOL Annex IV – Sewage and MARPOL Annex V garbage*

MGN 448(M), *Standards of training, certification and watchkeeping convention, 1978 as Amended Manila amendments: Medical certification, hours of work and alcohol limits*

MGN 468 (M), *Voluntary towage endorsement scheme*

MIN 469(M), *Requirements for updating training in accordance with the 2010 Manila amendments to the STCW convention 1978*

MGN 471(M), *Maritime labour convention, 2006: Definitions*

MIN 472(M), *New requirements for security training for shipboard personnel*

MGN 490(M), *Maritime labour convention: Application to small vessels of less than 200 GT that are ordinarily engaged in commercial activities*

MGN 491(M), *Maritime labour convention: Application to workboats of 200 GT to less than 500 GT*

MGN 492(M+F), *Health and safety at work: Protecting those not employed by the ship owner*

MGN 497(M+F), *Dangerous goods – including chemicals and other materials – Storage and use on board ship*

MGN 505(M), *Human element guidance – Part 1 fatigue and fitness for duty: Statutory duties, causes of fatigue and guidance on good practice*

MSN 1560, *Survival at sea*

MSN 1731(M+F), *The merchant shipping and fishing vessels personal protective equipment regulations 1999*

MSN 1769(M), *International labour organization convention (ILO)178 and recommendation 185 – Concerning the inspection of seafarers' working and living conditions*

MSN 1842(M), *Maritime labour convention, 2006: Hours of work and entitlement to leave application of the merchant shipping (hours of work) regulations 2002 and the merchant shipping (maritime labour convention) (hours of work)(amendment) regulations 2014*

MSN 1849(M), *Maritime labour convention, 2006 – On-board complaints procedure*

Additionally, there is new Workboat Code (currently as guidance) which can be found at: <https://www.gov.uk/government/publications/workboat-code>

'The MCA has procedures for permitting fishing vessels to undertake a limited number of other operations including guardship duties. For further information contact the MCA at: shipping.safety@mcga.gov.uk'

Note: The above list is not exhaustive. MSNs are referred to in UK regulations and contain statutory requirements. MGNs refer to, and contain guidance and interpretation on, the UK and international requirements.

National Archives (<http://www.legislation.gov.uk>)

Lifting operations and lifting equipment regulations 1998 (LOLER)

Manual handling operations regulations 1992 (as amended)

The construction (design and management) regulations 2007 (CDM)

The management of health and safety at work regulations 1999 – also the MS and FV (health and safety at work) regulations 1997 (as amended)

Note: The above list is not exhaustive; a full list of regulations including LOLER can be found via the national archives website.

RenewableUK (<http://www.RenewableUK.com>)

First aid needs assessment – Guidelines for renewable energy projects

Guidelines for selection and operation of jack-ups in marine renewable energy industry

Health and safety training entry and basic-level health and safety training and competence standards: Scope and application to large wind projects

Incident response: Offshore wind and marine projects

Marine safety training (MST)

Medical fitness to work – wind turbines – Guidelines for near offshore and land based projects

Offshore wind and marine health and safety guidelines

Safety circular: Notices to mariners

Vessel safety guide – Guidance for offshore renewable energy developers

Working at height & rescue training standard

Other resources:

Basic offshore induction and emergency training (BOSIET)

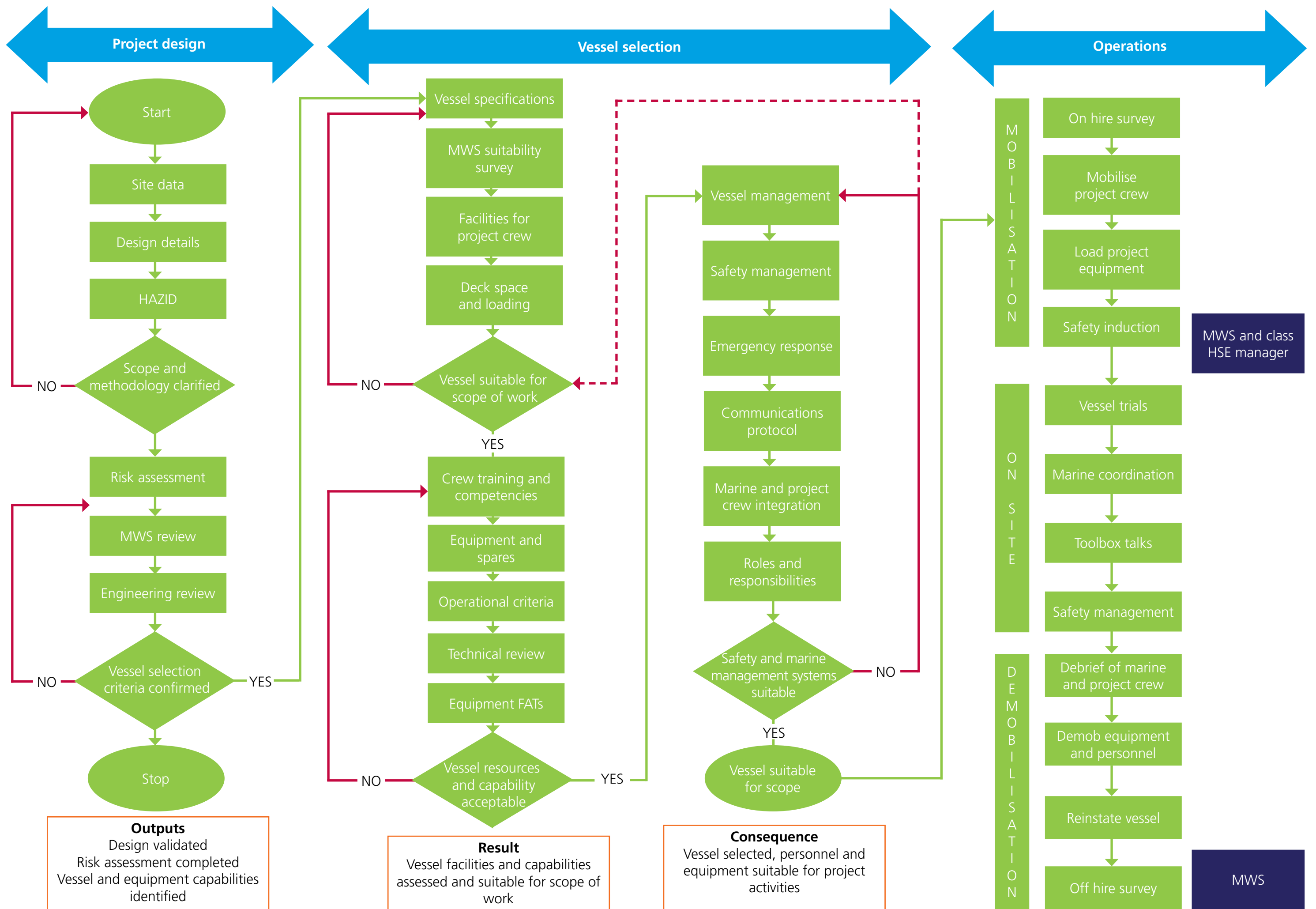
BS 5760-5 Reliability of systems, equipment and components. Guide to failure modes, effects and criticality analysis (FMEA and FMECA)

IEC 60812: Analysis techniques for system reliability

IMO MSC resolution 36(63) Annex 4 – Procedures for failure mode and effects analysis

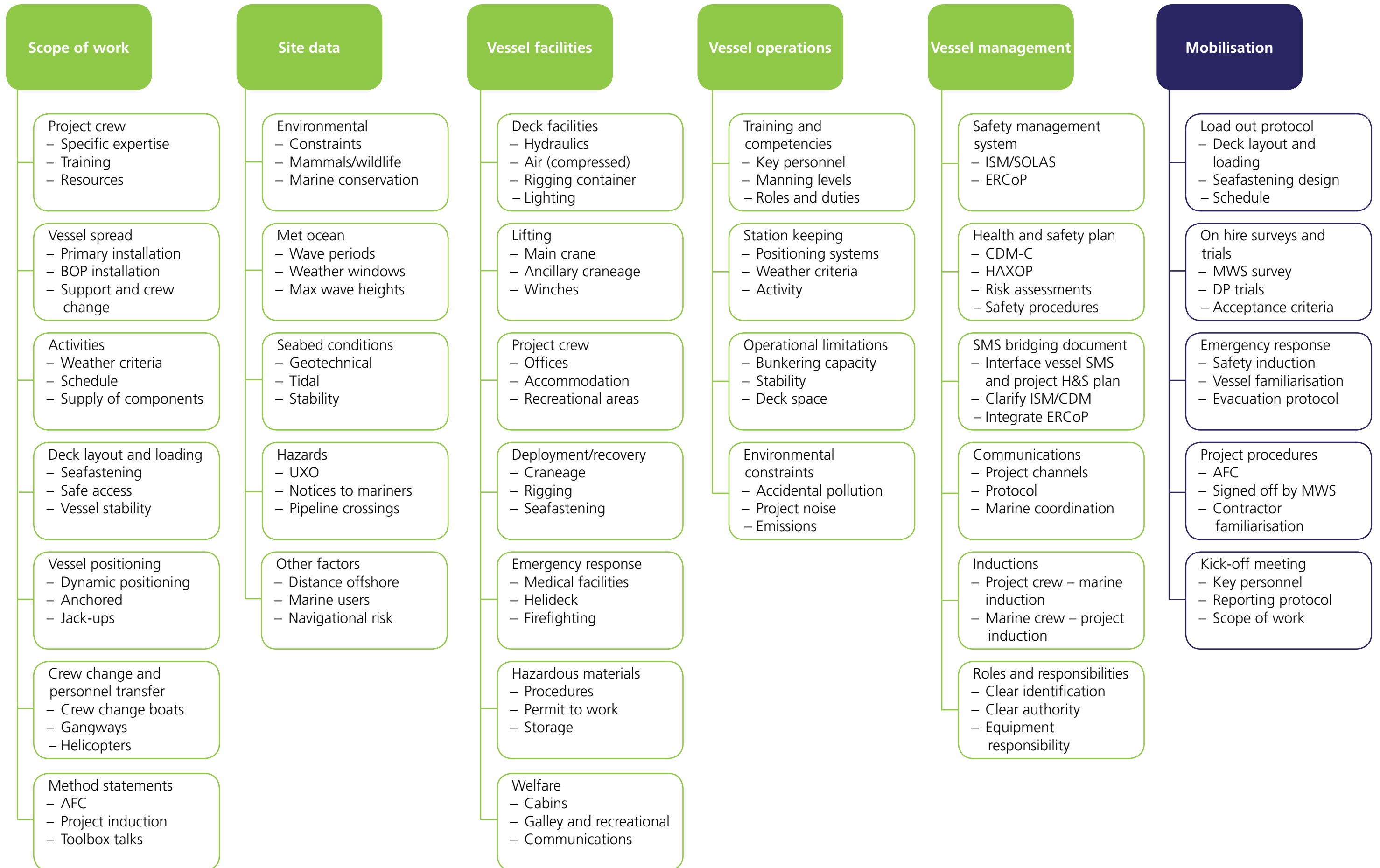
Procedure for failure mode and effects analysis (FMEA)












US Department of Defense MIL-STD-1629A



Annex A Vessel selection process flowchart

Vessel selection – significant factors



Pictorial reference	Vessel type	Accommodation (Pers – average)	Types	Length (metres – average)	Width/beam (metres – average)	Draught (metres – min to max)	Max lift (tonnes – min to max)	Notes * Detailed vessel information is available via vessel owners or specialist websites.
	Barge	10	1	115*	32*	4 to 7	220 to 13 000	Barges are utilised for a range of activities including – accommodation units, transportation of components and inter array cable lay.
		10	2	90*	30*	4 to 7	220 to 12 500	
		10	3	84*	23*	4 to 7	220 to 6 500	
	Jack-Up barge	20+	1 and 2	30*	20*	2 to 11	280 to 1 600	Transport of components and inter array cable lay. Dedicated pile gate to hold monopole up to 3 m. Able to handle more complex projects.
		50+	3	60*	32*	2 to 11	280 to 1 600	
	Wind farm installation vessel (WIV)	100	1	160*	50*	2 to 10	280 to 1 600	Carry and install 12 units of the 3,6 MW wind turbine generators (WTG). Jack-Up 15 m above sea level.
	Heavy lift vessel	120	1	180*	36*	4 to 14	1 000 to 14 200	Fully equipped Helideck.
	Semi submersible	120	2	200*	36*	4 to 28	1 200 to 14 000	Fully equipped Helideck.
	Dynamic positioning diving support vessel (DPDSV)	Var*	Var*	100*	20*	4 to 10	0 to 1 500	Working alongside are typically remote operated vehicles (ROVs) and work remote operated vehicles (WROVs). Fitted with 19-man saturation diving system.
	Air range diving support vessel (ARDSV)	Var*	Var*	40*	9*	2 to 11	0 to 30	Diver deployment is usually over the side or stern of the vessel. Generally limited lifting capability.
	Offshore support vessel (OSV)	Var*	Var*	100*	15*	2 to 10	0 to 2 000	Range of support services including, fire fighting and medical. Can also provide safety standby vessels, supply vessels and crew change, construction support and anchor handling tugs (AHTs).
	Cable lay vessel	Crew	Var*	120*	28*	2 to 10	1 000 to 8 500	They are able to lay, trench and survey the cable from an integrated system. DP2 system.
	Rock dump vessel	Crew	Var*	175*	26*	2 to 15	1 000 to 25 000	Accurately dump up to 3 000 tons/hour through a flexible fall pipe system. DP2 system.
	Flotel	Var*	Var*	100*	25*	3 to 15	0 to 2 000	A range of different units in operation from small anchored cruise liners, jack-up accommodation units and multi purpose vessels that require support in stores and workshop facilities.
	Dynamic Positioning (DP) vessel (DP systems can be built into most commercial vessels)	20+*	DP1	Var*	Var*	4 to 28	1 000 to 14 200	Loss of position may occur in the event of a single fault. Loss of position should not occur from a single fault of an active component or system. Loss of position should not occur from any single failure including burnt fire sub division or flooded watertight compartment.
		20+	DP2	Var*	Var*	4 to 28	1 200 to 14 000	
		20+	DP3	Var*	Var*	4 to 28	1 200 to 14 000	

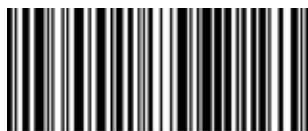
* Detailed vessel information is available via vessel owners or specialist websites.

Annex C Vessel matrix



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